ATTACHMENTS:

Attachment A: AQRV Impact Assessment—Nitrogen Deposition in Denali National Park

Attachment B: BACT Evaluation—SCR for the Combustion Turbines, Annual Emission Limits and Flares

Attachment C: NPS Authorities and Obligation to Comment on PSD Permits that May Affect Class I Areas

Attachment A:
AQRV Impact Assessment—Nitrogen Deposition in Denali National Park (NP)

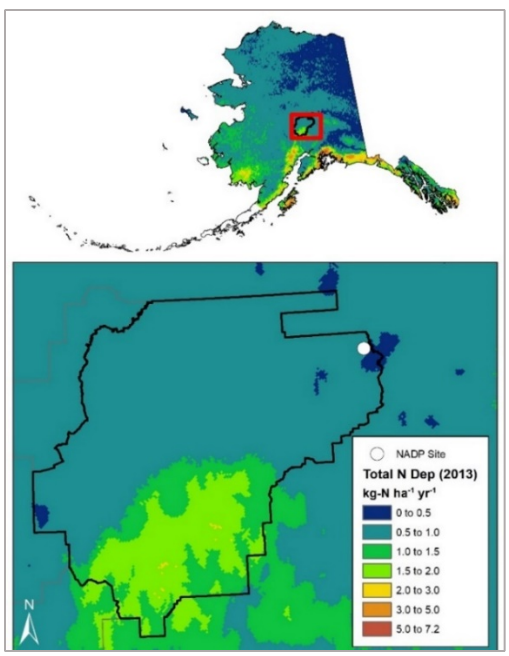
Introduction
Current estimated levels of nitrogen pollutant deposition (1.0 – 2.0 kg/ha/yr) in the southern end of the park are potentially causing declines in sensitive lichen communities. The additional nitrogen deposition from the AK LNG Liquefaction facility (as well as other AK LNG-related emissions) could exacerbate these concerns.

Modeling performed by both the applicant and the Federal Land Management Agencies (FLMs) demonstrates that nitrogen oxide (NOx) emissions from the facility alone (and in conjunction with other AK LNG emission sources) results in additional nitrogen deposition above NPS ARD significance thresholds.[1] The modeled deposition impacts from the AK LNG sources are most significant in the southern end of the park, which overlaps with the geographic extent of the areas that already receive the highest estimated deposition inputs and are potentially impacted by current deposition. The AK LNG sources will result in increased nitrogen deposition in the most vulnerable areas of the park.

Estimates of Current Total Nitrogen Deposition in Denali NP

Hember et al. (2018) developed a model for total nitrogen (N) deposition for 2013 that shows a range within the park from 0.5 to 2.1 kg-N/ha/yr (median 0.8 kg-N/ha/yr), with the highest deposition occurring in the southern regions of the park.

Figure A-1: Estimated Background Nitrogen Deposition in Denali NP.



[1] The FLAG 2010 guidance defines the DAT as "*… the additional amount of nitrogen or sulfur deposition within an FLM area, below which estimated impacts from a proposed new or modified source are considered negligible. In other words, if the new or modified source has a predicted nitrogen or sulfur deposition impact below the respective DAT, the NPS and FWS will consider that impact to be negligible, and no further analysis would be required for that pollutant. In cases where a source's impact equals or exceeds the DAT, the NPS/FWS will make a project-specific assessment of whether the projected increase in deposition would likely result in an "adverse impact" on resources considering existing AQRV conditions, the magnitude of the expected increase, and other factors*." This Attachment summarizes the existing AQRV conditions for Denali NP as part of the project-specific assessment.

Nitrogen Deposition—Risk to Lichen Communities in Denali NP

Lichens are a critical component of Denali NP's ecosystems, aiding in nutrient cycling in nutrient-poor systems and providing food, forage and habitat for many species (Stehn et al. 2015). There are 431 unique lichen species known to occur within Denali NP and lichens are found in many habitats throughout the park, often covering a large proportion of the landscape. A complex web of interactions connects members of the ecosystem, and consequently, lichens significantly affect the ecosystems in which they live, serving important roles in park ecosystem functioning.

Lichens lack root structures and instead "filter" moisture and nutrients from the air. Because of this, lichen species are often sensitive to air pollution but vary in sensitivity among species—an understanding of the specific species present as well as their known tolerance for air pollution is an important consideration when determining the potential effects of pollutant deposition. One tool that can assist managers in addressing species or ecosystem response to air pollution is called a critical load.

Critical loads are scientifically defined thresholds designed to aid land managers in identifying the level of deposition below which harmful impacts to ecosystems, ecosystem components or individual species do not occur (Porter et al. 2005). When deposition exceeds a critical load threshold the integrity of the ecosystem begins to decline. Critical load values have been identified for cyanolichen communities, as well as for 42 individual lichen species documented to occur within Denali NP.

Lichen Community Response Curves: Geiser et al. (2019) developed a community response curve for cyanolichen communities. Cyanolichens are important because they provide habitat and nutrient-rich food for mollusks and other invertebrates and help balance N cycling in the forest (Geiser et al. 2019). A 20% decline in cyanolichen communities occurs at deposition levels above 1.3 kg nitrogen/ha/yr and a 30% decline in cyanolichen communities occurs at deposition levels above 1.9 kg-N/ha/yr,[2] indicating that cyanolichen communities in the southern end of the park may already be experiencing declines due to current deposition.

Individual Species Response: There are 431 known lichen species within Denali NP, and 97 of these species have a calculated critical load of N for a reduction in abundance (Stehn et al. 2015, Geiser et al in prep.). Of the 97, there are 42 lichen species within Denali NP that have a nitrogen critical load for a 20% decline in detectability between 1.0 and 1.6 kg-N/ha/yr. Thirty-four of these species are expected to decline by up to 50% within a range of 1.3 to 1.9 kg-N/ha/yr. Of the 42 species in Denali NP with identified critical load values, 33% are cyanolichens, 14% are forage lichens and 52% are matrix lichens. The median critical load value for the individual Denali NP cyanolichen species is the same nitrogen deposition load (1.3 kg-N/ha/yr) as the critical load to protect cyanolichen communities already published.

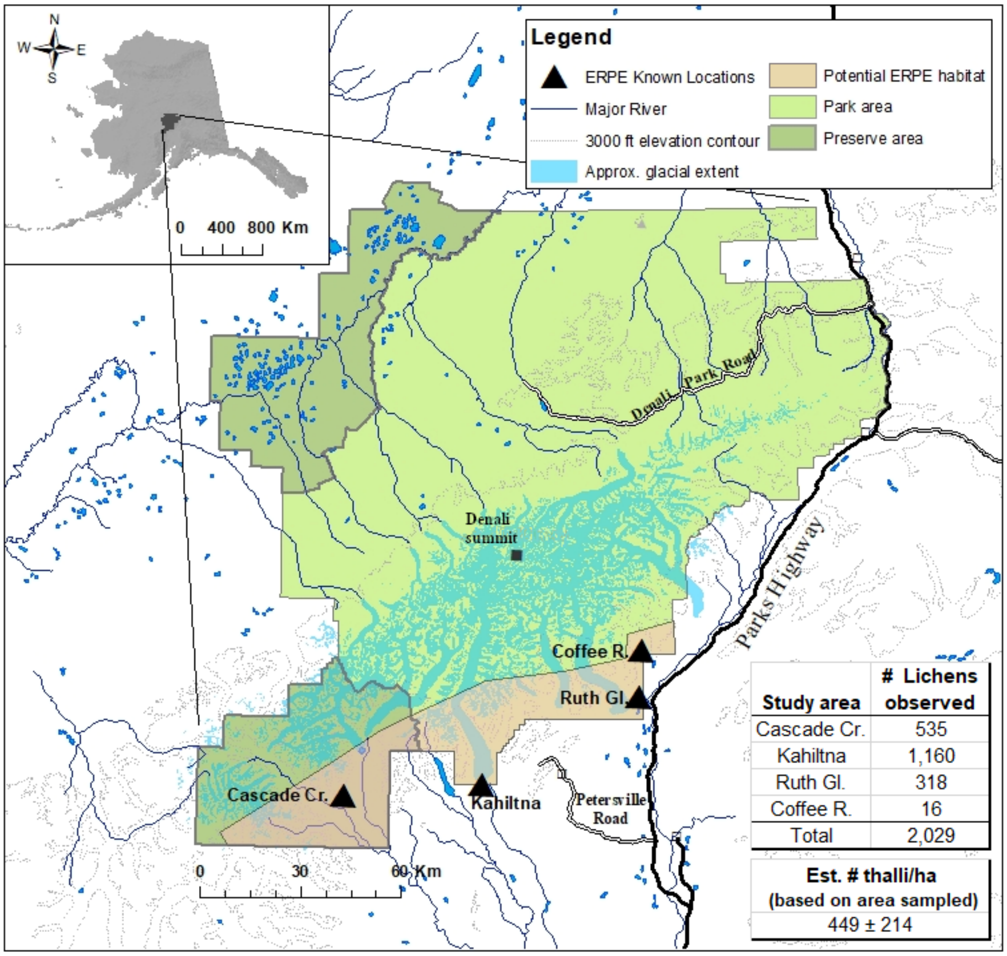
Boreal felt lichen—an IUCN Critically Endangered Lichen: Of concern within the cyanolichen communities is the globally rare boreal felt lichen (*Erioderma pedicellatum*), which has only recently been discovered in the U.S. at sites within Denali NP. The species is listed as critically endangered by the International Union for Conservation of Nature (IUCN). Given the species rarity, the boreal felt lichen was not directly assessed in the studies referenced above but is known to co-occur with sensitive cyanolichen species that are potentially in decline.

Individual lichens in the Denali population live primarily on the twigs of spruce trees and achieve most of their nutrient needs through absorption of moist air or receipt of water-borne nutrients flowing or dripping through the tree canopy (Stehn et al. 2013). Nutrients are passively absorbed through their thalli, or body surface, increasing their potential susceptibility to pollutant deposition. Regional air pollution has been linked to declines in *Erioderma pedicellatum* in Atlantic Canada (Maass & Yetman 2002) and Norway

[2] Boot-strapped 95% confidence interval on this CL, 0.49 – 1.3 kg N, meaning that 1.3 kg/ha/yr is at the high end of the range for this CL.

(Goudie et al. 2011). Known locations of *Erioderma pedicellatum* are in the southern portion of Denali NP, which coincide with areas estimated to receive the highest levels of current nitrogen deposition and the areas most impacted by the AK LNG facility.

Figure A-2: Known Locations of the Boreal Felt Lichen (Erioderma pedicellatum) in Denali NP (from Stehn et al. 2013)



Modeled Nitrogen Deposition from AK LNG Source

We re-ran the modeling analysis with four emission scenarios.[3] The results for each scenario are provided in Table A-1 below. All modeled emission scenarios exceed the NPS nitrogen deposition analysis threshold (DAT); however, the magnitude and geographic extent of the DAT exceedances change based on the modeled emission scenario. We note that on an annual basis, the facility-wide potential to emit is considerable when the annual flare emissions are accounted for (up to 5,040 TPY NOx). Because the deposition analysis evaluates an annual flux in deposition (kilograms per hectare per year), the FLM analysis also considered annual potential to emit from the flares (accounting for the annual limitations of 500 hours per year for the wet and dry flares and 144 hours per year for the low pressure flare). Additionally, the FLM agency modeling analysis considered the emissions from the liquefaction facility alone as well as in conjunction with the mainline compressor and heater stations associated with the much larger AK LNG project. The additional emissions from the compressor stations

[3] Air resources staff in the FLM agencies—including the Fish and Wildlife Service and NPS air resources staff.

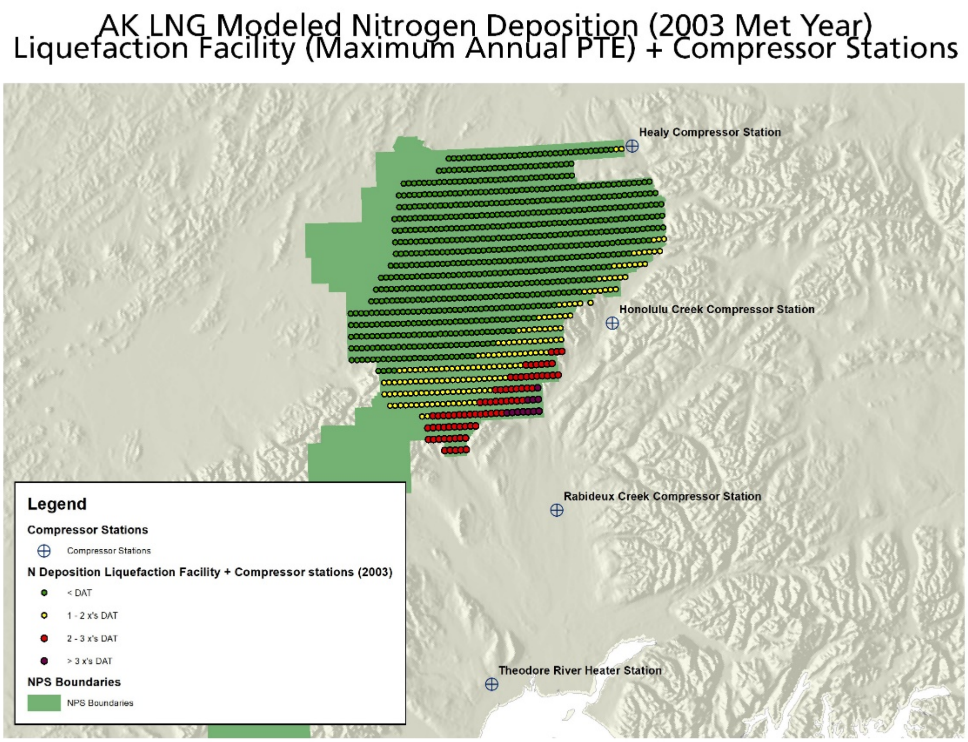
were considered in the analysis under the additional impacts analysis provisions of 40 C.F.R 52.21.[4] These provisions call for an impact analysis that considers other industrial source growth associated with the facility.

Table A-1: FLM Deposition Modeling Results for the AK LNG Liquefaction Facility

Model Year	Modeling Scenario	Max N Dep (kg/ha/yr)	DAT Exceedance (X's over DAT)
2003	Liquefaction Facility Only - LFF Normal Ops	0.0079	1.58
2003	Liquefaction Facility + Compressor Stations - LFF Normal Ops	0.0131	2.62
2003	Liquefaction Facility Only - LFF Max Annual PTE	0.0134	2.68
2003	Liquefaction Facility + Compressor Stations - LFF Max Annual PTE	0.0185	3.7

As noted previously, the geographic extent of the modeled nitrogen deposition from the AK LNG facility occurs in the southern and southeastern end of Denali NP, which also coincides with the areas estimated to receive the highest amounts of current cumulative deposition. (See Figures A-3 through A-5)

Figure A-3: Modeled Nitrogen Deposition for the AK LNG Liquefaction Facility (Flares Maximum Annual PTE) plus the AK LNG Mainline Compressor and Heater Stations



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[4] 40 CFR 52.21 (o) *Additional impact analyses.* (1) The owner or operator ***shall provide*** an analysis of the impairment to visibility, soils and vegetation that would occur as a result of the source or modification and general commercial, residential, ***industrial and other growth associated with the source or modification***.

Figure A-4: Modeled Nitrogen Deposition for the AK LNG Liquefaction Facility Alone (Flares Maximum Annual PTE)

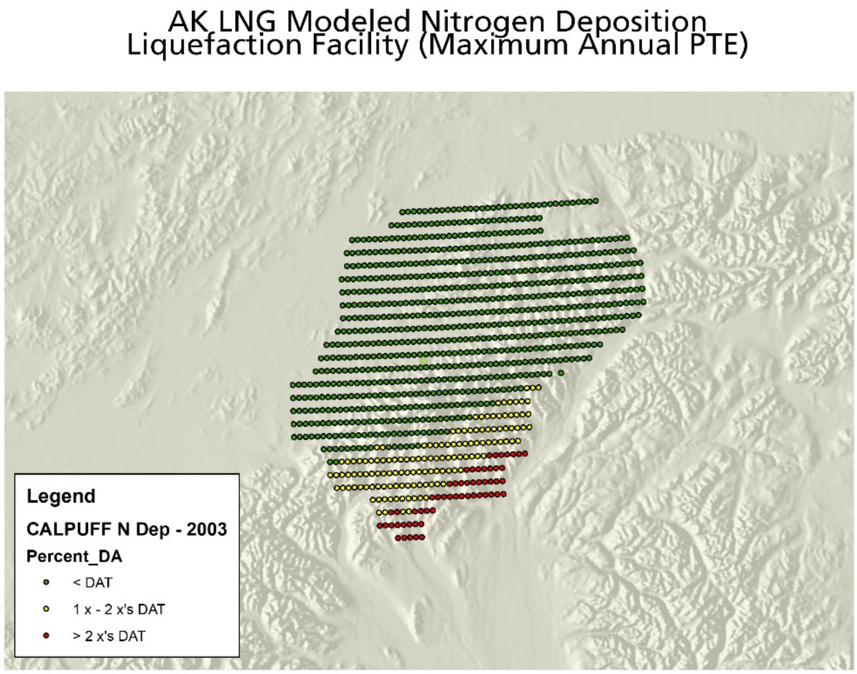
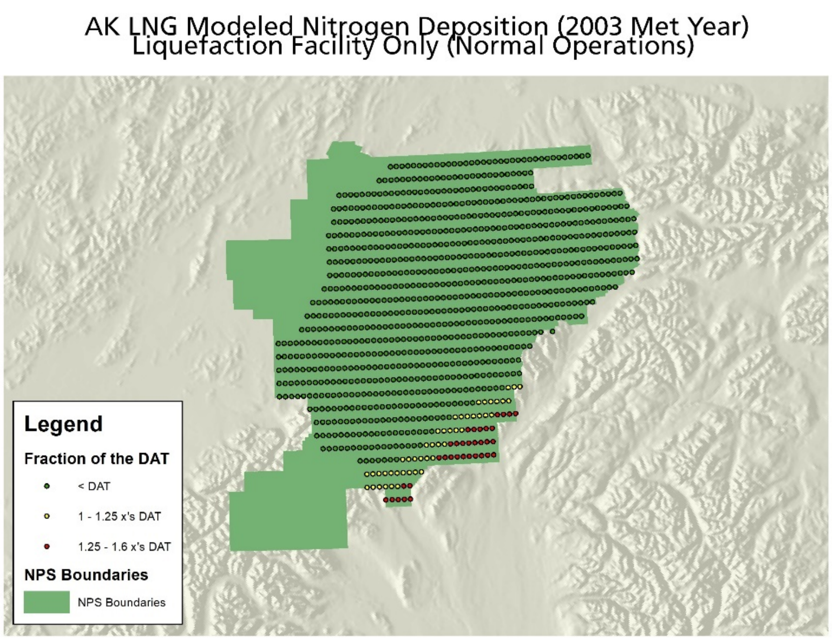


Figure A-5: Modeled Nitrogen Deposition for the AK LNG Liquefaction Facility Alone (Flares in Pilot Purge Mode Only—No Flaring Events)



Additional Impacts Analysis

AGDC provided an additional impacts analysis in their March 2018 Project Information Form Attachment 10. The "Additional Impacts Analysis" is required under 40 CFR 52.21(o). Several of the conclusions reached in that report contradict the information provided in our comments—we would like to address these.

First, in their growth analysis required under 40 CFR 52.21(o)(2), the applicant concludes: "*No industrial or commercial growth is likely to occur as the requirements for the project are expected to fit within the current infrastructure in the area*." We note that there are several proposed compressor and/or heater stations to be located along the pipeline delivering natural gas to the liquefaction facility, three of which are in proximity to Denali NP, the only NPS Class I area in Alaska (see map above). This source growth is clearly connected with the liquefaction facility, as it is part of the overall AK LNG project, and therefore, it is relevant to the Class I impacts analysis. For this reason, our revised modeling analysis also considered the compressor and heater stations and we recommend that AGDC's analysis should as well.

Second, the vegetation impacts analysis required under 40 CFR 52.21(o)(1) concluded: "*Therefore, a project that demonstrates compliance with the NAAQS easily demonstrates compliance with USEPA's threshold screening values and indicates the project will not cause deleterious effects to vegetation*." The analysis went on to acknowledge however that "*lichen species are particularly sensitive to sulfur dioxide (SO2)*" and utilized a 1989 U.S. Forest Service document to consider impacts to lichens in the Tongass National Forest and concluded the "*ambient air quality impacts are overstated and they are still not expected to result in adverse growth effects or tissue injury to vegetation in the project area*." Based on the information provided above, AGDC's information is outdated, does not consider the potential deleterious effects of nitrogen deposition on lichens, and inaccurately concludes that the NAAQS are protective of sensitive vegetation species. As we note above, lichens in Denali NP may be negatively impacted by nitrogen deposition and the AK LNG project may exacerbate these concerns.

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Attachment B:

BACT Evaluation of SCR for the Combustion Turbines, Annual Emission Limits and Flares

Combustion Turbines NOx BACT— Introduction
The AK LNG applicant (AGDC) concluded that Selective Catalytic Reduction (SCR) technology is not economically feasible for the four power generation turbines and six compressor turbines at the liquefaction facility. The Alaska Department of Environmental Conservation (ADEC) proposes to approve this conclusion. We have evaluated the technical accuracy of the BACT analysis and conclusions and found several deficiencies in the applicant's BACT evaluation. When corrected, SCR is much more cost effective for the AK LNG liquefaction facility turbines than estimated by AGDC. Furthermore, AGDC's own estimates are well within BACT cost-effective thresholds set by other states. (A summary of our analysis revisions and results are provided below.) **We recommend that ADEC reconsider the AK LNG NOx BACT determination for the combustion turbines in light of the information presented in this technical attachment, as well as the information regarding nitrogen deposition impacts presented in Attachment A. This recommendation is based on the following three premises:**

1. Other sources in Alaska have either proposed or installed SCR as NOx BACT for similar combustion turbines, including the Agrium plant, which is an existing fertilizer manufacturing facility located adjacent to the proposed liquefaction facility site. It can be inferred that these sources find SCR to be an economically feasible option, even in Alaska where costs are generally higher. AGDC has not adequately demonstrated why similar costs are not feasible for the liquefaction facility.
2. The cost effectiveness estimates provided by ADEC and AGDC are within the range of BACT cost effectiveness thresholds determined to be acceptable in other states, including determinations that require SCR on combustion turbines. Furthermore, given the fact that costs are generally higher in Alaska relative to the rest of the U.S., it would be reasonable to conclude that BACT cost effectiveness thresholds should be somewhat higher in Alaska as well, or at a minimum on par with other regions of the U.S. Setting an unreasonably low threshold in an inherently high cost area essentially eliminates the application of BACT throughout the region, as most technologies could be found economically infeasible, even when such technologies are widely available.
3. Our revisions to the cost analysis indicate SCR may be more cost effective than estimated by AGDC.

Combustion Turbines NOx BACT— AK LNG versus Agrium Inc.
AK LNG's industrial neighbor, the Agrium fertilizer plant, is also in the process of obtaining a PSD permit to restart its facility. Despite the fact that these facilities are on similar permitting timeframes, are located adjacent to one another and each propose to install new combustion turbines, there is a significant discrepancy in the NOx BACT determinations between these sources.[5] Agrium U.S. Inc. proposes to install SCR as BACT for their five 55.4 MMBtu/hr Solar Turbines.[6] However, AGDC has concluded that the same technology is not economically feasible for the four 430 MMBtu/hr power generation turbines

[5] A fundamental precept of BACT is that similar emission units in similar situations should have similar emission limits, unless it is demonstrated that there are significant differences; that demonstration has not been made.
[6] While we agree with the determination that SCR is BACT, we continue to recommend that lower NOx emission limits are achievable for the Agrium emission units, as evidenced by the vendor quote obtained by AK LNG for their turbines.

and six 1164 MMBtu/hr[7] compressor turbines at the liquefaction facility. Based on the TARs, ADEC proposes to approve each of these determinations.

We note that the Agrium Solar turbines are much smaller units than those proposed for the AK LNG liquefaction facility. In general, the "economy of scale" concept indicates that the smaller the unit, the lower the potential emissions reduction and the less cost-effective a measure becomes on a $/ton basis. While we do not have a cost evaluation for SCR on the Agrium turbines (a cost analysis is not required if a top-level control is selected), it is likely more expensive per ton of NOx removed to control the Agrium turbines than to control the AK LNG liquefaction facility turbines, calling AGDC's economic feasibility determination into question.

Combustion Turbines NOx BACT—Cost Thresholds Set by Other States

Notwithstanding the lower cost effectiveness estimates we provide below, we note that the cost estimates provided by ADEC and AGDC in their most recent November 5, 2020 revisions to their cost estimates are well within the range of BACT cost effectiveness thresholds used by other states:

- Pennsylvania: In their 2018 Technical Support Document for Revisions to the General Plan Approval and/or General Operating Permit for Natural Gas Compressor Stations, Processing Plants, and Transmission Stations, PA set a $10,000/ton cost effectiveness threshold for SCR on turbines and reciprocating internal combustion engines. This document concluded that "SCR is BAT for turbines greater than or equal to 15,900 bhp" (BAT is Best Available Technology). Accordingly, the PA Department of Environmental Protection (DEP) established a General Permit NOx limit of 2.0 ppmvd for turbines equipped with SCR[8] in the 15,900 HP or greater size class and noted that stack tests demonstrate NOx emissions from turbines in this size range equipped with SCR are capable of achieving emissions in the range of 1.6 to 1.8 ppmvd. The turbines located at the AK LNG facility are significantly larger than 15,900 HP and well within the size range determined by PA DEP to be cost effective for SCR. We also note that PA DEP's general permit rule applies to turbines utilized in load-following applications including natural gas compression turbines at compressor stations and gas processing plants and are similar to the turbines at the liquefaction facility.
- Texas: In their recently released draft Regional Haze SIP, Texas identified a $10,000/ton threshold for BACT determinations. "For the upper-end of the cost thresholds, $10,000 per ton of NOX and of SO2 emissions reduced was considered because this threshold may be used for permitting new, modified, and reconstructed sources of air pollutants under the New Source Review (NSR) air permitting program."
- Colorado RACT: CDPHE has utilized a $12,000-$19,000/ton cost threshold in several recent RACT determinations (CDPHE, personal communications, 2020).
- New Mexico: Recent permit applications submitted to the NM Environment Department for combustion turbines at oil and gas sources reflect a proposed NOx BACT limit of 2.0 ppmvd with SCR, including the XTO Husky Central Delivery Point.
- Reasonable Progress Analyses: Finally, we have begun reviewing reasonable progress four factor cost analyses prepared for sources throughout the country. Not all states have set cost thresholds for the second round of Regional Haze planning, but we have seen several states propose or recommend cost thresholds in the range of $5,000 up to $10,000 per ton for *retrofits*. Retrofit thresholds set by states are usually lower than thresholds established for new or modified sources, as retrofits are generally imposed upon a source that is not otherwise undergoing any proposed

[7] Note the heat input values reported for the LF facility turbines reflect rated capacity and therefore do not match those reported in the pre-permit and pre-TAR, which reflect "the rating for each unit at the yearly average ambient temperature for the Liquefaction Plant of 40°F." Our analysis reflects the rated capacity as reported by the applicant and used in the applicant's BACT analysis.

[8] PA DEP established a dual BAT limit for turbines in this size class with "emission limits of 9.00 ppmvd for NOX uncontrolled and 2.0 ppmvd for NOX through use of SCR."

physical operational change. Yet, in many of these states, retrofit thresholds appear to be higher than what AGDC would consider cost effective for a greenfield source.

Combustion Turbines NOx BACT— Results

We summarize our estimates below, along with AGDC and ADEC reported results. (Note: The AGDC reported values are the revised results provided in the summary table in a 11/9/2020 email from Lisa Haas with AGDC to Dave Jones with ADEC.) Documentation of our various analysis assumptions are provided in the following sections.

- Liquefaction Facility Power Generation Turbines:
  - Our initial results – **<u>$5,873/ton</u>** to **<u>$6,041/ton</u>** NOx removed (2019$) using TCI based on EPA default method in the CCM, 7th edition and TCI based on revised vendor quote calculations
  - Our revised results—**$7,840/ton** NOx removed (2019$) using TCI based on revised vendor quote calculations and AGDC 11/5/2020 revised electricity costs.
  - AGDC result: $10,759/ton NOx removed (2017$)
  - ADEC result: $9,878/ton NOx removed

- Liquefaction Facility Compression Turbines:
  - Our initial results – **<u>$4,319/ton</u>** to **<u>$4,987/ton</u>** NOx removed (2019$) for TCI based on EPA default method in the CCM, 7th edition for an SCR inlet temperature of 730˚ F and 970˚ F, respectively, and **<u>$4,383/ton</u>** to **<u>$5,051/ton</u>** NOx removed (2019$) for TCI based on revised vendor quote calculations and an SCR inlet temperature of 730˚ F and 970˚ F, respectively.
  - Our revised results—**$6,237/ton** NOx removed (2019$) using TCI based on revised vendor quote calculations and AGDC 11/5/2020 revised electricity costs.
  - AGDC result: $10,506/ton NOx removed (2017$)
  - ADEC result: $10,519/ton NOx removed

As noted above, the revised cost estimates, including some of ADEC's own revised estimates, are within the range of cost-effective thresholds established by other states for BACT determinations (and, in some cases, analysis of retrofits).

Combustion Turbines NOx BACT—Documentation of Our Technical Evaluation:

We completed our cost analyses using the EPA Control Cost Manual (CCM) Section 4, Chapter 2 – SCR 7th edition. Two scenarios were used to estimate the Total Capital Investment (TCI) in our estimates. The first scenario used the appropriate EPA default TCI equation provided in the 7th edition CCM.

The second scenario used the vendor quotes provided in Appendix C.1, AeriNOx SCR Quote (January 2020) of AGDC's BACT Information Request Response, along with adjustments to the applicant's TCI calculations (CCM 6th edition) to override the estimates in the EPA 7th edition method TCI calculations. AGDC contends that their 6th edition CCM estimates "are likely more accurate for the Alaska LNG Project than the 7th edition results, because the 7th edition has limited capability for the user to enter site specific information. Site-specific conditions for both the GTP and the Liquefaction Facility are significantly different from the 'standard' EPA model because of the increased transportation requirements to get equipment to Alaska and the operating conditions."[9] We reviewed the applicant's TCI calculations under their CCM 6th edition analysis. While we agree that vendor quotes are likely more reliable than study-level estimates, AGDC added many non-site-specific construction costs using "CCM defaults" to their vendor quote information. We found that the applicant was likely double counting some TCI fees by including CCM default calculations for line items that were also included in the vendor

[9] While it is likely that the cost of transporting equipment into the interior of Alaska is relatively high, both the Agrium and the AGDC LF facilities are located immediately on the Cook Inlet with easy access to shipping.

quote. Several fees appeared to be unreasonably escalated without adequate documentation. We revised the TCI estimates using the vendor quotes accordingly. Our revisions to the applicant's TCI calculations are documented in the spreadsheets for each type of turbine in the "Vendor_TCI_Estimate-revised" tabs. ***It is worth noting that the results of our revised TCI estimates based on the vendor quotes are roughly equivalent to the EPA default method for calculating TCI in the 7th edition CCM.***

Summary of Other Analysis Changes:

- **Interest Rate** – The applicant used a 7% and 5.5% interest rate in their Control Cost Manual 6th edition analysis and Control Cost Manual 7th edition analysis, respectively. In our analysis, we reduced the interest rate to 3.25% (The ADEC analysis also used the bank prime rate).

    - Basis for change: Section 1 – Introduction to the EPA Control Cost Manual (CCM) recommends the use of the current bank prime rate, which has been at 3.25% for the past seven months with little likelihood of changing in the near future.

- **Reagent Costs –** In our analysis we reduced the ammonia costs from $2.24/gal for 19% aq. to $0.167/gal for 19% aq. (The CCM default for a 29% ammonia solution is $0.293/gallon.)

    - Basis for change: AGDC's 12/3/2019 BACT information request response on pdf page four in the "LNG Assumptions" section states "Ammonia cost based on $0.30/pound (Weekly Fertilizer Review, 4/2015)." We point out several flaws in this assumption:

      First, it appears that this assumption is *not* based on a vendor quote. Instead, AGDC is relying on outdated publicly available (although difficult to find) commodity pricing provided by an online agriculture industry magazine. If you compare AGDC's $0.30/pound ($600/ton) 2015$ estimates for ammonia to the USGS commodity pricing source cited in the 7th edition SCR CCM chapter, costs are roughly similar, with USGS reporting average annual ammonia costs in the $470-$530/ton range in the 2014-2015 timeframe. As such, these commodity pricing estimates are outdated. Furthermore, the 2015 "Brenntag quote" cited by AGDC in their "GTP Assumptions" and provided in Appendix C.2 appears to be a cost calculation sheet provided by a consultant (URS) as opposed to an actual vendor price quote and is specific to the GTP, not the liquefaction facility.

      Our liquefaction facility analysis updated the ammonia commodity pricing to reflect the 2019 cost year used in our analysis ($230/ton). We relied upon the USGS source cited in the 7th edition SCR CCM chapter,[10] as it appeared this was no less applicable than Fertilizer Weekly review and because AGDC did not provide a reference or link for their estimates. Therefore, we could not replicate or find this information in the Weekly Fertilizer Review source cited.

      Second, it appears that the applicant did not correctly convert from $/lb (or $/ton) pure NH3 costs to $/gal because they did not account for the solution concentration in the conversions, which significantly inflates the $/gal costs of the reagent, as provided for in the EPA 7th edition SCR CCM chapter. This is based on information provided in Appendix C.2, as well as on page 4 of the January 10, 2020 BACT Cost Effectiveness information request response. For instance, on page 4, the applicant notes that reagent costs for the LNG facility (CCM 6th edition inputs) are $0.30 per pound or $600/ton of pure NH3 (2015 cost year – again, this value is roughly two and a half times higher than the recent national average of $230/ton for

[10] https://www.usgs.gov/centers/nmic/nitrogen-statistics-and-information

2019).[11] Following the methodology in EPA's revised 2019 CCM SCR Chapter, the $0.30 per pound cost would convert to $0.437/gal after accounting for 19% solution (See Figure 1 below and rows 51-80 in the INPUTs_Conversions_Data_Sources tab in the attached spreadsheets for EPA's conversion calculations).

- **Cost Year:** We changed the cost year from 2017 to 2019 using CEPCI. This would have the effect of increasing the costs relative to AGDC's.
- **Electricity Costs** - We performed several analyses with a range of estimated electricity costs ($0.0244/kWh to $0.103/kWh), as compared with the applicant's estimate of $0.127 to $0.16/kWh.[12]
  - <u>Basis for change</u>: The AK LNG liquefaction facility will generate power onsite with the four power turbines firing pipeline natural gas.

    AGDC will not pay utility power usage fees. We recognize that despite this, there will likely be electricity costs incurred by the applicant due to natural gas usage that would otherwise be a salable product, as well as operating and maintenance costs associated with the power generation turbines. In initial reviews, we attempted to account for this using EIA spot prices for fuel (EIA, $2.56/MMBtu)[13] and natural gas usage in the power turbines generating onsite power. Based on our initial input, AGDC revised their electricity costs at the request of ADEC. We note that AGDC has not provided rigorous justification for their revised cost estimates. Nonetheless, we revised our analysis to use the low end of AGDC's estimates for electricity costs at $0.103/kWh. We used the lower end of the range because this is more in line with electricity cost estimates used in the Agrium BACT analysis.[14] The Agrium application used an electricity cost estimate of $0.101/kWh. Like AGDC, the Agrium facility will operate combustion turbines for on-site power production—the Agrium pre-tar states "electrical power comes from gas turbine generators and by purchase from a local utility." However, unlike the AK LNG facility, Agrium will be required to purchase natural gas and some fraction of their electrical needs from an outside supplier. Yet, Agrium's estimated electrical costs are lower than AGDC's low-end estimates. AGDC has not provided addition documentation to verify these estimates. Accordingly, we used the low end of AGDC's estimates.
- **SCR Inlet Temperature:** We revised the SCR inlet temperature for both the power turbines and the compressor turbines.
  - <u>Basis for the assumption:</u>
    - <u>Power Turbines</u>: The applicant used an SCR inlet temp of 314˚ F. However, we note that the PG turbines are operated in combined cycle mode. The inlet temp assumed by the applicant is the same as the stack exit temperature used in the modeling analysis and likely represents the stack exit temperature following the Heat Recovery Steam Generator (HRSG). Generally, in a combined cycle

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[11] The AGDC analysis did not provide an actual vendor quote, but assumed an NH3 cost that is roughly two and a half times higher than the national average. USGS commodity pricing summaries reflect an average NH3 cost of $230/ton in 2019. We note that (1) the liquefaction facility is located adjacent to a fertilizer processing plant, a potential local source of NH3 that intends to restart in the near future, and (2) if NH3 cannot be obtained locally, the facility has a co-located shipping port. Either way, the ARD analysis assumed a $/ton commodity price equivalent to the national average for 2019.

[12] In a November 5, 2011 memorandum, AGDC revised their electricity costs in response to staff level input from the NPS.

[13] Reported value from EIA, and represents the average of the daily closing spot prices for natural gas at the Henry Hub in Louisiana. Spot prices were used rather than industrial consumer prices, as the fuel utilized at the source is a salable product. https://www.eia.gov/naturalgas/monthly/pdf/table_03.pdf

[14] See the electricity cost estimates in the Agrium BACT VOC and CO control costs analyses.

configuration, the SCR is placed between the turbine and the HRSG, and thus the SCR inlet temperature would be ideal for SCR operating efficiency (roughly 730˚ F).

- Compressor Turbines: The applicant assumed an SCR inlet temp of 970˚ F. The analysis was run with the applicant's inlet temperature assumption as well as a revised inlet temperature of 730˚ F to reflect either the addition of tempering air or the use of high-temperature catalyst (which is not accounted for in the workbook). Results are similar and are reported below.

- **Controlled and Uncontrolled Emission Rates**: We assumed the same uncontrolled and controlled emission rates as the applicant.
  - Basis for the assumption: The applicant assumed a controlled NOx rate for all turbines of 2.0 ppmvd @ 15% O_2 based on a vendor quote provided in Appendix C.1 to the January 10, 2020 BACT Cost Effectiveness information request response. We used the same emission rate because it is based on a vendor guarantee. For the uncontrolled emission rate, we note that AGDC has not identified the specific type of turbine to be constructed. Therefore, pre-control emissions could be higher than the 15 ppmvd assumed by AGDC (up to 25 ppmvd). Nonetheless, our analysis assumed the 15 ppmvd uncontrolled rate. If the turbine ultimately selected has a higher uncontrolled rate of 25 ppmvd, it would result in a higher control efficiency (92%) and a lower cost effectiveness estimate.

Examples of reagent cost calculations using calculation methods presented in the 7th edition EPA CCM chapter on SCR (see spreadsheets for additional detail):

Figure B-1: AGDC Reagent Cost Assumptions & Calculation Corrections for the LNG Facility.

Conversions for NH3 Reagent Costs (if given NH3 costs in $/ton using USGS source referenced in CCM**)

99.5 % Anhydrous conversion from pure NH3:	
600	$/ton pure NH3
0.3	$/lb pure NH3
11.45	$/ft3 (Anhydrous) density
1.53	$/gal NH3
1.52	$/gal 99.5% NH3 solution

29.4% Aqueous conversion from pure NH3:	
600	$/ton pure NH3
0.3	$/lb pure NH3
16.83	$/ft3 (29% Aqueous) density
2.25	$/gal NH3
0.662	$/gal 29% NH3 solution

19% Aqueous conversion from pure NH3:	
600	$/ton pure NH3
0.3	$/lb pure NH3
17.19	$/ft3 (19% Aqueous) density
2.30	$/gal NH3
0.437	$/gal 19% NH3 solution

50% Urea Conversion	
600	$/ton Urea
0.3	$/lb Urea
21.30	$/ft3 Urea
2.85	$/gal Urea
1.424	$/gal 50% Urea Solution

NH3 Densities		
19% Aqueous:	57.3 lb/ft3	7.66 lb/gal
29% Aqueous:	56.1 lb/ft3	7.50 lb/gal
99.5% Anhydrous:	38.15 lb/ft3	5.10 lb/gal
50% Urea:	71 lb/ft3	9.49 lb/gal

Pure NH3/Urea Costs:	600	$/ton**
Commodity Year:	2016	
Select NH3/Urea Type:	29.4% Aqueous	

Conversion checks using EPA CCM default assumption of $0.293:

Calculation Back Check If given $/gal - CCM Default back calculate:

266	$/ton NH3	**2016**
78.1	$/ton 29% aqueous solution	
0.039	$/lb	
2.19	$/ft3	
0.293	$/gal	
700	$/ton Urea	**Year?**
349.8	$/ton 50% Urea solution	
0.175	$/lb	
12.42	$/ft3	
1.660	$/gal	

**USGS NH3 commodity price statistics (cited in CCM SCR Chapter): https://www.usgs.gov/centers/nmic/nitrogen-statistics-and-information

Annual Emission Limits and Flares

We recommend that the draft permit is revised to include annual emission limitations (in tons per year) for all criteria pollutants. In addition, the potential flaring emissions from this facility are considerable. We recommend that any best practices identified in the "flaring minimization plan" (which is to be completed prior to operation) are made enforceable by ADEC through the permit conditions and that the state consider short-term operational limits for the flares.

Attachment C: NPS Authorities and Obligation to Comment on PSD Permits that May Affect Class I Areas

The 1977 Amendments to the Clean Air Act:

- Established the Prevention of Significant Deterioration (PSD) preconstruction permit program. The Alaska Department of Environmental Conservation (ADEC) is responsible for issuing PSD permits in the state under an EPA approved CAA state implementation plan (18 AAC 50.306).

- Designated Denali National Park (along with 48 other NPS units) as a *Class I area*. Class I areas are afforded additional protection and consideration under provisions of the Act.[15]

- Specified roles and responsibilities for the Federal Land Managing Agencies (FLMs) to ensure Class I protection goals are achieved (42 U.S.C. §7475):

    - Permitting authorities "*shall provide notice of the permit application to the Federal Land Manager and the Federal official charged with direct responsibility for management of any lands within a class I area which may be affected by emissions from the proposed facility*." (§7475 (d)(2)(A))

    - FLMs "*shall have an affirmative responsibility to protect the air quality related values (including visibility) of any such lands within a class I area and to consider, in consultation with the Administrator, whether a proposed major emitting facility will have an adverse impact on such values*." (§7475 (d)(2)(B))

    - Congress clarified its intent with respect to the FLM's CAA role in Senate Report No. 95-127, 95th Congress, 1st Session, 1977: "*The Federal Land Manager holds a powerful tool. He is required to protect Federal lands from deterioration of an established value, even when Class I [increments] are not exceeded. ... While the general scope of the Federal Government's activities in preventing significant deterioration has been carefully limited, the FLM should assume an aggressive role in protecting the air quality values of land areas under their jurisdiction. In cases of doubt the land manager should err on the side of protecting the air quality-related values for future generations*."

[15] Initial classifications included national parks over 6, 000 acres and national wilderness areas over 5,000 acres that were in existence on August 7, 1977. The result was 158 "mandatory" Class I areas, managed by the National Park Service, the U.S. Fish and Wildlife Service (FWS) and the U.S. Forest Service. Tuxedni Wilderness, managed by the FWS, is also potentially affected by the AK LNG Liquefaction facility.