3.26 CLIMATE CHANGE

The Climate Change section addresses the potential effects of the proposed action on climate change as indicated by the Donlin Gold Project's greenhouse gas (GHG) emissions, and the implications of climate change for the environmental effects of the proposed action, by examining climate change impacts on the project, and climate change impacts on resources.

SYNOPSIS

This section addresses climate change by summarizing existing conditions and expected effects. Expected effects for climate change are evaluated to the extent possible in two ways: 1. Evaluation of potential effects of the proposed action on climate change, and 2. Evaluation of the effects of climate change on the environmental effects of the proposed action. As of March 2017, CEQ 2016 final guidance on addressing climate change in accordance with NEPA was rescinded, and this evaluation is in accordance with CEQ 2014 draft guidance.

Three types of analysis are provided in this section, per CEQ 2014 guidelines: 1. Potential effects of the proposed action on climate change are addressed by analyzing the project activity contribution to greenhouse gas (GHG) emissions, under Atmosphere; 2. Potential effects of climate change on the environmental effects of the proposed action are assessed for Water Resources, Permafrost, Biological Resources, and Subsistence; and 3. Effects on the proposed project from climate change are assessed for Water Resources and Permafrost. Effects are described by major project component (Mine Site, Transportation Corridor, and Pipeline) and by project phase (Construction, Operations, and Closure). Where information is available, differences between alternatives are discussed; however, CEQ 2014 guidelines only provide for consideration of potential effects of a proposed action on climate change or implications of climate change for the environmental effects of a proposed action.

EXISTING CONDITION SUMMARY

Atmosphere – Assessment of direct GHG emissions provide a quantified approach to evaluating the project's contribution to climate change. Where possible, indirect emissions are assessed or qualitatively described. The state of Alaska accounts for about one percent of U.S. GHG emissions. The majority of Alaska's GHG emissions are from the petroleum and natural gas industry, with about one percent from the mining industry. Permafrost melt is also expected to release GHGs (carbon dioxide and methane) to the atmosphere.

Water Resources – Combined with warmer winters and less snow cover as compared to historic norms, large-scale stream flow changes may impact barge schedules as well as other resources within the Project Area. Although effects of climate change on surface water resources are complex and difficult to quantify, predicted increases in average precipitation may cause changes in stream flow. Changes in hydrology may also impact permafrost, biological, and subsistence resources.

Permafrost – Permafrost removal from the proposed action may accelerate the rate of loss of remaining permafrost within the Project Area. Permafrost stability or anticipated changes to existing permafrost conditions will influence design and construction considerations for the project associated with settlement and ground stability issues. Permafrost is predicted to thaw within the Project Area due to climate change. As permafrost soils warm, organic carbon reservoirs trapped in the frozen subsurface are mobilized, causing carbon dioxide and methane to be released into the atmosphere. Changes in permafrost may also impact biological and subsistence resources.

Biological Resources and Subsistence – Although effects of climate change on biological and subsistence resources are complex and difficult to quantify, climate change is expected to cause changes in vegetation and wetlands, impacting wildlife and subsistence resources.

EXPECTED EFFECTS SUMMARY

Alternative 1 - No Action

Climate change would continue to have effects as predicted within the Project Area. This alternative would not further contribute to climate change in the Project Area, other than climate change inputs already resulting from exploration work and baseline studies.

Alternative 2 - Donlin Gold's Proposed Action

Atmosphere - GHG emissions are considered under Council on Environmental Quality (CEQ) 2014 draft guidelines to evaluate a proposed action's impacts on climate change and applicable GHG reduction strategies. The duration of GHG emissions would occur throughout all three project components for all three project phases. GHG emissions would occur within the Project Area in all three components; consistent with the nature of climate change emissions, the impacts would be global. At the Mine Site, direct GHG emissions from project activities would be a small percentage of Alaska's annual GHG emissions. Indirect GHG emissions associated with Construction and Operations would result from emissions associated with transporting supplies and construction materials to the Mine Site, and oil and gas production associated with the natural gas and diesel used to power mining operations. For the Transportation Corridor and Pipeline components, maximum annual direct GHG emissions are estimated to represent less than one percent of Alaska's annual GHG emissions. Indirect GHG emissions associated with Construction and Operations within the Transportation Corridor and Pipeline components would result from operations of air traffic between Anchorage (or other point of origin) and the Mine Site airstrip, construction airstrips along the pipeline ROW, and ocean traffic.

Water Resources - Hydrologic effects due to climate change would range from scenarios where sufficient barge days would be available under a low water climate change scenario to meet proposed shipping needs, to scenarios where a faster pit lake filling rate could require changes in water management/treatment strategies in post-Closure. The duration of climate change effects could last through the life of the project (Transportation Corridor and Pipeline components) and into post-Closure (Mine Site). The extent of project effects would be considered to occur in areas within the EIS Analysis Area. There is no particular context framework for water resources in terms of climate change.

Permafrost - Impacts to and from permafrost due to climate change would range from scenarios in which there would be little noticeable additional ground settlement from climate change, to scenarios in which design and BMPs at major mine structures and along the pipeline route are effective in controlling permafrost hazards, differential settlement, and thermal erosion; although specific low probability conditions may exist that could cause other scenarios, such as permafrost excavation at toe of the Waste Rock Facility (WRF). Project-related impacts to climate-altered permafrost would be limited to intermittent areas of permafrost and would be localized beneath facility footprints and cleared areas. Permafrost thaw effects would range from occurring during the life of the project, such as settlement and revegetation reaching equilibrium within several years, to having areas where restoration of permafrost would not be expected. Context is defined as the region being an area of discontinuous permafrost.

Biological Resources and Subsistence – The effects of climate change on the environmental effects of the proposed action for biological and subsistence resources include vegetation type changes and changes in wetland quality or quantity. Project activities will remove vegetation and change hydrology. With expected climate change effects such as changed precipitation and temperature patterns, a general drying trend, and different fire regime, vegetation types or wetlands may not have the same composition, structure, or function after project activities are conducted. In turn, wildlife habitat would be impacted by vegetation and wetland changes, causing impacts to wildlife and bird species. Biological resource changes would impact subsistence resources. Intensity of impacts would be incremental, and duration could be short or long term, depending on whether or not an ecological threshold has been crossed. The extent is considered to be within the EIS Analysis Area, although interrelated biological changes may extend over large regions. There is no particular context for biological resources regarding climate change.

OTHER ALTERNATIVES – This section discusses differences between Alternative 2 and the following alternatives, but does not include a comprehensive discussion of each alternative's impacts if they are the same as or similar to Alternative 2 impacts.

Alternative 3A - LNG Powered Trucks - This alternative would reduce consumption of diesel, reduce barge trips, and reduce tanker trucks and thereby reduce GHG emissions relative to Alternative 2. There would be less potential for low water barge impacts (fewer trips needed), but a slight increase in the effects of climate change on permafrost thaw at the Bethel Dock (activities at the Bethel Dock would be a connected action).

Alternative 3B - Diesel Pipeline - This alternative would replace the natural gas pipeline proposed under Alternative 2 with a diesel pipeline. GHG emissions and the resulting impacts to climate change under Alternative 3B GHG emissions would be similar to those discussed under Alternative 2 for Construction and Closure of all project components, including Pipeline operations. Alternative 3B would result in lower GHG emissions during Operations due to reduced barging, and elimination of fugitive GHGs from the natural gas pipeline and compressor station. However, this reduction would be more than offset by increased GHGs from combustion of diesel in the Mine Site combustion equipment. There would be slightly fewer climate effects on project use of water resources along the Transportation Corridor due to fewer barge trips, but slightly more effects along the pipeline route (more stream crossings subject to climate change impacts).

Alternative 4 - Birch Tree Crossing Port - This alternative would have slightly higher GHG emissions during Construction of the longer access road under Alternative 4.

During Operations, project-related activities for the Transportation Corridor would have reduced GHG emissions from less barging, but increased GHG emissions from the increased travel distance for trucks. There would be less potential for climate-caused low water barge effects, but slightly more climate-caused effects along the Crooked Creek ice road.

Alternative 5A - Dry Stack Tailings - This alternative would include variations in tailings methods within the Mine Site that would not cause a substantial change in GHG emissions or impacts to climate change from those identified under Alternative 2. Flexible mine water management and design of operating pond would be able to accommodate climate-caused precipitation effects.

Alternative 6A - Dalzell Gorge Route - This alternative would include an alternative route for part of the natural gas pipeline in the Pipeline component that would not cause a substantial change in GHG emissions or impacts to climate change from those identified under Alternative 2. Increased precipitation and breakup discharge due to climate change may cause an increase in the occurrence of glaciation or aufeis effects.

3.26.1 CLIMATE CHANGE DEFINITION

Climate change is defined by the American Meteorology Society as:

> Any systematic change in the long-term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer. Climate change may be due to natural external forcings, such as changes in solar emission or slow changes in the earth's orbital elements; natural internal processes of the climate system; or anthropogenic forcing (AMS 2013).

In the 1992 United Nations Framework Convention on Climate Change, climate change is defined as:

> A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC 1992).

Many lines of evidence suggest that recent global warming of the past half-century is due primarily to human activities (USGCRP 2014). The likelihood that observed warming since the middle of the twentieth century is a result of human influence has increased from very likely to extremely likely, with the level of confidence having increased from very low to very high (IPCC 2013).

Naturally occurring greenhouse gasses (GHGs), including carbon dioxide, methane, nitrous oxide, ozone, and water vapor, are produced by volcanoes, forest fires, and biological processes. Anthropogenic GHGs also include sulfur hexafluoride, perfluorocarbons, hydrofluorocarbons, and chlorofluorocarbons produced by burning fossil fuels, industrial and agricultural processes, waste management, and land use changes. The EPA has determined that six key well-mixed GHG emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) may reasonably be anticipated to adversely affect public health and welfare (EPA 2009a). The most common GHG emitted through anthropogenic activities is carbon dioxide. In 2012, for example, carbon dioxide (CO_2) accounted for about 82 percent of all U.S. anthropogenic GHG emissions (EPA 2014d). Anthropogenic emissions of GHGs are thought to be the dominant cause of observed climate warming since the mid-twentieth century. Continued emissions of GHGs are predicted to continue the trajectory of further warming and changes in all components of the climate system (IPCC 2013, NOAA 2013a).

3.26.2 REGULATORY FRAMEWORK

Listed below are federal guidance, promulgated federal regulations on GHGs relevant to the project, and U.S. Department of Transportation (USDOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) guidance on special permits that is pertinent to climate change predictions of permafrost thaw.

3.26.2.1 COUNCIL ON ENVIRONMENTAL QUALITY (CEQ) GUIDANCE

The Council on Environmental Quality (CEQ) released its initial draft guidance for considering GHGs and the effects of climate change under the National Environmental Policy Act (NEPA) in February 2010; revised draft guidance in December 2014; and final guidance in August 2016. This final guidance was rescinded in March 2017 through Executive Order (EO) 13783, Promoting Energy Independence and Promoting Economic Growth. There may be revisions in the regulatory framework regarding climate change in the future; however, at the time of publication, this document retains the analysis that was performed under the draft 2014 CEQ guidelines.

The 2014 revised draft guidance memorandum was developed to assist federal agencies in their consideration of the effects of GHG emissions and climate change when evaluating proposed federal actions in accordance with the National Environmental Policy Act (NEPA) and the CEQ Regulations Implementing the Procedural Provisions of NEPA. The guidance was meant to provide greater clarity and more consistency in how agencies address climate change in the environmental impact assessment process. Under this draft guidance, agencies have discretion in how they tailor their individual NEPA reviews to accommodate the approach outlined in the guidance, consistent with CEQ Regulations and their respective implementing procedures and policies (CEQ 2014). Specific agency considerations include:

1. The potential effects of a proposed action on climate change as indicated by GHG emissions; and
2. The implications of climate change for the environmental effects of a proposed action.

The draft 2014 CEQ guidance indicates that 25,000 metrics tons (MT) of carbon dioxide equivalent (CO_2-e) per year is the reference point above which a quantitative analysis is warranted. As noted in this guidance, the nature of the proposed action and its relationship to climate change must be considered to determine if a detailed analysis is warranted in the EIS. The Donlin Gold Project would be expected to result in an increase of GHG emissions greater than 25,000 MT per year, and so an analysis in this EIS is warranted and was performed.

3.26.2.2 EPA AND STATE OF ALASKA REGULATIONS

The EPA has taken several actions to track and develop standards for GHG emissions from mobile and stationary sources under the Clean Air Act (CAA), including implementation of regulations for GHG emission standards for light- and heavy-duty vehicles, for heavy-duty engines, and for renewable fuel standards for the purpose of reducing GHG emissions. These regulations and their applicability to the project are discussed in more detail in Section 3.8, Air Quality.

The EPA requires large stationary source emitters of GHGs to report GHG emissions annually in order to inform policy makers. Calculations of six GHGs (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) identified in the Kyoto protocol are applied to determine total project GHG emissions. Because carbon dioxide is the reference gas for climate change, measures of non-carbon dioxide GHGs are converted into carbon dioxide equivalent (CO_2-e) based on their global warming potential (GWP) (or potential to absorb heat in the atmosphere). GWPs for these covered gases are shown in Section 3.8, Air Quality. These mandatory reporting requirements and their applicability to the project are described in more detail in Section 3.8, Air Quality.

The EPA has incorporated GHG permitting requirements into its New Source Review (NSR) and Title V permitting programs. The Alaska Department of Environmental Conservation (ADEC) has adopted the EPA's Prevention of Significant Deterioration NSR, Nonattainment NSR, and Title V GHG permitting provisions into 18 AAC 50. The ADEC has not incorporated GHG permitting into its minor NSR permit program. State of Alaska permitting requirements for GHG emissions, and their applicability to the project, are discussed in more detail in Section 3.8, Air Quality.

3.26.2.3 PHMSA SPECIAL PERMITS

PHMSA issues special permits, an order that waives or modifies compliance with a regulatory requirement if the pipeline operator requesting it demonstrates the need and PHMSA determines that granting a special permit would be consistent with pipeline safety. Special permits are authorized by statute in 49 USC § 60118(c), and the application process is set forth in 49 CFR 190.341. PHMSA performs extensive technical analysis on special permit applications and typically conditions a grant of a special permit on the performance of alternative measures that will provide an equal or greater level of safety. The project would require a special permit because climate change may cause thaw of permafrost in sections of the proposed natural gas pipeline. Alternative pipeline designs to accommodate permafrost thaw effects would be evaluated by PHMSA prior to issuance of a special permit. See Appendix E for PHMSA Enclosure B.

3.26.3 AFFECTED ENVIRONMENT

This section describes affected environment in separate sections for atmosphere, water resources, permafrost, and biological resources and subsistence in the context of climate change. Climate change impacts directly affecting Alaska include temperature increases, precipitation pattern changes, reduced sea ice, ocean acidification, increased extreme weather events, increased permafrost thawing, shrinking glaciers, and coastal erosion from sea level rise (NOAA 2013a; USGCRP 2014; Chapin III et al. 2014). Complex interactions in natural systems present challenges to quantified analysis of climate change effects on resources. Interpretation of the best available data, models, and information is summarized to evaluate climate change effects per resource. Models, where available, contain inherent uncertainty and limitations, which are discussed in the applicable sections.

Recent climate model simulations for Alaska used both high and low future global GHG emissions scenarios, with sources of climate information considered and approved by the National Climate Assessment Development and Advisory Committee (SNAP 2013). Climate change effects predicted from these scenarios that would most likely affect the Project Area include:

- Predicted increases in the frequency and intensity of storms, which may increase flooding and erosion in the Project Area;
- Increased winter and springtime temperatures with increased winter precipitation, which may cause flooding from increased snowpack or rapid springtime temperature increases;
- Thawing permafrost, which may cause infrastructure damage to roads, utility infrastructure, pipelines and buildings;
- Increased chance of drought during predicted warmer, drier summers, which may limit river transportation (including barging) and increase the likelihood or intensity of wildfires;
- Reduction in wetland quantity or quality, resulting from permafrost melt and draining of wetlands, along with a general drying trend in the region; and
- Shifts in vegetation composition, structure, and function, which may in turn impact wildlife habitat, wildlife populations, and subsistence resources.

3.26.3.1 ATMOSPHERE

Baseline climate conditions (e.g., temperature, rainfall) are described in Section 3.4, Climate and Meteorology. Climate change impacts, such as warmer air and ocean temperatures, more high-intensity rainfall events, and more frequent heat waves, have been linked the accumulation of GHGs in the atmosphere (EPA 2012).

Alaska accounts for less than one percent of the total GHG (CO_2-e) emissions in the U.S. annually (Table 3.26-1). GHG emissions from the U.S. represent approximately 18 percent of the worldwide GHG emissions (Environment Canada 2011).

On a per capita basis in 2010, Alaska activities emitted about 55 MT of CO_2-e annually, significantly higher than the national average of 18 MT per year CO_2-e (ADEC 2015). Alaska's high per capita rate, compared to the rest of the country, is influenced by its low population, cold climate, long winters with low light, and greater distances for transport of goods and people. In addition, Alaska is a major producer of oil and gas for export; activities related to oil and gas exploration and production generate GHG emissions (MAG 2009).

Table 3.26-1: Estimated Annual GHG Emissions (CO_2-e)[1]

Summary Year	GHG Emissions – Alaska (MMT)[2]	GHG Emissions – U.S. (MMT)[3]	Alaska vs U.S. GHG Emissions (%)
1990	44.93	6,233	0.72
2000	51.16	7,107	0.72
2005	54.64	7,254	0.75
2010	43.04	6,875	0.63

Notes:

1 MMT = Million Metric Tons

2 Source: ADEC, 2015

3 Source: EPA 2014d

Actual GHG emissions for stationary sources are reported to EPA in Alaska under the GHG reporting rule by industrial sector (Table 3.26-2). For calendar year 2013, approximately 64 percent of reported GHG emissions for Alaska under this rule came from the petroleum and natural gas industry, and approximately one percent from the mining industry. In the mining category, Red Dog Operations Mine, Coeur Alaska, Kensington Gold Mine, and Hecla Greens Creek Mine emit 152,985 MT per year, 32,469 MT per year, and 24,846 MT per year, respectively.

Table 3.26-2: Annual Reported GHG Emissions by Sector in Alaska[1]

Sector	Metric Tons CO_2-e	Percent of Alaska GHG Emissions[2]
Power Plants	3,451,787	18.8
Petroleum and Natural Gas Systems	11,791,276	64.4
Refineries	1,285,775	7.0
Other[3]	878,119	4.8
Waste	599,667	3.3
Mining	210,300	1.1
Chemicals	103,874	0.6
Total	**18,320,798**	**100.0**

Notes:

1 Calendar year 2013 emissions reported to EPA under the GHG reporting program reflect actual (rather than potential) emissions from large facilities (over 25,000 MT per year) only. Mobile sources of emissions are not required to be reported, thus are not included in the estimates shown in this table

2 Calculated using actual Alaska GHG emissions reported for calendar year 2013.

3 Other sources of GHG emissions not covered by named sectors, including tourism industry, fishing industry, retail industry, other non-specified business activities, personal vehicle use, or heating and cooling of homes.

Source: EPA 2014h

3.26.3.2 WATER RESOURCES

The effect of climate change on surface water characteristics, such as stream flow, within the affected environment of the project is complex and difficult to quantify. BGC Engineering Inc. (BGC) (2011a) reviewed the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007) to develop an understanding of climate change predictions for the

Project Area. The IPCC provides regional climate change predictions of temperature and precipitation for multiple regions in the world, including Alaska. In terms of water resources, precipitation changes may impact stream flow most directly. BGC (2011a) reported that the IPCC projects that the average precipitation in Alaska could increase by 21 percent by the end of the twenty-first century, based on 21 Global Climate Models (GCMs). Significant warming will likely occur, especially during winter months, in the northern portions of Alaska and Canada due primarily to shorter periods of snow cover (BGC 2011a). Average warming by the end of the twenty-first century in southwest Alaska in the region of the project is projected to range from an increase of 5 to 8 degrees Fahrenheit (°F) depending on the GCMs used (Figure 3.26-1) (Chapin III et al. 2014; Markon 2012).

The IPCC predictions for temperature and precipitation are typically based on relatively large-scale grid cells. In Alaska, downscaled climate datasets applying five best-fit GCMs (Walsh et al. 2008) are available from the Scenarios Network for Alaska + Arctic Planning (SNAP) as a five-model ensemble. The five-model SNAP (2012) ensemble datasets partially narrow the uncertainties of applying a wide range of GCMs to Alaska by using only those GCMs selected based on historical trends (Walsh et al. 2008). This study utilized outputs for an intermediate climate change scenario, where carbon dioxide increases from present day concentrations to 720 parts per million by the year 2100 (known as scenario A1B). The study then determined how each of 15 GCMs outputs concurred with actual climate data for years 1958-2000 for three climate variables (surface air temperature, air pressure at sea level, precipitation) in order to select the top five Alaska models.

The five-model SNAP ensemble narrowed potential uncertainty by generating independent, as well as combined, climate change predictions. SNAP then linked outputs from the five GCMs with historical climate data for Alaska at a 2-kilometer (km) resolution from Parameter Elevation Regressions on Independent Slope Models (PRISM). The predicted results from the GCMs linked with the average monthly PRISM data were used by SNAP to generate pixelated 2-km grids throughout Alaska for average monthly temperature and precipitation for every year projected out to 2099. From these datasets, SNAP created statewide maps of average monthly temperature and precipitation as well as climate change predictions for 353 communities, including Crooked Creek, located 10 miles south of the Mine Site, and several additional communities along the Kuskokwim River (SNAP 2012) (Figure 3.26-2), as described in the following subsections.

Precipitation predictions in the five-model SNAP ensemble provide an indication of future changes due to climate change that can be compared among different parts of Alaska; however, potential inconsistencies in historical precipitation records used to make these predictions should be noted. The evaluation of precipitation trends from numerous studies in Alaska differ in analysis period and methodology, and present different conclusions, while not fully addressing issues of temporal inconsistencies in the datasets (McAfee et al. 2013).

3.26.3.2.1 MINE SITE

BGC (2011a, b) compiled SNAP climate change data for the Mine Site using Crooked Creek community data as an analog, with the goal of identifying ranges in precipitation that could have an effect on the adequacy of mine infrastructure design. Using a similar approach, Table 3.26-3 presents SNAP (2012) data, showing predicted changes in average monthly precipitation at Crooked Creek based on the intermediate climate change scenario A1B for four periods: 2010-

2019, 2040-2049, 2060-2069, and 2090-2099. Average monthly precipitation at the Mine Site is provided alongside Crooked Creek historical data and modeled Crooked Creek SNAP data to show the differences in datasets that represent current conditions in the mine area.

Based on SNAP (2012) modeled data for Crooked Creek, precipitation during winter months (October to March) is projected to increase from current conditions over these decades. Summer months show an increase in precipitation through 2069, then a slight decline in mid-summer through 2099, but a net overall increase for summer months combined. SNAP data predict a minor increase in precipitation at Crooked Creek (about 2 percent) for the 2040-2049 period, which is less than local historical differences between the Mine Site and Crooked Creek. More significantly, a 17- to 25-percent increase in precipitation is predicted for the 2060-2099 decades, which represent the post-Closure period at the mine. It should be noted that an increase in precipitation does not necessarily correlate directly with an equivalent increase in runoff and stream flow.

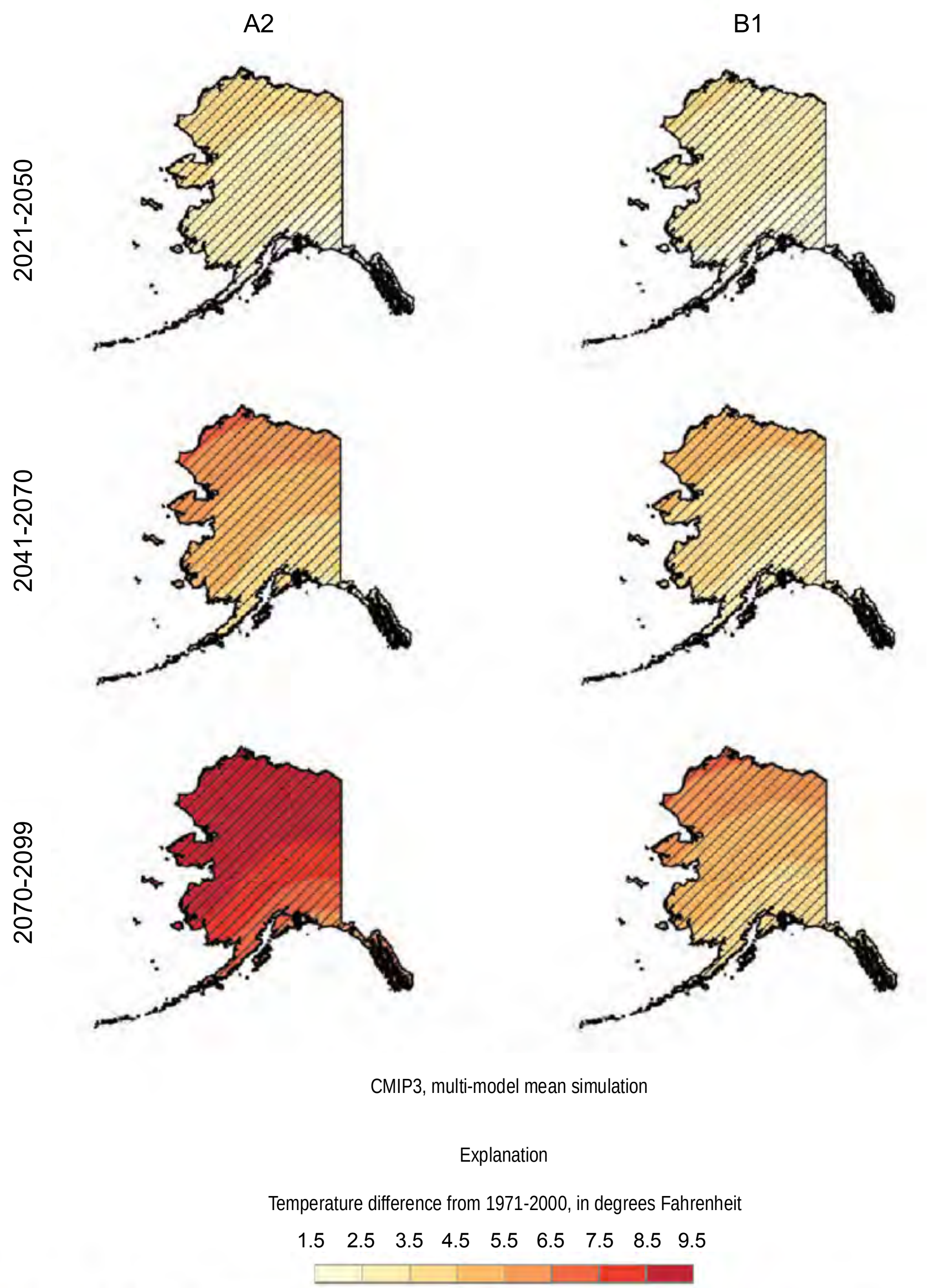
Table 3.26-3: Predicted Precipitation Changes in Mine Area from Climate Change

Month	Crooked Creek Historical Avg. Monthly Precipitation[1] (inches)	Avg. Monthly Precipitation for Mine Site[2] (inches)	Predicted Average Monthly Precipitation[3] (inches)			
			2010-2019 (Construction)[4]	2040-2049 (Operations)[4]	2060-2069 (Closure/ Post-Closure)[4]	2090-2099 (Closure/ Post-Closure)[4]
January	0.87	1.16	0.98	1.1	1.38	1.34
February	0.59	0.89	0.71	0.71	0.75	0.94
March	0.55	0.80	0.59	0.63	0.71	0.79
April	0.32	0.40	0.32	0.35	0.39	0.47
May	0.67	1.05	0.63	0.63	0.83	0.83
June	1.54	2.15	1.57	1.57	1.97	1.81
July	2.01	2.61	2.24	1.97	2.28	2.17
August	3.35	3.70	3.66	3.66	4.02	4.21
September	2.2	2.66	2.44	2.36	2.76	2.99
October	1.38	1.74	1.3	1.54	1.61	1.89
November	0.91	1.17	0.87	1.06	1.06	1.34
December	0.94	1.30	0.94	1.05	1.18	1.54
Total	**15.33**	**19.63**	**16.25**	**16.64**	**18.94**	**20.32**
% Increase	**-**	**-**	**-**	**2%**	**17%**	**25%**

Notes:

1 Historical average monthly data for Crooked Creek for the period 1961–1990 (SNAP 2012).
2 Synthetic dataset for total precipitation (snowfall plus rainfall) based on data from Crooked Creek, scaled to the proposed Project Area (BGC 2011f). (Also shown in Table 3.4-1, Section 3.4, Climate Change and Meteorology.)
3 SNAP (2012) data for the community of Crooked Creek.
4 Approximate phase of the proposed project.

Source: BGC 2011a; SNAP 2012



Multi-model mean annual differences in temperature (°F) between the three future periods and 1971–2000, from 15 CMIP3 model simulations. Areas with hatching indicate that more than 50 percent of the models show a statistically significant change in temperature. CMIP3: Coupled Model Intercomparison Project Phase 3; A2: Intergovernmental Panel on Climate Change emissions scenario that assumes a continuation of recent trends in fossil fuel use; B1: Intergovernmental Panel on Climate Change emissions scenario that assumes a vigorous global effort to reduce fossil fuel use.

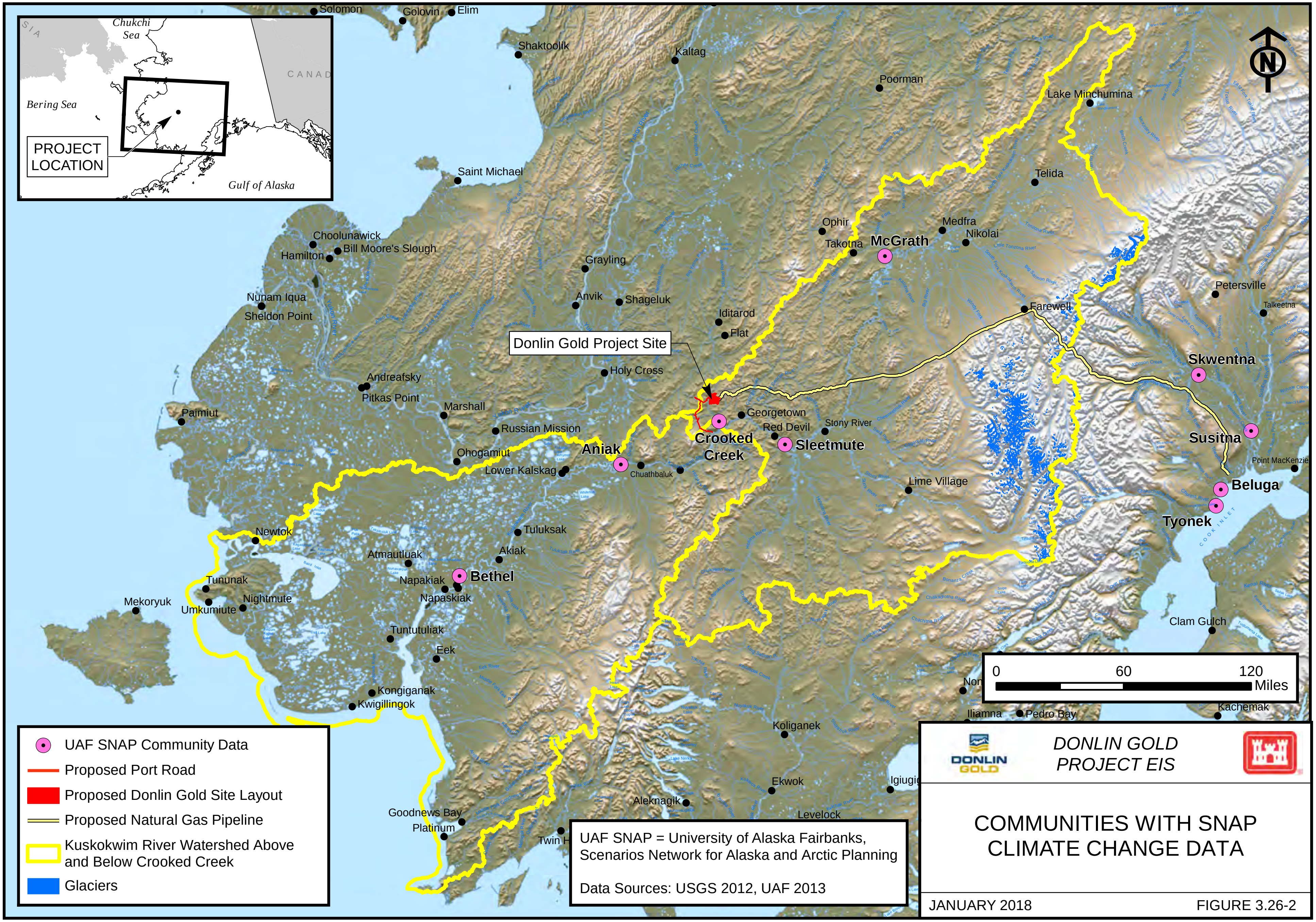
Data Source: Markon et al. 2012

DONLIN GOLD PROJECT EIS

PROJECTED AIR TEMPERATURE TRENDS IN ALASKA FOR TWO CLIMATE SCENARIOS

JUNE 2017

FIGURE 3.26-1


DONLIN GOLD PROJECT EIS
COMMUNITIES WITH SNAP CLIMATE CHANGE DATA
JANUARY 2018
FIGURE 3.26-2
UAF SNAP Community Data
Proposed Port Road
Proposed Donlin Gold Site Layout
Proposed Natural Gas Pipeline
Kuskokwim River Watershed Above and Below Crooked Creek
Glaciers
UAF SNAP = University of Alaska Fairbanks, Scenarios Network for Alaska and Arctic Planning
Data Sources: USGS 2012, UAF 2013
0
60
120
Miles
PROJECT LOCATION
Chukchi Sea
Bering Sea
Gulf of Alaska
Donlin Gold Project Site
McGrath
Skwentna
Susitna
Beluga
Tyonek
Aniak
Crooked Creek
Sleetmute
Bethel
Solomon
Golovin
Elim
Shaktoolik
Kaltag
Poorman
Lake Minchumina
Telida
Saint Michael
Ophir
Takotna
Medfra
Nikolai
Choolunawick
Bill Moore's Slough
Hamilton
Grayling
Anvik
Shageluk
Nunam Iqua
Sheldon Point
Iditarod
Flat
Farewell
Petersville
Talkeetna
Holy Cross
Andreafsky
Pitkas Point
Marshall
Russian Mission
Georgetown
Red Devil
Stony River
Paimiut
Ohogamiut
Lower Kalskag
Chuathbaluk
Lime Village
Point MacKenzie
Newtok
Tuluksak
Akiak
Atmautluak
Napakiak
Napaskiak
Tununak
Mekoryuk
Umkumiute
Nightmute
Tuntutuliak
Eek
Clam Gulch
Kongiganak
Kwigillingok
Iliamna
Pedro Bay
Kachemak
Koliganek
Ekwok
Aleknagik
Levelock
Goodnews Bay
Platinum
Cook Inlet

3.26.3.2.2 TRANSPORTATION CORRIDOR AND PIPELINE

Water levels on the Kuskokwim River during the Construction and Operations phases are of interest as use of the river for barging materials and fuel to the mine is part of the proposed action. Precipitation in the Kuskokwim River watershed represents a significant input for stream flow in the river; therefore, precipitation predictions at several locations along the river were compared. Table 3.26-4 presents the predicted change in average monthly precipitation at five river communities (Bethel, Aniak, Crooked Creek, Sleetmute and McGrath) for two decadal periods (2010-2019 and 2040-2049) based on SNAP (2012) data. These two periods represent pre-Construction and later Operations phases, requiring transportation of material and fuel on the Kuskokwim River. Based on the SNAP modeled data, each location is projected to experience an average increase in annual precipitation by approximately two to three percent from current levels through 2049. On a month-to-month basis, precipitation during winter months (October to March) would generally increase from current conditions, and most summer months would experience a decrease in precipitation at each location.

Aniak and McGrath are projected to have the greatest increase in precipitation during winter months (October to March), with changes of 24.1 and 24.6 percent, respectively, which may also indicate an increase in spring breakup flow (Table 3.26-4). The greatest decrease in precipitation during the open water season is predicted to occur in July at Aniak, Crooked Creek, and Sleetmute, with changes of -11.9, -12.1, and -13.1 percent, respectively. Although the predicted change in precipitation during summer months appears to be more negative than positive, the changes are relatively small (all less than -13.1 percent) compared to the winter month increases. Summer low flows are affected by both monthly and seasonal changes in precipitation; therefore, the impacts to stream flow due to decreased precipitation during summer months are likely to be balanced to some degree by possible increases in subsurface flow from increased precipitation during fall and winter. Additionally, a -13 percent change in precipitation does not necessarily suggest that there will be a -13 percent change in stream flow or water depth in the Kuskokwim River.

Local observations of Traditional Ecological Knowledge (TEK), including precipitation-related phenomena, are catalogued by the Alaska Native Tribal Health Consortium (ANTHC 2015) in a statewide Local Environmental Observer (LEO) Network database. For the Kuskokwim River area, these include anecdotal observations of recent low snow years, early breakup, thin river ice, and open water in winter, which may be related to climate warming. For example, observations in Bethel in 2014 document a mild winter, very low snow conditions, and thin river ice in the months of January through April. The LEO Network (ANTHC 2015), established in 2012, is envisioned as a long-term database that may be applied to assist with tracking climate change effects statewide.

Monthly SNAP precipitation data (2012) are available for several communities near the pipeline route in the Cook Inlet basin, and as mapped decadal averages at a 2 km resolution throughout the less populated parts of the route through the Alaska Range and Kuskokwim Basin.

In the Alaska Range, Kuskokwim basin drainages, and Kuskokwim Hills, average annual precipitation is predicted to increase on the order of 2 to 15 percent, with the higher increases mapped in the Alaska Range and lower increases in the Kuskokwim Hills and villages along the Kuskokwim River (SNAP 2012) (Table 3.26-4). Average annual precipitation in the Cook Inlet basin communities is anticipated to increase about three to four percent over the life of the project as a result of climate change (Table 3.26-5). Most of the increased precipitation at the

Cook Inlet locations is predicted to occur as snowfall in winter months (November and January) and during breakup in May. These increases would be balanced in part by drier weather in early summer (e.g., June precipitation decreases). The combined greater winter snowfall and precipitation increases in May suggest that greater discharge could occur during breakup than would be anticipated in the absence of climate change effects.

Other studies in the Cook Inlet basin that focus on climate modeling later in the century (Prucha et al. 2011) suggest that much of the expected increased precipitation in winter could occur as rain, and that a reduced snowpack could occur with smaller intermittent melting episodes throughout the winter, rather than a large breakup. As shown in Table 3.26-4 and Table 3.26-5, precipitation changes are expected to be unevenly distributed across different seasons.

Thus, while climate change predictions suggest that an overall increase in precipitation may occur in the vicinity of the mine and along the Kuskokwim River, it is difficult to quantify resulting changes to stream flow given the uncertainties inherent in the predicted precipitation trends and the complex watershed mechanisms influencing runoff. Given the uncertainties and watershed complexities, predicted changes in the SNAP data of less than 20 percent, such as summer decreases in precipitation in Kuskokwim River communities, may not be statistically significant or reliable enough to use for stream flow predictions; and further modeling of the data in an attempt to glean implications for water levels would compound these uncertainties (SNAP 2012, 2013).

3.26.3.3 PERMAFROST

The presence of permafrost is associated with many components of the project. Permafrost stability or anticipated changes to existing permafrost conditions can significantly influence design and construction considerations associated with settlement and ground stability issues. For these reasons, climatic changes affecting permafrost conditions over the lifespan of a project can affect engineering and construction design.

Permafrost susceptibility to thaw can vary considerably within a narrow range of temperatures referred to as “warm” and “cold” permafrost conditions. Permafrost conditions that are considered “warm” remain just below freezing (32°F), and cold permafrost conditions remain below 30°F (-1 degree Celsius [°C]) (Markon et al. 2012). Warm permafrost often exists in a fragile thermal equilibrium, and is more susceptible to potential thaw. Permafrost conditions associated with the Project Area are considered warm. This includes the Mine Site, select segments of Transportation Corridor components (i.e., roads), and localized segments of the pipeline alignment (BGC 2006; CH2M Hill 2011b). Sporadic, discontinuous permafrost in the Mine Site area is typically less than 31.6°F (BGC 2006). Similarly, discontinuous segments of warm permafrost along the pipeline alignment are typically between 31°F and 32°F (CH2M Hill 2011b).

Mean annual air temperature (MAAT) generally -coincides with permafrost distribution, but does not necessarily correspond with linear warming (temperature) of permafrost (Smith et al. 2010; Markon et al. 2012). Topography, surface water, groundwater movement, soil properties, vegetation, and snow can also affect permafrost in addition to anthropogenic disturbances. Snow depth insulative properties can be as influential as warming temperatures (Jorgenson 2011). Zones of permafrost distribution in the northern hemisphere generally correlate with MAAT (Jorgenson 2011), as shown in Table 3.26-6.

Table 3.26-4: Predicted Precipitation Changes along Kuskokwim River from Climate Change

Month	Predicted Average Monthly Precipitation (inches)														
	Bethel			Aniak			Crooked Creek			Sleetmute			McGrath		
	2010-2019[1]	2040-2049	Precip. Change[2] (%)	2010-2019	2040-2049	Precip. Change[2] (%)	2010-2019	2040-2049	Precip. Change[2] (%)	2010-2019	2040-2049	Precip. Change[2] (%)	2010-2019	2040-2049	Precip. Change[2] (%)
January	0.63	0.75	**19.0**	0.79	0.98	**24.1**	0.98	1.1	**12.2**	0.87	0.94	8.0	0.87	0.91	4.6
February	0.51	0.51	0.0	1.02	1.02	0.0	0.71	0.71	0.0	0.75	0.75	0.0	0.79	0.79	0.0
March	0.63	0.67	6.3	0.94	1.02	8.5	0.59	0.63	6.8	0.59	0.63	6.8	0.79	0.83	5.1
April	0.79	0.79	0.0	0.67	0.71	6.0	0.32	0.35	9.4	0.63	0.67	6.3	0.75	0.87	**16.0**
May	0.75	0.79	5.3	0.98	0.98	0.0	0.63	0.63	0.0	0.67	0.71	6.0	0.79	0.79	0.0
June	1.46	1.61	**10.3**	1.46	1.54	5.5	1.57	1.57	0.0	1.42	1.38	-2.8	1.57	1.46	-7.0
July	2.2	2.01	-8.6	2.68	2.36	**-11.9**	2.24	1.97	**-12.1**	2.13	1.85	**-13.1**	2.32	2.17	-6.5
August	3.31	3.15	-4.8	4.88	4.76	-2.5	3.66	3.66	0.0	3.66	3.74	2.2	2.87	2.95	2.8
September	2.28	2.09	-8.3	2.99	2.87	-4.0	2.44	2.36	-3.3	2.56	2.48	-3.1	2.2	2.13	-3.2
October	1.34	1.61	**20.1**	1.3	1.57	**20.8**	1.3	1.54	**18.5**	1.26	1.46	**15.9**	1.34	1.5	**11.9**
November	1.06	1.26	**18.9**	1.1	1.3	**18.2**	0.87	1.06	**21.8**	0.79	0.94	**19.0**	1.14	1.42	**24.6**
December	1.02	1.1	7.8	1.1	1.22	**10.9**	0.94	1.05	**11.7**	0.87	0.94	8.0	1.46	1.54	5.5
Total	16.0	16.3	2.3	19.9	20.3	2.1	16.3	16.6	2.4	16.2	16.5	1.8	16.9	17.4	2.8

Notes:

1. 2010-2019 represents the Construction Phase, and 2040-2049 the late Operations Phase.
2. **Bold** data represent changes > 10%.

Source: SNAP 2012

Table 3.26-5: Predicted Precipitation Changes near Pipeline Route in Cook Inlet Basin from Climate Change

Month	Tyonek (Alternative 6A)			Beluga (Alt. 2, near MP 0)			Susitna (Alt. 2, near MP 20)			Skwentna (Alt. 2, near MP 50)		
	2010-2019[1]	2040-2049	Precip. Change[2] (%)	2010-2019[1]	2040-2049	Precip. Change[2] (%)	2010-2019[1]	2040-2049	Precip. Change[2] (%)	2010-2019[1]	2040-2049	Precip. Change[2] (%)
January	1.93	2.2	**+14.0**	1.65	1.85	**+12.1**	1.5	1.73	**+15.3**	2.32	2.68	**+15.5**
February	1.5	1.54	+2.7	1.42	1.46	+2.8	1.38	1.42	+2.9	2.13	2.17	+1.9
March	1.22	1.26	+3.3	1.14	1.18	+3.5	1.06	1.1	+3.8	1.54	1.57	+1.9
April	1.3	1.34	+3.1	1.02	1.02	0.0	0.91	0.94	+3.3	1.26	1.3	+3.2
May	1.22	1.42	**+16.4**	1.34	1.54	**+14.9**	1.26	1.42	**+12.7**	1.5	1.61	+7.3
June	1.61	1.5	-6.8	1.73	1.57	-9.2	1.69	1.54	-8.9	2.24	2.05	-8.5
July	2.13	2.13	0.0	2.2	2.2	0.0	2.4	2.4	0.0	2.83	2.76	-2.5
August	3.39	3.54	+4.4	3.82	4.02	+5.2	4.33	4.49	+3.7	4.09	4.25	+3.9
September	4.21	4.25	+1.0	4.65	4.72	+1.5	4.09	4.13	+1.0	4.33	4.37	+0.9
October	3.19	3.43	+7.5	3.27	3.46	+5.8	3.11	3.27	+5.1	3.58	3.78	+5.6
November	2.2	2.4	+9.1	1.81	2.01	**+11.0**	1.5	1.65	**+10.0**	2.05	2.32	**+13.2**
December	2.76	2.68	-2.9	2.36	2.32	-1.7	2.24	2.17	-3.1	3.43	3.35	-2.3
Total	26.7	27.7	+3.9	26.4	27.4	+3.6	25.5	26.3	+3.1	31.3	32.2	+2.9

Notes:

1 2010-2019 represents the Construction Phase, and 2040-2049 the late Operations Phase.
2 **Bold** data represent changes > 10%.

Source: SNAP 2012

Table 3.26-6: Permafrost Zone Correlation to Air Temperature in Alaska

Permafrost Zone	% Area	MAAT Range	% Land Surface by Region of Alaska
Continuous	>90%	21.2°F	32% of northern reaches
Discontinuous	50-90%	21.2 to 28.4°F	31% of south-central and interior
Sporadic	10-50%	28.4 to 32°F°	8% of southern portions
Isolated	0-10%	32 to 35.6°F	10% of southern portions

Notes:

°F = degrees Fahrenheit
MAAT = Mean Annual Air Temperature

Source: Jorgenson 2011; Markon et al. 2012

Review of Alaska's climate records indicates a seasonally inconsistent 4°F average-annual extended (air) temperature increase from 1949 to 2005; however, southwestern Alaska has seen smallest average-annual temperature increase of 1.8° to 2.5°F (Markon et al. 2012). Regional climate forecasts and projected mean annual temperature range estimates have been modeled for future time periods using two emission-based scenarios (Figure 3.26-1). The A2 scenario assumes a continuation in the recent trend of fossil fuel use, and B1 assumes a vigorous global effort to reduce fossil fuel use (Markon et al. 2012). The projected time period temperature increases for each of the scenarios are listed in Table 3.26-7.

Table 3.26-7: Projected Air Temperature Increases in Alaska for Two Climate Scenarios

Time Period	Scenario B1 MAAT Range	Scenario A2 MAAT Range
2021 to 2050	0 to 4°F	0 to 6°F
2041 to 2070	2 to 6°F	2 to 8°F
2070 to 2099	2 to 8°F	4 to 9.5°F

Notes:

°F = degrees Fahrenheit
MAAT = Mean Annual Air Temperature

Source: Markon et al. 2012

Permafrost temperature increases of 2 to 5°F have been documented in northern Alaska since the 1980s (Markon et al. 2012). Local observations of permafrost conditions in the Kuskokwim River area note increased permafrost degradation and settlement along traditional use trails associated with the mild winter of early 2014 (ANTHC 2015).

A permafrost degradation model developed by the Geophysical Institute Permafrost Laboratory at the University of Alaska, Fairbanks (UAF), which is driven by climate model outputs (emission scenario projections), predicts a northward expansion of permafrost thaw (Figure 3.26-3). The results from two simulation outputs (temperature and snowfall, based on emission scenarios) and five-model SNAP ensemble intercomparisons (downscaling) (Walsh et al. 2008) project an increase in mean annual ground temperatures at a 3-foot depth in permafrost. Since the project has an estimated lifespan of approximately 37.5 years (including Construction, Operations, and Closure phase activities), the projected permafrost model simulations for the 2040–2049 period are temporally applicable to operations, and the 2090-2099 period applicable to about 40 years post-Closure. Ground temperature increases projected by the 2040-2049 simulations are on the order of 2°F for the mine area, roughly 2 to 4°F for the Bethel area, and range from about 0 to 4°F over the length of the pipeline corridor. Increases projected for the 2090-2099 period are in the range of 2 to 7°F for the Mine Site and Bethel area, and 0 to 7°F for the pipeline corridor depending on location and model. Although predictions beyond 2099 are speculative, if warming trends continue, permafrost would continue to degrade beyond the twenty-first century.

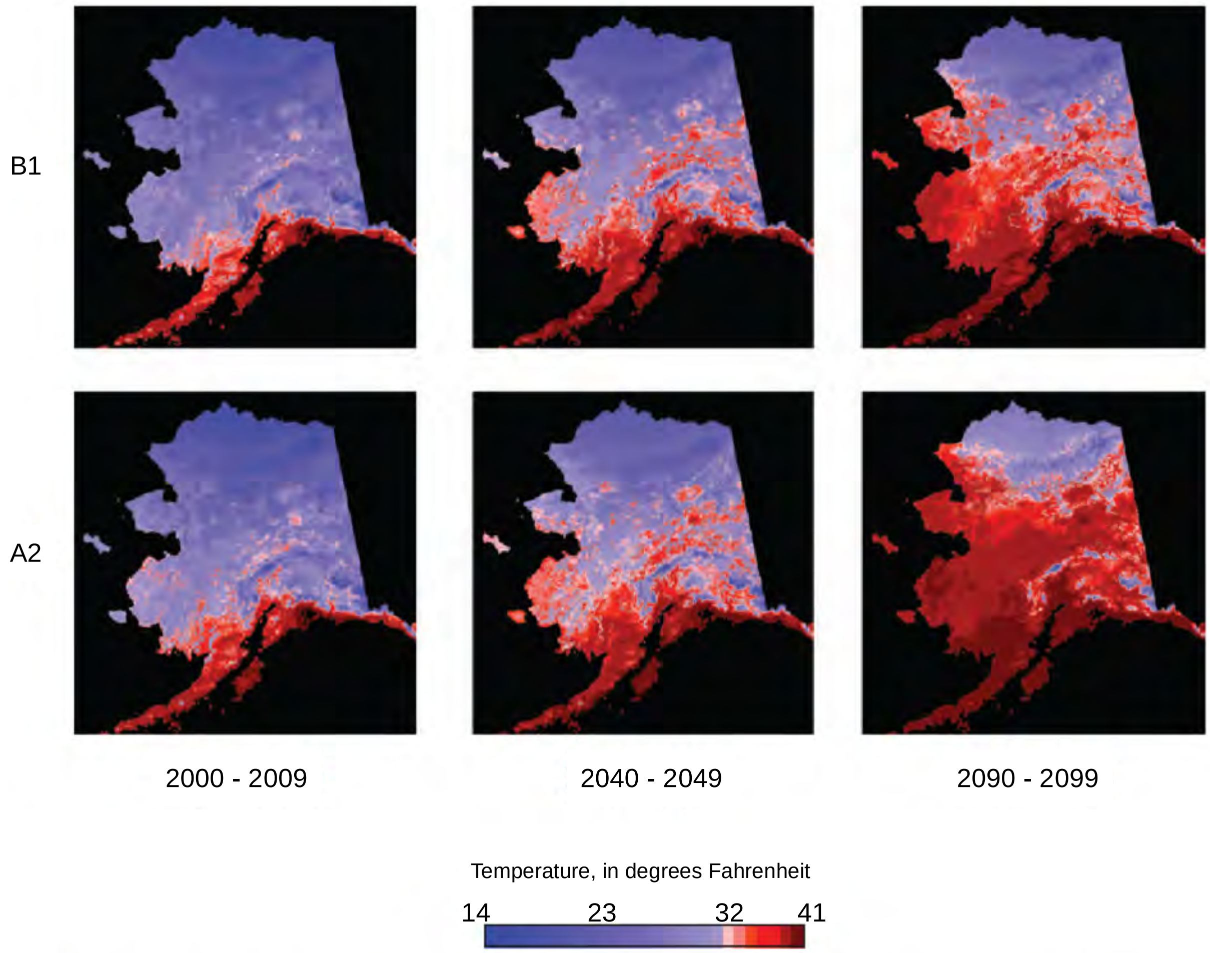
Near-future (decadal scale) permafrost considered most vulnerable to surface thaw in a warming environment include warm permafrost (sub-arctic and boreal) and permafrost with high ground ice content in the near-surface (>20 percent excess ice by volume). Thaw effects are generally most pronounced in the upper 33 feet of high-ice-content permafrost, resulting in settlement and thermokarst terrain. Accelerated thawing from future warming could include as much as the top 10 to 30 feet of discontinuous permafrost by 2100 (Markon et al. 2012).

Melting permafrost can also introduce carbon dioxide and methane into the atmosphere. Currently, Earth's atmosphere contains about 850 gigatons of carbon. Almost twice that amount (about 1,400 gigatons) is estimated to be frozen in Earth's permafrost. As permafrost soils warm, organic carbon reservoirs trapped in the ice are mobilized, causing carbon dioxide and methane to be released. Methane is predominantly released from melting permafrost in wetland habitats such as ponds, lakes, and swamps. Thus, models predict that if climate change results in the region becoming warmer and drier, more carbon dioxide will be released. If the region gets warmer and wetter, more methane will be released. Methane is 25 times more potent at trapping energy as a GHG than carbon dioxide, resulting in a much larger impact on climate change. The rate, location, and method of how the carbon in the permafrost decays will impact how much carbon is released into the atmosphere.

3.26.3.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

Project-related impacts to vegetation and wetlands are described in Section 3.10, Vegetation and Nonnative Invasive Species, and Section 3.11, Wetlands. Project-related impacts to wildlife, birds, and TES-listed species are described in Section 3.12, Wildlife, and Section 3.14, Threated and Endangered Species. Project-related impacts to fish and aquatic resources are described in Section 3.13, Fish and Aquatic Resources. Project-related impacts to subsistence resources are described in Section 3.21, Subsistence.

Climate change is expected to have profound effect on local and regional Alaskan ecosystems (Chapin III et al. 2006, 2010; McGuire 2014; Walsh et al. 2008). Climate change impacts are complex and interrelated between all biological resources interacting with the physical environment, with cascading impacts on subsistence. Improved local (downscaled) climate models are increasingly available (SNAP 2012, 2015) to predict changes to biological resources by including specific biological variables in modeling efforts. The five-model SNAP ensemble performs well for Arctic climates (Walsh et al. 2008); however, models are based on values derived from global weather station data, subject to problems of spatial sampling and short or discontinuous data (Serreze et al. 2000).



Mean annual ground temperatures at 3-ft depth in permafrost model simulations driven by output from climate models run under B1 (upper panels) and A2 (lower panels) emissions scenarios. As indicated by color bars, blue shades represent temperatures below 32ºF; red shades represent temperatures above 32ºF.

Data Source: Markon et al. 2012

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PROJECTED GROUND TEMPERATURE TRENDS IN ALASKA FOR TWO CLIMATE CHANGE SCENARIOS

JUNE 2017

FIGURE 3.26-3

Climate change impacts that may affect biological resources and subsistence may include:

- Large-scale biome shifts;
- Local or regional vegetation or wetland community type shifts;
- Hydrological changes resulting in wetland drying and habitat changes;
- Phenological changes;
- Species distribution changes;
- Wildland fire regime changes;
- Increased potential for nonnative invasive species (NNIS) introduction and spread;
- Increased or altered pathogen patterns;
- Waterbody changes; and
- Shifts in subsistence timing, access, seasons, or harvest volume.

3.26.3.4.1 VEGETATION AND WETLANDS

Specific climate change impacts to vegetation and wetlands in Alaska include (McGuire 2015; BLM 2012a; Chapin III et al. 2003, 2006, 2008, 2014):

- Changes in distribution and growth rates of vegetation, leading to changes in vegetation community composition / type;
- Phenological shifts and changes;
- Rising tree lines in the southcentral Alaska region mountain ranges;
- Drying waterbodies / reduction in waterbody size (caused by warmer temperatures increase evaporation; permafrost thaw allowed lakes to drain more rapidly; and greater accumulation of plant material caused by greater plant growth);
- Woody vegetation encroachment into tundra or wetlands, replacing lichens and other tundra vegetation;
- Increases in potential habitat for NNIS; and
- Higher risk of drought, wildfire, and insect infestations / outbreaks.

Vegetation Types

Local and regional vegetation community changes are anticipated for much of Alaska in predictions through 2099 (McGuire 2014; SNAP 2012). SNAP's Integrated Ecosystem Model forecasts large scale biome shifts in Alaska and Northwest Canada in the next 100 years due to warming temperatures, less available water (precipitation and evapotranspiration changes), and changing fire regime (SNAP 2015). The boreal region is warming approximately twice as fast the global average, potentially leading to large-scale instability in the boreal forest (Scheffer et al. 2012). Specific changes may include a northward expansion of current shrub range; increased growth rates of forbs, shrubs and graminoids; and decreased cover of mosses and lichens (McGuire 2015; BLM 2012a; Chapin III et al. 2003, 2006, 2008, 2014).

Scenarios suggest that present and future warming, well documented in drier interior forests of Alaska, will lead to significant shifts in the characteristics of historic levels of disturbance (producing novel disturbance interactions), and potentially leading to large-scale white spruce forest dieback (Lenton et al. 2008) where fire was historically rare (i.e., possible type conversion to hardwood, shrub, or bluejoint reedgrass [Calamagrostis Canadensis] grass cover as soil conditions and seed sources shift). During the past five decades, the tree line in the Kenai Mountains been observed to rise an average of one meter per year (Dial et al. 2007), approximating a 300,000 acre loss of alpine tundra. Southcentral Alaska vegetation communities have experienced drying trends in recent decades, resulting in fewer wetlands and a corresponding increase in upland species (Berg et al. 2009; Klein et al. 2005). Higher transpiration, less available water, and a lower albedo caused by woody vegetation increases contributes to a drier landscape with fewer or smaller waterbodies compared to current conditions.

The growing season length (concurrent days above freezing) has increased by nearly 50 percent since the beginning of the twentieth century (Wendler and Shulski 2009, Beck et al. 2011) and is projected to increase another 60 percent over the next century, to over 200 days (SNAP 2012). Northern plants, with their inherent conservative growth strategies, may be able to take advantage of the increasing growing opportunities in the late fall via acclimation (plasticity). Local populations can either: acclimate to the new climate regimes; be out-competed by better-adapted immigrants; adapt after immigration of new genetic diversity; or go locally extinct.

Trees, as slow-growing, sedentary organisms, may have low adaptive capacity (the ability of a species, habitat, or ecosystem to accommodate or cope with climate change impacts with minimal disruption). Temperate and boreal trees often show high degrees of adaptation to local environments in that local genotypes are the best performers (Howe et al. 2003, Aitken et al. 2008), however, genotypes that are locally adapted to current local conditions may not be well adapted to future local climates. Certain populations of trees, at higher elevations or at edges of their optimal climate range, may be more susceptible to climate change due to genetic isolation. Genetic constraints on the timing of dormancy in northern genotypes may allow more southern genotypes (adapted to photoperiod regimes with longer growing seasons) to eventually immigrate into northern environments and outcompete current flora. Actual lag time depends on non-climate factors including seed dispersal ability, photoperiod requirements, or soil type compatibility. In interior Alaska, seed dispersal capability is thought to limit tree species' ability to move northward, causing a lag at the front end of northward migration and subsequent decline at the southern range edge. Climate and forest growth research in Canada suggests that many tree species are already lagging up to 80 miles in latitude outside their ideal climate range (Gray and Hamann 2013). Immigration and adaptation may require long time periods spanning multiple generations.

Phenological shifts have been noted in studies and in observations in the LEO Network (ANTHC 2015), such as earlier timing of bud burst in the spring and altered berry production. Because the range of seasonal temperature changes is magnified at higher latitudes, embracing an understanding of phenological responses may help frame responses to change. Studies of phenological processes in Alaska and other near-polar sites have shown dramatic changes in various plant responses to a warmed temperature. Species are already responding by flowering earlier, leafing out earlier, returning earlier, or blooming before pollinators appear (Apps and McGuire 2005, Berg and Anderson 2006). Species with poor phenological adaptability may be stressed in periods of climate warming, leading to migration or extinction.

Carbon sequestration and loss is another complex aspect of potential vegetation community type changes within the Project Area. Increases in above-ground plant biomass may increase carbon and nitrogen storage, especially with shifts to higher proportions of woody vegetation; however, the subsequent loss of both elements from deep soil layers may offset the gains (Genet et al. 2013). Overall, most tundra carbon storage experiments indicate a small net loss of carbon and nitrogen from vegetation changes, resulting in a net carbon loss within non-forested ecosystems in Alaska (Mack et al. 2004).

Permafrost thaw has been shown to create ground subsidence, leading to water-filled depressions. See the above section on Permafrost for details on physical resource Affected Environment (Section 3.26.3.3). Adjacent areas may then drain, causing a shift from a wetland to an upland. Most of the Project Area has discontinuous permafrost, so vegetation community type changes would be variable and difficult to predict precisely.

The predicted warmer temperatures are expected to decrease the duration of winter snow cover, leading to earlier snowmelt and a longer growing season (Euskirchen et al. 2009). The shorter period of snow cover and longer duration of warmer summer months may change the seasonal distribution of river flow and to decrease the size of ponds and wetlands (Jones and Rinehart 2010).

Nonnative Invasive Species

Warming trends are thought to have increased the potential suitable habitat for NNIS (FWS 2009b), and a higher number of NNIS have been tracked and documented in Alaska in recent years (AKEPIC 2016). Habitat that would support NNIS is predicted to increase as the climate changes (Bradley et al 2010, USFWS 2009b).

Fire has been demonstrated to contribute to nonnative invasive plant population increases in Alaska. There is concern with positive feedback between NNIS (terrestrial plants in particular) and increased fire severity, in that nonnative invasive plants can increase and change fire risk, and fire operations can increase the risk of NNIS spread. Burned areas provide competition-free establishment areas as well as corridors for NNIS spread through undisturbed ecosystems (Villano and Mulder 2008). Increases in air temperature with a warming climate may lengthen the fire season and increase fire probability (Randerson et al. 2006). In addition, fire management activities may contribute to the spread of invasive populations by creating human and equipment movement vectors, prescribed burning may have positive effects on invasions as a control tool. Many nonnative invasive plant species display a wind-dispersed prolific spread if there are seed sources following a fire.

Warming could contribute to survival of NNIS that are not currently known to occur in Alaska, but may thrive in warmer climates, such as hydrilla (Hydrilla spp.) that has caused ecological and economic harm in other locations in North America but prefer warmer waters than currently occur in Alaska.

Fire and Pathogens

Increased fire frequency and intensity is already evident throughout much of Alaska (Schuur et al. 2014). Potentially novel and unpredictable fuel and vegetation characteristics may also contribute to large-scale vegetation type changes and potentially abrupt regime shifts (Paine et al. 1998; Scheffer et al. 2001; Apps and McGuire 2005; Taylor et al. 2006).

Wildfire return intervals are likely changing, although the new trajectory is not apparent across much of the state. Human-caused ignitions have increased in recent years, and in some locations in southcentral Alaska, increased fuel loads from beetle-killed trees and drier, warmer early spring and summer conditions suggest that wildfire risk may be increasing. Lightning strikes have also been documented as increasing in some locations in the state with changed weather patterns. Spruce bark beetle outbreaks, rising temperatures, and changing precipitation patterns may cause fire frequency or intensity increases, which could cause large-scale changes to the landscape (e.g., white spruce forest could convert to grasslands). The Alaska Frame-based Ecosystem Code (ALFRESCO) model focuses on system interaction and feedbacks to predict landscape level change by varying fire intensity and frequency. Results from interior Alaska models indicate that fire frequency changes strongly influence landscape-level vegetation patterns through feedbacks that increase future fire frequency and intensity (SNAP 2012).

A resurgence in spruce bark beetle activity in south-central and southwest Alaska since the 1990s has resulted in > 1.2 million ha of forest mortality, and sustained warming has led to greater expanse (synchrony) of outbreaks across the region than at any other time in the past 250 years (historical intervals ~ 50 years) (Berg et al. 2006, Werner et al. 2006, Sherriff et al. 2011). At the same time, the region has experienced a dramatic increase in fire frequency where fires were historically uncommon with long fire-free intervals (estimates of 400-600 year intervals for white spruce [*Picea glauca*], and ~ 70 year intervals for black spruce [*Picea mariana*]) (Berg and Anderson 2006). Interactions between fire and insect outbreaks are expected to produce positive feedbacks under current climate scenarios, resulting in further warming (Goetz et al. 2007, Running 2008, IPCC 2014).

Fire may have positive impacts to overall vegetation types across a landscape. Deciduous tree species depend on fires for large-scale reestablishment. Birch readily grows on post-fire sites burned to mineral soil in vast patches from long-distance seed dispersal. Quaking aspen generally resprouts from root suckers which quickly grow in nutrient-rich post-fire soils. Cottonwoods, including both balsam poplar and black cottonwood, produce light tufted wind-dispersed seeds, and can resprout from lateral roots and even stems or branch fragments. Black spruce is entirely fire-dependent for regeneration, as its resin-sealed cones require the heat of fire to melt and release seeds. Black spruces' structure is very fire susceptible, with flammable low growing short crowns that tend to burn completely in fires. Seeds are released between one to three years following a fire that kills the tree, and seedling growth can occur in both mineral and organic mat areas. White spruce does not need fire to release seeds, but adjacent stands will produce large seed crops after a hot, dry summer to recolonize burned areas (Berg and Anderson 2006).

3.26.3.4.2 FISH AND WILDLIFE

Species distribution and abundance are likely to change, resulting in changes to ecosystem functions, habitat range, and interconnected food webs (Liebezeit et al. 2012; Ims and Fuglei 2005). Expected changes in water bodies include species range shifts to fish tolerant of warmer waters; temporal shifts in prey and predators; food web alterations from temperature and acidification changes; habitat changes such as turbidity increase; or shifts in anadromous fish run timing (ADF&G 2010b; IUCN 2009). Interpretation of studies on biological responses to climate change need to be considered carefully, as many climate change impacts may be masked by species interactions, meaning that responses could be overlooked or misinterpreted as evidence that climate change has no effect on a particular species (Post et al. 2009). Potential food web alterations caused by temperature changes or ocean acidification may have profound impacts to fish population and marine mammals. Impacts of climate change to aquatic resources are extremely complex and not well understood at this time.

Studies in Alaska and the region have begun examining the complex factors in potential climate change impacts to wildlife and birds, but results are limited. Changes to fish and wildlife resources are anticipated by the State of Alaska, and addressed in a climate change strategy to assess likely effects and develop adaptation strategies (ADF&G 2010b). A revised State of Alaska Wildlife Action Plan contains details of threats and impacts to wildlife populations in Alaska, with provisions for potential policy and regulation changes, and adaptive strategies to meet climate change impacts to wildlife and birds (ADF&G 2015m).

Fish

Changes in lake stratification due to warming water temperatures may affect reproduction and distribution patterns in freshwater fish species. Increased or altered precipitation may enhance nutrient loading in lakes and wetlands, increasing connectivity and potential for cross-lake fish colonization and aquatic system food web changes (Post et al. 2009). Higher water temperatures may lead to increased metabolic stress for fish species, resulting in lower tolerance thresholds for those species to land-use impacts. Although moderately warmer water conditions may have some positive effects, such as a more productive feeding season enabling fish to better survive winter, overall, the effects would not be positive for fish.

For Pacific salmon, the overall trend is that conditions in a few cold-water locations may improve for certain life stages, but the overall impacts of a warming climate are negative (Crozier et al. 2014; IUCN 2009; Tolimieri and Levin 2004). Ocean acidification is also a concern, appearing to affect zooplankton production, which then affects species such as sockeye salmon that feed on zooplankton (ADF&G 2010b). In the Pacific Northwest, new literature generally supports previous concerns that climate change will cause moderate to severe declines in salmon, especially with interacting factors such as water diversion, accelerated mobilization of contaminants, hypoxia, and NNIS (Crozier et al. 2014). Warmer temperatures will reduce incubation and cause earlier hatching times, leading to phase mismatch between juveniles and food source (AYK SSI 2006).

Marine fishery assemblages may also shift northward, or may include increases in predatory fish presence or NNIS habitat more favorable to species such as green crab (ADF&G 2010b). Warming is expected to have negative impacts on most salmon species life cycles (Crozier et al. 2014).

Wildlife and Birds

In some areas of Alaska, shrubs are replacing lichens and other tundra vegetation. Loss of lichens, an important winter food source for caribou, may lead to declines in growth and abundance of this species. Caribou, in turn, are a critical food source for predators such as bears and wolves, as well as for some Alaska Natives (ACIA 2004).

Vegetation community type changes resulting from climate change may impact wildlife habitat positively or negatively. Interior river basins may experience increases in woody vegetation cover and reduction in wetlands, negatively affecting moose and waterfowl habitat. An increase in open water areas may increase habitat diversity and add value for wildlife. Changing fire regimes may affect wildlife differently; moose may benefit from earlier successional stages, but woodpeckers dependent on old growth forest may be negatively impacted (ADF&G 2010b). Decreases in coastal winter habitat may reduce food availability for shorebirds.

Drying of wetlands would result in negative impacts to species that rely on shallow water and wet meadows, and shrub expansion may reduce the quality and availability of some types of habitats. Changes in marine productivity could negatively affect food webs important to bird species, such as reduction in clam beds used in winter by spectacled eiders. A positive effect may be that productivity of some species could increase due to a longer open water season, which could also increase food productivity in aquatic systems. Coastal dependent bird species such as spectacled eider, identified as a threatened species, may also lose habitat if sea levels rise sufficiently to inundate current coastal habitats (ADF&G 2010b).

Pathogens

Warming conditions resulting from climate change may lead to increases in infectious disease in wildlife, or conditions that favor the release of persistent environmental pollutants that can affect the immune system and favor an increased disease rate (Bradley et al. 2005). Increased disease may negatively affect wildlife populations and impact their viability.

3.26.3.4.3 SUBSISTENCE

The effects of climate change in Alaska strongly affect Alaska Native communities, which are highly vulnerable to these rapid changes, but have a deep cultural history of adapting to change (Chapin III et al. 2014). At this time, there are limited studies that examine the combination of indigenous observations and understanding of climate in the context of climate change.

One of the most important recent and ongoing impacts to subsistence users due to climate change is less predictable ice thickness, combined with widespread and frequent instances of open water in the winter. For the Kuskokwim River area, the LEO Network (2015) includes observations for the Kuskokwim River of recent low snow years, early breakup, thin river ice, and open water in winter, which may be related to climate change. For example, observations in Bethel in 2014 document a mild winter, very low snow conditions, and thin river ice in the months of January through April. These changes and uncertainties make for very dangerous winter ice-travel conditions.

Observations of climate change impacts to all resources can illuminate potential subsistence impacts. In particular, phenological documentation of life stages of plants and animals have been traditional and necessary for humans throughout history. This ancient practice let people know when to plant crops, when to harvest, or when to hunt and fish. Phenological observations were key to successful hunting, fishing, gathering, and farming, and therefore to survival. The LEO Network partnership provides a broad, expanding network of local observations to help synthesize this understanding over time (ANTHC 2015).

Subsistence harvest opportunities may be affected by potential shifts in hunting seasons. In other cases, shifts in distribution or abundance of favored species may affect harvest opportunity (ADF&G 2010b). Economic losses to coastal and riverine communities may occur as the abundance and location of traditional harvest species, such as moose and caribou, change. For example, climate change is likely a contributing factor to recent declines in moose populations in Unit 19A and Kuskokwim River chinook runs. However, with the current state of knowledge, it is not possible to definitively identify the degree to which climate change, among many other factors, is causing the declines(ACIA 2004).

3.26.3.5 SPILL RESPONSE

The effects of project-related spills (described in Section 3.24, Spill Risk) on climate change are considered not applicable under the current regulatory framework. The analyses of spill scenarios are provided in Section 3.24.

3.26.4 ENVIRONMENTAL CONSEQUENCES

This section addresses the potential effects of the proposed action on climate change, indicated by the Donlin Gold Project's GHG emissions, under the Atmosphere subheading. This section also addresses the implications of climate change for the environmental effects of the proposed action, under the Water Resources, Permafrost, and Biological Resources and Subsistence subheadings below. It is recognized that impact analysis requires consideration of the future conditions in which the proposed facilities will be constructed, operated, and closed. Direct and indirect impacts for all three project phases, where applicable, are discussed. Other action alternatives are discussed briefly where there are differences from the proposed action. The proposed action is analyzed quantitatively, where possible, in accordance with CEQ 2014 guidelines.

3.26.4.1 ALTERNATIVE 1 – NO ACTION

Under the No Action Alternative, the Donlin Gold Project would not be developed, and Donlin Gold would not establish a mine site, develop transportation facilities, or construct a natural gas pipeline in the proposed Project Area. While this alternative would introduce no new GHG emissions, the effects of climate change would still occur based on existing projections. Existing GHG emissions and related climate change effects on various resources would be the same as described in Affected Environment (above Section 3.26.2).

3.26.4.2 ALTERNATIVE 2 – DONLIN GOLD'S PROPOSED ACTION

Based on comments on the Draft EIS from agencies and the public, one route option has been included in Alternative 2 to address concerns due to pipeline crossings of the Iditarod National Historic Trail (INHT):

- North Option: The MP 84.8 to 112 North Option would realign this segment of the natural gas pipeline crossing to the north of the INHT before the Happy River crossing and remain on the north side of the Happy River Valley before rejoining the alignment near MP-112 where it enters the Three Mile Valley. The North Option alignment would be 26.5 miles in length, compared to the 27.2 mile length of the mainline Alternative 2 alignment it would replace, with one crossing of the INHT and only 0.1 mile that would be physically located in the INHT right-of-way (ROW). The average separation distance from the INHT would be 1 mile.

3.26.4.2.1 ATMOSPHERE

As climate change is a global issue, no standard methodology currently exists to assess how a proposed project's GHG emissions would translate into physical effects on the global environment. However, because GHG emissions contribute to impacts on climate change, it is appropriate to analyze GHG emissions when assessing the impacts of a project on climate change (CEQ 2014). As shown in Section 3.8, Air Quality, Table 3.8-18 (Annual Mine Site Operations Phase Emissions), the Donlin Gold Project could cause direct emissions of up to 1,761,000 tons per year of CO_2-e during Operations, which converts to 1,598,000 MT per year. This is above the 2014 CEQ guidance threshold of 25,000 MT per year, thus at this time the project warrants a discussion of climate change in the NEPA process under CEQ guidance (CEQ 2014).

For comparison, the oil and gas industry in Alaska emits a total of about 11,800,000 MT per year; and three large operating mines in Alaska (Greens Creek, Kensington, and Red Dog) each have reported annual GHG emissions in the range of roughly 25,000 to 150,000 MT (Section 3.26.3.1). Direct comparisons between Donlin Gold and other mines is difficult, because existing mines are reporting actual emissions from only a subset of sources tracked by the GHG reporting rule while the Donlin Gold estimates represent worst-case scenario emissions from mobile, fugitive and point sources. Regardless, the Donlin Gold mine would emit substantially more GHGs than existing mines, in part because the extraction of gold from the refractory ore at the Donlin deposit is more energy-intensive than the other mine processes.

To provide context, project GHG emissions are compared to total Alaska GHG emissions (Table 3.26-8). There are currently no approved applicable GHG reduction strategies to use for providing additional context. The most recent year of CO_2-e emissions data that is available for the state of Alaska is 2010, when CO_2-e emissions were 43.0 million MT (MMT) (ADEC 2015). Estimated annual project emissions range from less than 0.5% of the total GHG emissions for Alaska in 2010 during construction and closure to approximately 3.7% during operation years. (Note: tabulated emission estimates for GHG emissions from the various project phases and components for the Donlin Gold Project were provided in Section 3.8, Air Quality, as total tons or tons per year. These are converted to metric tons (MT) or MT per year in this section.)

Mine Site

Construction

Direct GHG emissions from the heavy equipment required for construction and permafrost degradation and removal would occur during the entirety of the Construction Phase, anticipated to be three to four years. Benchmarked against the 2010 emission inventory, the emissions would be less than one percent of annual GHG emissions for the state of Alaska (Table 3.26-8). All direct emissions would occur at the Mine Site but consistent with the nature of climate change, their impacts would be global.

Indirect GHG emissions associated with construction of the Mine Site would result from activities associated with transporting supplies and construction materials to the Mine Site and from the oil and gas production and refining required to generate the fuel used to power project sources. There are currently no defined methodologies for estimating indirect emissions from oil and gas production and refining, which is highly dependent on the design, operation, and product composition; fuel purchased on an open market the supplier will likely vary over time based on availability and economics. The impacts from transporting supplies are discussed under the Transportation Corridor section below.

Operations

Operations for the Mine Site would last approximately 27.5 years. Direct GHG emissions would be generated by a dual-fueled (natural gas and diesel) multi-engine power plant, as well as from mobile machinery and the mining equipment necessary for extraction and processing gold throughout the life of the project. All activities and impacts would occur at the Mine Site; but consistent with the nature of climate change their impacts would be global. Benchmarked against the 2010 emission inventory, the GHG emissions would be 3.7 percent of annual GHG emissions for the state of Alaska (Table 3.26-8).

To further place the project emissions into perspective, Table 3.26-8 shows annual GHG emission from selected other mines in Alaska as reported to EPA under the GHG reporting program. The reported GHG emissions from these other mine sites are not directly comparable to the Donlin Gold Project because they do not include as exhaustive of an inventory of activities as is included here. The other mines are also expected to have lower GHG emissions because of their smaller relative scale and the nature of the mining operations.

In addition to the previously discussed emissions from fuel production, indirect GHG emissions associated with operations of the Mine Site would result from emissions associated with transporting supplies and construction materials to the Mine Site. The impacts from transporting supplies are discussed under the Transportation Corridor section below.

Closure

To minimize the time needed for reclamation, closure activities would take place in areas that are no longer required for active mining whenever possible during Operations. GHG emissions would be generated by the equipment necessary to conduct reclamation activities within the Mine Site including pit backfilling; stabilizing pit highwalls; regrading, slope contouring and restoration; pumping TSF water to the ACMA pit; covering the tailings impoundment; and building removal. Post-reclamation monitoring activities would continue beyond the five-year closure timeframe. For example, one small generator would remain at the Mine Site to operate the post-reclamation water treatment plant until such time the discharge meets water quality standards, and the airstrip would remain permanently. Benchmarked against the 2010 emission inventory, the GHG emissions would be less than one percent of annual GHG emissions for the state of Alaska (Table 3.26-8).

Indirect GHG emissions from project-related activities during the closure and reclamation of the Mine Site may occur due to transportation of supplies and employees to and from the site.

Table 3.26-8: Annual Mine Site GHG Emissions [a]

Project Phase	Project-related CO_2-e Emissions (tpy)	Project-related CO_2-e Emissions (MMT/yr)	Percentage of CO_2-e Emissions for the State of Alaska in 2010[b] (%)
Construction	203,300	0.1844	0.43%
Operations	1,761,000	1.598	3.72%
Closure	194,300	0.1762	0.41%

Notes:

a The project-related $CO_{2\text{-e}}$ emissions are summarized in tons for construction (over the entire 3 to 4 year construction period) and in tons per year (average annual emissions) for operations and closure, as outlined in Section 3.8, Air Quality. For the purposes of this analysis, all construction emissions are assumed to occur in one year.

b Total CO_2-e emissions were 43.0 MMT for the state of Alaska in 2010.

Source: EPA 2014d; Air Sciences 2015b; ADEC 2015; Cardno 2015b

Transportation Corridor

Construction

GHG emissions from fossil fuel combustion would occur from construction equipment, and aircraft, land vehicles and vessels associated with transporting supplies and construction materials to the Mine Site. Direct emissions would occur along the Transportation Corridor. Direct GHG emissions would occur during the entirety of construction. Benchmarked against the 2010 emission inventory, the GHG emissions would less than one percent of annual GHG emissions for the state of Alaska (Table 3.26-9).

Indirect GHG emissions associated with the Transportation Corridor construction would result from operations of air traffic between Anchorage (or other points of origin) and the Mine Site airstrip, and ocean traffic.

Operations

GHG emissions associated with Operations in the Transportation Corridor would result from the combustion of fossil fuels in aircraft, ocean barges, tugs associated with river barges, and tanker trucks delivering diesel. Direct GHG emissions would be less than one percent of annual GHG emissions for the state of Alaska (Table 3.26-9).

Indirect GHG emissions associated with Operations would result from cruise operations of air traffic between Anchorage (or other points of origin) and the Mine Site airstrip, and ocean traffic.

Closure

The mine access road would remain for long-term monitoring of the Mine Site. Reclamation activities for other Transportation Corridor facilities would occur during the five-year period following final mine closure. GHG emissions generated by the equipment necessary to conduct closure, reclamation, and post-reclamation activities would last up to 50 years. Direct GHG emissions were not calculated for this phase, but are expected to be less than Operations due to minimal activities and fuel combustion during closure. Impacts would be considered less than one percent of annual GHG emissions for the state of Alaska, as displayed in Table 3.26-9.

No indirect GHG emissions from Transportation Corridor-related activities are anticipated to occur during the Closure phase. Direct GHG emissions at the Transportation Corridor would be within immediate Project Area (Table 3.26-9). In addition to the previously discussed indirect emissions from fuel production, indirect GHG emissions associated with Construction and Operations would result from cruise operations of air traffic between Anchorage (or other point of origin) and the Mine Site airstrip, and ocean traffic.

Table 3.26-9: Annual Transportation Corridor Component GHG Emissions[a]

Project Phase	Project-related CO_2-e Emissions (tpy)[b]	Project-related CO_2-e Emissions (MMT/yr)	Percentage of CO_2-e Emissions for the State of Alaska in 2005 (%)[c]
Construction	312,300	0.2833	0.66
Operations	73,000	0.0663	0.15
Closure	20	0.00002	0.00

Notes:

a Emissions from third party-operated Dutch Harbor Port site are not included. Emissions from the Bethel Port site are considered direct emissions, but they are not included because information is not available. Activities at the Bethel Port would be a connected action (see Chapter 1, Section 1.2.1, Connected Actions).

b The project-related $CO_{2\text{-}e}$ emissions are summarized in tons for construction (over the entire construction period) and in tons per year (average annual emissions) for operations and closure, as outlined in Section 3.8, Air Quality. For the purposes of this analysis, all construction emissions are assumed to occur in one year.

c Total CO_2-e emissions were 43 MMT for the state of Alaska in 2010.

nc = not calculated

Sources: EPA 2014d; Air Sciences 2015b; ADEC 2015; Cardno 2015c

Pipeline

Construction

Direct GHG emissions would occur during the 3- to 4-year Construction Phase. During the first year, activities include ROW clearing and grading of access roads and shoofly roads, preparation of the compressor station site and campsites, camp construction, pipeline storage yards construction, airstrip construction and upgrades, and development of barge landings and material sites. The Angyaruaq (Jungjuk) Port and Bethel Port would be used during pipeline construction as well. Impacts from these activities are included under the Transportation Corridor component. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

During Years 2 through 3 or 4, the primary activity would be pipeline installation. Construction-related GHG emissions would be generated by helicopter traffic, diesel-powered mobile equipment, pipe installation equipment, and equipment operating at material sites. GHG emissions would vary depending on the construction stage, and would be localized and transitory as construction activity proceeds at various locations along the length of the pipeline. Benchmarked against the 2010 emission inventory, the GHG emissions would be less than one percent of annual GHG emissions for the state of Alaska (Table 3.26-10).

In addition to the previously discussed emissions from fuel production, indirect GHG emissions from project-related activities are anticipated to result from vessels associated with transporting construction equipment and material to the pipeline route area.

Operations

The compressor station at MP 5 would be powered by natural gas; therefore, it would have combustion-caused GHG emissions. The pipeline facilities (e.g., compressor station, metering stations, mainline block valves, pipeline) would emit fugitive GHG emissions due to leaks from pipeline segments, valves, and fittings; and from permafrost degradation. In addition, there would be project-related maintenance activities that would occur along the pipeline ROW, such as vehicle and helicopter traffic (SRK 2013b). There would be no vented GHG emissions due to pipeline blowdown for planned maintenance (Rieser 2014a). Direct GHG emissions impacts would be less than one percent of annual GHG emissions for the state of Alaska (Table 3.26-10).

Closure

Direct GHG emissions during closure and reclamation of the pipeline would result from small hand tools used to cut aboveground sections of the pipeline. Maximum direct GHG emissions are expected to be less than during Construction and Operations. No indirect GHG emissions from project-related activities are anticipated to occur along the pipeline route during Closure.

Table 3.26-10: Annual Pipeline Component GHG Emissions

Project Phase	Project-related CO_2-e Emissions (tpy)[a]	Project-related CO_2-e Emissions (MMT/Yr)	Percentage of CO_2-e Emissions for the State of Alaska in 2005[b]
Construction	259,700	0.2356	0.55
Operations	18,800	0.0171	0.04
Closure	20	0.00002	0.00

Notes:

a The project-related $CO_{2\text{-e}}$ emissions are summarized in tons for construction (over the entire construction period) and in tons per year (average annual emissions) for operations and closure, as outlined in Section 3.8, Air Quality. For the purposes of this analysis, all construction emissions are assumed to occur in one year.

b Total CO_2-e emissions were 43.0 MMT for the state of Alaska in 2010.

nc = not calculated

Source: EPA 2014d, Air Sciences 2015b, ADEC 2015, Cardno 2015e.

Summary of Impacts for Alternative 2 – Atmosphere

Intensity of GHG emissions impacts would be considered less than one percent of annual GHG emissions for the state of Alaska (Construction at 0.66%, and Operations at 0.15%), as displayed in Table 3.26-9. Direct GHG emissions were not calculated for the Closure Phase, but are expected to be less than Operations due to minimal activities and fuel combustion during Closure. Intensity of GHG emissions during Construction, Operations, and Closure of all components of this project would represent at their maximum less than 4 percent of the emissions from the state of Alaska in 2010. The project would be one of the largest mining sources of GHG emissions in the state of Alaska. In terms of duration, direct GHG emissions would occur throughout the life of the project, and would be generated by the equipment necessary to conduct closure, reclamation, and post-reclamation activities that may last up to 50 years. In terms of extent, emissions would occur locally at the Transportation Corridor facilities themselves. In context, GHG emissions are analyzed following the draft CEQ 2014 guidelines.

3.26.4.2.2 WATER RESOURCES

This section analyzes how climate change could affect project impacts on water flow, including incremental effects that climate change would have on base case impacts identified in Sections 3.5, Surface Water Hydrology, and Section 3.6, Groundwater Hydrology. Key indicators include predicted precipitation changes from climate trends and consequent changes in project impacts to streamflow and groundwater recharge, and the implications of these changes on project plans, facility designs, and related risks to the environment.

The criteria for evaluating the levels of effects in this section are generally the same as those presented in Section 3.5, Surface Water Hydrology, Table 3.5-24, as applied to the incremental effects of climate change on project impacts to water flow.

Mine Site

Construction and Operations

The effect of climate change on precipitation and hydrology at the Mine Site has implications for infrastructure design and the capacity of major mine facilities to handle different water regimes under future climate change scenarios. The approach taken at the Mine Site with respect to hydrologic design is generally consistent with the U.S. Global Change Research Program (Bierbaum et al. 2014) and NOAA (2015b) guidance for adaptation based on identification of climate change vulnerabilities, risks, and options.

Effects on TSF. A 25 percent increase in annual precipitation was selected to represent the effects of climate change on the TSF during Operations in sensitivity runs on the Mine Site water balance model (BGC 2011g, 2014b; Weglinski 2015b). The 25 percent increase case is considered conservative in that the SNAP data predicts much less than this (two percent increase) for the life of the mine, and the TSF would be closed and capped by the time of the predicted 25 percent climate change increase.

A stochastic model was used for the sensitivity analysis, which allows calculation of the probability of a particular outcome to quantify risk. The results indicated that, prior to development of the operations water treatment plan (WTP) design, a 25 percent precipitation increase would result in an average annual water storage requirement in the TSF impoundment roughly three times that of the base case (71,000 acre-feet vs. 24,000 acre-feet, respectively), or as much as 91,000 acre-feet for the 95th percentile probability value. With the current water treatment design and enhanced evaporation during operations (BGC 2016c; SRK 2017b), the 95th percentile TSF volume at the end of operations would be much less, about 17,000 acre-feet. Even in the event of a 25 percent increased precipitation climate change case on top of the 95th percentile stochastic predictions, pond volumes would be within the ultimate TSF design capacity of about 384,000 acre-feet, which includes the combined volume of initial settled tails (334,000 acre-feet), plus pond, flood storage, and emergency freeboard (about 50,000 acre-feet) (BGC 2011a, 2014b; SRK 2017b).

Other facilities at the Mine Site provide additional flexibility to move, store, and reduce water buildup at the TSF during extended periods of higher precipitation. The Upper and Lower CWDs have a combined total capacity of about 10,400 acre-feet, and the WTP could be operated year-round to reduce water buildup by treating and discharging a maximum of 7,200 acre-feet / year (SRK 2017b).

Thus, with the revised operations WTP design, the effects of a 25 percent increase in precipitation would be within the range of effects for the original Alternative 2 analysis (Weglinski 2015b), as the TSF would be designed to the same capacity but contain much less process water throughout operations. Based on impact assessment criteria in Table 3.5-24 (Section 3.5, Surface Water Hydrology), adverse impacts from the added effects of climate change are unlikely because the TSF design would be adequate for predicted conditions, and Mine Site water management would be flexible enough to accommodate the extra water from potential climate change precipitation increases.

Effects on Pit Dewatering and Freshwater Requirements. The Operations WTP proposed under Alternative 2 is expected to provide maximum flexibility in overall water management, including that of pit dewatering water and freshwater needed for the process plant. The 25 percent precipitation increase described above for the TSF was also used in water balance sensitivity runs to estimate the effect of climate change on the volume of pit dewatering water under Alternative 2. The results indicate that total dewatering volume during Operations would increase by an average of about 200 acre-feet annually in the event of a 25 percent precipitation increase (BGC 2014b). The increased precipitation case would also result in a reduction in total freshwater requirements from Snow Gulch reservoir, because there would be more dewatering and mine contact water available to meet process water need.

The Operations WTP would be designed for an average flow on a seasonal basis of about 2,500 gallons per minute (gpm), and would have a maximum rated flow of about 4,600 gpm (Hatch 2017). Assuming the 200 acre-foot per year increase in dewatering water under the increased precipitation case all requires treatment, the anticipated increase in flow would equate to about 190 gpm over an eight-month seasonal treatment period, well within the excess operational capacity of the water treatment process. Thus, Mine Site water management would be able to accommodate anticipated net increases in dewatering water from potential climate change precipitation increases without redesign or modification.

Extreme Events. Uncertainties inherent in applying climate change trends to the effects analysis of the proposed action are discussed in the above Section 3.26.3.2, Climate Change, Water Resources. An important modeling objective is to determine the potential impact of extreme events on engineered structures, as these events tend to drive facility designs more than monthly or annual average changes that are derived from climate models. There are conflicting results from different research with regard to the impact of climate change on rare events such as are used to design spillways. A recent NOAA study in Alaska (Perica et al. 2012) indicated no statistically significant trends in the one-hour and one-day annual maximum series. Although there is evidence that average annual precipitation would increase as a result of climate change in the next 30 years, Perica et al. (2012) found no evidence that the magnitude and frequency of rare events is changing. Other studies suggest that the number of very heavy precipitation events (i.e., defined as those that comprise one percent of all daily events) have increased about 5 to 11 percent since 1980, and that their frequency will continue to increase in the future (Walsh et al. 2014).

The effects of extreme precipitation events and both wetter and drier climates on facilities at the Mine Site have been evaluated through application of low probability events based on local historic records from the 1950s to present. As described in Section 3.5, Surface Water Hydrology, major water containment structures at the Mine Site have been designed in accordance with ADNR (2005) Dam Safety Guidelines that prescribe the use of certain maximum runoff events for the inflow design flood (IDF) depending on dam hazard rating. For example, these include the 24-hour probable maximum precipitation plus 200-year snowmelt for Class I facilities like the TSF dam, and the 24-hour probable maximum precipitation including snowmelt for Class II structures like some water dams at the Mine Site; and three days of underdrain flow plus the 200-year, 24-hour rainfall event for the SRS pond and wells (BGC 2011a). In addition, a mitigation recommendation is provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation, to incorporate a potentially longer-term event (time of concentration) into final design of major structures at the mine. This would ensure that the maximum rainfall event used for the IDF design is adequate, and reduce the likelihood that an extreme event lasting longer than 24 hours could cause overtopping, erosion, and/or and a release of impaired water quality to the environment.

In addition to the design of major structures, BGC (2014b, 2015f) assessed precipitation and runoff effects, based on 30-year historical trends, for the 10th and 90th percentiles of the precipitation distribution to evaluate significantly drier and wetter than average conditions to determine overall water management strategies at the Mine Site. Individual years within the historic datasets can exhibit annual precipitation that fluctuates 40 percent above and below the average. These ranges are significantly greater than the trends in average annual precipitation predicted by SNAP data over the life of the mine (two percent increase).

Water balance models were developed for the Mine Site based on these trends for both above-average and below-average conditions, and for different phases (Operations and Closure). The results were used to develop a set of operational rules or strategies for the Mine Site to handle the large range of expected conditions (see Section 3.5, Surface Water Hydrology). As mine operations proceed, water balance models and sensitivity analyses are typically updated based on a longer period of record, and facility designs or operational strategies are modified to handle changes in precipitation predictions. For example, additional capacity could be added to the SRS or the schedule for tailings dam raises altered if wetter years are predicted, or more Snow Gulch reservoir water or dewatering water could be reserved for processing if drier trends are predicted.

Thus, incremental effects due to climate change are unlikely because current designs and water balance planning account for wide historic ranges that are greater than predicted precipitation trends during the life of the mine, during Construction and Operations.

Closure

As described in Section 3.6 (Groundwater Hydrology), the effect of a wet climate scenario was evaluated in sensitivity runs on the mine groundwater model for the purpose of analyzing effects on pit lake filling rates (BGC 2014c). By increasing groundwater recharge and streamflows by a factor of two, the pit lake was calculated to fill in 30 years, as compared to the base case of 60 years. As the pit lake fills, the water level would be monitored and the pit lake model would be recalibrated as data become available (SRK 2016e). The effect of fill rate on water management of freeboard at the pit lake in post-closure is discussed in Section 3.5, Surface Water Hydrology. The managed maximum lake stage would be approximately 33 feet below the lowest point on the pit rim. In the event of pump failure, a faster fill rate could mean that the lake would reach the spill point in two to three years, as compared to five to seven years for the base case. Because two to three years is adequate time to fix potential equipment problems, the likelihood of potential overflow of contaminated pit lake water to Crooked Creek is considered low to medium, in that the freeboard (the difference between the managed stage and the spill point) is adequate for expected conditions, even under a wet climate scenario, although water treatment strategies may need to be reassessed to accommodate a potentially faster fill rate. Additional mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation for reassessing the effect of climate change on water balance and groundwater models in post-closure approximately every 10 years in order to adequately anticipate effects on pit filling and other project structures.

Transportation Corridor

Barging

The effect of climate change on precipitation could impact barging in the Kuskokwim River during Construction and Operations. Predicted precipitation changes along the river are based on SNAP precipitation data from several river communities (Figure 3.26-1, Table 3.26-11). The relationship between precipitation and change in discharge is a complex issue, and a difficult one to translate to effects on barging. A simplistic model was developed to predict the order of magnitude of the effect that climate change is likely to have on proposed barging activities.

Methodology for Estimating Available Barging Days. Based on assuming a direct and proportional response between precipitation and discharge, SNAP precipitation predictions were applied to Kuskokwim River discharge data in order to evaluate the effect of potential summer month decreases on water flow and available barging days in the Kuskokwim River (URS 2014). A series of computations were conducted on 60 years of Kuskokwim River discharge data collected at the USGS Crooked Creek gauge (USGS 2014b) to evaluate the likelihood that the proposed number of barging days (110) under Alternative 2 would be available (AMEC 2014). The computations initially counted available barge days and their probability of occurrence over the period of record under three base case scenarios: 1) the total number of days in each of the 60 years of record that exceeded a minimum discharge of 39,000 cfs needed to operate between Nelson Island and the Angyaruaq (Jungjuk) Port (AMEC 2014; Enos 2014); 2) the number of days greater than 39,000 cfs within the proposed 110-day shipping season between June 1 and September 18 (AMEC 2014); and 3) the number of days constrained by estimated dates of breakup and freezeup available from the National Weather Service (2014).

The discharge record was then reduced based on the monthly SNAP data to represent a possible future climate change discharge record (Table 3.26-12). The average of the monthly precipitation changes for the communities of Crooked Creek, Sleetmute, and McGrath for the decade 2040-2049 were selected to represent the effects of climate change on future flow conditions in the Kuskokwim River, as precipitation happening in these communities and the surrounding hills is considered most likely to contribute to discharge conditions below Crooked Creek. For months in which the mean monthly precipitation at the villages is predicted to increase, no change was made to the daily discharge record. However, it was assumed that the daily discharge associated with each year of record would decrease by the same percentage as the mean monthly precipitation at the village.

Table 3.26-11: Average Monthly Precipitation Change Applied to Kuskokwim River Discharge Record

Month	Predicted Average Monthly Precipitation Change for Crooked Creek, Sleetmute, and McGrath[1] (%)	Average Monthly Precipitation Change Applied to Kuskokwim River Daily Discharge Record (%)
April	+10.6	0
May	+2.0	0
June	-3.3	-3.3
July	-10.6	-10.6
August	+1.7	0
September	-3.2	-3.2
October	+15.4	0

Notes:

1 Average of 3 communities' predicted change in precipitation for decade 2040-2049.

Source: SNAP 2012

Results of Available Barge Days Analysis. The results of the discharge computations for both the base case scenarios and the scenario with reductions due to climate change are shown in Table 3.26-12. The climate change case indicates that the median number of days a barge could operate is 140 per year. In 9 out of 10 years, barges could operate for at least 113 days, and in none of the 60 years of record would the available days be less than 95.

The results suggest that even with a change in precipitation similar to what the SNAP estimates suggest, the number of days available for barging would not be outside the range considered by Donlin Gold in developing the barge plan for the proposed project. Though measureable, the change in number of days available as a result of climate change appears to be small compared to the year-to-year variability. In addition, the analysis conservatively does not account for increases in flow predicted for certain months by the SNAP data (e.g., May and August).

Because the results of the climate change scenario are based on potential use of all days between breakup and freezeup, low water years could require an adjustment in the dates of operation to earlier in spring or later in the fall than assumed under base case Scenario #2 (June 1 to Sept. 18 shipping season). This is considered part of the proposed action as one possible method of increasing the amount of supplies that can be barged in a year (AMEC 2014). Additional proposed mitigations and contingencies for low water conditions are described in Section 3.5, Surface Water Hydrology, and are included in Chapter 5, Impact Avoidance, Minimization, and Mitigation. These include collection of daily and real-time barge draft data for forecasting river depths, storage of sufficient inventory at the mine and Bethel as backup for reduced barging days, chartering a third tow, operating with reduced under keel clearance, and implementation of the barge stranding plan (AMEC 2014; Donlin Gold 2013e). These measures are expected to be effective in minimizing the potential effect of low water years on barge stranding risk and mine shipping needs.

Table 3.26-12: Available Barge Days on Kuskokwim River under Base Case and Climate Change Scenarios

Probability of Occurrence[1] (%)	Base Case Scenarios[2]			Climate Change Scenario[2]
	#1: All Available Days ≥39,000 cfs[3] (Jan. 1-Dec. 31)	#2: Available Days ≥39,000 cfs within June 1-Sept. 18 Shipping Season[4]	#3: Available Days within Breakup and Freezeup[5]	#4: Available Days ≥39,000 cfs after Reducing Discharge by SNAP Precipitation Predictions[6]
10	184	110	153	153
20	173	110	152	148
30	168	110	146	145
40	167	110	143	141
50	163	110	141	140
60	159	110	139	137
70	151	110	135	131
80	146	104	127	125
90	135	93	121	113
Maximum No. of Days	197	110	171	171
Average No. of Days	160	106	138	136
Minimum No. of Days	110	73	96	95

Notes:

1 Percentage of years in which number of days is equal to or greater than value presented.
2 Based on 60-year discharge record at Kuskokwim River-Crooked Creek gage (USGS 2014b). The years 1951, 1994, and 1995 have only partial records with some data missing for potential barging months; thus, they have not been used in the analyses.
3 Conservative minimum discharge reading at Kuskokwim River-Crooked Creek gage needed to operate between Nelson Island and the Angyaruaq (Jungjuk) Port (AMEC 2014; Enos 2014).
4 Proposed by Donlin Gold (AMEC 2014).
5 Estimated based on NWS (2014) dates for breakup, first boat, last boat, and freezeup.
6 Based on average monthly precipitation reductions shown in Table 3.26-11 (SNAP 2012), and applying same monthly reduction to each day of record within month.

cfs = cubic feet per second

Source: URS 2014c

Mine Access Road

The effect of climate change on precipitation has potential implications for the capacity of culverts and bridges along the mine access road to handle breakup flow and high precipitation events during the life of the mine as well as the post-Closure period. Donlin Gold is considering replacing some culverts along the mine access road at closure with low water crossings, due to the anticipated low level of use and monitoring in post-Closure (Chapter 5, Impact Avoidance, Minimization, and Mitigation). Predicted climate change effects on precipitation in the vicinity of the mine access road are similar to those predicted for the Mine Site and the other Kuskokwim River drainages described above (Table 3.26-4); these include an overall increase in annual precipitation, with lower summer precipitation balanced by higher precipitation in fall and winter months, which could result in greater snowmelt during breakup. However, as described above under Mine Site, recent studies are conflicting as to the prediction of statistically significant trends in rare precipitation events in Alaska from climate change (Perica et al. 2012; Walsh et al. 2014). Because rare events are typically used to design culverts and bridges, and because the culverts may be replaced with low water crossings, the added effects of climate change may or may not be noticeable, and the design is anticipated to be adequate for the conditions.

Pipeline

Climate change effects on precipitation in the Pipeline component during Operations could cause changes in erosion patterns along the cleared ROW and scour potential at waterbody crossings. Average annual precipitation in Cook Inlet basin, Alaska Range, and Kuskokwim Hills is anticipated to increase on the order of 2 to 15 percent over the life of the project as a result of climate change (SNAP 2012), with the higher increases in the Alaska Range and lower increases in the Kuskokwim Hills. Most of the increased precipitation in Cook Inlet basin is predicted to occur in winter months and during breakup, although the winter increases could occur as rain, resulting in a reduced snowpack with smaller intermittent melting episodes, rather than a large breakup. Effects from increased snowmelt and precipitation at breakup represent potentially worse effects on the pipeline structure (such as scour) than intermittent snowmelt.

Greater discharge at breakup could cause increased risk of bank erosion and scour along major river crossings, e.g., in areas of known river erosion along the Jones and South Fork Kuskokwim rivers (Figure 3.3-4, Section 3.3, Geohazards and Seismic Conditions) and at other major rivers draining the Alaska Range and Kuskokwim Hills (Figure 3.5-15, Section 3.5, Surface Water Hydrology). While the duration of scour effects on the integrity of the pipeline would be long-term, lasting through the life of the project, the abandoned-in-place pipeline in post-Closure could also cause increased bed or bank erosion locally if exposed.

At HDD river crossings, the pipeline would be installed well below (typically 10s or 100s of feet below) any river scour hazard, and the ends of the HDD segments would be set back from the riverbanks at distances ranging from 400 to 3,900 feet (Section 3.2, Soils). Typical burial depths at other stream crossings would be 4 feet, except at river crossings with high scour potential, where the pipeline would be buried up to 10 feet below the thalweg (SRK 2013b). Thalweg depths have been determined based on site-specific calculations of the 100-year event scour depth at each crossing (CH2M Hill 2011c). In addition, the length of increased cover depth along river crossings assumes that active channels could move anywhere within historic floodplains.

Additional geotechnical investigation would be conducted prior to final design (Section 3.2, Soils) to evaluate site-specific conditions for PHMSA permitting. Additional mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation to address monitoring and rehabilitation in post-Closure that could reduce effects to low intensity levels.

Potential increased precipitation and discharge at breakup could also cause erosion along the cleared ROW. Revegetation during reclamation immediately following construction is expected to stabilize early in the Operations Phase.

Increased precipitation and breakup discharge could cause an increase in the occurrence of glaciation or aufeis effects at co-located ROW and INHT segments between MP 84 and MP 97. As described in Section 3.2, Soils, localized glaciation (usually extending less than 1/4 mile along the trail) is known to occur along the trail in the Alaska Range in winter, and can accumulate about 1 to 10 feet thick of solid ice (BLM 2015d), a situation which could be exacerbated by the collocated pipeline ROW and be hazardous for trail users due to slippery cross slopes associated with the flowage. Best management practices (BMPs) and erosion and sedimentation control (ESC) measures emplaced to promote non-erosive drainage from existing and new water sources and pathways, and regular monitoring and maintenance during Operations (Section 3.2, Soils), are expected to minimize these effects along the ROW and collocated INHT sections and crossings.

Summary of Impacts for Alternative 2 – Water

In terms of intensity, climate change effects were assessed on the impacts that major structures and water management at the Mine Site have on water flow. For Alternative 2, climate effects may or may not be discernable beyond extremes predicted by the historical record, hydrologic designs meet or exceed state guidelines and would be adequate to accommodate climate change effects, and water management and treatment strategies are flexible enough to accommodate potential long-term precipitation trends. This analysis is based partly on state and global studies that do not exhibit confident trends in rare events, and on infrastructure designs that appear robust enough to accommodate modest increments in rare events that may be caused by climate change outside of extremes already predicted by the historical data. For the Transportation Corridor, sufficient barge days would be available even under a climate change scenario to meet proposed shipping needs without increased risk of barge stranding, and the barge plan and proposed contingencies are expected to be adequate to accommodate predicted climate change trends during Operations. Impacts would be reduced post-Closure for the mine access road where culverts are replaced with low water crossings. Impacts may occur at facilities that remain in post-Closure such as culverts and bridges that could experience the longer-term trends of increased precipitation. In the Pipeline component, effects of climate change on ROW erosion during Operations could be mitigated by revegetation and stabilization early in Operations, and most scour hazards at river crossings would be mitigated by designing for the 100-year flood.

The duration of climate change effects are not expected to cease within the life of the mine or post-Closure. The geographic extent of effects would range from some hydrologic effects limited to within Mine Site boundaries (e.g., small water diversion structures) and some affecting Crooked Creek beyond the Mine Site (e.g., pit dewatering reducing winter flow) with or without climate change effects. In the Transportation Corridor, potential impacts may last throughout barging operations and use of the road throughout post-Closure. In the Pipeline component potential impacts on the integrity of the pipeline could last through the life of the project, with local erosion effects from a potentially exposed pipeline continuing into post-Closure.

While the extent of climate change effects is global, the extent of project effects would be considered limited to critical sections of the Kuskokwim River or certain road drainages, but may involve potential contingencies that could extend from Bethel along the Transportation Corridor to the Mine Site. Climate change could potentially cause increased scour at breakup, but impacts are expected to be limited in that the depth of cover designed for the 100-year event would be within the limits of historical variation, although these conditions could plausibly be exceeded in post-Closure in the event of precipitation increases from climate change. In the Pipeline component, erosion and scour impacts would be limited to the immediate vicinity of the pipeline corridor.

In context, while climate change is a wide-ranging global phenomenon and water in the Mine Site and along the Kuskokwim River in the Transportation Corridor is an abundant resource, the river flow is shared with other users and other river traffic is important to the welfare of river communities. Water in the Pipeline component region is an abundant resource, with the effects of erosion and scour hazards are governed by regulation. Water would be considered an abundant resource; water is shared with other resources, and its use and related structure design is governed by regulation.

3.26.4.2.3 PERMAFROST

Mine Site

Mine Site permafrost is discussed extensively in Section 3.2, Soils. Mine site effects on permafrost in the absence of climate change, the types of permafrost-related hazards that could impact the project in the absence of climate change, and the proposed design features that could mitigate these hazards are described in Section 3.2, Soils. These include thaw settlement where soils are removed to construct roads and Mine Site infrastructure; excavation of most permafrost soils at dams and the toe of the Waste Rock Facility (WRF) to improve foundation conditions; excavation of upper permafrost soils beneath the tailings impoundment to reduce differential thaw settlement; and berms and collection ponds at overburden stockpiles to capture sediment flow from melting permafrost soils. In addition, permafrost degradation at the Mine Site could cause a release of trapped carbon into the atmosphere. An analysis of fugitive GHGs indicate than less than 0.1 percent of overall project GHG emissions result from permafrost degradation. Estimates of GHG emissions from both permafrost degradation and drying of wetlands soils from pit dewatering are discussed in Section 3.8, Air Quality.

Regional climate change trends suggest that northward expansion of permafrost thaw would occur, and that ground temperatures in the Mine Site area could increase by roughly 1.5°F to 2°F over the life of the mine (Markon et al. 2012), potentially thawing already warm permafrost in the mine region to more than 32°F. However, changes in soil cover at the Mine Site would have a comparably greater effect on permafrost thaw than climate change, as removal or disturbance of soils in most areas of the Mine Site are expected to accelerate thaw much faster than climate change would on undisturbed soils. In most areas of the Mine Site, excavation or thaw from project activities during Construction and Operations would be expected to reach the bottom of permafrost (Table 3.2-4), even without additional climate change effects. Small areas of the Mine Site where soils are left in place, or compacted but not removed, could experience some additional thaw degradation and settlement during mine Operations due to climate change, but these areas comprise a small percentage of the total area where soils are completely removed or covered. In areas where permafrost soils are not removed but are covered by project facilities (e.g., overburden piles), climate change is expected to have little effect on increasing the rate of permafrost thaw, due to the insulating effect of the added ground cover material. Areas of the Mine Site with coarse-grained surficial deposits (e.g., Crooked Creek terrace gravels) would not experience much thaw settlement regardless of whether thaw is caused by soil removal or climate change. Thus, the incremental effect of climate change on permafrost at the Mine Site would be small, and impacts would be similar to those of Alternative 2 in the absence of climate change.

Transportation Corridor

The occurrence of discontinuous permafrost along the mine access road and Angyaruaq (Jungjuk) Port and Bethel Port (a connected action) is discussed in Section 3.2, Soils. The types of effects that the Transportation Corridor could have on permafrost in the absence of climate change, the types of permafrost-related hazards that could impact these project facilities in the absence of climate change, and the proposed design features that could mitigate the hazards are also described in Section 3.2, Soils. These effects include differential thaw settlement along the road and at the ports, use of geotextile material to mitigate permafrost loss that occurs on road sections, and thawing of permafrost soils in the Jungjuk waste soil stockpile. In addition, estimates of permafrost thaw that could lead to GHG emissions are provided in Sections 3.2 and 3.8.

Regional climate change trends predict that ground temperatures in the area from Bethel to the Mine Site could increase by roughly 1.5°F to 3.5°F over the life of the mine (Markon et al. 2012), potentially thawing already warm permafrost in the area. However, removal of soils during construction at these facilities, and possible excavation of permafrost to mitigate the effects of differential settlement on structures (e.g., docks, tanks), would have a comparably greater effect on permafrost thaw than climate change, as disturbance of soils in most areas of the road and ports are expected to accelerate thaw much faster than climate change would on undisturbed soils. In most areas of the Transportation Corridor, thaw from project activities during Construction and Operations would reach the bottom of permafrost (Table 3.2-5), even without additional climate change effects. In areas where permafrost soils are not removed but are covered by project facilities (e.g., fill along road), climate change is expected to have little effect on increasing the rate of permafrost thaw or causing increased differential settlement, due to the insulating effects of the added material.

In areas where project-induced thaw is not expected to reach the bottom of permafrost over the life of the mine, climate warming trends are likely to cause additional thawing beyond what would be caused by the project in the absence of warming trends. Based on climate change modeling results for the Pipeline ROW using McGrath temperature trends (predicted 4°F increase / 100 years [Fueg 2014]), translated to Bethel conditions (predicted 2°F increase / 100 years [Markon et al. 2012]), the amount of additional thaw at the Bethel Dock due to climate change may be on the order of 5 to 10 percent deeper, which would contribute roughly 4 percent more permafrost soil loss than from the project alone without these warming trends. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Pipeline

The occurrence of discontinuous permafrost along the pipeline corridor is discussed in Section 3.2, Soils. The types of effects that the pipeline corridor could have on permafrost in the absence of climate change, the types of permafrost-related hazards that could impact these project facilities in the absence of climate change, and proposed design features that could mitigate the hazards are also described Section 3.2, Soils. These include differential thaw settlement along the trench at transition points between thaw unstable permafrost and either thaw stable permafrost or soils with no permafrost; strain-based design of the pipe to allow for flexibility, pipe construction features, and strain monitoring methods to mitigate differential settlement;

thermal erosion of the cleared ROW or cuts in thaw unstable soils; and BMPs and an Erosion Sediment Control Plan (ESCP) measures to mitigate thermal erosion.

Regional climate change trends predict that ground temperatures along the pipeline corridor could increase by 0°F to 3.5°F over the life of the mine (Markon et al. 2012), potentially thawing already warm permafrost in the Pipeline component region. Pipeline thermal modeling was performed by CH2M Hill (2011a, b) and Zarling (2011), and updated by Fueg (2014), to evaluate thaw settlement effects in response to the buried thermal regime. Methodology, models, and assumptions are described in Section 3.2, Soils. The models were run as 1) a base case using historical annual temperatures from Farewell Lake and 2) as climate change cases for both a 30-year mine Operations Phase and a 75-year post-Closure period. The modeled climate change cases assume a mean annual temperature increase over time of 0.04°F / year (or 4°F / 100 years) due to global climate change, which is consistent with temperature trends in McGrath over the past 36 years and the lower range of predicted statewide air temperature increases from climate change models.

Clearing of ROW vegetation during construction and maintenance, which initiates permafrost degradation and continues to contribute to thawing over time, would be the same in both the base case and climate change cases. Likewise, the lateral extent of permafrost degradation would be the same in both cases, coinciding with the extent of permafrost covering about 60 miles of the pipeline route and occurring intermittently between about MP 100 and MP 215, but the amount of degradation and vertical thaw settlement would be more in the climate change case. Initial analyses (CH2M Hill 2011a, b; Zarling 2011) yielded predicted thaw depths beneath the disturbed ROW and trench of 8 to 33 feet for the 30-year climate warming case, which represents a 4-foot increase in thaw depth due to climate change over the mine life. Based on the updated modeling results (Fueg 2014), thaw depth predictions in the climate change case were 30 feet for the Operations Phase and 50 feet for the ROW after 75 years (roughly 45 years into post-Closure), which represent increases of 3 to 13 feet of thaw depth over that of the base case (i.e., no contribution from climate change).

Permafrost soils can act as a source of carbon dioxide and methane emitted to the atmosphere when thawed. The total amount of soils along the pipeline route that are predicted to thaw during Operations and Closure assuming no contribution from climate change is roughly 37 million tons. Based on the incremental depths of thaw predicted for the climate change case and the same soil density and ROW width assumptions used in the base case, an additional 9 million tons of permafrost soil are predicted to thaw during Operations and Closure.

The amount of ground settlement associated with the above thaw depth predictions ranges from 0 to 23.5 feet during Operations and up to 43 feet in post-Closure, which represent increases in the range of 0 to 13 feet above the base case due to climate change. As described in Section 3.2, Soils, boreholes with the highest predicted settlements due to climate change are located in the Alaska Range along the Threemile Creek / Jones River portion of the alignment near MPs 115 to 120. This is an area with additional geohazards such as landslides where specialized construction techniques (e.g., HDD or deep bedrock trenching) are proposed that would also address concerns about thaw settlement by drilling beneath or removing permafrost-bearing overburden (Fueg 2014). Thus, the primary area of concern for thaw settlement would be on the north side of the Alaska Range between the North Fork Kuskokwim River (MP 147) and the main stem Kuskokwim River (MP 240). About 37 percent of geoprobe holes in this area contain permafrost, with thaw settlement estimates ranging from 0.2 to 7.3 feet at ground surface during Operations, and 0.2 to 8.6 feet in post-Closure, which represent increases in the range of 0 to 2 feet above the base case due to climate change. Thus, the effect of climate change on permafrost along the pipeline route is expected to be less than thaw settlement caused by ROW clearing in the absence of climate change, as vegetation removal during construction and ROW maintenance contributes the most to permafrost degradation.

These percentages and settlement estimates are considered conservative. The geoprobes specifically targeted areas of suspected ice-rich permafrost. Probes which were unable to penetrate material at depths shallower than the estimated thaw depth were assumed in the model to continue with the final soil layer logged, even though a probe unable to penetrate something other than frozen soils (such as boulders or bedrock) would be less likely to contain deep permafrost.

As described in Section 3.2, Soils, the effects of differential settlement on pipeline integrity would be addressed through PHMSA Special Permit conditions. Conditions specific to the Operations Phase could include, for example, in-line tool inspections, strain gauges in problematic segments, and frequency of PHMSA permit reviews.

The unmitigated effects of ground settlement and thermal erosion during Operations could lead to adverse changes in drainage patterns and erosion. Mitigation for these effects would be addressed primarily during construction by placing a mound of fill over the trench to allow for settlement, and by employing BMPs and ESCP measures in permafrost areas of the ROW as described in Section 3.2, Soils. In addition, some erosion stabilization would occur over time due to revegetation regardless of ground settlement, although scattered locations along the north side of the Alaska Range could experience settlement-related drainage channeling and erosion. These areas would be addressed through routine monitoring and ROW maintenance during Operations. Additional fill may be required in some areas on an ongoing basis through proactive monitoring and maintenance. These actions are expected to reduce the intensity of effects.

The amount of additional ground settlement that is predicted to occur along the north side of the Alaska Range in post-Closure due to climate change is predicted to be in the range of 0 to 3.4 feet beyond that of the Operations Phase (Fueg 2014), which could lead to occasional high intensity erosion effects if unmitigated. These effects are expected to be partly mitigated through the Reclamation and Closure Plan (SRK 2017f) compiled specifically for termination and reclamation, which may include visual overflight monitoring and placement of additional fill and/or other erosion control measures as needed (SRK 2013b). The Reclamation and Closure Plan would not necessarily cover the post-Closure period, however, and mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation, for consideration of additional bonding that would allow continuation of monitoring and stabilization activities that would reduce the intensity of localized persistent thaw settlement.

Summary of Impacts for Alternative 2 – Permafrost

In terms of intensity, climate change effects on permafrost impacts would range from little noticeable additional ground settlement from climate change in areas of coarse-grained deposits to design and excavation of permafrost soils beneath major structures being adequate to mitigate potential thaw hazards, or design and BMPs at major mine structures and along pipeline route being effective in controlling permafrost hazards, differential settlement, and thermal erosion. As in the base case (i.e., no contribution from climate change), specific low probability permafrost conditions may exist that could cause impacts (e.g., at the toe of the WRF) that could be reduced through additional mitigation (discussed in Chapter 5, Impact Avoidance, Minimization, and Mitigation). In post-Closure, effects would be due to reclamation preserving remaining permafrost, although climate change would result in less permafrost preservation than the base case. Beneficial effects (preservation of remaining permafrost) could also occur in some areas following reclamation.

The extent of climate change effects on permafrost would extend beyond the Project Area, although project–related effects on climate-altered permafrost would be localized beneath facility footprints and cleared areas. In the Pipeline component, effects on and from climate-altered permafrost would be localized along intermittent ice-rich areas of the ROW (mostly along the north flank of the Alaska Range between MPs 150 and 215) and within the immediate vicinity of the cleared ROW. Permafrost thaw effect duration would range from the life of the mine, (e.g., unstable foundations reach equilibrium within life of mine) to permanent, in cases where restoration of permafrost not expected. In context, discontinuous permafrost and climate change have a broad regional to global distribution.

3.26.4.2.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

Predicted climate change has the potential to influence the expected effects of the Donlin Gold Project on vegetation and wetlands, and by extension, on wildlife, birds, Threatened and Endangered Species (TES), fish and aquatic resources, and subsistence. Changes may be positive, neutral, or negative.

Vegetation Types

Climate change may have some effects on vegetation community type composition during the life of the project, although a substantial increase in woody vegetation within the Pipeline component resulting in the need for more frequent brushing is unlikely. In modeling efforts to date, the predicted time frame of large-scale vegetation shifts is expected to be after Closure, as most scenarios give a range of outcomes per emissions scenario in decadal increments for vegetation with scenarios created for 100 year time frames (McGuire 2015; SNAP 2012).

Construction activities that remove or displace soil and vegetation will result in greater potential permafrost thaw rates. In some locations, permafrost thawing could cause subsidence of the surface, creating wet depressions, affecting surface water flow patterns, and contributing to subsequent upland conversion in adjacent areas. Reclamation or mitigation goals may be more difficult in areas where permafrost loss causes more open water due to depressions, particularly along the pipeline corridor. Planned permafrost protective measures may be less effective in a warmed or a drier climate.

Decreased available water may have a negative effect on regrowth of vegetation in reclamation areas. Wetland reclamation areas may become too dry to qualify as wetlands, requiring adjustment to reclamation plans to meet project goals. Potentially rerouting water courses or adding erosion and sedimentation control measures may add complexity to planned measures.

Beneficial impacts may occur in reclamation. Increased temperatures and shifts in precipitation may result in a higher number of growing degree days and longer growing seasons, which may foster success of vegetation growth at reclamation sites. Also, natural revegetation may be facilitated by warmer temperatures resulting in more growing degree days.

Nonnative Invasive Species, Fire, and Pathogens

Fire severity is predicted to increase over time in Alaska. Fire regime changes may be more immediate than large-scale biome shifts during the life of the project and the post-Closure years. Increases in fire frequency, extent, and burn severity are predicted within the EIS Analysis Area (Rupp and Springsteen 2009), along with increased insect outbreaks of native insect species such as the spruce bark beetle (Chapin III et al. 2010). Landscape models indicate that the Mine Site area may be subject to more extreme changes than the other two components due to geography in relation to the area weather patterns (Rupp and Springsteen 2009). Vegetated areas along active roads or other active operations would be most vulnerable to accidental fire, which could spread to beyond the Project Area. Fires could cause changes in vegetation community type composition and could increase potential for NNIS introduction and spread by creating new open habitat areas.

With all project activities, there is risk of NNIS introduction and spread if BMPs, mitigation measures, or adaptive management strategies are not applied. Donlin Gold's Invasive Species Prevention and Management Plan (ISPMP, Appendix U) includes discussion of cooperation and coordination with appropriate agencies and landowners, continuing as necessary throughout the life of the project to ensure the proper implementation of the plan in achieving its intended purpose, including adaptation to potential climate change.

Fish and Wildlife

Shifts in populations due to habitat changes, changes in behaviors, or new species occurring in the region, combined with Construction and Operations impacts, may require adaptive management in Donlin Gold practices and plans that address wildlife and related resources, such as the Wildlife Avoidance/Avian Protection Plan and the Human Encounter/Interaction Plan.

Subsistence

The small number of jobs, high cost of living, and rapid social change make rural communities highly vulnerable to climate change effects through impacts on traditional hunting and fishing and cultural connection to the land and waters (Chapin III et al. 2006, 2014). Understanding the multi-scaled interaction of climate with subsistence livelihoods will help to understand vulnerability and adaptive capacity potential in rural Alaskan communities (McNeely 2009). Subsistence practices may have to be flexible in time, season, and harvest volume to accommodate both habitat and climate shifts during Construction and Operations Phases. For example, a later or earlier run time for certain fish species combined with mine Construction and Operations activities may affect individual's ability to access or have time to harvest the species.

Summary of Impacts for Alternative 2 - Biological Resources and Subsistence

The effects of predicted climate change on vegetation and wetlands under Alternative 2 may increase in later project years if temperatures increase as expected. The intensity of climate change impacts to biological resources and subsistence is expected to increase with projected changes in precipitation and increases in temperature, based on analysis of available data.

In terms of duration, impacts to biological resources and subsistence are expected to be long term, and may be dynamic, with some impacts noted quickly, and others poorly understood and operating at greater time scales. Some impacts are noted in Alaska already; quantified evidence for negative impacts due to climate change is being increasingly documented through anecdotal observations, inventory and monitoring efforts, and within published literature.

In terms of extent, impacts are expected to occur locally, with changes in vegetation community types or shifts in use patterns by wildlife, with local changes tied to broad regional landscape shifts in vegetation type at the biome level, or large-scale fire regime changes.

In context, there is no specific legislative framework for assessing the implications of climate change to biological resources or subsistence. Quantification of impacts at the project level is not possible given the complex nature of biological system response to change. Overall, project-related impacts of climate are expected to be incremental for biological resources and subsistence.

3.26.4.2.5 MITIGATION AND MONITORING FOR ALTERNATIVE 2

The effects determinations take into account impact reducing design features (Table 5.2-1 in Chapter 5, Impact Avoidance, Minimization, and Mitigation) proposed by Donlin Gold and also the Standard Permit Conditions and BMPs (Section 5.3) that would be implemented.

Design features important in reducing impacts from climate change include:

- The project design at the Mine Site includes water management strategies that would maintain flow and storage within the design capacity of structures, provide flexibility for extra storage in high precipitation years, provide sufficient water supplies for processing in low precipitation years, and minimize storage if not needed through water treament and discharge;
- The project design includes the use of natural gas to fuel the power plant and the other dual-fuel fired units at the Mine Site, which would result in lowering GHG emissions by 9.6 MMT CO_2-e during the mine life of 27.5 years compared to diesel fuel;
- The Alaska Pollutant Discharge Elimination five-year permit would be reevaluated, as required, including water flow models and/or pit lake modeling as appropriate. The adequacy of post-Closure WTP technology would also be reevaluated as pit lake water monitoring is conducted; and treatment technologies would be adjusted, as necessary, as a result of this evaluation; and
- Donlin Gold would implement barge guidelines for operating at certain river flow rates, and conduct ongoing surveys of the Kuskokwim River navigation channel to identify locations that should be avoided to minimize effects on bed scour and the potential for barge groundings. As part of the proposed operation, equipment will be available to free or unload/lighter barges in the event of groundings. The equipment will be available as part of ongoing operations, it will not all be dedicated standby equipment.

Standard Permit Conditions and BMPs important in reducing impacts from climate change include:

- Preparation and implementation of a Reclamation and Closure Plan (SRK 2017f);
- Appropriate bonding/financial assurance; and
- Monitoring of water withdrawals to ensure permitted limits are not exceeded.

Additional measures are being considered by the Corps and cooperating agencies to further minimize project impacts, as reasonable and practicable, and are further assessed in Chapter 5, Impact Avoidance, Minimization, and Mitigation (Section 5.5 and Section 5.7). Examples of additional measures being considered that are applicable to this resource include:

- Reexamine the continuing applicability of key portions of the water balance model at regular intervals as determined by the data collected and operational or closure conditions and experience, specifically by incorporating climate change precipitation predictions to be reevaluated periodically in post-Closure. Incorporate climate change precipitation predictions into water balance and groundwater model updates, in order to adequately anticipate climate change effects on pit filling and other project structures such as reclamation components; and
- The need for monitoring and rehabilitation in post-Closure should be addressed in the revised Stabilization, Rehabilitation, and Reclamation Plan prior to Closure; include discussion of additional financial assurance to cover these activities.

3.26.4.3 ALTERNATIVE 3A – REDUCED DIESEL BARGING: LNG-POWERED HAUL TRUCKS

3.26.4.3.1 ATMOSPHERE

Under Alternative 3A, the project would use liquefied natural gas (LNG) instead of diesel to power the large haul trucks to move waste rock and ore from the open pits during operations. These large trucks would account for approximately 75 percent of the total annual diesel consumption in Alternative 2. During Operations, Alternative 3A would reduce consumption of diesel, reduce barge trips, and reduce tanker trucks compared to Alternative 2.

No change in diesel consumption would occur at any component of the Donlin Gold Project during construction and closure under Alternative 3A, and thus no change in GHG emissions for those phases from the levels discussed under Alternative 2 would occur.

LNG burns cleaner than diesel due to its lower carbon content (DOE 2013). Because LNG is a low-carbon, clean-burning fuel, a switch to LNG, especially when considering life cycle emissions, can result in substantial reductions of GHGs compared to diesel (DOE 2013). In the case of GHGs, combustion of natural gas (while not LNG, natural gas has been used as a proxy) results in approximately 28 percent fewer emissions than diesel fuel combustion (based on heat content). This figure takes into account heat content of the fuels (in units of million British thermal units [mmBtu]), GHG emissions from the natural gas combustion produces 53.06 kilograms CO_2-e per mmBtu (kg / mmBtu), whereas diesel (Distillate fuel oil No. 2) combustion produces 73.96 kg CO_2-e / mmBtu (EPA 2014j). Based on this information, it is anticipated that this alternative would result in approximately a 28 percent reduction in GHG emissions from haul trucks.

The reduced diesel consumption under Alternative 3A would not affect GHG emissions associated with the Pipeline component.

3.26.4.3.2 WATER RESOURCES

Mine Site and Pipeline

The effects of climate change on hydrology impacts for the Mine Site and Pipeline components would be the same under Alternative 3A as Alternative 2. Adding an LNG facility at the Mine Site and reducing tank storage capacity would not change hydrologic effects discussed under Alternative 2, and there would be no changes to the Pipeline component under this alternative.

Transportation Corridor

Because the number of barge trips would be reduced under Alternative 3A by more than half, the effects of climate change on Kuskokwim River flow would cause less impact on the project than Alternative 2. With fewer barge trips, there would be almost no need to operate barges on the Kuskokwim River in low water conditions to meet resupply requirements, and there would be less risk of barge stranding or need for other shipping contingencies.

Summary of Impacts for Alternative 3A – Water

Water impacts are expected to be similar to Alternative 2. Impacts from hydrologic design of major facilities are expected to be adequate to accommodate climate change effects of increased precipitation. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.3.3 PERMAFROST

Mine Site

The effect of climate change on permafrost impacts depends on the amount of disturbed versus undisturbed soils that would occur under Alternative 3A, as soil removal or other ground disturbances would have a comparatively greater effect on permafrost than climate change, which would cause increased thawing only in areas of undisturbed soils. Because facility footprints and the extent of disturbed soils would be about the same under Alternative 3A as Alternative 2, the effect of climate change on permafrost would be the same.

Transportation Corridor

The reduction in fuel storage expansion at the Bethel Dock (a connected action) under this alternative would decrease the extent of permafrost effects. However, because climate change would only cause increased thawing in areas of undisturbed soils, there would be a slight increase in the effects of climate change on permafrost for those soils (approximately five acres) that remain undisturbed under this alternative as compared to Alternative 2. This increase would likely result in measurable permafrost thaw due to climate change for these five acres under Alternative 3A; whereas under Alternative 2, the soils would be disturbed and the effects of climate change would not be noticeable (i.e., permafrost thaw would occur regardless of climate change effects). This slight increase in effects under Alternative 3A, however, would not change the range of impact criteria for Alternative 3A compared to Alternative 2.

Pipeline

The effect of climate change on permafrost impacts associated with the Pipeline component of Alternative 3A would be the same as Alternative 2, as there would be no difference in soil disturbance between the two alternatives for the Pipeline component.

Summary of Impacts for Alternative 3A – Permafrost

While there could be a slight increase in the effects of climate change on permafrost thaw under Alternative 3A at the Bethel Dock (a connected action), the increase would be relatively small compared to the project as a whole. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.3.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

The effects of climate change on impacts of the project on biological resources and subsistence under Alternative 3A would be similar to those described under Alternative 2. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.4 ALTERNATIVE 3B – REDUCED DIESEL BARGING: DIESEL PIPELINE

Alternative 3B would replace the natural gas pipeline proposed under Alternative 2 with a diesel pipeline. Two options to Alternative 3B have been added based on Draft EIS comments from agencies and the public:

- Port MacKenzie Option: The Port MacKenzie Option would utilize the existing Port MacKenzie facility to receive and unload diesel tankers instead of the Tyonek facility considered under Alternative 3B. A pumping station and tank farm of similar size to the Tyonek conceptual design would be provided at Port MacKenzie. A pipeline would extend northwest from Port MacKenzie, route around the Susitna Flats State Game Refuge, cross the Little Susitna and Susitna rivers, and connect with the Alternative 3B alignment at approximately MP 28. In this option, there would be no improvements to the existing Tyonek dock; a pumping station and tank farm would not be constructed near Tyonek; and the pipeline from the Tyonek tank farm considered under Alternative 3B to MP 28 would not be constructed.
- Collocated Natural Gas and Diesel Pipeline Option: The Collocated Natural Gas and Diesel Pipeline Option (Collocated Pipeline Option) would add the 14-inch-diameter natural gas pipeline proposed under Alternative 2 to Alternative 3B. Under this option, the power plant would operate primarily on natural gas instead of diesel as proposed under Alternative 3B. The diesel pipeline would deliver the diesel that would be supplied using river barges under Alternative 2 and because it would not be supplying the power plant, could be reduced to an 8-inch-diameter pipeline. The two pipelines would be constructed in a single trench that would be slightly wider than proposed under either Alternative 2 or Alternative 3B and the work space would be five feet wider. The permanent pipeline ROW would be approximately two feet wider. This option could be configured with either the Tyonek or Port MacKenzie dock options.

3.26.4.4.1 ATMOSPHERE

GHG emissions and the resulting impacts to climate change under Alternative 3B would be similar to those discussed under Alternative 2 for construction and closure of all project components, including Pipeline operations. Impacts would be similar for both the Port MacKenzie Option and the Collocated Natural Gas and Diesel Pipeline Option.

Alternative 3B would result in lower GHG emissions during Operations due to reduced barging, and elimination of fugitive GHGs from the natural gas pipeline and compressor station. However, this reduction would be more than offset by increased GHGs from combustion of diesel in the Mine Site combustion equipment. The magnitude would not be expected to change from Alternative 2 levels for any of the components. GHG emissions impacts would be similar to those described under Alternative 2.

Summary of Impacts for Alternative 3B – Atmosphere

GHG emissions impacts would be similar to those described under Alternative 2. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.4.2 WATER RESOURCES

Mine Site

Hydrologic effects at the Mine Site due to climate change are expected to be the same under Alternative 3B as Alternative 2. Effects of increased precipitation on the design of major structures would not change under this alternative.

Transportation Corridor

The number of barge trips on the Kuskokwim River would be reduced by about half under Alternative 3B. As a result, the effects of climate change on Kuskokwim River flow are expected to cause less impact on the project than Alternative 2. With fewer barge trips, there would be almost no need to operate barges in low water conditions to meet resupply requirements, and there would be less risk of barge strandings or need for other shipping contingencies. Thus, the magnitude of potential climate change effects may or may not be noticeable.

Pipeline

The additional section of pipeline between Tyonek and Beluga under this alternative would cross an additional five streams using open cut methods. Predicted climate change effects on precipitation along this section of the pipeline are similar to other sections of the pipeline in the Cook Inlet basin. There could be a slight increase in potential erosion and scour under this alternative due to the additional stream crossings; however, the magnitude of effects for all stream crossings would be the same as described under Alternative 2 (i.e., design burial depths anticipated to be adequate for conditions).

Summary of Impacts for Alternative 3B – Water

Water impacts would be similar to those described under Alternative 2. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.4.3 PERMAFROST

Mine Site

The slight reduction in footprint of the fuel storage area at the Mine Site under Alternative 3B is likely to be offset by use of the same area for other purposes (e.g., laydown). Because there would be almost no difference in soil disturbance between Alternatives 2 and 3B, the effects of climate change on permafrost impacts would be considered the same.

Transportation Corridor

The area of soil disturbance at the Angyaruaq (Jungjuk) Port and Bethel Port (a connected action) is expected to be approximately the same under this alternative as Alternative 2; thus, the effect of climate change on permafrost would be the same. There would be no change in effects due to the addition of the Tyonek Dock and tank farm under this alternative, as no permafrost is expected in this area.

Pipeline

There would be no change in effects due to the addition of the Tyonek to Beluga section of the pipeline route under this alternative, as no permafrost is expected in this area. Permafrost-related ground deformation associated with this alternative in the absence of climate change is expected to be similar to Alternative 2, as the diesel would be within a few degrees of ambient ground conditions and ROW clearing-related effects would be the same. The effects of climate change on permafrost impacts under this alternative are also expected to the same as Alternative 2, as the amount of soil disturbance in permafrost areas would be about the same between the two alternatives.

Summary of Impacts for Alternative 3B – Permafrost

While there would be differences in soil disturbance between Alternatives 3B and 2, most of these are located in areas with no permafrost. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.4.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

Impacts to biological resources and subsistence under Alternative 3B would be similar to those described under Alternative 2. Impacts would also be similar in both options. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.5 ALTERNATIVE 4 – BIRCH TREE CROSSING PORT

3.26.4.5.1 ATMOSPHERE

Alternative 4 would move the location of the Angyaruaq (Jungjuk) Port and mine access road in Alternative 2 to BTC. This would result in reduced distance of river barging and longer road trips between the BTC Port and the Mine Site. This alternative would affect only the Transportation Corridor component (land and water) during the Construction and Operations phases. GHG emissions, from traffic along the 76-mile BTC Road during Construction and Operations are expected to increase compared to the shorter 30-mile road length in Alternative 2. For both Construction and Operation phases, the increase in overall emissions due to the longer road would be largely offset by the reduced barging emissions.

3.26.4.5.2 WATER RESOURCES

Mine Site and Pipeline

The effects of climate change on hydrology impacts for the Mine Site and Pipeline components would be the same under Alternative 4 as Alternative 2, as there would be no change in proposed facilities for these two components.

Transportation Corridor

Barging

Under Alternative 4, the number of barge trips on the Kuskokwim River would be the same, but the round trip travel distance would be reduced by about 40 percent. In addition, several critical (shallow) sections of the river upstream of the BTC Port would be avoided under this alternative. However, there would still be two critical sections of the river downstream of the BTC Port under Alternative 4 (Figure 3.5-29, Surface Water Hydrology).

The flow cutoff for operating on the lower section of the river is the same as that of the upper river (greater than 39,000 cfs at the Crooked Creek gauge), because Nelson Island below BTC is the controlling case. That is, the flow needed to get through Nelson Island under Alternative 4 is the same as the flow needed to get to Angyaruaq (Jungjuk) Port under Alternative 2 (Enos 2014). With a shorter barge travel time, fewer barge days would be required under this alternative to meet fuel and cargo shipping requirements, and the need for seasonal changes or other contingencies would be reduced.

As a result, the effects of climate change on Kuskokwim River flow are expected to cause less impact on the project under Alternative 4 than Alternative 2. With shorter barge trips and fewer barge days, there would be almost no need to operate barges in low water conditions to meet resupply requirements, and there would be less risk of barge strandings or need for other shipping contingencies. Climate change potentially reducing summer flows on the river is not likely to have a noticeable effect on the project.

BTC Road

Predicted climate change effects on precipitation in the vicinity of the BTC Road (see Aniak, Table 3.26-4) are similar to those predicted for the mine access road under Alternative 2. While there would be an increased number of bridges and culverts along the BTC Road as compared to the mine access road, impacts would be the same for both alternatives (i.e., the effect of climate change may or may not be noticeable, and designs based on extreme events are expected to be adequate for conditions).

Summary of Impacts for Alternative 4 – Water

While barging routes would be shorter under Alternative 4 compared to Alternative 2, impacts would remain unchanged for water. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.5.3 PERMAFROST

Mine Site and Pipeline

The areas of soil disturbance for the Mine Site and Pipeline components under Alternative 4 would be the same as Alternative 2. Thus, the effects of climate change with respect to permafrost would be the same.

Transportation Corridor

Impacts to and from permafrost under this alternative in the absence of climate change are expected to be greater than those of Alternative 2, due to the increased length of the BTC Road and Crooked Creek temporary ice road crossing permafrost areas. Climate change would increase the rate of thaw, but project-induced thaw along the road is expected to continue to the bottom of permafrost during the life of the mine (Table 3.2-5); thus, increased climate warming trends would not add to the total volume of thawed soils.

Climate change could increase permafrost degradation effects along the Crooked Creek winter road, depending on the degree of vegetation and soil compaction, and at the Bethel Dock. Climate warming trends could add on the order of 5 to 10 percent more thaw depth to the estimates presented in Table 3.2-5 for these facilities (see Section 3.26.4.2.3), or about 2 percent more total permafrost soils lost under Alternative 4 than those in Table 3.2-5. At the Crooked Creek winter road, the added climate change effects are more likely to be noticeable at the surface and long-term than project-induced effects alone, depending on the rate of vegetation recovery.

Summary of Impacts for Alternative 4 – Permafrost

While there could be an increase in the effects of climate change on permafrost thaw under Alternative 4 along the Crooked Creek winter road and Bethel Dock, the increase would be relatively small compared to the project as a whole. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

3.26.4.5.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

Impacts to biological resources and subsistence under Alternative 4 would be similar to those described under Alternative 2. Design features, Standard Permit Conditions and BMPs most important for reducing impacts are described in Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2.

3.26.4.6 ALTERNATIVE 5A – DRY STACK TAILINGS

This alternative includes two options:

- Unlined Option: The TSF would not be lined with an LLDPE liner. The area would be cleared and grubbed and an underdrain system placed in the major tributaries under the TSF and operating pond to intercept groundwater base flows and infiltration through the DST and convey it to a Seepage Recovery System (SRS). Water collecting in the SRS pond would be pumped to the operating pond, lower CWD, or directly to the processing plant for use in process.
- Lined Option: The DST would be underlain by a pumped overdrain layer throughout the footprint, with an impermeable LLDPE liner below. The rock underdrain and foundation preparation would be completed in the same manner as the Unlined Option.

3.26.4.6.1 ATMOSPHERE

This alternative would affect the Mine Site during the Operations and Closure phases. The additional use of mobile machinery for transport and dewatering at the filter plant would increase mobile emissions, and the increase in power consumption would cause an increase in stationary emissions from the power plant. This alternative would also affect the Transportation Corridor component during the Operations Phase, as there would be a six percent increase in barge traffic compared to Alternative 2 (BGC 2014a). GHG emission estimates are expected to increase around three percent over Alternative 2.

3.26.4.6.2 WATER RESOURCES

<u>Mine Site</u>

Construction

Alternative 5A (both Options 1 and 2) would involve slightly different major water-retaining structures than Alternative 2 that could be affected by the predicted increase in precipitation caused by climate change. Stochastic water balance models (WBMs) have been developed for Alternative 5A, which take into account the same wet and dry climate scenarios as under Alternative 2 (that is, WBM runs based on 10^{th} to 99^{th} percentile precipitation conditions) (BGC 2015j). These provide results over a greater range of conditions than the predicted average annual climate change increase over the Operations Phase of two to three percent. For example, WBMs for Alternative 5A predict that, if 99^{th} percentile precipitation conditions occur continuously over the mine life, the ultimate cumulative TSF operating pond volume would be about 20 percent higher than the 50^{th} percentile or average condition (99,000 vs. 82,000 acre-feet, respectively). Both of these are well within the total storage capacity of the pond, about 125,000 acre-feet, as it is designed to store an extra year of contingency water production (BGC 2014a). The total storage capacity of pond under Alternative 5A is about 50 percent higher than the average precipitation condition.

The effects of a 25 percent climate-caused precipitation increase on pit dewatering volume, and on the amount of freshwater needed from Snow Gulch reservoir, would be the same under Alternative 5A (both options) as for Alternative 2. In addition, the flexibility provided by the WTP design under Alternative 2 would be the same under Alternative 5A. Flexible Mine Site water management under Alternative 5A means that major water containment structures would be able to accommodate extra runoff and dewatering water from potential climate change precipitation increases.

Closure

Because the operating pond and other water dams would be removed in closure, the effects of climate change on pond volumes and related water management activities would not occur in post-Closure. There would be an increased rate of seepage flow to the SRS in post-Closure under Option 1 (unlined dry stack), which would be pumped to the pit lake. Under Option 2 (lined dry stack), the same increased seepage flow (compared to Alternative 2) would report directly to the pit lake in post-Closure. Because the increased volume of seepage flow through the dry stack under both options of Alternative 5A compared to Alternative 2 (about 30 to 80 gpm more) represents a relatively small amount of the total water filling in the pit lake from other sources (about 4,000 gpm), the effect of increased precipitation from climate change during post-Closure would be about the same as Alternative 2 (i.e., the management of water levels to maintain freeboard would be similar and, like Alternative 2, would be conducted in perpetuity).

Transportation Corridor and Pipeline

The effects of climate change on hydrology for the Transportation Corridor and the Pipeline components would be the same under Alternative 5A as Alternative 2, as there would be no change in proposed facilities for these two components of the project.

Summary of Impacts for Alternative 5A – Water

The magnitude of climate change effects on major structures and water management at the Mine Site may be that effects may or may not be discernable beyond extremes predicted by the historical record, and hydrologic designs adequate to accommodate most climate change effects. The duration, geographic extent, and context of climate change effects would be the same as Alternative 2.

The magnitude of hydrologic effects due to climate change under Alternative 5A (including effects on the Transportation Corridor and Pipeline components which do not change under this alternative from Alternative 2) would mostly range between effects that may or may not be discernable beyond extremes predicted by the historical record, to that of sufficient barging days available to meet shipping needs. The duration, geographic extent, and context of climate change effects would be the same as Alternative 2.

Water impacts would be similar to those described under Alternative 2. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.6.3 PERMAFROST

Mine Site

Soil and permafrost disturbances beneath the dry stack tailings and operating pond under Alternative 5A would be slightly greater than those for Alternative 2, but not significantly different. Permafrost excavation beneath the dam footprints would be higher under Alternative 5A, increasing the amount of this material stored in the TSF overburden stockpile and the amount of permafrost melting in the pile; however, this effect is expected to occur in the absence of climate change. Thus, the effects of climate change on permafrost impacts under this alternative are expected to be the same as Alternative 2.

Transportation Corridor and Pipeline

The areas of soil disturbance for the Transportation Corridor and Pipeline components under Alternative 5A would be the same as Alternative 2. Thus, the effect of climate change on permafrost impacts would be the same.

Summary of Impacts for Alternative 5A – Permafrost

While there could be slight increases in permafrost impacts under Alternative 5A associated with the Mine Site, the effects of climate change would be the same as Alternative 2. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.6.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

The effects of climate change on impacts of the project on biological resources and subsistence under Alternative 5 would be similar to those described under Alternative 2. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.7 ALTERNATIVE 6A – MODIFIED NATURAL GAS PIPELINE ALIGNMENT: DALZELL GORGE ROUTE

3.26.4.7.1 ATMOSPHERE

Alternative 6A would not cause much change to GHG emissions or impacts to climate change in any of the phases or project components from those identified under Alternative 2. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.7.2 WATER RESOURCES

Mine Site and Transportation Corridor

The effects of climate change on water impacts for the Mine Site and Transportation Corridor would be the same under Alternative 6A as Alternative 2, as there would be no change in proposed facilities for these two components of the project.

Pipeline

The alternate pipeline route through the Alaska Range under Alternative 6A would traverse high mountain terrain that is expected to have similar climate change impacts to hydrology as that of the Alaska Range section of Alternative 2. Based on mapped SNAP (2012) data, precipitation is predicted to increase as much as 15 percent in the Alaska Range over the life of the mine. The monthly distribution of precipitation changes at lower elevations along the alternative route are expected to be similar to that of Skwentna (see Table 3.26-5).

Increased precipitation and breakup discharge due to climate change could cause an increase in the occurrence of glaciation or aufeis effects at collocated ROW and INHT segments between MP 84 and MP 142 of Alternative 6A. Localized glaciation is known to occur along the trail in the Alaska Range in winter, a situation which could be exacerbated by the collocated pipeline ROW near stream crossings and be hazardous for trail users. While BMPs and regular Operations activities would minimize these effects, incremental glaciation effects from climate change could be greater under Alternative 6A than Alternative 2, due to the greater number of trail crossings and co-located segments under Alternative 6A (21 more crossings and 10.5 more co-located miles).

The predicted magnitude of hydrologic climate change effects would be similar between the Alternative 2 and 6A routes, although the extent of potential increased glaciation effects could be greater under Alternative 6A.

Summary of Impacts for Alternative 6A – Water

Water impacts would be similar to those described under Alternative 2, although the extent of potential increased glaciation effects could be greater under Alternative 6A. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.7.3 PERMAFROST

Mine Site and Transportation Corridor

The areas of soil disturbance for the Mine Site and Transportation Corridor components under Alternative 6A would be the same as Alternative 2. Thus, the effect of climate change on permafrost impacts would be the same.

Pipeline

As described in Section 3.2, Soils, there appears to be less permafrost occurrence and related impacts along the Alaska Range section of Alternative 6A than that of Alternative 2. However, this is based on data of varying quantities and confidence between the two routes, and ground conditions are more likely to be similar with regard to permafrost between the two alternatives. Thus, the effect of climate change on permafrost impacts along Alternative 6A is expected to be similar to Alternative 2.

Summary of Impacts for Alternative 6A – Permafrost

While there could be slight differences in permafrost impacts between Alternatives 6A and 2, these differences and the effects of climate change would likely be small compared to those of the project as a whole. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.7.4 BIOLOGICAL RESOURCES AND SUBSISTENCE

The effects of climate change on impacts of the project on biological resources and subsistence under Alternative 6 would be similar to those described under Alternative 2. Water impacts would be similar to those described under Alternative 2. Design features, Standard Permit Conditions and BMPs most important for reducing climate change impacts are described in Alternative 2.

3.26.4.8 ALTERNATIVES IMPACT COMPARISON

A comparison of the impacts to climate change by alternative is presented in Table 3.26-13.

Table 3.26-13: Comparison by Alternative* for Climate Change

Resource Area	Alternative 2 – Donlin Gold's Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B –Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A –Dalzell Gorge Route
Atmosphere	GHG emissions would represent at most 4% of state of Alaska emissions in 2010. Impacts would last the life of the project, with GHG emissions occurring throughout the duration of the project	Approximately 28% reduction in GHG emissions from haul trucks, based on the number of fewer haul truck trips required compared to Alternative 2.	Anticipated to have higher GHG emissions; however, impacts would be similar to Alternative 2.	GHG emissions not substantially different than Alternative 2.	Anticipated to have approximately 3% GHG emissions as compared to Alternative 2,	GHG emissions not substantially different than Alternative 2.
Water Resources	Climate effects may or may not be discernable beyond predicted extremes. Hydrologic designs would meet state guidelines and would be adequate to accommodate climate change effects. Water management and treatment strategies would accommodate potential long-term precipitation trends.	Less potential for low water barge impacts (fewer trips needed). Other impacts would be the same as Alternative 2.	Slightly less effects along Transportation Corridor (fewer barge trips); slightly more effects along Pipeline component (more stream crossings subject to climate effects). Other impacts would be the same as Alternative 2.	Less potential for low water barge effects. Other impacts would be the same as Alternative 2.	Flexible mine water management and design of operating pond would be able to accommodate climate-caused precipitation changes. Other impacts would be the same as Alternative 2.	Potential for slightly higher climate-caused precipitation and aufeis effects. Other impacts would be the same as Alternative 2.

Table 3.26-13: Comparison by Alternative* for Climate Change

Resource Area	Alternative 2 – Donlin Gold's Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B –Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A –Dalzell Gorge Route
Permafrost	Slightly more climate change effects on Transportation Corridor (Bethel Dock, a connected action) and Pipeline ROW than from project-induced thaw. Climate change would not add to project-induced effects at the Mine Site, but could affect intermittent areas of permafrost not impacted by project activities. Small beneficial effects (preservation of remaining permafrost) could occur in some areas following reclamation.	Same as Alternative 2. While there could be a slight increase in the effects of climate change on permafrost thaw at the Bethel Dock (a connected action), the increase would be relatively small compared to the project as a whole.	Same as Alternative 2.	Slightly more climate-caused effects along Crooked Creek winter road and Bethel Dock (a connected action). Other impacts would be the same as Alternative 2.	Slight increases in permafrost impacts, but overall impacts would be the same as Alternative 2.	Same as Alternative 2.
Biological Resources	Effects on biological resources (primarily vegetation and wetlands) would be incremental and include changes in vegetation community types or shifts in use patterns by wildlife, with changes tied to broad regional landscape shifts in vegetation type at the biome level, or large-scale fire regime changes.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Subsistence	Subsistence losses to coastal and riverine communities may occur as traditional harvest species change relative location and abundance. Effects would be incremental.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

Notes: *The No Action Alterative would have no additional impacts.