Willow Master Development Plan

Appendix E.3C

Non-GHG Air Quality and Public Health Analysis of Downstream Combustion of Willow Oil*

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CONTENTS

TABLES

NOTE:

This appendix is new for the Willow Master Development Plan Supplemental Environmental Impact Statement.

1.0 PURPOSE AND OVERVIEW

BLM requested a qualitative non-greenhouse gas (GHG) analysis of the air quality and public health impacts of the downstream combustion of Willow oil for inclusion in the Willow Master Development Plan Final Supplemental Environmental Impact Statement (SEIS). The public health impacts of GHG emissions from the Willow Project are accounted for in the social cost of GHG estimates provided in the SEIS.

2.0 TECHNICAL APPROACH

Combustion of products refined from Willow oil would lead to emissions of criteria and hazardous air pollutants which would impact air quality and public health. Recognizing that there are numerous uncertainties and limitations in any such assessment, a qualitative assessment of air quality and public health impacts from downstream combustion of Willow oil has been conducted.

First, we discuss the pathway of Willow oil including the uncertainties in such information. The types of refined products likely derived from Willow oil are determined using the five year national average (2017-2021) of refinery and blender outputs from the U.S. Energy Information Administration (EIA) (EIA 2022a). These include products such as motor gasoline, distillate fuel oil, jet fuel, petroleum coke, asphalt oil, and lubricants. The combustion of these products by a variety sources, such as on-road and off-road vehicles and stationary sources, results in emissions of criteria and hazardous pollutants, including nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter with an aerodynamic diameter of 2.5 microns (µm) or less ($PM_{2.5}$), particulate matter with an aerodynamic diameter of 10 µm or less (PM_{10}), lead (Pb), benzene, 1,3-butadiene, formaldehyde (HCHO) and other volatile organic compounds (VOCs). As the final destination of the petroleum products is uncertain and impacts of air quality are typically local/regional, we qualitatively discuss how downstream combustion of petroleum products would affect local and regional air quality, such as impacts to ambient concentrations of ozone, $PM_{2.5}$, PM_{10}, sulfur dioxide, and nitrogen dioxide. Air quality impacts from non-combustion end uses of Willow oil are included in this study. A comparison between alternatives is also presented.

From an air quality perspective, some of the most concerning pollutants resulting from downstream oil combustion are ozone (O_3), $PM_{2.5}$, PM_{10}, SO_2, and nitrogen dioxide (NO_2), which are each discussed below. Ammonia (NH_3) and VOCs are also included in this report since they are emitted from combustion processes and serve as precursors to ozone and PM formation. The focus of the public health assessment is on O_3, NOx, SO_2, $PM_{10\text{-}2.5}$[1], $PM_{2.5}$, benzene, 1,3-butadiene, n-hexane, and formaldehyde as these could have either high exposure or high toxicity.

3.0 WILLOW OIL PATHWAY

An overview of Willow oil transport within Alaska is described in SEIS Section 2.5, *Project Components Common to All Action Alternatives*. Briefly, sales-quality crude oil would be transported via the Willow Pipeline from the on-site Willow Processing Facility to the Alpine Sales Pipeline. From here, it would be transported to the Kuparuk Pipeline and then to the Trans-Alaska Pipeline System (TAPS) near Deadhorse, AK. TAPS would transport the oil from the North Slope to the Valdez Marine Terminal on the southern coast of Alaska. Bulk oil tankers would then transport it to refineries. Historically, nearly 80% of the oil produced in Alaska was transported to refineries in California and Washington, 15% was refined within Alaska, and the remaining 5% was shipped to Hawaii or exported to international destinations (EIA 2022b). However, there is considerable uncertainty in the exact final destinations of Willow oil. Prior to transport, crude oil would be minimally processed on site to remove debris (e.g., sand), gases, and water. Any gas produced as a result of Willow project activity would be either beneficially used onsite or reinjected into the well and is already accounted for in the direct emission analysis for the Project (SEIS Section 3.3.2.2, *Environmental Consequences, Air Emissions Inventory*).

[1] $PM_{10\text{-}2.5}$ is the coarse fraction of PM_{10}, i.e., PM_{10} minus $PM_{2.5}$

4.0 REFINED PRODUCTS

Because the final destination and end use of Willow oil is uncertain, national average data is used to determine the types of refined products potentially derived from Willow oil. The U.S. Energy Information Administration (EIA) reports the percent yield of individual petroleum products from U.S. refineries on a yearly basis. As mentioned above, the majority of crude oil produced in Alaska is transported to refineries within the U.S., so domestic averages provide a reasonable basis for this analysis.

Motor gasoline is the primary petroleum product manufactured in U.S. refineries, contributing an average of 46.7% of the total yield over the five year period from 2017-2021 (EIA 2022a). Distillate fuel oil and kerosene-type jet fuel follow in production, contributing 30.0% and 9.2% of the yield during that period, respectively. Together, these three products made up nearly 86% of total U.S. refinery output. The remaining 14% consists of several additional products which are listed in Table E.3.C-1 (EIA 2022a).

Some refinery products, such as lubricants and asphalt and road oil, are not combusted and their impacts are therefore not included in this study. Combustible petroleum products can be burned by a variety of sources including on-road and off-road vehicles and stationary sources.

Table E.3.C-1. Average product yield from U.S. refineries.

Petroleum Product	Refinery Yield (%) 2017-2021 Average
Finished motor gasoline	46.7
Distillate fuel oil	30.0
Kerosene-type jet fuel	9.2
Petroleum coke	5.1
Still gas	4.0
Hydrocarbon gas liquids	3.7
Asphalt and road oil	2.0
Residential fuel oil	2.0
Naphtha for petrochemical feedstock use	1.1
Lubricants	1.0
Other oils for petrochemical feedstock use	0.6
Miscellaneous products	0.5
Special naphthas	0.2
Finished aviation gasoline	0.1
Kerosene	0.1
Waxes	0.0

Source: EIA 2022a

Note: The individual products do not sum to 100 percent due to refinery processing gain, which is due to crude oil having a higher specific gravity than the finished products.

5.0 EMISSIONS FROM PRODUCT COMBUSTION

The focus of this study is on emission of criteria and hazardous air pollutants. The six main criteria air pollutants relevant to emissions from petroleum product combustion are CO, NO_x, $PM_{2.5}$, PM_{10}, SO_2, and Pb. O_3 is also a criteria air pollutant but is not directly emitted. Based on the U.S. EPA's 2017 National Emissions Inventory (NEI) (EPA 2017), petroleum product combustion in the U.S. annually emits 3.07×10^7 tons of CO, 6.31×10^6 tons of NO_x, 4.23×10^5 tons of PM_{10}, 2.85×10^5 tons of $PM_{2.5}$, 3.04×10^5 tons of SO_2, and 4.85×10^2 tons of Pb. Emissions from individual products and sources are listed in Table E.3.C-2 and described further in the sections below.

NH_3 and VOCs are not defined as criteria air pollutants by the EPA but instead are precursors to secondary PM and O_3. Petroleum product combustion emits 1.06×10^5 tons of NH_3 and 2.90×10^6 tons of VOCs. Many VOCs are also defined as hazardous air pollutants (HAPs), which are compounds that can cause cancer or other severe health problems. 187 individual HAPs are included in the EPA NEI. Due to the large number of these pollutants, this study focuses on those most relevant to petroleum product combustion that have greatest potential to impact air quality and human health, including 1,3-butadiene, benzene, HCHO, and hexane. Annual emission rates for NH_3, total VOCs, and these individual HAPs are provided in Table E.3.C-3.

Table E.3.C-2. Total U.S. annual petroleum product combustion emissions of criteria air pollutant by percentage from source sector groups

Petroleum product and source sector	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	Pb
Gasoline: On-road light duty	58.83%	29.91%	32.50%	17.43%	6.83%	--
Gasoline: On-road heavy duty	2.02%	0.98%	0.88%	0.48%	0.15%	--
Gasoline: Off-road mobile	32.79%	3.05%	9.55%	12.86%	0.33%	0.0%
Fuel oil: On-road light duty	1.17%	2.33%	1.97%	2.01	0.13%	--
Fuel oil: On-road heavy duty	1.48%	22.18%	21.26%	20.07%	1.27%	--
Fuel oil: Off-road mobile	1.29%	13.22%	14.74%	21.15%	0.39%	0.02%
Fuel oil: Railroad	0.38%	9.51%	4.05%	5.79%	0.23%	0.02%
Fuel oil: Commercial marine vessels	0.32%	13.39%	8.27%	11.40%	60.10%	0.84%
Fuel oil: Commercial/ Institutional	0.05%	0.57%	0.69%	0.96%	2.06%	0.54%
Fuel oil: Electric generation	0.03%	0.87%	1.24%	1.52%	13.02%	0.18%
Fuel oil: Industrial	0.09%	1.44%	1.69%	2.23%	6.34%	1.66%
Fuel oil: Residential	0.03%	0.53%	0.91%	1.18%	3.79%	0.42%
Jet and aircraft fuel	1.53%	2.03%	2.27%	2.93%	5.33%	96.32%
Total petroleum product combustion emissions (tons/year)	3.07×10^7	6.31×10^6	4.23×10^5	2.85×10^5	3.04×10^5	4.85×10^2

Source: EPA 2017
Note: Total emissions (in tons/year) are calculated as a sum of emissions in the categories.

Table E.3.C-3. Total U.S. annual petroleum product combustion emissions (by percentage from source sector groups

Petroleum product and source sector	NH_3	Total VOC	1,3-buta diene	Benzene	HCHO	Hexane
Gasoline: On-road light duty	85.12%	52.01%	51.02%	53.52%	18.32%	69.19%
Gasoline: On-road heavy duty	1.29%	1.03%	0.74%	1.08%	0.55%	1.43%
Gasoline: Off-road mobile	0.70%	34.79%	35.93%	34.42%	9.90%	27.98%
Fuel oil: On-road light duty	1.33%	1.34%	0.90%	0.44%	5.10%	0.16%
Fuel oil: On-road heavy duty	7.00%	3.44%	2.06%	1.22%	16.08%	0.52%
Fuel oil: Off-road mobile	1.10%	2.62%	1.18%	3.84%	28.40%	0.19%
Fuel oil: Railroad	0.34%	0.98%	0.41%	0.81%	8.73%	0.16%
Fuel oil: Commercial marine vessels	0.59%	1.49%	0.37%	0.28%	2.76%	0.23%
Fuel oil: Commercial/ Institutional	0.22%	0.09%	0.0%	0.01%	0.23%	0.0%
Fuel oil: Electric generation	0.58%	0.05%	0.0%	0.02%	0.08%	0.06%
Fuel oil: Industrial	0.26%	0.20%	0.01%	0.04%	0.40%	0.03%
Fuel oil: Residential	1.47%	0.04%	--	0.0%	0.08%	0.0%
Jet and aircraft fuel	--	1.91%	7.37%	1.32%	9.37%	0.04%
Total petroleum product combustion emissions (tons/year)	1.06×10^5	2.90×10^6	1.19×10^4	7.26×10^4	6.70×10^4	5.22×10^4

Source: EPA 2017
Note: Total emissions (in tons/year) are calculated as a sum of other categories

5.1 Mobile Sources

5.1.1 Motor Gasoline

Motor gasoline is the most used petroleum product in the U.S. Gasoline is primarily used in the transportation sector and is dominated by light-duty vehicles (e.g., cars, sport utility vehicles, small trucks), which make up 91% of total gasoline use (EIA 2022c). Additional uses include recreational vehicles and boats, small aircraft, equipment and tools used in various industries (e.g., construction, farming, forestry), and portable electricity generators. Combustion of motor gasoline emits both criteria and hazardous pollutants.

Criteria and hazardous air pollutant emissions from on-road light and heavy-duty vehicles and off-road sources are listed in Table E.3.C-2 and Table E.3.C-3. Off-road emissions include vehicles and equipment used in the following categories: airport services, construction, farm, industrial, lawn and garden, light commercial, logging, railway maintenance, recreational, and recreational marine vessels (EPA 2017). CO, NH_3, VOCs, 1,3-butadiene, benzene, and hexane have their highest petroleum product emissions from motor gasoline. For all pollutants in Table E.3.C-2 and Table E.3.C-3 (except Pb), emissions from light duty vehicles dominate the motor gasoline emissions.

5.1.2 Distillate Fuel Oil

Distillate fuel oil, which includes diesel fuel and heating oil, is the second most used petroleum product in the U.S. Approximately 77% of diesel fuel is used in the transportation sector in freight and delivery trucks, trains, buses, boats, electricity generators, and farm, construction, and miliary vehicles and equipment. Some cars and light trucks also have diesel engines.

Criteria and hazardous air pollutant emissions from various sources are listed in Table E.3.C-2 and Table E.3.C-3. NO_x, PM_{10}, $PM_{2.5}$, SO_2, and HCHO have their highest petroleum product emissions from distillate fuel oil. For all criteria pollutants except $PM_{2.5}$, SO_2, and Pb, on-road heavy duty vehicles have the largest diesel fuel emission rates. $PM_{2.5}$ emissions from off-road mobile equipment are slightly higher but comparable to on-road heavy duty vehicles. More than 95% of the SO_2 mobile distillate fuel oil emissions are from commercial marine vessels. NH_3, total VOC, 1,3-butadiene, and hexane emissions are primarily from on-road heavy duty vehicles, and benzene and HCHO emissions are mostly from off-road equipment sources.

5.1.3 Kerosene-type Jet Fuel

Jet fuel is used in commercial, private, and military aircraft. Combustion of jet fuel provides the main source of Pb emissions, contributing 96% of total Pb petroleum product emissions. For all other pollutants in Table E.3.C-2 and Table E.3.C-3, jet fuel makes up less than 10% of the total petroleum product emissions.

5.2 Stationary Sources

Stationary source emissions are predominantly from distillate fuel combustion used for commercial and residential heating, industrial boilers, and power plant electricity generation (EIA 2022d). Emissions of all pollutants discussed in this report are dominated by mobile sources. With the exception of SO_2, stationary sources make up 0 to 6% of the total emissions from petroleum product combustion. 25% of SO_2 emissions are from stationary sources, primarily from electric generation. Of the emissions from stationary source, hexane emissions are the highest from electric generation, while industrial combustion sources have the highest emissions of all other air pollutants assessed here.

6.0 AIR QUALITY IMPACTS

The EPA has set National Ambient Air Quality Standards (NAAQS) for the six criteria air pollutants (i.e., CO, NO_x, PM, SO_2, Pb, and O_3) under the Clean Air Act. In particular, primary standards are intended to protect public health. Ambient air concentration data for each pollutant is used to determine if a geographic area is in compliance with the standards. Regions in exceedance are classified as nonattainment areas and must enact plans to achieve attainment.

Since combustion of all petroleum products emit criteria and hazardous air pollutant emissions, local ambient concentrations of these pollutants would likely increase in areas where products from Willow oil are combusted. This may contribute to an area exceeding either national or local air quality standards. Air quality involves complex physical and chemical transformations at a local/regional level, so impacts would vary considerably depending on background concentrations, meteorology, and other local pollutant sources. If any pollutant concentration is near or above its standard in a particular area, the combustion of oil products may contribute to or exacerbate nonattainment. Potential pollutant concentration change resulting from combustion is therefore often a key driver of public policy to mitigate air quality and public health impacts in such areas.

Because the majority of refined petroleum products are combusted in mobile sources, the impacts of criteria and hazardous air pollutant emissions from combustion would likely be greatest in areas with heavy vehicle usage and high roadway density (Henneman 2021). Motor gasoline is the dominant product from crude oil and is used predominantly in densely populated urban centers. Transportation corridors, such as railroads, diesel truck routes, and marine ports, are also expected to see a greater influence from petroleum product combustion than other remote or rural areas. Downstream combustion of oil would therefore likely have the greatest overall impact in these areas. Emissions vary from vehicle to vehicle, however, and are not constant over the entire drive cycle (Wallingford 2022), and so the impact of emissions from downstream combustion of Willow oil on local air quality would depend on the specific vehicle fleet in use, driving and traffic patterns, and existing local/regional air quality.

6.1 Ozone Pollution

Both NO_x and VOCs are emitted by petroleum product combustion so downstream oil use would potentially increase O_3 concentrations. The magnitude of any O_3 change due to combustion is subject to background NO_x and VOC concentrations (and whether a region has limited NO_x or VOC), their local sources, and other local conditions, which would cause considerable variation from region to region. Ground-level O_3 has potential respiratory health impacts and environmental impacts (i.e., vegetation damage). Increased O_3 concentrations that result from NO_x and VOC emissions may cause exceedances of air quality standards which can aggravate these health and environmental effects.

The levels of O_3 are historically highest in summer months and afternoons due to increased sunlight. Local meteorology and weather (i.e., temperature, relative humidity, wind speed) play a significant role in O_3 concentrations, with warm dry weather favoring O_3 formation (EPA 2022b). Petroleum product combustion occurring in warmer months would therefore cause a larger impact on O_3 concentrations.

Formation of O_3 requires time, resulting in the highest levels typically observed downwind of NO_x and VOC emission sources. Wind patterns would therefore play a large role in where the peak O_3 formation occurs relative to the emission sources. Petroleum products burned in stationary point sources, for example distillate fuel used in power plants, would likely cause increases in O_3 downwind of the source. Most petroleum products are burned in mobile sources however which are dispersed over a larger area, causing broader regional changes to O_3 levels. Once formed, O_3 can also be transported based on weather and wind patterns.

Light duty motor vehicles are the largest source of NO_x and VOC emissions from petroleum product combustion. This, in addition to motor gasoline being the dominant product from crude oil, indicates that ambient levels of NO_x and VOCs would be most impacted in regions with high vehicle use such as densely populated urban centers. Throughout much of the U.S., the mobile sector provides the greatest source of precursor NO_x that leads to O_3 formation (Foley 2015). O_3 levels would consequently see the largest increases in these regions (especially if the regions are NOx-limited to begin with), particularly in areas with high levels of direct sunlight.

6.2 Particle Pollution

Particles (both PM_{10} and $PM_{2.5}$) are emitted directly from combustion processes (primary) and are formed chemically in the atmosphere (secondary). Precursors for secondary particle formation include SO_2, NO_x, NH_3, and VOCs which can be oxidized by hydroxyl radicals (OH) or O_3 (EPA 2022b). VOCs emitted in diesel exhaust are particularly efficient at producing particles (Srivastava 2022).

Both PM_{10} and $PM_{2.5}$ are directly emitted from petroleum product combustion. In the U.S., light-duty gasoline powered vehicles have the highest annual PM_{10} petroleum product emissions (32% of total) and off-road diesel fuel mobile sources have the highest $PM_{2.5}$ petroleum product emissions (21% of total) (Table E.3.C-2). The influence of direct emissions on ambient concentrations of PM_{10} would therefore be greatest in areas with high on-road vehicle use, for example in cities and along roadways. $PM_{2.5}$ concentrations would be most impacted by direct emissions where off-road diesel vehicles and equipment are used, for example at construction sites or where recreational vehicles are driven. Direct $PM_{2.5}$ emissions from on-road heavy duty diesel vehicles and on-road light duty gasoline vehicles are comparable to off-road diesel emissions, so cities and transportation corridors would also see increased $PM_{2.5}$ concentrations as a result of combustion. Compared to most gaseous pollutants, particles are deposited more quickly and have a shorter atmospheric lifetime. The greatest impact on ambient concentrations would therefore likely occur close to emission sources.

Emissions of SO_2, NO_x, NH_3, and VOCs from petroleum product combustion can contribute to secondary PM formation. The relatively high emissions from mobile sources would likely lead to the greatest impacts on secondary PM levels in regions with high vehicle use. NO_x, NH_3, and VOCs in particular have their highest petroleum product combustion emissions in the U.S. from on-road light duty vehicles. SO_2 is also emitted from on-road vehicles but its largest petroleum product emission is from commercial marine vessels. Influence of SO_2 emissions on concentrations of secondary particles would therefore likely be greatest along shipping routes. Electric generation using distillate fuel is the second most important source of SO_2 emissions. PM formation downwind of power plants will also likely be impacted by petroleum product combustion.

Differences in emissions of these precursor species from region to region would cause the chemical makeup of particles to differ across the country. Seasonal changes in fuel use would also contribute to PM composition and concentration variations. SO_2 emissions from power plants are particularly variable throughout the year due to electricity demands for residential and commercial heating and cooling purposes (EPA 2022b).

6.3 NO_x and SO_2

The impact of NO_x on O_3 and secondary particle formation is discussed above but NO_x itself is a criteria pollutant regulated by the EPA. Direct emissions of NO_x from petroleum product combustion would increase ambient levels and may cause exceedances of national or local standards. The impacts would likely be greatest near the emission source. In the U.S., annual NO_x emissions are greatest from light duty motor gasoline vehicles (Table E.3.C-2) so the greatest risk of exceedance would likely be in regions with high vehicle use such as in densely populated urban centers.

Similarly, the influence of SO_2 on particle formation is discussed above but it is also a criteria pollutant. Commercial marine vessels dominate SO_2 emissions and would consequently lead to the greatest increases in ambient SO_2 levels along commercial shipping routes. Electricity generation using distillate fuel also emits SO_2 so concentrations would also likely increase near these stationary power plant locations.

6.4 Hazardous Air Pollutants

The downstream combustion of Willow oil may result in localized increases in ambient air concentrations of HAPs such as benzene, 1,3-butadiene, n-hexane, and formaldehyde. These increases may be larger in areas that do not benefit from reductions in other combustion emissions. Potential health impacts of these HAPs are discussed in the section on downstream public health impacts.

7.0 ENVIRONMENTAL JUSTICE

A literature review was conducted to evaluate potential impacts to disproportionately impacted communities associated with the transport, refinement, and use of oil such as that produced by the Willow Project. The criteria used to identify relevant articles included:

- Geographic scope of the United States
- The emission source type (transportation, refineries, petrochemical processing, and jet fuel)
- Inclusion of environmental justice (i.e., disparate impacts)

Articles that conducted a case study or had scope so narrow that results were not applicable to other regions were not included. The availability of relevant and scientifically sound articles varied based on the applicable emission source type. In general, articles evaluating mobile sources were plentiful while articles related to refineries, petrochemical processing, and jet fuel consumption were scarce. Three key categories, mobile sources, airports and seaports, and refineries, are discussed below.

7.1 Mobile Sources

Considerable research has been conducted towards understanding the health implications of air pollutants. Due to rapid development and urbanization, vehicle emissions have quickly become a leading source of air pollution (Houston 2016). Growing evidence supports that individuals that live near high volume roadways are exposed to elevated concentrations of HAPs and their associated health implications (Houston 2016). Expanding research demonstrates the intricacies of environmental disparities associated with exposure gradients and socioeconomic factors. As such, the following articles were selected to discuss the size and distribution and socio-economic makeup of communities that live along high volume roadways, and the exposure risk paired with associated health implications.

A study conducted by Rowangould (2013) evaluated the size, distribution, and characteristics of communities living within 500 meters (1,640 feet) to high volume roadways across the nation. High volume roadways were defined as having an average annual daily traffic (AADT) rate greater than 25,000. Their analysis of highway networks, traffic density, and census block data uncover patterns of exposure disparities of vehicular sourced air pollutants across socioeconomic and racial groups. Their findings reveal that 59.5 million people, or approximately 19% of the US population, live within proximity to high volume roads. Approximately one quarter (27.4%) of the people living in proximity to high volume roads identify as non-white, of those people that identify as non-white 23.7% identify as Black and 29.4% identify as Latino. The average median household income of these census blocks was found to be $1,221 less than the average US household of $46,525. These statistical trends support corresponding literature that demonstrate that minority and low-income households are more likely to live near high volume roads. Though it was observed that 84% of counties show some level of disparity, Rowangould noted that the aggregated values temper the severity of disparities in some cities and states with higher density cities and vehicle traffic. For example, the national average of individuals living near high volume roadways is 19.3% as compared to California's at 40%.

A corresponding study by Houston (2016) analyzes the unequal burden of disadvantaged neighborhoods exposure to hazardous mobile pollutants. They discuss societally embedded practices that have systematically segregated racial and economic classes in Southern California. Environmental justice research suggests that historic societal discrimination and exclusionary zoning practices have been the driving factor that has sidelined disadvantaged communities to live in areas with elevated concentrations of pollutants. Their findings identified that high-poverty rate communities have twice the traffic density compared to communities with lower poverty rates and minority communities have 2.5 times the traffic density than communities with a lower fraction of minorities. In Southern California, it was observed that on-road emissions were the sources for 76% of CO, 45% of VOC, and 63% of NOx. In general, researchers have found that disparities among traffic distribution such as with these are associated with higher risk of health effects that corelate with vehicle related pollutants.

7.2 Airports and Seaports

The multifaceted processes involved in the movement of goods have been known to release hazardous air pollutants in the surrounding environment such as benzene, toluene, black carbon, ultrafine particulate matter, and chlorinated compounds (Bendtsen, 2021; Houston, 2008). Bendtsen (2021) conducted a literature review of the available scientific research regarding the health effects of airport emissions. Their study encompassed a broad scope of diverse emission sources across all airport activities, from combustion of several types of jet engine fuel emissions to general occupational exposures. Their discussions are often centered around the production and distribution of ultrafine particles as they are commonly a major contributor to the exposure pathway of these harmful air toxins. Ultrafine particles (UFP) are a subclass of particulate matters characterized by having an aerodynamic diameter less than 100 nanometers. Due to their size, UFPs can penetrate deeply within the respiratory system of exposed individuals and cause long-lasting health problems (EPA, 2022). Studies have found the tendency to find notable concentrations of toxic substances such as lead, sulfates, and metals on the particle surface (Miranda, 2011). Applicable conclusions from Bendtsen's analysis were that aircraft emissions are dominated by UFPs less than 20 nanometers, the physio-chemical composition of aircraft emissions contain similar values for components (such as black carbon, hydrocarbons, and metals) to that of diesel exhaust and the highest concentrations of these contaminants have been measured downwind from aircraft runways.

Houston's (2008) research identified the limitations of prior analysis of seaport related diesel emissions and discusses associated environmental justice concerns. The research notes that studies have often used inefficient source data that generalizes and often misrepresents traffic volumes of heavy duty diesel trucks on residential streets to and from the major port operations. Due to the levels of toxic air contaminants that are known to be emitted from these vehicles, the elevated traffic in these freight corridors have raised concerns for the adjacent communities. For example at one port in California, the socioeconomic composition of these communities are majority minority with 65% of the residents identifying as Hispanic and 8% non-Hispanic white. Additionally, 29% of the residents had incomes below the federal poverty level with 52% of the population having less than a high school education versus 18% and 30% for the county as a whole. Their findings have identified sustained levels of HDDT traffic levels averaging around 400 to 600 trucks per hour throughout the day and often directly adjacent to sensitive populations such as school children.

7.3 Oil Refineries

HAPs such as benzene, toluene, hydrocarbons, and other volatile pollutants have been known to be emitted from oil refineries. HAPs have been classified as such by the EPA due to their ability to cause serious health impacts to those exposed. A case study by Williams (2020) conducts a preliminary analysis evaluating the association between proximity to oil refineries and cancer risk in Texas. Incidences of cancer diagnosis from 2010 to 2014 were gathered from individuals 20 years old or older living within 30 miles of an oil refinery. Their findings reveal a dose-response association between proximity to an oil refinery and elevated risk of cancer diagnostics across all observed cancer types. However, due to the nature of this study, Williams emphasizes the need to recognize the potential inherent biases and assumptions associated with the study design. Limitations to the analysis include lack of exposure information and lack of residence history, not controlling for all known confounding factors such as access to care or occupational exposures, and the use of coarse socioeconomic community data.

8.0 DOWNSTREAM PUBLIC HEALTH IMPACTS

There are several possible approaches to understanding the potential health impacts of oil combustion. The first is to examine evidence that directly studies the impact of burning oil. However, there are few situations where oil combustion products can be studied in isolation as opposed to exposure to the entire mix of air pollution from multiple sources. The second approach examines potential health impacts of the components of oil combustion. There are a large number of chemicals generated from the burning of oil; we have chosen to examine the subset which are likely, either due to their concentration or their toxicity, to contribute the most to potential health effects: CO, $PM_{2.5}$, PM_{10}, NO_2, SO_2, benzene, 1,3-butadiene. formaldehyde, and *n*-hexane. Some of the health information is derived from epidemiological studies and other information comes from toxicology studies. Both provide useful information individually, but often our understanding of the health effects literature comes from an integration of both types of studies, particularly for chemicals such as these were there is a large amount of available information.

Epidemiology studies are observational studies which examine how often various diseases occur in different populations of people and examine the strength of the statistical association between exposure (in this case to oil combustion products) and individual diseases. Since exposures are not controlled, epidemiology studies often have exposures to other substances that may also be responsible for the observed disease (known as potential confounders). Statistical techniques may be used to differentiate between the exposure of interest and potential confounders.

Toxicology studies use controlled exposure conditions to examine health effects outcomes. Toxicology studies are often performed in laboratory animals and exposures are carefully controlled (duration of exposure and concentration of tested agent). If the health endpoint is not extreme, toxicology studies can also be performed in people where individuals are contained in an exposure chamber for relatively short durations (minutes to hours) and the exposures in the chambers are carefully controlled. Examples of acceptable health endpoints are mild, reversible irritation, as well as blood markers of a process that might lead to a disease.

McDuffie et al (2021) examines different sources of $PM_{2.5}$ on a global scale to determine which sources sectors and fuels contribute the most to the global burden of disease across different regions, countries, and subnational areas. This study estimates 3.85 million deaths occur globally each year from total $PM_{2.5}$ exposure in its evaluation of the contribution from anthropogenic and manmade sources in different regions. This study allows us to address the potential contribution of the "liquid oil and natural gas" sector to global disease, both domestically and internationally.

8.1 The complex mixture: Oil combustion

This section summarizes epidemiology evidence for associations between oil combustion products as a whole and short-term and/or long-term health effects. Studies were identified by performing a literature search through PubMed, a search engine supported by the U.S. National Institutes of Health's National Library of Medicine which contains details of journal citations and abstracts for biomedical and life science literature from around the world. Findings were considered for this section if they focused on exposure to oil combustion itself, or exposure to air pollutants that the authors believe originated primarily from oil combustion processes. Health outcomes studied included asthma/allergic symptoms, oxidative DNA damage, birthweight, heart rate variability, mortality and hospitalizations, and inflammatory markers.

Very few epidemiological studies directly measure exposure to oil combustion. While a few studies examine populations believed to be occupationally exposed to PM dominated by oil combustion sources, most studies instead measure PM and its components and apply statistical methods to attribute pollutants back to their sources (a technique known as source apportionment). For example, the presence of high concentrations of the metals nickel and vanadium are often used as an indicator of oil combustion sources. However, the lack of direct source measurements weakens these studies' ability to associate health impacts to oil combustion specifically.

Two studies examine the association of oil combustion products and asthma or allergic symptoms (Lawrence et al. 2022; Sigsgaard et al. 2015). One study involved cleanup workers without prior diagnosis of asthma who were followed after the 2010 Deepwater Horizon Oil spill (Lawrence et al., 2022). These workers were exposed to oil burning and flaring so were anticipated to be exposed to oil combustion products. Examining information on asthma symptoms between 2011 and 2013, increased asthma in oil cleanup workers was observed as compared to non-workers. However, no trends were noted within the worker population based on work tasks associated with burning or flaring. The other asthma-related study (Sugiyama et al., 2020) uses source apportionment to identify oil combustion sources for school children in Fukuoka, Japan, examining the association between daily oil-attributable $PM_{2.5}$ and self-reported symptoms. They observed increased risk of nasal symptoms (e.g., sneezing, runny nose, congestion) but not ocular or dermal symptoms (e.g., itching, irritation) associated with exposure to increased daily concentrations of oil attributable $PM_{2.5}$.

Two studies (Bell et al. 2010; Ottone et al. 2020) examined association between maternal exposure to $PM_{2.5}$ modeled to be linked with oil combustion and its potential with birth outcomes. Both studies linked PM to oil combustion based on its nickel and vanadium content. One study (Bell et al. 2010) compared average daily $PM_{2.5}$ concentrations measured between 2000 and 2004 in 4 counties in the Northeast United States and compared these values to various birth outcomes. Estimated total exposure to $PM_{2.5}$ from oil combustion was not associated with either decreased birthweight or full-term births with weights less than 2,500 grams (5.5 pounds). However, increased nickel or vanadium content of the PM was associated with an increased risk of being small for gestational age (having birthweights below the 10^{th} percentile for gestational age) and increased nickel content was associated with decreased average birthweight. The other study (Ottone et al. 2020) examined preterm birth, low birth weight, and small for gestational age outcomes in a northern Italy population. Daily average gestational exposures to $PM_{2.5}$ from 2012 to 2014 were estimated and source apportionment techniques were used to identify the influence of traffic, biomass burning, oil combustion, anthropogenic mixes, and secondary sources. Although an increased risk of preterm birth was found to be associated with exposure to oil-associated $PM_{2.5}$, especially at the highest exposures, no associations were found for low birthweight or small-at-term births. Evidence for associations with birth outcomes is limited by the small number of studies and lack of consistent results.

One study (Chen et al., 2020) examined cardiac outcomes associated with exposure to oil combustion products. Using source apportionment techniques to attribute $PM_{2.5}$ oil combustion products, daily ambient $PM_{2.5}$ concentrations were compared to heart rate measurements in the elderly population of Beijing, China. Authors reported that both increased daily cumulative $PM_{2.5}$ exposures attributable to oil combustion were associated with greater heart rate variability. No association was reported for very low frequency band results. The small sample size of individuals with measurements (22) and the cross-sectional study design limited the strength of this study.

Two studies (Chen et al., 2020; Samoli et al., 2016) examined mortality and hospitalizations patterns and their association with PM exposure believed to be associated with oil combustion. One study followed the populations of various European countries, estimating total $PM_{2.5}$ exposure in a city by using the annual 2010 average $PM_{2.5}$ concentrations measured at monitoring sites (Chen et al., 2020). High concentrations of vanadium and nickel in the $PM_{2.5}$ were used to attribute the material to oil combustion. Increasing $PM_{2.5}$ concentrations from oil combustion was found to be associated with increased risk of non-malignant respiratory-related mortality and general natural-cause mortality, but not with cardiovascular or lung cancer-related mortality. Dependence on a single year and annual average exposure data is a weakness of this study. A second study (Samoli et al., 2016) examined mortality and hospitalizations in London as compared to daily ambient PM_{10} concentrations. Source apportionment techniques were used to link PM_{10} with oil combustion sources. Authors concluded that higher concentrations PM_{10} believed to originate from oil were associated with increased respiratory related hospitalizations in subjects aged 14 and under, but not other age groups. No associations were observed for PM_{10} in either overall or cardiovascular-specific hospitalizations or mortality.

One study (Dai et al., 2016) examined concentrations of $PM_{2.5}$ in the ambient air and markers of inflammation in blood samples. Using source apportionment techniques to link $PM_{2.5}$ concentrations to oil combustion processes, 2-day average concentrations of $PM_{2.5}$ were associated with increased blood markers for some inflammation markers (ICAM-1 and VCAM-1) but not others (IL-6 or CRP).

One study, involving boilermakers occupationally exposed to oil combustion products (Kim et al., 2004), examined the presence of a biomarker for oxidative DNA damage (8-hydroxyguanosine; 8-OH-dG) in urine and evaluated whether there was an association with exposure to $PM_{2.5}$ from residual oil fly ash. DNA damage is not in itself a health effect but might be indicative of increased cancer risk. By comparing pre-shift and post-shift concentrations of urinary 8-OH-dG, investigators found increasing concentrations of total $PM_{2.5}$, as well as $PM_{2.5}$ with vanadium, manganese, nickel, and lead, were associated with higher urinary 8-OH-dG. The small sample size (20 workers) and brief study period (5 days) limited the conclusions that could be drawn from this study.

Taken together, these studies suggest that there may be various health impacts from exposure to oil combustion. However, there are only 2 studies that directly examine populations which have been exposed to oil combustion products (Kim et al., 2004; Lawrence et al., 2022), and one of these studies (Kim et al., 2004) looks at biomarkers that are only indirectly linked to health impacts. This evidence can be viewed as suggestive at best.

8.2 Criteria Pollutants

The following sections briefly review evidence for associations between short-term or long-term inhalation exposures to criteria pollutants CO, O_3, PM, NO_2, and SO_2. This information was summarized from the associated Integrative Science Assessment documents prepared by EPA in support of the NAAQS. Each document also discusses potentially susceptible populations. The primary literature, which includes both epidemiological and toxicological studies (including controlled human exposure studies), is reviewed in depth in individual EPA documents.

Most epidemiology studies of criteria pollutants involve studying large populations who are exposed to the pollutant in the ambient air. This means that individuals are exposed to a mixture of many different chemicals, including a set associated with various combustion sources. This makes it more difficult to tease out the impact of one criteria pollutant from another, but it may be possible using statistical tools. Key to supporting the epidemiology studies is supporting evidence from toxicology studies. Furthermore, since large populations are examined in these epidemiology studies, exposures are often estimated using measurements at central monitoring sites. These concentrations are then applied to an entire location (for example a city), even though the pollutant concentration may vary within that location. Finally, different averaging times are often applied to the measurements, so associations are examined compared to short-term averages or long-term averages.

When EPA evaluates criteria pollutants for health effects, they look at all streams of scientific evidence: epidemiology studies, and toxicology studies (including both controlled human exposure studies in people and studies in laboratory animals) and come up with a set of determinations: causal relationship; likely to be causal relationship; suggestive of but not sufficient to infer a causal relationship; inadequate to infer the presence or absence of a causal relationship; or not likely to be a causal relationship. Table 4 outlines the criteria for each determination.

Table E.3.C-4. Weight-of-Evidence for causality determinations.

Determination	Health Effects
Causal relationship (Causal)	Evidence is sufficient to conclude that there is a causal relationship with relevant pollutant exposures (e.g., doses or exposures are generally within one to two orders of magnitude of recent concentrations). That is, the pollutant has been shown to result in health effects in studies in which chance, confounding, and other biases could be ruled out with reasonable confidence. For example: (1) controlled human exposure studies that demonstrate consistent effects, or (2) observational studies that cannot be explained by plausible alternatives or that are supported by other lines of evidence (e.g., animal studies, mode-of-action information). Generally, the determination is based on multiple high-quality studies conducted by multiple research groups.
Likely to be causal relationship (Likely)	Evidence is sufficient to conclude that a causal relationship is likely to exist with relevant pollutant exposures. That is, the pollutant has been shown to result in health effects in studies where results are not explained by chance, confounding, and other biases, but uncertainties remain in the evidence overall. For example: (1) observational studies show an association, but co-pollutant exposures are difficult to address and/or other lines of evidence (controlled human exposure, animal, or mode of action information) are limited or inconsistent or (2) animal toxicological evidence from multiple studies from different laboratories demonstrate effects but limited or no human data are available. Generally, the determination is based on multiple high-quality studies.
Suggestive of but not sufficient to infer a causal relationship (Suggestive)	Evidence is suggestive of a causal relationship with relevant pollutant exposures but is limited, and chance, confounding, and other biases cannot be ruled out. For example: (1) when the body of evidence is relatively small, at least one high-quality epidemiologic study shows an association with a given health outcome and/or at least one high-quality toxicological study shows effects relevant to humans in animal species or (2) when the body of evidence is relatively large, evidence from studies of varying quality is generally supportive but not entirely consistent, and there may be coherence across lines of evidence (e.g., animal studies, mode of action information) to support the determination.
Inadequate to infer the presence or absence of a causal relationship (Inadequate)	Evidence is inadequate to determine that a causal relationship exists with relevant pollutant exposures. The available studies are of insufficient quantity, quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of an effect.
Not likely to be a causal relationship (Not likely)	Evidence indicates there is no causal relationship with relevant pollutant exposures. Several adequate studies, covering the full range of levels of exposure that human beings are known to encounter and considering at-risk populations and life stages, are mutually consistent in not showing an effect at any level of exposure.

Source: EPA 2015

Table 5 summarizes the health impacts associated with exposure to various health effects, along with the weight of evidence, as summarized by the EPA Integrated Science Assessments.

Table E.3.C-5. Health impacts from criteria pollutants.

Health impact	Exposure duration	CO EPA (2010)	NO_2 EPA (2016)	SO_2 EPA (2017)	Ozone EPA (2020)	$PM_{2.5}$ EPA (2019, 2022)	$PM_{10-2.5}$ EPA (2019, 2022)
Respiratory	Short-term	Suggestive	Causal	Causal	Causal	Likely	Suggestive
Respiratory	Long-term	Inadequate	Likely	Suggestive	Likely	Likely	Inadequate
Cardiovascular	Short-term	Likely	Suggestive	Inadequate	Suggestive	Causal	Suggestive
Cardiovascular	Long-term	Suggestive	Suggestive	Inadequate	Suggestive	Causal	Suggestive
Central nervous system	Short-term	Suggestive	*	*	Suggestive	Suggestive	Inadequate
Central nervous system	Long-term	Suggestive	*	*	Suggestive	Suggestive	Suggestive
Birth outcomes and developmental	Consider a wide range of exposure durations	Suggestive	Suggestive /Inadequate	Inadequate	Suggestive	Suggestive	Inadequate
Total mortality	Short-term	Suggestive	Suggestive	Suggestive	Suggestive	Causal	Suggestive
Total mortality	Long-term	Not likely	Suggestive	Inadequate	Suggestive	Causal	Suggestive
Cancer	Long-term	*	Suggestive	Inadequate	Inadequate	Likely	Suggestive
Metabolic effects	Short-term	*	*	*	Likely	Suggestive	Inadequate
Metabolic effects	Long-term	*	*	*	Suggestive	Suggestive	Suggestive

Health impact	Exposure duration	CO EPA (2010)	NO_2 EPA (2016)	SO_2 EPA (2017)	Ozone EPA (2020)	$PM_{2.5}$ EPA (2019, 2022)	$PM_{10-2.5}$ EPA (2019, 2022)
Susceptible Populations	Long-term or short-term	People with underlying coronary artery disease, and possibly the elderly, fetuses, people with anemia, people with obstructive lung disease, and people with diabetes	People with asthma, children, and older adults	People with pre-existing asthma, particularly children	People with pre-existing asthma, children, older adults, individuals with reduced intake of certain nutrients (i.e., vitamins C and E), and outdoor workers.	Strong evidence: Children, minorities (specifically Black), and people of low socioeconomic status. Suggestive evidence: people with pre-existing cardiovascular or respiratory disease, overweight or obese, with particular genetic variants, current or former smokers. Inadequate evidence: pre-existing diabetes, older life stages, residential location, gender, or diet.	Strong evidence: Children, minorities (specifically Black), and people of low socioeconomic status. Suggestive evidence: people with pre-existing cardiovascular or respiratory disease, overweight or obese, with particular genetic variants, current or former smokers. Inadequate evidence: pre-existing diabetes, older life stages, residential location, gender, or diet.

Note: CO (carbon monoxide); EPA (U.S. Environmental Protection Agency): NO_2 (nitrogen dioxide); $PM_{2.5}$ (particulate matter less than 2.5 microns in aerodynamic diameter); PM_{10} (particulate matter less than or equal to 10 microns in aerodynamic diameter); SO_2 (sulfur dioxide)
* Causal determination not presented

8.3 Hazardous Air Pollutants

Unlike for criteria pollutants, HAPs are evaluated under the Integrative Risk Information System (IRIS) and have toxicological review documents prepared. The toxicological review is a critical review of the physicochemical and toxicokinetic properties of the chemical and its toxicity in humans and experimental systems. The assessment presents reference values for noncancer effects of a chemical (reference concentration or RfC for inhalation exposure) and a cancer assessment (including both a qualitative and quantitative risk), where supported by available data. Table 6 summarizes the most sensitive noncancer endpoint, the cancer assessment, and the benchmark health values for benzene, *n*-hexane, formaldehyde, and 1,3-butadiene.

Table E.3.C-6. Health impacts from select hazardous air pollutants.

Health Impact	Benzene EPA (2002, 1998)	*n*-Hexane EPA (2005)	Formaldehyde EPA (1999); Kaden et al. (2010)	1,3-Butadiene EPA (2002a, b)
Noncancer endpoints (most sensitive)	Immune – hematotoxicity	Nervous system	Irritation at site of contact (e.g., skin, eyes, upper respiratory)	Reproductive system
RfC (mg/m^3)	3×10^{-2}	7×10^{-1}	Not assessed under the IRIS Program	2×10^{-3}
Cancer assessment	Known human carcinogen (Leukemia)	Inadequate information to assess cancer potential	Probable human carcinogen	Known human carcinogen
Cancer potency (per $\mu g/m^3$)	2.2×10^{-6}	Inadequate information to assess carcinogenic potential	1.3×10^{-5}	3×10^{-5}

Note: EPA (U.S. Environmental Protection Agency); mg/m^3 (milligrams per cubic meter); RfC (reference concentration); $\mu g/m^3$ (micrograms per cubic meter).

8.4 Global burden of disease

By using global emissions inventories along with datasets of anthropogenic emissions and atmospheric chemistry modeling, McDuffie and colleagues were able to simulate $PM_{2.5}$ concentrations in different geological regions and estimate total disease burden for six mortality endpoints and two neonatal disorders associated with exposure to ambient $PM_{2.5}$ (McDuffie et al., 2021). They then estimated the contribution from various sources of origin, including the category “Liquid Oil and Natural Gas” which contains light oil, heavy oil, and diesel oil. In the United States, total $PM_{2.5}$ concentrations were modeled as 7.8 $\mu g/m^3$, which the investigators estimate would be associated with 47,000 deaths a year or 13.2% of the total global burden of disease. These deaths were largely estimated to be from stroke and ischemic heart disease.

Globally, 27.3% of $PM_{2.5}$ was modeled to originate from fossil fuel combustion activities, with an additional 20% attributable to solid biomass fuel, particularly for residential heating and cooking activities. Natural gas was modeled to be the largest contributor to $PM_{2.5}$ in the United States. Population-weighted exposures to $PM_{2.5}$ were relatively lower in the United States compared to many other countries, but the United States had high burdens of disease because of demographic differences (e.g., older populations) and lower prevalence of infectious diseases.

9.0 COMPARISON OF ALTERNATIVES

Five different alternatives are analyzed in the SEIS. Under Alternative A (No Action), the Project would not occur and thus no oil would be produced and there would not be impacts to air quality and public health directly from the downstream combustion of Willow oil. All other alternatives would have a greater impact compared to Alternative A. The main difference between the remaining four alternatives (Alternative B, C, D, and E) is the anticipated amount of oil produced. Alternatives B, C, and D are each expected to produce the same amount oil over the 30- or 31-year Project lifespan, 628.9 million barrels of oil (MMBO). Consequently, the downstream impact of oil combustion would be approximately the same for these alternatives. Alternative E is expected to produce 613.5 MMBO, slightly less than Alternatives B, C, and D. Less oil produced would lead to less downstream combustion and emissions. The overall air quality and health impacts from the downstream combustion of Willow oil under Alternative E would therefore likely be slightly less than Alternatives B, C, and D.

9.1 Foreign Impacts from Oil Combustion

Exposure to $PM_{2.5}$ and the burden of disease from that exposure varies globally, based on demographics as well as $PM_{2.5}$ concentrations. Seventy-seven percent of the deaths attributable to $PM_{2.5}$ worldwide are in east Asia and south Asia, where $PM_{2.5}$ concentrations are 5-10-fold higher than those in the United States. A variety of factors contribute to this, including the health and age of the overall population, as well as the $PM_{2.5}$ exposure concentrations and the sources of the $PM_{2.5}$. For example, coal combustion is much greater in China and India as compared to the United States, leading to more $PM_{2.5}$ from that source. Since $PM_{2.5}$ composition will vary with source, these differences might impact the overall burden of disease in these locations, making the relative impact of oil combustion lower in these countries. On the other hand, the modeled disease impact of $PM_{2.5}$ sources in the United States (where the population weighted annual $PM_{2.5}$ concentration in 2017 was 7.8 $\mu g/m^3$) is higher than the modeled disease impacts other countries with higher $PM_{2.5}$ exposures (for example, Iran where 2017 annual $PM_{2.5}$ concentrations were 38.3 $\mu g/m^3$). This is likely due to the greater proportion of elderly in the United States, as the elderly are a susceptible population.

The potential impact of foreign oil combustion on air quality and public health would be similar to those discussed above except that impacts would be higher if emission controls were less stringent and impacts would also be influenced by the atmospheric environment in the region and the population characteristics.

9.2 Uncertainties and Limitations of Analysis

Uncertainties in information and data gaps preclude a fully quantitative analysis. Some of the key uncertainties and limitations of the analysis are discussed below.

- Air quality involves complex physical and chemical transformations at a local/regional level which is dependent on local emissions and meteorology and may vary from national averages.
- The uncertainty in the final destination and end use of Willow oil means that specific pollutant concentration impacts cannot be determined.
- There are significant differences in vehicular emissions based on type and age of vehicle, driving patterns, etc., which would impact local emissions from mobile sources.
- Lack of local concentration values prevents an assessment of potential air quality standard exceedances.
- Many of the health effects associated with exposure rely on specific concentrations, yet the discussion above only discusses general associations. It is very possible that chemical concentrations (for both criteria pollutants and HAPs) are below the concentrations where health impacts are observed.
- Significant uncertainties exist when modeling PM to sources and when modeling resulting PM concentrations.

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Appendix E.4
Soils, Permafrost, and Gravel Resources
Technical Appendix

There is no technical appendix for this resource

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1.0 CONTAMINATED SITES TECHNICAL INFORMATION

1.1 Assessment Criteria and Methodology

The potential for the Willow Master Development Plan Project (Project) to encounter contamination from existing sites was evaluated using records of existing contaminated sites and spills within 0.5 mile of the Project to identify the locations, characteristics, and quantities of existing contamination. The locations of existing contamination were evaluated against the Project activities to assess the likelihood of encountering contamination. The likelihood of encountering contamination during Project construction was assessed using a rating system of very low to high. Ratings are a function of spill status (cleanup complete or active) and distance of the site from the Project footprint. Table E.5.1 presents the assessment criteria for contaminated sites.

Table E.5.1. Contaminated Sites Assessment Criteria

Location	Active Status	Cleanup Complete or Cleanup Complete with Institutional Controls Status
Within 100 feet of Project activity	Moderate	Low
Between 100 and 500 feet of Project activity	Low	Very low
Greater than 500 feet from Project activity	Very low	Very low

1.2 Contaminated Site Details

Table E.5.2 provides a summary of contaminated sites within 0.5 mile of the Project (Figure 3.5.1).

Table E.5.2. Contaminated Sites within 0.5 mile of the Project*

ADEC Hazard ID	Site Name	Event Year	Status	Distance to Project Activity (miles)	Likelihood of Encountering
1446	Kuparuk Construction Service (KCS)	1992	Cleanup complete-institutional controls	0.3	Very low
2923	Lonely AFS Dewline - Diesel Tank SS10	1995	Cleanup complete	0.0	Low
2924	Lonely AFS Dewline - Beach Diesel SS003	1995	Cleanup complete	0.2	Very low
2925	Lonely AFS Dewline - Hangar Pad SS13	1995	Cleanup complete	0.0	Very low
2926	Lonely AFS Dewline - Landfill LF007	1995	Cleanup complete	0.0	Low
2927	Lonely AFS Dewline - Diesel Spills SS05	1995	Cleanup complete	0.0	Moderate
2928	Lonely AFS Dewline - POL Storage SS04	1995	Cleanup complete	0.0	Low
2932	Lonely AFS Dewline - Garage SS09	1995	Cleanup complete	0.0	Very low
2933	Lonely AFS Dewline - Landfill LF011/SS006	1995	Cleanup complete	0.1	Very low
2934	Lonely AFS Dewline - Sewage Disposal SS01	1995	Cleanup complete	0.2	None[a]
2935	Lonely AFS Dewline - Drum Storage SS02	1995	Cleanup complete	0.1	None[b]
2936	Lonely AFS Dewline - Module Train SS012	1995	Cleanup complete	0.0	Low
4223	Lonely AFS Dewline - AOC 1, 2, & 3	2005	Cleanup complete	0.0	Very low

Source: (ADEC 2022a)

Note: ADEC (Alaska Department of Environmental Conservation); AFS (Air Force site); AOC (area of concern); DEW (Distant Early Warning); POL (petroleum, oil, and lubricant).

[a] Site 2934 was noted by the Alaska Department of Environmental Conservation as having eroded into the Beaufort Sea in August 2008.

[b] Site 2935 was noted by the Alaska Department of Environmental Conservation as having eroded into the Beaufort Sea in April 2015.

1.3 Registered Facilities*

Table E.5.3 provides a summary of U.S. Environmental Protection Agency–regulated facilities within 0.5 mile of the Project that may be affected by the release, or threat of release, of hazardous substances, pollutants, or contaminants from Project activities (Figure 3.5.1).

Table E.5.3. U.S. Environmental Protection Agency–Regulated Facilities within 0.5 mile of the Project*

EPA Registry ID	Facility Name	Description	Release of Hazardous Substance, Pollutants, or Contaminant (yes/no)	Number of Releases (size/type)	Distance from Project Activity (miles)
110056899281	Alpine oil field	Crude petroleum and natural gas extraction, drilling oil and gas wells, and support activities for oil and gas operations	Yes	6 (266 gallons/ non-crude oil; 248.5 gallons/hazardous substance)	0.0
110041479030	Alpine airstrip	Airport operations	No	0	0.0
110022527121	Camp Lonely	Airport operations and crude petroleum and natural gas extraction	Yes	3 (10 gallons/ non-crude oil) (3 gallons/hazardous substance)	0.0
110064809916	USAF Dewline Site POW-1: Pt. Lonely	Very small quantity generator	No	0	0.0

Source: (ADEC 2022b; EPA 2022)
Note: EPA (U.S. Environmental Protection Agency).

2.0 REFERENCES

ADEC. 2022a. Contaminated Sites Program Databases. Accessed January 5, 2022. https://dec.alaska.gov/Applications/SPAR/PublicMVC/CSP/Search.

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EPA. 2022. FRS Facility Detail Report Database. Accessed January 4, 2022. https://www.epa.gov/frs/frs-query.

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Willow Master Development Plan

Appendix E.6
Noise Technical Appendix

There is no technical appendix for this resource

January 2023

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Willow Master Development Plan

Appendix E.7
Visual Resources Technical Appendix

January 2023

Appendix E.7A
Visual Resources Technical Appendix

Appendix E.7B
Visual Contrast Ratings Worksheets

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Willow Master Development Plan

Appendix E.7A
Visual Resources Technical Appendix

January 2023

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Table of Contents

List of Tables

List of Acronyms

BLM	Bureau of Land Management
NPR-A	National Petroleum Reserve in Alaska
Project	Willow Master Development Plan Project
VCRW	Visual contrast rating worksheets
VRI	Visual Resource Inventory
VRM	Visual Resources Management

Glossary Terms

Background zone: Areas visible within 5 to 15 miles from viewer locations.

Distance zones: The level of visibility and distances from important viewer locations, including travel routes, human use areas, and observation points. Distance zones consist of foreground-middleground (0 miles to 5 miles), background (5 to 15 miles), and seldom-seen (not visible or beyond 15 miles). The Willow Master Development Plan Project's (Project's) estimated nighttime lighting conditions are determined by the heights of drill rigs and communications towers. The Project would be visible out to 30 miles, based on the direct line-of-sight limits due to the curvature of the earth and regional atmospheric conditions.

Foreground-middleground distance zone: Areas visible within less than 5 miles from key observation points.

Scenic quality: The relative worth of a landscape from a visual perception point of view expressed as a quantitative measure of qualitative criteria associated with landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications (BLM 2020).

Seldom seen areas: Areas within the foreground-middleground and background zones that are not visible, or areas that are visible but are beyond the background zone (more than 15 miles from key observation points).

Sensitivity level: The measure of public concern for scenic quality (as determined through the Visual Resource Inventory process).

Viewshed: The total landscape seen from a point, or from all or a logical part of a travel route, use area, or waterbody.

Visual resources: Visible physical features on a landscape, including land, water, vegetation, animals, structures, and other features.

Visual Resource Inventory: The process of determining the visual value of BLM-managed lands through the assessment of the scenic quality rating, sensitivity level, and distance zones of visual resources within those lands.

Visual Resource Inventory classes: Four visual resource inventory classes into which all BLM-managed lands are placed based on scenic quality, sensitivity levels, and distance zones, as determined through the Visual Resource Inventory process.

Visual Resources Management classes: Categories assigned to public lands based on scenic quality, sensitivity level, and distance zones with consideration for multiple-use management objectives. There are four classes; each class has an objective that prescribes the amount of change allowed in the characteristic landscape. Visual resource management classes are assigned through BLM Resource Management Plans (in this case, the IAP for the NPR-A).

Visual Resources Management: The system used by BLM to manage visual resources (including in the NPR-A). It includes inventory and planning actions to identify visual values and to establish objectives for managing those values.

1.0 VISUAL RESOURCES

1.1 Visual Resources Management in the National Petroleum Reserve in Alaska

The following descriptions, worksheets, and tables support the analysis in the Willow Master Development Plan Environmental Impact Statement Section 3.7, *Visual Resources*, and tier to previous Bureau of Land Management (BLM) studies. Section 3.7 discusses existing conditions in Section 3.7.1, *Affected Environment*, and discloses impacts to scenery and people, and conformance with **BLM Visual Resources Management** (VRM) objectives (BLM 2022) in Section 3.7.2, *Environmental Consequences*. The BLM **Visual Resource Inventory** (VRI) (BLM 2012) provides the visual baseline conditions using the indicators of scenic quality, sensitivity, and distance zones. The BLM scenic quality rating is the basis for determining impacts to scenery in the analysis area. The BLM sensitivity levels and distance zones are the basis for determining impacts to people (human environment) in the analysis area.

The referenced figures and tables in this appendix contain quantitative and qualitative information for:

1. **Scenic quality** is the relative worth of a landscape from a visual perception point of view expressed as a quantitative measure of qualitative criteria associated with landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications.
2. **Sensitivity level** is the measure of public concern for scenic quality (as determined through the VRI process).
3. **Distance zones** are the level of visibility and distances from important viewer locations, including travel routes, human use areas, and observation points. Distance zones consist of the foreground-middleground (0 miles to 5 miles), background (5 to 15 miles), and seldom-seen (not visible or beyond 15 miles) zones. The Willow Master Development Plan Project's (Project's) estimated nighttime lighting conditions are determined by the heights of drill rigs and communications towers which would be visible out to 30 miles, based on the direct line-of-sight limits due to the curvature of the earth and regional atmospheric conditions.
4. **VRI classes** are four visual resource inventory classes which all BLM-administered lands are placed into based on scenic quality, sensitivity levels, and distance zones, as determined through the VRI process.
5. **VRM classes** are categories assigned to public lands based on scenic quality, sensitivity level, and distance zones with consideration for multiple-use management objectives. There are four classes. Each class has an objective that prescribes the amount of change allowed in the characteristic landscape. VRM classes are assigned through BLM Resource Management Plans, which for the National Petroleum Reserve in Alaska (NPR-A) is the Integrated Activity Plan (BLM 2022).

The BLM's VRM class objectives are defined in Table E.7.1.

Visual contrast rating worksheets (VCRW), located in Appendix E.7B, *Visual Contrast Rating Worksheets*, document:

1. The forms, lines, colors, and textures of landforms/water, vegetation, and structures in the characteristic landscape.
2. The forms, lines, colors, and textures of landforms/water, vegetation, and structures of the project.
3. The visual contrasts in the categories are strong, moderate, weak, and none; conformance with VRM objectives; and recommended mitigations, if any.

Table E.7.1. Bureau of Land Management Visual Resources Management Class Objectives

Class	Management Objective
I	The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.
II	The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen but should not attract the attention of the casual observer. Any changes must repeat the basic (design) elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.
III	The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.
IV	The objective of Class IV is to provide for management activities that require major modifications to the existing character of the landscape. The level of change to the landscape can be high. The management activities may dominate the view and may be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of the basic visual elements of form, line, color, and texture.

Source: BLM 1986

The Project's VCRWs are included in Appendix E.7B and include:

- VCRW-1: Contrast Ratings and Conformance for Foreground-Middleground Viewing Situations in VRM Class IV Areas
- VCRW-2: Contrast Ratings and Conformance for Background and Seldom-Seen Viewing Situations in VRM Class IV Areas
- VCRW-3: Contrast Ratings and Conformance in VRM Class II Areas
- VCRW-4: Contrast Ratings and Conformance for Foreground-Middleground Viewing Situations in VRM Class III Areas (Option 3)
- VCRW-5: Contrast Ratings for Foreground-Middleground Viewing Situations (Non-BLM lands)
- VCRW-6: Contrast Ratings for Background and Seldom-Seen Viewing Situations (Non-BLM lands)

1.2 The Willow Project and Visual Resources Analysis Area

The analysis area for visual resources is the area within line-of-sight from ground-eye-level to the tallest components of the Project (drill rig and communications tower lighting). For this Project, that area (also known as the **viewshed**) is 30 miles, with the exception of the diesel and seawater pipelines from near Nuiqsut to Kuparuk, which would be colocated with existing pipeline infrastructure and has a viewshed of 15 miles (Figure 3.7.1).The Project viewshed includes all areas from which the proposed facilities would be visible based on topographical obstruction and viewer distance from the Project (0- to 5-miles **foreground-middleground zone** and the 5- to 15-miles **background zone**.

1.2.1 State Lands

State lands that occur within the analysis area are not subject to known visual management standards. The BLM visual contrast rating process has been applied to non-BLM lands to provide a qualitative analysis of the potential degree of contrast of Project facilities when viewed from 0- to 5-miles foreground-middleground zone and the 5- to 15-miles background zone.

1.3 Bureau of Land Management Scenic Quality in the Project Viewshed

The BLM scenic quality classes are the basis for determining impacts to scenery in the analysis area. Due to the natural character of existing conditions in the viewshed, the Project would be strongly contrasting with scenery due to the broad, panoramic landscape where few human-made or built features occur. The Project's impacts to scenery are determined by comparing the view characteristics of the action alternatives with views of the characteristic landscape. The relative scenic quality (Class A, B, or C) is assigned to a landscape by applying the VRI scenic quality evaluation factors with scenic quality A having the highest rating and scenic quality C having the lowest. The Project would result in substantial changes in the visual landscape for public land users and viewers in the foreground-middleground and background distance zones and the level of change and scenic quality would reduce the inventoried scenery class designations in the viewshed based on the introduction of Project components that are not common in the landscape. Table E.7.2 shows the acreages and percentages of scenic quality classes where viewers would have visibility toward the Project. The scenic quality classes are shown in Figure 3.7.2, and the Project's viewshed is shown in Figure 3.7.1.

Table E.7.2. Scenic Quality Classes in the Analysis Area and Viewshed

Area	Class A Acres (%)	Class B Acres (%)	Class C Acres (%)	No Data Acres (%)	Unclassified, Not in NPR-A Acres (%)	Total Acres (%)
In analysis area	180,538.9 (3.0%)	28,979.4 (0.5%)	2,399,945.0 (39.9%)	1,777.6 (less than 0.1%)	3,411,329.1 (56.7%)	**6,020,792.4 (100%)**
In Project viewshed	161,764.8 (3.3%)	20,508.4 (0.4%)	1,720,473.0 (35.4 %)	1,481.2 (less than 0.1%)	2,954,376.6 (60.8%)	**4,857,122.8 (100%)**

Note: NPR-A (National Petroleum Reserve in Alaska). Areas outside of NPR-A are not managed by the Bureau of Land Management and thus do not have scenic quality classifications.

1.4 Bureau of Land Management Sensitivity Levels and Distance Zones in the Project Viewshed

The BLM sensitivity level and distance zones are the basis for determining impacts to people/viewers in the analysis area. Higher user concern for scenery would be more susceptible to visual impacts than lower concern and near distance zones would be more susceptible to visual impacts than far distance zones. Visual contrasts for viewers are determined by comparison of the view characteristics of the Project with views of the characteristic landscape. The Project would result in strong visual contrasts and viewer impacts that are strong in comparison with existing conditions, including visually dominant forms, lines, colors, and textures of landforms, water, vegetation, and structures. The Project would result in strong contrasts to scenic quality for viewers in the foreground-middleground, and background distance zones, and the level of contrast likely would reduce the inventoried sensitivity level designations in the analysis area. Table E.7.3 shows the acreages and percentages of BLM sensitivity classes where viewers would have visibility toward the Project. Table E.7.4 summarizes BLM distance zones where viewers would have visibility toward the Project. The Project's viewshed is shown in Figure 3.7.1, BLM sensitivity levels are shown in Figure 3.7.3, and the distance zones are shown in Figure 3.7.4.

Table E.7.3. Sensitivity Classes in the Analysis Area and Viewshed

Area	High Acres (%)	Medium Acres (%)	Low Acres (%)	No Data Acres (%)	Unclassified, Not in NPR-A Acres (%)	Total Acres (%)
In analysis area	2,611,241.0 (43.4%)	0.0 (0.0%)	0.0 (0.0%)	0.9 (less than 0.1%)	3,409,551.4 (56.6%)	**6,020,792.4 (100%)**
In Project viewshed	1,904,227.5 (42.4%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	2,952,894.9 (60.8%)	**4,857,122.4 (100%)**

Note: NPR-A (National Petroleum Reserve in Alaska). Areas outside of NPR-A are not managed by the Bureau of Land Management and thus do not have sensitivity classifications.

Table E.7.4. Distance Zones in the Analysis Area and Viewshed

Area	Foreground-Middleground Acres (%)	Background Acres (%)	Seldom Seen Acres (%)	Unclassified, Not in NPR-A Acres (%)	Total Acres (%)
In analysis area	2,169,481.5 (36.0%)	441,759.4 (7.3%)	0.0 (0.0%)	3,409,551.4 (56.6%)	**6,020,792.4 (100%)**
In Project viewshed	1,560,104.2 (32.1%)	344,123.3 (7.1%)	0.0 (0.0%)	2,952,894.9 (60.8%)	**4,857,122.4 (100%)**

Note: NPR-A (National Petroleum Reserve in Alaska). Areas outside of NPR-A are not managed by the Bureau of Land Management and thus do not have distance zone classifications.

1.4.1 State Lands

Similar to BLM lands, Project facilities and lighting would affect scenery and people by impacting the undisturbed characteristic landscape (including night skies). State lands in the area of Project activity for the action alternatives would be in areas of existing activity (e.g., Oliktok Dock, Alpine Annual Resupply ice road), while state lands along the Module Delivery Option 3 ice road route from Kuparuk DS2P to the Colville River ice bridge would follow a route without permanent infrastructure, though there are other temporary winter activities that occur in the area (e.g., North Slope Borough's Community Winter Access Trail).

Along the Option 3 ice road route, visual contrast from Project facilities and activity (including light sources during operations) would cause the greatest visual impacts in foreground-middleground views due to the broad, panoramic landscape and lack of intervening land features. Overall contrasts would diminish based on viewer location and proximity to existing oil and gas infrastructure in the Kuparuk area. In viewing areas distant from the developed Kuparuk area, moderate to weak construction-related contrasts in the background and **seldom seen areas** (5-15 and greater miles) would occur.

1.5 Bureau of Land Management Visual Resource Inventory Classes in the Project Viewshed

The BLM VRI classes indicate the overall value of landscape on BLM lands. Views to the action alternatives from more valued landscapes have greater potential for impacts than do views from less valued landscapes. Table E.7.5 shows the acreages and percentages of existing BLM VRI classes in the analysis area and the Project's viewshed. Construction, operations, and reclamation activities would result in overall landscape values that strongly contrast with existing conditions. The Project would result in strong contrasts to the landscape for viewers in the foreground, middleground, and background distance zones, and the level of impact would likely reduce the inventoried BLM VRI class designations in the analysis area. The VRI classes are shown in Figure 3.7.5, and the Project's viewshed is shown in Figure 3.7.1.

Table E.7.5. Visual Resource Inventory Classes in the Analysis Area and Viewshed

Area	Class I Acres (%)	Class II Acres (%)	Class III Acres (%)	Class IV Acres (%)	Unclassified, Not in NPR-A Acres (%)	Total Acres (%)
In analysis area	0.0 (0.0%)	209,518.3 (3.5%)	1,959,963.2 (32.6%)	441,759.4 (7.3%)	3,409,551.5 (56.6%)	**6,020,792.4 (100%)**
In Project viewshed	0.0 (0.0%)	182,273.1 (4.1%)	1,377,831.0 (30.7%)	344,123.3 (7.7%)	2,952,894.9 (60.8%)	**4,857,122.3 (100%)**

Note: NPR-A (National Petroleum Reserve in Alaska). Areas outside of NPR-A are not managed by the Bureau of Land Management and thus do not have Visual Resource Inventory classifications.

1.6 Bureau of Land Management Visual Resources Management Classes Within the Analysis Area*

Conformance with VRM management classes is based on the characteristics of Project facilities that are physically located within the VRM classified lands. The VRM classes were assigned to these lands by the NPR-A IAP/EIS Record of Decision (BLM 2022). The VRM Class objectives for each alternative (BLM 2022) takes into consideration VRI information and overall BLM land management objectives for each resource managed within the NPR-A.

VRM Class objectives (BLM 2022) identify 1,179,885.4 acres of VRM Class II within the analysis area (19.6% of the analysis area) and 1,335,405.2 acres of VRM Class IV (22.2% of the analysis area). There are no VRM Class I or III objectives identified within the analysis area (Figure 3.7.6). The acres of each VRM class within the Project viewshed provides a summary of the amount of those areas from which a viewer could see the Project facilities (Table E.7.6).

Table E.7.6. Visual Resources Management Classes in the Analysis Area and Viewshed Objectives*

Area	Class I Acres (%)	Class II Acres (%)	Class III Acres (%)	Class IV Acres (%)	In NPR-A, No BLM Surface Authority Acres (%)	Unclassified, Not in NPR-A Acres (%)	Total Acres (%)
In analysis area	0.0 (0.0%)	1,179,572.5 (19.6%)	0.0 (0.0%)	1,335,404.1 (22.2%)	96,264.3 (1.6%)	3,409,551.4 (56.6%)	**6,020,792.3 (100.0%)**
In Project viewshed	0.0 (0.0%)	907,300.4 (29.8%)	0.0 (0.0%)	905,215.8 (18.6%)	89,130.4 (1.8%)	2,995,476.1 (61.7%)	**4,857,122.4 (100.0%)**

Note: NPR-A (National Petroleum Reserve in Alaska). Areas outside of NPR-A are not managed by the Bureau of Land Management and thus do not have Visual Resources Management classifications.

Conformance with the VRM objectives is determined by comparison of the forms, lines, colors, and textures of view characteristics of the Project with forms, lines, colors, and textures of views of the existing characteristic landscape where they are physically located. Within the analysis area, the Project would not conform with VRM Class II objectives but would conform with VRM Class III and IV objectives as allocated for each VRM Class Alternative described above.

2.0 REFERENCES

BLM. 1986. *BLM Manual H-8410-1: Visual Resource Inventory*. Washington, D.C.

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Willow Master Development Plan

Appendix E.7B
Visual Contrast Rating Worksheets

January 2023

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Form 8400-4
(June 2018)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
VISUAL CONTRAST RATING WORKSHEET

Date: 03/08/2019
District Office: Arctic
Field Office:
Land Use Planning Area:

SECTION A. PROJECT INFORMATION

1. Project Name Willow	4. KOP Location (T.R.S) Varies	5. Location Sketch See 2020 FEIS - Appendix A: Figure 3.7.6 Visual Resource Management Classes
2. Key Observation Point (KOP) Name Foreground-MiddlegroundViews		
3. VRM Class at Project Location Class IV	(Lat. Long) Varies	

SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Planar horizontal land, lakes and ponds.	Planar horizontal surface of grasses in summer turning to snow cover for 9-10 months..	None
LINE	Strongly horizontal land, lakes, and ponds..	Horizontal surface of grasses in summer turning to snow cover for 9-10 months.	None
COLOR	Very light to medium tan earth. Water reflecting colors of sky in summer turning to snow cover for 9-10 mo	Light to medium green turning to tan to brown grasses in summer and uniform snow cover for 9-10 months	None
TEX-TURE	Smooth land, lakes, and ponds	Smooth grasses and snow cover	None

SECTION C. PROPOSED ACTIVITY DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Flat, planar pads and roads	Geometric patterns of present and absent grasses.	Strongly planar vertical and horizontal drill and valve structures. Cylindrical tanks. Geometric roads, pads, vehicles.
LINE	Horizontal pads and curvilinear roads	Horizontal and angular lines at edges of geometric shapes.	Strongly vertical and horizontal lines. Vertical and horizontal lines at edges of geometric shapes
COLOR	Tans and greys	Greens, tans, and greys.	Light to dark orange structures and multicolored equipment. White, blue, and red facility, vehicle lighting, sky glow.
TEX-TURE	Smooth.	Smooth to coarse at a distance.	Moderate to coarse.

SECTION D. CONTRAST RATING __SHORT TERM ✓ LONG TERM

1. DEGREE OF CONTRAST		LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
		STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE
ELEMENTS	FORM		✓				✓			✓			
	LINE		✓				✓			✓			
	COLOR		✓				✓			✓			
	TEXTURE			✓				✓			✓		

2. Does project design meet visual resource management objectives? ✓ Yes ___No
(Explain on reverses side)

3. Additional mitigating measures recommended
✓ Yes ___No (Explain on reverses side)

Evaluator's Names: Chris Bockey
Date: 12/31/2019

(Continued on Page 2)

SECTION D. (Continued)

Comments from item 2.

Strong construction-related contrasts in the foreground and middleground seen areas (0-5 miles) would occur for the 10-11-year time period specified (Chapter 2.4.6.10.2) for drilling and from the presence of drill rigs and construction equipment. Strong contrasts would be caused by the structural forms, lines, and colors and colors of lighting for facilities, equipment, and vehicles. These contrasts would conform with Visual Resource Management Class IV management objectives (see following table). These noticeable forms and lines are required for function and the highly contrasting colors are needed for safety in the region's extreme weather conditions. Thus, they would cause strong contrasts in the characteristic landscape and mitigations of color would not be feasible.
Dark Sky BMP Re: down-shielded lighting – This BMP would limit direct (line-of-sight) visibility of the standard Osha-mandated lighting at facilities. However, down-shielding in snow cover conditions is known to increase reflectiveness toward the sky and the resultant sky glow and light dome would cause problematic navigation issues for humans and fauna.
Strong contrasts would be reduced to moderate and then weak during the operations, maintenance, and reclamation phases of the project. These phases would be portrayed by pads, roads, pipelines, and vehicles, and, eventually, less-noticeable forms, lines, and colors in the landscape.

BLM Visual Resource Management Class Objectives
Class I Objective The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.
Class II Objective The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic (design) elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

Class III Objective The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention, but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.
Class IV Objective The objective Class IV is to provide for management activities that require major modifications to the existing character of the landscape. The level of change to the landscape can be high. The management activities may dominate the view and may be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of the basic visual elements of form, line, color, and texture.
Source: BLM 1986, 2008b.

Additional Mitigating Measures (See item 3)

Form 8400-4
(June 2018)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
VISUAL CONTRAST RATING WORKSHEET

Date: 03/08/2019
District Office: Arctic
Field Office:
Land Use Planning Area:

SECTION A. PROJECT INFORMATION

1. Project Name Willow	4. KOP Location (T.R.S) Varies	5. Location Sketch See 2020 FEIS - Appendix A: Figure 3.7.6 Visual Resource Management Classes
2. Key Observation Point (KOP) Name Background-Seldom Seen Views		
3. VRM Class at Project Location Class IV	(Lat. Long) Varies	

SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Planar horizontal land, lakes and ponds.	Planar horizontal surface of grasses in summer turning to snow cover for 9-10 months..	None
LINE	Strongly horizontal land, lakes, and ponds..	Horizontal surface of grasses in summer turning to snow cover for 9-10 months.	None
COLOR	Very light to medium tan earth. Water reflecting colors of sky in summer turning to snow cover for 9-10 mo	Light to medium green turning to tan to brown grasses in summer and uniform snow cover for 9-10 months	None
TEX-TURE	Smooth land, lakes, and ponds	Smooth grasses and snow cover	None

SECTION C. PROPOSED ACTIVITY DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Flat, planar pads and roads	Geometric patterns of present and absent grasses.	Strongly planar vertical and horizontal drill and valve structures. Cylindrical tanks. Geometric roads, pads, vehicles.
LINE	Horizontal pads and curvilinear roads	Horizontal and angular lines at edges of geometric shapes.	Strongly vertical and horizontal lines. Vertical and horizontal lines at edges of geometric shapes
COLOR	Tans and greys	Greens, tans, and greys.	Light to dark orange structures and multicolored equipment. White, blue, and red facility, vehicle lighting, sky glow.
TEX-TURE	Smooth.	Smooth to coarse at a distance.	Moderate to coarse.

SECTION D. CONTRAST RATING __SHORT TERM ✓ LONG TERM

1. DEGREE OF CONTRAST	FEATURES: LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
ELEMENTS	STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE
FORM			✓				✓			✓		
LINE			✓				✓			✓		
COLOR			✓				✓			✓		
TEXTURE			✓				✓				✓	

2. Does project design meet visual resource management objectives? ✓ Yes ___No
(Explain on reverses side)

3. Additional mitigating measures recommended
✓ Yes ___No (Explain on reverses side)

Evaluator's Names: Chris Bockey
Date: 12/31/2019

(Continued on Page 2)

SECTION D. (Continued)

Comments from item 2.

Moderate to weak construction-related contrasts in the background and seldom seen areas (5-15 and greater miles) would occur for the 10-11-year time period specified (Chapter 2.4.6.10.2) for drilling and from the presence of drill rigs and construction equipment. Moderate contrasts would be caused by the structural forms, lines, and colors and colors of lighting for facilities and vehicles. These contrasts would conform with Visual Resource Management Class III and IV management objectives (see following table). These noticeable forms and lines are required for function and the highly contrasting colors are needed for safety in the region's extreme weather conditions. Thus, they would cause strong contrasts in the characteristic landscape and mitigations of color would not be feasible.
Dark Sky BMP Re: down-shielded lighting – This BMP would limit direct (line-of-sight) visibility of the standard Osha-mandated lighting at facilities. However, down-shielding in snow cover conditions is known to increase reflectiveness toward the sky and the resultant sky glow and light dome would cause problematic navigation issues with humans and fauna.
Moderate contrasts would be reduced to weak during the operations, maintenance, and reclamation phases of the project. These phases would be portrayed by pads, roads, pipelines, and vehicles, and, eventually, less-noticeable forms, lines, and colors in the landscape.

BLM Visual Resource Management Class Objectives
Class I Objective The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.
Class II Objective The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic (design) elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.
Class III Objective The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention, but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.
Class IV Objective The objective Class IV is to provide for management activities that require major modifications to the existing character of the landscape. The level of change to the landscape can be high. The management activities may dominate the view and may be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of the basic visual elements of form, line, color, and texture.
Source: BLM 1986, 2008b.

Additional Mitigating Measures (See item 3)

Form 8400-4
(June 2018)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
VISUAL CONTRAST RATING WORKSHEET

Date: 03/08/2019
District Office: Arctic
Field Office:
Land Use Planning Area:

SECTION A. PROJECT INFORMATION

1. Project Name Willow	4. KOP Location (T.R.S) Varies	5. Location Sketch See 2020 FEIS - Appendix A: Figure 3.7.6 Visual Resource Management Classes
2. Key Observation Point (KOP) Name Foreground-MiddlegroundViews		
3. VRM Class at Project Location Class II	(Lat. Long) Varies	

SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Planar horizontal land, lakes and ponds.	Planar horizontal surface of grasses in summer turning to snow cover for 9-10 months..	None
LINE	Strongly horizontal land, lakes, and ponds..	Horizontal surface of grasses in summer turning to snow cover for 9-10 months.	None
COLOR	Very light to medium tan earth. Water reflecting colors of sky in summer turning to snow cover for 9-10 mo	Light to medium green turning to tan to brown grasses in summer and uniform snow cover for 9-10 months	None
TEX-TURE	Smooth land, lakes, and ponds	Smooth grasses and snow cover	None

SECTION C. PROPOSED ACTIVITY DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Flat, planar pads and roads	Geometric patterns of present and absent grasses.	Strongly planar vertical and horizontal drill and valve structures. Cylindrical tanks. Geometric roads, pads, vehicles.
LINE	Horizontal pads and curvilinear roads	Horizontal and angular lines at edges of geometric shapes.	Strongly vertical and horizontal lines. Vertical and horizontal lines at edges of geometric shapes
COLOR	Tans and greys	Greens, tans, and greys.	Light to dark orange structures and multicolored equipment. White, blue, and red facility, vehicle lighting, sky glow.
TEX-TURE	Smooth.	Smooth to coarse at a distance.	Moderate to coarse.

SECTION D. CONTRAST RATING __SHORT TERM ✓ LONG TERM

1. DEGREE OF CONTRAST	LAND/WATER BODY (1) STRONG	MODERATE	WEAK	NONE	VEGETATION (2) STRONG	MODERATE	WEAK	NONE	STRUCTURES (3) STRONG	MODERATE	WEAK	NONE
ELEMENTS: FORM		✓				✓			✓			
LINE		✓				✓			✓			
COLOR		✓				✓			✓			
TEXTURE			✓				✓			✓		

2. Does project design meet visual resource management objectives? ___Yes ✓ No (Explain on reverses side)

3. Additional mitigating measures recommended ✓ Yes ___No (Explain on reverses side)

Evaluator's Names: Chris Bockey
Date: 12/31/2019

(Continued on Page 2)

SECTION D. (Continued)

Comments from item 2.

Strong construction-related contrasts in the foreground and middleground seen areas (0-5 miles) would occur for the 10-11-year time period specified (Chapter 2.4.6.10.2) for drilling and from the presence of drill rigs and construction equipment. Strong contrasts would be caused by the structural forms, lines, and colors and colors of lighting for facilities, equipment, and vehicles. These contrasts would not conform with Visual Resource Management Class II management objectives (see following table). These noticeable forms and lines are required for function and the highly contrasting colors are needed for safety in the region's extreme weather conditions. Thus, they would cause strong contrasts in the characteristic landscape and mitigations of color would not be feasible.

Dark Sky BMP Re: down-shielded lighting – This BMP would limit direct (line-of-sight) visibility of the standard Osha-mandated lighting at facilities. However, down-shielding in snow cover conditions is known to increase reflectiveness toward the sky and the resultant sky glow and light dome would cause problematic navigation issues for humans and fauna.
Strong contrasts would be reduced to moderate and then weak during the operations, maintenance, and reclamation phases of the project. These phases would be portrayed by pads, roads, pipelines, and vehicles, and, eventually, less-noticeable forms, lines, and colors in the landscape.

BLM Visual Resource Management Class Objectives
Class I Objective The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.
Class II Objective The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic (design) elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

Class III Objective The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention, but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.
Class IV Objective The objective Class IV is to provide for management activities that require major modifications to the existing character of the landscape. The level of change to the landscape can be high. The management activities may dominate the view and may be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of the basic visual elements of form, line, color, and texture.
Source: BLM 1986, 2008b.

Additional Mitigating Measures (See item 3)

Form 8400-4
(June 2018)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
VISUAL CONTRAST RATING WORKSHEET

Date: 12/31/2019

District Office: Arctic

Field Office:

Land Use Planning Area:

SECTION A. PROJECT INFORMATION

1. Project Name Willow EIS - Option 3	4. KOP Location (T.R.S) Varies	5. Location Sketch See 2020 FEIS - Appendix A: Figure 3.7.6 Visual Resource Management Classes
2. Key Observation Point (KOP) Name Foreground-Middleground Views		
3. VRM Class at Project Location Class III	(Lat. Long) Varies	

SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Planar horizontal land, lakes and ponds.	Planar horizontal surface of grasses in summer turning to snow cover for 9-10 months..	Strongly planar vertical and horizontal drill and valve structures. Cylindrical tanks. Geometric roads, pads, vehicles.
LINE	Strongly horizontal land, lakes, and ponds.	Horizontal surface of grasses in summer turning to snow cover for 9-10 months.	Strongly vertical and horizontal lines. Vertical and horizontal lines at edges of geometric shapes
COLOR	Very light to medium tan earth. Water reflecting colors of sky in summer turning to snow cover for 9-10 mo	Light to medium green turning to tan to brown grasses in summer and uniform snow cover for 9-10 months	Light to dark orange structures and multicolored equipment. White, blue, and red facility, vehicle lighting, sky glow.
TEX-TURE	Smooth land, lakes, and ponds	Smooth grasses and snow cover	Moderate to coarse.

SECTION C. PROPOSED ACTIVITY DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Flat, planar road	Indistinguishable	Geometric structures for construction camp at DS2P, vehicles.
LINE	Curvilinear road	Indistinguishable	Vertical and horizontal lines at edges of geometric shapes associated with construction camp.
COLOR	Tans and greys	Indistinguishable	Light to dark structures and multicolored equipment of construction camp, vehicle lighting, sky glow.
TEX-TURE	Smooth.	Indistinguishable	Moderate to coarse.

SECTION D. CONTRAST RATING ✓ SHORT TERM __LONG TERM

1. DEGREE OF CONTRAST

ELEMENTS	LAND/WATER BODY (1) STRONG	MODERATE	WEAK	NONE	VEGETATION (2) STRONG	MODERATE	WEAK	NONE	STRUCTURES (3) STRONG	MODERATE	WEAK	NONE
FORM				✓				✓			✓	
LINE			✓					✓			✓	
COLOR			✓					✓			✓	
TEXTURE				✓				✓			✓	

2. Does project design meet visual resource management objectives? ___Yes ___No
(Explain on reverses side)

3. Additional mitigating measures recommended ___Yes ___No (Explain on reverses side)

Evaluator's Names: Chris Bockey
Date: 12/31/2019

(Continued on Page 2)

SECTION D. (Continued)

Comments from item 2.

Weak construction-related contrasts in the foreground and middleground seen areas (0-5 miles) would occur for the time period specified for delivery of drillsite modules. Due to the existing infrastructure in the foreground and middleground area associated with Oliktok and Kuparuk, generally weak contrast would be caused by the introduction of temporary structural forms, lines, and colors and colors of lighting for construction camp facilities, equipment,vehicles and ice road. Degree of contrast is identified below.

Degree of Contrast Criteria
None - The element contrast is not visible or perceived.
Weak - The element contrast can be seen but does not attract attention.
Moderate - The element contrast begins to attract attention and begins to dominate the characteristic landscape.
Strong - The element contrast demands attention, will not be overlooked, and is dominant in the landscape.

BLM 1986, 2008b.

Additional Mitigating Measures (See item 3)

Form 8400-4
(June 2018)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
VISUAL CONTRAST RATING WORKSHEET

Date: 01/09/2020
District Office: N/A
Field Office: N/A
Land Use Planning Area: N/A

SECTION A. PROJECT INFORMATION

1. Project Name Willow	4. KOP Location (T.R.S) Varies	5. Location Sketch See 2020 FEIS - Appendix A: Figure 3.7.1 Visual Resource Analysis Area
2. Key Observation Point (KOP) Name Foreground-MiddlegroundViews		
3. VRM Class at Project Location Non-BLM Managed Lands	(Lat. Long) Varies	

SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Planar horizontal land, lakes and ponds.	Planar horizontal surface of grasses in summer turning to snow cover for 9-10 months..	None
LINE	Strongly horizontal land, lakes, and ponds..	Horizontal surface of grasses in summer turning to snow cover for 9-10 months.	None
COLOR	Very light to medium tan earth. Water reflecting colors of sky in summer turning to snow cover for 9-10 mo	Light to medium green turning to tan to brown grasses in summer and uniform snow cover for 9-10 months	None
TEX-TURE	Smooth land, lakes, and ponds	Smooth grasses and snow cover	None

SECTION C. PROPOSED ACTIVITY DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Flat, planar pads and roads	Geometric patterns of present and absent grasses.	Strongly planar vertical and horizontal drill and valve structures. Cylindrical tanks. Geometric roads, pads, vehicles.
LINE	Horizontal pads and curvilinear roads	Horizontal and angular lines at edges of geometric shapes.	Strongly vertical and horizontal lines. Vertical and horizontal lines at edges of geometric shapes
COLOR	Tans and greys	Greens, tans, and greys.	Light to dark orange structures and multicolored equipment. White, blue, and red facility, vehicle lighting, sky glow.
TEX-TURE	Smooth.	Smooth to coarse at a distance.	Moderate to coarse.

SECTION D. CONTRAST RATING __SHORT TERM ✓ LONG TERM

1.

DEGREE OF CONTRAST	LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
ELEMENTS	STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE
FORM		✓				✓			✓			
LINE		✓				✓			✓			
COLOR		✓				✓			✓			
TEXTURE			✓				✓			✓		

2. Does project design meet visual resource management objectives? ___Yes ___No
(Explain on reverses side)

3. Additional mitigating measures recommended
✓ Yes ___No (Explain on reverses side)

Evaluator's Names: Merlyn Paulson/ Chris Bockey
Date: 01/09/2020

(Continued on Page 2)

SECTION D. (Continued)

Comments from item 2.

Strong construction-related contrasts in the foreground and middleground seen areas (0-5 miles) would occur for the 10-11-year time period specified (Chapter 2.4.6.10.2) for drilling and from the presence of drill rigs and construction equipment. Strong contrasts would be caused by the structural forms, lines, and colors and colors of lighting for facilities, equipment, and vehicles.These noticeable forms and lines are required for function and the highly contrasting colors are needed for safety in the region's extreme weather conditions. Thus, they would cause strong contrasts in the characteristic landscape and mitigations of color would not be feasible.

Dark Sky BMP Re: down-shielded lighting – This BMP would limit direct (line-of-sight) visibility of the standard Osha-mandated lighting at facilities. However, down-shielding in snow cover conditions is known to increase reflectiveness toward the sky and the resultant sky glow and light dome would cause problematic navigation issues for humans and fauna.

Strong contrasts would be reduced to moderate and then weak during the operations, maintenance, and reclamation phases of the project. These phases would be portrayed by pads, roads, pipelines, and vehicles, and, eventually, less-noticeable forms, lines, and colors in the landscape.

Additional Mitigating Measures (See item 3)

Form 8400-4
(June 2018)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
VISUAL CONTRAST RATING WORKSHEET

Date: 03/08/2019
District Office: Arctic
Field Office:
Land Use Planning Area:

SECTION A. PROJECT INFORMATION

1. Project Name Willow	4. KOP Location (T.R.S) Varies	5. Location Sketch See 2020 FEIS - Appendix A: Figure 3.7.1 Visual Resource Analysis Area
2. Key Observation Point (KOP) Name Background-Seldom Seen Views		
3. VRM Class at Project Location Non-BLM Managed Lands	(Lat. Long) Varies	

SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Planar horizontal land, lakes and ponds.	Planar horizontal surface of grasses in summer turning to snow cover for 9-10 months..	Strongly planar vertical and horizontal drill and valve structures. Cylindrical tanks. Geometric roads, pads, vehicles.
LINE	Strongly horizontal land, lakes, and ponds..	Horizontal surface of grasses in summer turning to snow cover for 9-10 months.	Strongly vertical and horizontal lines. Vertical and horizontal lines at edges of geometric shapes
COLOR	Very light to medium tan earth. Water reflecting colors of sky in summer turning to snow cover for 9-10 mo	Light to medium green turning to tan to brown grasses in summer and uniform snow cover for 9-10 months	Light to dark orange structures and multicolored equipment. White, blue, and red facility, vehicle lighting, sky glow.
TEX-TURE	Smooth land, lakes, and ponds	Smooth grasses and snow cover	Moderate to coarse.

SECTION C. PROPOSED ACTIVITY DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Flat, planar pads and roads	Geometric patterns of present and absent grasses.	Strongly planar vertical and horizontal drill and valve structures. Cylindrical tanks. Geometric roads, pads, vehicles.
LINE	Horizontal pads and curvilinear roads	Horizontal and angular lines at edges of geometric shapes.	Strongly vertical and horizontal lines. Vertical and horizontal lines at edges of geometric shapes
COLOR	Tans and greys	Greens, tans, and greys.	Light to dark orange structures and multicolored equipment. White, blue, and red facility, vehicle lighting, sky glow.
TEX-TURE	Smooth.	Smooth to coarse at a distance.	Moderate to coarse.

SECTION D. CONTRAST RATING __SHORT TERM ✓ LONG TERM

1. DEGREE OF CONTRAST

ELEMENTS	Land/Water Body (1) STRONG	MODERATE	WEAK	NONE	Vegetation (2) STRONG	MODERATE	WEAK	NONE	Structures (3) STRONG	MODERATE	WEAK	NONE
FORM			✓				✓			✓		
LINE			✓				✓			✓		
COLOR			✓				✓			✓		
TEXTURE			✓				✓				✓	

2. Does project design meet visual resource management objectives? ___Yes ___No (Explain on reverses side)

3. Additional mitigating measures recommended ✓ Yes ___No (Explain on reverses side)

Evaluator's Names: Merlyn Paulson/ Chris Bockey

Date: 01/09/2020

(Continued on Page 2)

SECTION D. (Continued)

Comments from item 2.

Overall contrast would diminish based on viewer location and proximity to existing drilling infrastructure in the area of Kuparuk.

In viewing areas distant from the area of Kuparuk, moderate to weak construction-related contrasts in the background and seldom seen areas (5-15 and greater miles) would occur for the 10-11-year time period specified (Chapter 2.4.6.10.2) for drilling and from the presence of drill rigs and construction equipment. Moderate contrasts would be caused by the structural forms, lines, and colors and colors of lighting for facilities and vehicles.

These noticeable forms and lines are required for function and the highly contrasting colors are needed for safety in the region's extreme weather conditions. Thus, they would cause moderate contrasts in the characteristic landscape and mitigations of color would not be feasible.

Dark Sky BMP Re: down-shielded lighting – This BMP would limit direct (line-of-sight) visibility of the standard Osha-mandated lighting at facilities. However, down-shielding in snow cover conditions is known to increase reflectiveness toward the sky and the resultant sky glow and light dome would cause problematic navigation issues with humans and fauna.

Moderate contrasts would be reduced to weak during the operations, maintenance, and reclamation phases of the project. These phases would be portrayed by pads, roads, pipelines, and vehicles, and, eventually, less-noticeable forms, lines, and colors in the landscape.

Additional Mitigating Measures (See item 3)