AIR SCIENCES INC.

Response to EPA R10 March 11, 2009, Letter of Incompleteness

PREPARED FOR:
SHELL OFFSHORE INC.

PROJECT NO. 180-15
MAY 18, 2009

Shell Offshore Inc.
3601 C Street, Suite 1314
Anchorage, AK 99503

May 18, 2009

Ms. Janis Hastings
Associate Director
United States Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, Washington, 98101

Re: Response to EPA Region 10 March 12, 2009 2nd Letter of Incompleteness - Revised Preconstruction Permit Application for Frontier Discoverer Drillship in Chukchi Sea, Alaska, beyond the 25-mile Alaska Seaward Boundary

Dear Ms. Hastings:

Shell has reviewed EPA Region 10's (R10's) 2nd Incompleteness Determination Letter dated March 12, 2009, and hereby submits a response in the form of: 1.) the attached revised impact sections of the application, and 2.) the attached keyed-responses to Attachments A and B of the 2nd Incompleteness Letter, which includes references to various meeting, telephonic and electronic communications between Shell and R10 that have been utilized to assist in issue clarification and resolution. This mutually-agreed-to response format captures the extent and cooperative spirit of our consultation and coordination since March 12, 2009.

As you know, Shell is seeking this pre-construction permit to allow for drilling in the Chukchi Sea in 2010. The original permit application dated December 11, 2008 (received at R10 December 19) was deemed incomplete by R10 on January 16, 2009. Shell responded to this 1st Incompleteness Determination on February 24, 2009, and then received the 2nd Incompleteness Determination on March 12, 2009.

Shell sincerely appreciates R10's efforts over the last 55 days to enhance management communication, resolve technical completeness issues, and realize scheduling efficiencies. We are hopeful that this investment of time results in further optimization of the permit-processing schedule that will provide for alignment of Shell's commitment milestones for 2010 drilling and R10's issuance of the final permit. An updated timeline illustrating issues related to alignment of these events (see Shell and R10 Final Permit Issuance dates) is attached, and as we move on with the permit writing process, we look forward to discussing additional ways to align those milestones with permit issuance. . As a courtesy, the timeline also includes a second permit application for the Frontier Discoverer while operating in the Beaufort Sea. That application should be submitted to R10 later this week, but it is included here for semi-parallel permit processing planning.

As you know, a significant incompleteness issue was resolved when R10 was informally notified by e-mail (April 29, 12:20p) that Shell no longer is basing its application on an ambient air boundary associated with a safety zone, although the safety zone is likely to become a part of the exploration program. The ambient air boundary is considered to be the Discoverer's hull for purposes of this application.

We believe that today's response addresses all of the issues listed in R10's March 12, 2009 Incompleteness Letter, Attachments A and B, but we would also like to acknowledge our mutual resolution of the emissions inventory and modeling procedures. The consequent emission inventory is included as Attachment D and remodeled impacts are included as Attachment E. Digital files have been sent to R10. These impact results show compliance with the ambient and incremental standards and reflect the final impacts. We have also responded to the additional source and model-related questions that have arisen subsequent to the March 12 incompleteness letter in the form of prior e-mail transfers of information. A list of the e-mails is included as Attachment C.

You will note that additional detail has been provided regarding the project, clarification of acceptable modeling methods, and revisions of emission factors to address R10's issues identified since the February 24, 2009 revised permit application. These are documented in the e-mails listed in Attachment C. The significant changes to our application include:

1) Reset of our ambient air boundary to the hull of the Discoverer,
2) Re-characterization of the ice management fleet exhaust release parameters for modeling purposes,
3) Removal of the Kapitan Dranitsyn from the list of candidate ice management vessels,
4) Definition of a hypothetical maximum emission (and impact) ice management vessel for permitting purposes to allow for the use of any lower-emitting unit, and
5) Quantification of emissions from associated activities.

Please contact Mark Schindler (907-230-8632), Rodger Steen (303-807-8024), or me (907-646-7112) for any additional detail R10 should need related to this application. We appreciate your attention to this additional application material, and its time sensitive nature.

Sincerely,

Susan Childs
Regulatory Affairs Manager, Alaska Venture

Attachment:

cc: *Pat Nair, EPA R10 (Boise)*
Herman Wong, EPA R10
Nancy Helm, EPA R10
Rob Wilson, EPA R10
Jeff Walker, MMS-Alaska Region
Lance Tolson, Shell
Cam Toohey, Shell
Keith Craik, Shell
Mark Schindler, Octane, LLC
Eric Hansen, Environ
Rodger Steen, Air Sciences Inc.

ATTACHMENT A

Shell Responses to EPA's March 12, 2009 Attachment A Issues

Attachment A – Shell Responses to EPA's March 12, 2009 Attachment A Issues

Air Quality Impact Analysis Comments to
Outer Continental Shelf Pre-Construction Air Permit Application
Frontier Discoverer Chukchi Sea Exploratory Drilling Program
Dated February 23, 2009 and Received by EPA on February 24, 2009

A. Ms. Susan Childs, Shell Offshore Inc. letter of 23 February 2009 to Mr. Richard Albright, U.S. EPA Region 10.

The Shell cover letter makes reference to EPA's concerns contained in the 12 November 2008 modeling protocol. It should be noted that while EPA received and reviewed the modeling protocol, written comments were never provided to Shell to consider prior to the submission of the 11 December 2008 Prevention of Significant Deterioration (PSD) application for the Frontier Discoverer drill ship to conduct exploratory drilling in the Chukchi Sea. *Noted.*

B. Section 1, Introduction

Shell states that it will limit its drilling activities to current lease blocks. Figure 1-1 highlights the lease blocks at the Burger prospect. Please provide a close up graphic and a table listing (including coordinates) all lease blocks within Burger where Shell expects to drill. *Three copies of an enlarged map were mailed to Mr. Nair on January 24, 2009. A table of the lease block centriod coordinates has been e-mailed to EPA on March 20, 2009.*

C. Section 2, Project Description and Emissions

1. The emission rates used in the modeling analysis should be based maximum one hour rates. Please clarify from page 20 what is meant by the sentence "For purposes of dispersion modeling, the short-term PM and NO_x emissions represent maximum 24-hour values because the impact standards are averaged over 24 hours or longer." *The emission rates are based on maximum one-hour rates with adjustments made to the NOx and PM emissions to account for daily ORRs. For example, the PM emission rate for the cementing units is calculated as the maximum hourly rate multiplied by 0.3 to account for the 30 percent daily use restriction on those units.*

2. A discussion of baseline concentrations, major and minor source baseline dates, and trigger dates for applicable air pollutant should be included in the application. *EPA committed to addressing the air quality control region (AQCR) that applies to the Chukchi Sea in the December 23, 2008 meeting and again in the January 20, 2009 meeting. EPA has not yet provided Shell a determination of which AQCR this project is to be located within. For this permit application, Shell assumes that the AQCR is the entire Chukchi and Beaufort Seas combined, beyond the 25-mile Alaska seaward boundary, which is one logical jurisdictional boundary. There have been no sources permitted previously in this AQCR, so although all major source trigger dates have passed, the minor source baseline dates for NOx, SO2, and PM have not yet been triggered and no increment has been consumed.*

3. Please confirm that there will be no venting of any air pollutants into the atmosphere from exploratory wells. *Shell neither anticipates nor is planning for well venting.*

D. Section 5, Ambient Impacts

1. To demonstrate compliance with National Ambient Air Quality Standards (NAAQS) and air quality increments, Shell states that it is only subject to the requirements identified in 40 CFR Part 52.21(k) and (o). In actuality, Shell is subject to 40 CFR Part 52.21(k) through (p). *The application, in fact, addresses all of these requirements, confirming Shell's acknowledgement that all are required.*

2. The ISC-Prime model is not an EPA guideline model. Hence, R10 approval is required for its application in demonstrating compliance with NAAQS and increments. Please confirm in the application addendum. *We acknowledge that ISC-Prime is not a guideline model, but that it has previously been approved for use in the permitting of the Kulluk as a minor source and that it has been the primary dispersion model for Shell's Alaska OCS air permitting efforts, in consultation with R10, for 3 years.*

3. Table 5-1 lists the NAAQS and air quality increments for applicable air pollutants. For completeness, the table should also include ozone and lead, and Class I increments. *The ozone and lead standards are added to Table 5-1 of Attachment E. Per the April 6, 2009 meeting, EPA recognized that Shell is not required to evaluate Class I impacts since the project locations are well beyond the 300 kilometers (FLM distance of concern and upper limit of Calpuff model) from the nearest Class I areas. Regarding Class I issues, EPA clarified that it only wants Shell to notify the FLMs of the project. Shell believes that the addition of Class 1 increments to Table 5-1 would be confusing because they do not apply anywhere near the Chukchi Sea and Shell is not required to perform a Class I impacts analysis. Thus, the standards listed in Table 5-1 of Attachment E apply to Class II areas only.*

4. Each proposed ship will be represented as a volume source in the ISC-Prime modeling. As a result, R10 recommended the volume source height will be based on the lowest plume height of each ship. To find this height, Shell ran the SCREEN3 model using its full set of default meteorology. Shell's findings are listed in Table 5-2 for each ship. R10 has determined that these plume heights are not the minimal heights.

   Shell is requested to re-calculate the lowest plume height of each ship using the SCREEN3 model and meteorology consisting of D stability and a 20 meter per second wind speed. Shell is also requested to update the ISC-Prime modeling results in which the lowest plume height is not used for the height of the volume source. This would include text, tables, and graphics in the application. *The modeling analyses have been rerun to consider only meteorology consisting of D stability and a wind speed of 20 meters per second. The relevant updated text, tables, and modeling files are updated and included as part of Attachment E.*

5. Since the ISC-Prime modeling will have to be redone, R10 also recommends that the sigma-z's be based on the model user's guidance. *The sigma-z values are revised and are now based on the building height for each ship divided by 2.15, which is consistent*

with the ISC and AERMOD User's Guides. These values are provided in the revised Table 5-5 of Attachment E.

6. An Appendix D is contained in the application but not referenced in any of the sections. Please clarify. *Appendix D files are SCREEN3 model output for the loads analysis for the ships, as stated on the appendix title. Final plume rise (1,000 meters downwind from ships) from these files is utilized in the loads analysis for the ships which is summarized on Page 4 of Appendix B and expanded and included in Attachment E herein (Discoverer page 4).*

7. In Table 5-6,

a. please include ozone in terms of VOC and/or NO_x emission rates. *EPA has clarified that this comment was intended to ask Shell to address significant monitoring concentrations for ozone and that inclusion of this information in Table 5-6 is not appropriate. EPA is asking that Shell add a note in the Attachment E recognizing that ozone monitoring is required for the project since emissions of NOx from the project exceed 100 tons per year. The appropriate language has been added in Attachment E.*

b. please show the actual predicted distance even if greater than 50 kilometers. *As stated in Section 5.7 of Addendum E, utilization of a maximum SIA distance of 50 km is consistent with EPA modeling guidance and the Guideline on Air Quality Models (40CFR 51, Appendix W).*

8. When deemed complete, this application will likely establish the minor source baseline date for sulfur dioxide, nitrogen dioxide and particulate matter in the air quality control region. Please discuss the boundaries of the air quality control region and the minor source baseline date implications in more detail as it applies to Class II air quality increments. *In the December 23, 2008 and January 20, 2009 meetings between Shell and EPA, EPA agreed to define the AQCR and that has not yet formally occurred. Shell has addressed the baseline dates and increment consumption based on informal EPA information in our response to C. 2. above.*

9. The method used to derive concentrations based on owner requested limits is confusing. The explanation assumes 84 days for two drill sites. Please clarify. *The 84-day limit at each drill site has been eliminated from the ORRs and impact permit analyses. Other ORRs remain and they are treated in the following way. HPU and MLC engines have more restrictive limits of the seasonal fuel equivalent of 63 days of operation at engine capacity and the ice management fleet is restricted to a seasonal NOx emission limit, converted to a fuel limit based on a measured NOx emission factor.*

   First, the model is run to calculate the one-hour maximum impacts with all sources included at maximum emissions (called the "all" model runs) and these impacts are used to calculate maximum short-term impacts (one-, three-, and 24-hour maximum impacts). The annual impacts are estimated by multiplying the one-hour impacts by the annual persistence factor of 0.1, then ratioing these impacts by the days per year of operation to the full length of the year (365 days). Thus, the ratio of 63/365 for the HPU and MLC engines is used to calculate the annual impact. The number of days needed for the ice *management fleet to emit up to the NOx limit (1699 tons), is divided by 365 to calculate the annual ice management fleet impacts.*

Operationally, the annual impacts for the HPU and MLC engines are accomplished for the 168-day period by calculating the 1-hour impacts from all sources at maximum emissions then adjusted for a 63-day period. Then the model is run again calculating the one-hour concentrations from all sources at maximum emissions except the HPU engines, MLC air compressors, cranes, resupply vessel, OSR fleet, and ice management fleets (called the "No xxd" model runs) and then adjusting impacts by (168 days - 63 days)/365 days. The sum of the impacts from these two model runs for each pollutant represents the maximum combined impact for one drill site for the 84-day period. The same method is used for the impacts from the ice management fleet.

The files associated with this discussion are located in the "3_Final Disco Impacts" subfolder of the "ISC-PRIME Files" folder on the CD. These impacts are read into the EXCEL spreadsheet, Disco_v10_i10d2_Impact_Summary_051709_EPA.xls, where the calculations are performed as described above.

E. Section 6, Baseline Concentration

1. R10 will use the six months of air quality data collected at Wainwright to represent background air quality levels at the Burger prospect and for determining compliance with NAAQS. To determine data acceptability, Shell should submit:

    a. the six data collection monthly summaries,
    b. at least two quarterly audits reports, and
    c. a CD containing the hourly measured data of all gaseous air pollutants and the 24-hour average particulate matter concentrations. *OK.*

2. For any measured air quality data that may be missing or bad, please identify the code (e.g., 8888, 9999…etc.) used to indicate this type of data. *OK.*

3. Table 6-2 contains air quality measurements at Wainwright during the months of November and December 2008. Please explain how the annual average values were derived. *The annual average values for the Wainwright data are based on the highest monthly values for November through February 2009 data. The revised background table is provided in Attachment E, Table 6-2.*

F. Additional Impact Analyses

1. Please discuss the chemistry and formation of ozone in Subsection 8.4. *Language describing the basics of ozone formation is provided in the Attachment E.*

2. Please conduct a Class II visibility analysis using the VISCREEN model that is available from EPA SCRAM web site. This request is made pursuant to 40 CFR Part 52.21(o) and Section D in the October 1990 New Source Review Workshop Manual. A qualitative discussion is inadequate when there is a model available to conduct a screening analysis. *As recommended by EPA in our January 20, 2009*

meeting, a qualitative analysis would be sufficient because there are no visibility standards for the region to compare the results to. Such a qualitative analysis is presented in the revised application, which satisfied the rule quoted above. The drill sites are located more than 50 km from shore, beyond where people might see plumes and there is no nearby Class 1 area (visibility-sensitive area). Accordingly, quantification of impacts would not be meaningful for any purpose.

G. CD-ROM Files

1. Executables

The ISC-Prime program was modified to accept more than 1200 receptor points and more than six source groupings. Please run the modified ISC-Prime program using the test input file to confirm that the changes did not affect the model predictions. *The requested test runs for the different compiled versions of ISC-PRIME are provided on the CD. There is an insignificant difference in predictions between EPA's version and Shell's versions which is attributable to the differences in compilers utilized.*

2. ISC-Prime Files

a. All ISC-Prime model input files not using the lowest plume height of a ship to represent the height of a volume source will have to be revised and the model rerun with the correct information. See G.4 below. The initial sigma-y and sigma-z values will also need to be recalculated. *Please see response to comment D.4 above.*

b. The ISC-Prime runs do not include simultaneous operation of other sources. This would include the resupply ship and the 34-boats operating for eight hours. At a minimum, please include these operations in your modeling. *The ISC-PRIME runs include simultaneous operations of <u>all</u> sources. Simultaneous operations of all sources are provided in the ISC-PRIME files with "all" in the file names. These files are located in the "3_Final Disco Impacts" subfolder of the "ISC-PRIME Files" folder on the CD. These impacts are read into the EXCEL spreadsheet, Disco_v10_i10d2_Impact_Summary_051709_EPA.xls.*

c. Shell stated that the Frontier Discoverer will be aligned such that the bow will continuously face the prevailing wind direction. As a result, only a 270 degree wind direction is contained in the meteorological data file. Please discuss how much change in the wind direction before the Frontier Discoverer realigns itself to the new prevailing wind direction. Depending on the response, R10 may require to Shell model at the prevailing wind direction and at the prevailing wind direction plus the maximum change. *The Discoverer will be facing into the current wind, not necessarily the prevailing wind. The purpose is to minimize the need for ice management by minimizing the effective ship width as seen by the wind-driven flowing ice. Thus, for operational efficiencies, it is important to keep the bow into* *the ice floe. Frontier, the operator of the Discoverer, uses the rule of thumb that rig orientation should not exceed 15 degrees off ice drift direction over a short period of time, say one hour. Adjustments to orientation are made more than once per day and it is highly unlikely that it would be off this much and to the same side for an entire day.*

3. Results

Please identify which files contained in the ISC-Prime folder were read into the EXCEL Disco_v9_io3_impact_Summary_022309_EPA spreadsheet. *The plotfile (*.plt) output files read into the spreadsheet are from the "3_Final Disco Impacts" subfolder in the "ISC-PRIME Files" folder on the CD.*

4. SCREEN3 Files

The SCREEN3 meteorological input needs to be revised to incorporate R10's recommendation as described in its 16 January 2009 letter to Ms. Susan Childs and in above comment D.4. The volume source heights used to represent the ships are not based on the lowest plume heights calculated by SCREEN3. The lowest plume height is obtained by selecting D stability and a 20 meter per second wind speed. *Please see response to comment D.4 above.*

H. General Comments

1. Revised modeling runs and results should be provided on a CD-ROM. *Results are being provided with this analysis.*

2. Please provide all changes and updates as an addendum to the application. An errata sheet should also be provided to indicate the location of changes in the application. *The impacts are updated in Attachment E. Given the nature of changes in this analysis, where a single change in the beginning of the analysis, such as with an emission factor, carries through the entire analysis, much of the results have changed. Attachment E contains the changes in the impact sections of the February 23, 2009 application.*

ATTACHMENT B

Shell Responses to EPA's March 12, 2009 Attachment B Issues

Attachment B – Shell Responses to EPA's March 12, 2009 Attachment B Issues

Additional Comments to
Outer Continental Shelf Pre-Construction Air Permit Application
Frontier Discoverer Chukchi Sea Exploratory Drilling Program
Dated February 23, 2009 and Received by EPA on February 24, 2009

A. General Comments

Please provide copies of the Exploration Plan(s) for proposed Chukchi Sea operations. *As explained in Shell's February 23, 2009 revised application responses, Shell is not providing the Exploration Plan (EP) at this time because it has not yet been finalized for submission to the MMS. Upon submission to that agency, and their determination that it is a "public" document, Shell will be glad to provide it to the EPA for examination. If EPA is interested in particular sections of the EP as they may pertain to the air permit under review, please advise us and we will independently provide what information in those areas can be given EPA prior to the EP's submission to the MMS.*

Shell plans to submit the Chukchi Sea EP in the very near future. .

B. Introduction

Please provide complete details on all secondary emissions and associated growth, including the proposed activities at the shore-based locations identified in Figure 1-1. Emissions from these activities should be considered for inclusion in the modeling analysis. *Secondary growth could occur onshore and is discussed in the revised application, Section 2.1. The activities are those associated with personnel and equipment support of the operation of one offshore drilling vessel. Shell expects the Discoverer exploration activities to have essentially no increase in full-time population because Discoverer project employees who are not already permanent residents will leave the North Slope when off the vessel. Shell plans on leasing all of its on-shore facilities and at this time there is no plan for the construction of any new facilities. If there is any construction, it will likely be by a contractor and could be a storage building, the need of which will be determined by a local service contractor. Any buildings will probably serve multiple lessees. Shell expects to use leased aircraft and vehicles. Personnel will use existing commercial hotels, aircraft and vehicles.*

Emissions and consequent impacts for the heating on one 40,000 square foot storage building have been estimated and provided to EPA. These are also included in Attachment E. There is expected to be up to a maximum of three helicopter trips to the Discoverer per day, probably from Barrow. Each trip will involve about 1 minutes of engine operating at maximum power level while on the Discoverer deck. Emissions from this activity have also been estimated and provided in an April 14, 2009 e-mail to EPA.

C. Project Description and Emission Calculations

1. The application does not include all the pollutant-emitting activities associated with the project, e.g. drilling of relief wells, use of diverters, well control events, fuel tanks etc. Please provide detailed descriptions, emissions quantification and

include these emissions in the ambient air analysis, as appropriate. Please update the appendix to include all other pollutant-emitting activities addressed earlier in these comments. *In addition to the response Shell previously provided on this issue, responses discussing relief wells, diverters well control events and fuel tanks have also been provided in various e-mails. Fuel tank emissions are estimated to be less than 30 lb per year and the calculation is provided in the Attachment E.*

Regarding diverters, the diverter should be viewed in the same way as the SSBOP. It is an emergency protection device and not expected to be used except in the event of an influx, which is extremely rare, similar to the frequency of blowouts. The influx for which the diverter could be used could be fresh or salt water, or gas.

2. The application indicates that emissions calculations are not based on maximum emissions possible from the project. In some instances, emissions of some pollutants are greater at lower loads. Please provide a list of each emissions unit and pollutant emitting activity, and the following information: maximum physical rated capacity, minimum operating load/rate, normal operating load/rate, maximum operating load/rate, fuel/material usage at each of the three loads, and for each pollutant, the maximum emission rate at each rate. *There are no instances indicated in the revised application where emission unit emissions increase as loads decrease, as shown in Attachment E - Discoverer page 4. Emissions are calculated at maximum emission rate for each source unit under the activity resulting in greatest activity emissions to ensure that impacts are conservative.*

3. Please describe in detail exactly what instrumentation is already in place to support monitoring and recordkeeping efforts - for example, are the day tanks already equipped with totalizing, non-resettable, fuel meters. Please also address the precision of each monitoring instrument. *The instrumentation in place today is likely to change to match the needs of the permit conditions, so specifications of the present equipment are irrelevant. Shell will work with EPA to address the final necessary monitoring and recordkeeping instrumentation and specifications.*

4. Please explain for each emission unit whether the ratings presented in the appendices represent true, instantaneous maximum physical ratings or manufacturers' nominal ratings. *The revised application provides manufacturer's published nominal ratings.*

5. Please explain, for each emission unit, how maximum fuel consumption rates were determined. *The method of estimating fuel consumption for each emission unit is provided on each page of Appendix A, and on page 13 of 14 of Appendix B.*

6. For each emission unit, please list the minimum, normal and maximum loads during the project. List separately any usage that SOI believes is outside a "normal" operating scenario. *The maximum emissions are calculated herein. Section 2.18 and page 4 of Appendix B demonstrates that these result in maximum*

impacts. All other operating scenarios and associated net impacts will be lower than these and therefore will also be within standards.

7. For each emission unit/pollutant combination, please list the emission factor or emission rate at each of the minimum, normal and maximum loads during the project. List separately any usage that is of an unpredicted emergency basis. *See comment for item 6 above. Regarding emergencies, by definition, they are unpredictable and therefore cannot be described in any quantifiable way.*

8. It is not appropriate to use Tier II or III program limits as a representation of maximum emission rates. Please use a more suitable source for estimating emissions from these sources. *EPA has indicated that this is no longer an issue.*

9. Please provide a copy of the density and heat content analyses for the liquid fuels to be used on this project. *In the revised application footnotes 15 and 16 (located in Appendix F), Shell has provided copies of the density and heat content of marine diesel fuel available recently on the North Slope. Since the purchase of the fuel to be used with this source has not yet been contracted, nor refined yet, it is impossible to provide more accurate information.*

10. AP-42 does not provide a worst case assessment of emissions from the equipment associated with this project. The introduction to AP-42 cautions against using these values for permitting. SOI should contact manufacturers to determine worst case emission factors at each load (please provide copies of such communications) and conduct a review of other emission factors/rates to identify worst case emission factors and use those values in its analyses. Where other reliable data is not available, it may be appropriate to use the worst case emissions from the technical documents that support the relevant sections of AP-42. *Manufacturer and model-specific emission factors are used when available. When they are not, generic AP-42 emission factors are used, which is a common practice in permitting sources, especially small sources (under 5 tons per year). AP-42 emission factors are considered to be averages, and for a source such as the Discoverer with many engines, an average emission factor is an appropriate representation of the total emissions. EPA cautions in some of its guidebooks not to use the information for permitting, yet this caution does not govern in all situations with permitting. By way of illustrating the need for flexibility, Region 10 permitted an Idaho lumber company with larger emissions than those of the Discoverer, permit number R10T50200001 (Stimson Lumber Company), issued November 9, 2006 appropriately using AP42 emission factors, Oregon generic emission factors and "engineering judgment" for estimation of emissions throughout, which included a wood-burning boiler, a hog-fuel boiler, a sawmill and several other sources. This is but one example of many successful permit applications that use generic emission factors; therefore use of generic emission factors is in fact an acceptable means of estimating emissions when better data are not available.*

11. Please provide a copy of the operational parameters transmitted to DEC Marine. *The operational parameters to which the Caterpillar D399 tailpipe controls are*

designed are listed in (Appendix F, final reference, page 4) which is a D. E. C. Marine specification.

12. Please confirm that the vendor guarantees at least 70% control efficiency for all VOC emitted from the D399s. *D. E. C. Marine provides a statement of the typical VOC destruction efficiency range which is 70 to 90 percent (see text reference No. 1). This is not a guaranty.*

13. It is not clear how an hourly reading of engine emissions by the SCR control is adequate to control emissions from the engines, and minimize ammonia slip. Please explain how readings as infrequently as 4 times a day (i.e. hourly for each engine) are adequate where engine loads are subject to rapid change. *As described in the revised application, text reference 1, there are hourly checks of each engine's NO_x emissions. This is equivalent to 24 checks per engine per day. But, more importantly, the SCR system regulates the ammonia injection continually based on load. The hourly checks are used essentially to improve the load / ammonia injection algorithm.*

14. Please provide schematics showing how the SCR system will be installed into the Discoverer. *The schematics for the SCR converter are located at the end of Appendix F (as described in the February 23rd response to EPA comments, Attachment B, part F, item 25.)*

D. Ambient Impacts

1. Please provide a description of the legal authority for the ambient air boundary proposed by SOI. Explain when the safety zone will be in force. *Shell now demonstrates compliance with the ambient standards at the ship's hull, eliminating the need for an ambient air boundary beyond the hull.*

2. Please provide a description of how SOI proposes to monitor the ambient air boundary and ensure that public access is prevented. *Given the response provided above, this issue is no longer relevant.*

ATTACHMENT C

Additional Responses by E-Mail

Attachment C Additional Responses by E-Mail

E-mail technical responses to EPA questions

5/14/09 3:37p (to Pat Nair) Other possible ice mgmt vessels
5/14/09 2:48p (to Pat Nair) Proposed alternate handling of ice mgmt fleet, supply ship, Nanuq
5/7/09 3:56p, (to Pat Nair) OSR fleet
5/7/09 3:00p, (to Pat Nair) Suggestion on handling of ice mgmt fleet emissions
5/7/09 1:37p (to Pat Nair) EPA memo on NOx emissions
5/5/09 10:14a (to Pat Nair & Paul Boys) Updated emission Discover EI with 84-day well site limit removed
5/6/09 9:41p (to Pat Nair) Discoverer – ice management fleet ORR
5/4/09 3:46p (to Pat Nair) Draft EPA Discoverer emissions inventory
5/4/09 1:20p, (to Pat Nair) FW: Frontier Discoverer vessel & CDPF control efficiencies
5/4/09 12:12p, (to Pat Nair) Frontier Discoverer vessel & CDPF control efficiencies
5/1/09 12:14p, (to Pat Nair) cementing & logging emissions
4/30/09 4:05p (to Pat Nair) Tier 2 engine – possible filter
4/30/09 4:03p, (to Pat Nair & Herman Wong) Partial load impact analysis – CO & SO2
4/30/09 3:40p, (to Pat Nair) Incinerator emission factor report - again
4/30/09 12:19p, (to Pat Nair) FW Particulate matter emissions GS500C – follow-up
4/30/09 9:10a, (to Pat Nair) cementing and logging emissions
4/29/09 12:20p, (to Janis Hastings) Discoverer – notification of elimination of the ambient air boundary …
4/28/09 1:07p, (to Pat Nair & Herman Wong) Ice Mgmt fleet – alternate operating scenarios
4/28/09 12:37p, (to Pat Nair) Re: Diverters
4/28/09 9:16a, (to Herman Wong) RE: Volume Sources
4/27/09 7:52p, (to Pat Nair) Re: Shell Discoverer CDPF guarantees
4/27/09 4:42p, (to Herman Wong) RE: Volume Sources
4/27/09 1:25p, (to Pat Nair) Proposed compliance plan
4/27/09 10:46a, (to Pat Nair) Re: narrative on anchor retrieval
4/27/09 10:02a, (to Pat Nair & Paul Boys) Shell Discoverer CDPF guarantees
4/24/09 1:36p, (to Pat Nair) narrative on anchor retrieval
4/24/09 11:40a, (to Pat Nair) Dissolved hydrocarbon gas release
4/24/09 11:15a, (to Pat Nair) Diverters
4/22/09 3:41p, (to Pat Nair) FW: FW: Cementing v logging
4/22/09 3:38p. (to Herman Wong) Ice breakers
4/22/09 2:12p, (to Pat Nair) Supply ship transit emissions
4/21/09 3:31p, (to Pat Nair) FW: X/Q for icebreakers
4/21/09 12:30, (to Pat Nair) cementing v logging
4/15/09 10:53a, (to Pat Nair) Incinerator PM emissions
4/14/09 3:56p, (to Herman Wong) RE: The Ice Breaker and OSR Fleets
4/14/09 9:03p, (to Herman Wong) FW: Impact modeling for warehouse emissions - Wainwright or Barrow
4/14/09 8:18a, (to Pat Nair & Herman Wong) Impact modeling for warehouse emissions – Wainwright or Barrow
4/13/09 11:17a, (to Pat Nair) Discoverer – small source emissions spreadsheet
4/12/09 1:24p, (to Pat Nair) Associated emissions
4/9/09 9:10a, (to Pat Nair) RE: more on the D399 engines

4/6/09 3:45p, (to Pat Nair) Ice management fleet compliance condition
3/27/09 7:02a, (to Herman Wong) Modeling protocol – Discoverer in Beaufort
3/21/09 10:48a, (to Pat Nair) draft responses to EPA second incompleteness letter
3/18/09 2:29p, (to Pat Nair) Confirmation of Boise meeting – Disco/Chukchi application
2/2/09 11:40a, (to Herman Wong) RE: Plume Ht
1/28/09 3:16p, (to Pat Nair) Shell & Cat D399 stack test report
1/28/09 9:36a, (to Herman Wong) RE: Appendix A Comments
1/26/09 10:29a, (to Herman Wong) Shell Chukchi Icebreaker Characterization
1/23/09 11:30a, (to Pat Nair) Shell OCS and Leasing Stipulations – MMS
1/22/09 8:10a, (to Herman Wong) spreadsheet calcs Attach A, Item B, 9
1/21/09 3:09p, (to Pat Nair) Air Sciences application update.

ATTACHMENT D

Revised Emission Inventory

D.1 Revised Application Tables 2-1 to 2-4

D.2 Emissions by emission unit with BACT information

Table 2-1: Discoverer and Associated Vessels Emission Units with Maximum Hourly Emissions That Could Occur Simultaneously

		Rating		Maximum Fuel Consumption (MMBtu/hr) [1]	PM_{10}	$PM_{2.5}$	NO_x	Maximum Emissions (lb/hr) [1] SO_2	CO	VOC	Lead
Frontier Discoverer											
FD-1	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04
FD-2	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04
FD-3	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04
FD-4	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04
FD-5	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04
FD-6	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04
FD-7	Propulsion Engine	7,200	hp	0.0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00
FD-8	Em. Generator	131	hp	0.3	0.21	0.21	1.09	4.88E-04	0.60	0.11	8.86E-06
FD-9	MLC Compressor	540	hp	3.6	0.18	0.18	3.55	5.71E-03	3.11	3.55	1.04E-04
FD-10	MLC Compressor	540	hp	3.6	0.18	0.18	3.55	5.71E-03	3.11	3.55	1.04E-04
FD-11	MLC Compressor	540	hp	0.0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00
FD-12	HPU Engine	250	hp	2.0	0.10	0.10	5.41	3.11E-03	0.16	0.08	5.66E-05
FD-13	HPU Engine	250	hp	2.0	0.10	0.10	5.41	3.11E-03	0.16	0.08	5.66E-05
FD-14	Port Deck Crane	365	hp	2.8	0.04	0.04	6.20	4.41E-03	0.13	0.04	8.02E-05
FD-15	Starbd Deck Crane	365	hp	2.8	0.04	0.04	6.20	4.41E-03	0.13	0.04	8.02E-05
FD-16	Cementing Unit	335	hp	2.6	0.21	0.21	8.66	4.17E-03	0.48	0.15	7.58E-05
FD-17	Cementing Unit	335	hp	2.6	0.21	0.21	8.66	4.17E-03	0.48	0.15	7.58E-05
FD-18	Cementing Unit	147	hp	1.1	0.09	0.09	3.80	1.83E-03	0.21	0.07	3.33E-05
FD-19	Logging Winch[2]	128	hp	0.0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00
FD-20	Logging Winch[2]	36	kW	0.0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00
FD-21	Heat Boiler	7.97	MMBtu/hr	8.0	0.19	0.19	1.60	1.27E-02	0.62	0.01	7.17E-05
FD-22	Heat Boiler	7.97	MMBtu/hr	8.0	0.19	0.19	1.60	1.27E-02	0.62	0.01	7.17E-05
FD-23	Incinerator	276	lb/hr		1.13	0.97	0.69	0.35	4.28	0.41	0.03
	Total while drilling			80.7	4.07	3.90	61.05	0.47	15.76	8.47	3.14E-02

Associated Fleets			Maximum Fuel Consumption (MMBtu/hr) [1]	PM_{10}	$PM_{2.5}$	NO_x	Maximum Emissions (lb/hr) [1] SO_2	CO	VOC	Lead
Ice Management Fleet - Generic										
Diesel Engines			377.3	93.99	83.00	2,216.84	82.85	320.69	53.20	1.09E-02
Incinerators	2-154	lb/hr		2.05	1.40	0.46	0.39	46.20	15.40	3.28E-02
Total Ice Management Fleet			377.3	96.04	84.40	2,217.31	83.23	366.89	68.60	4.37E-02
Resupply Vessel - Generic			2.0	0.63	0.63	9.01	0.41	1.94	0.72	5.93E-05
OSR Fleet										
OSR Main Ship Total			17.6	5.27	4.20	84.24	3.87	28.02	9.73	1.38E-02
OSR Work Boats Total			12.9	0.38	0.38	19.54	2.60	0.85	0.40	3.73E-04
Total OSR Fleet			30.4	5.65	4.59	103.78	6.46	28.88	10.12	1.42E-02
		Total All Fleet	409.8	102.33	89.62	2,330.10	90.11	397.71	79.44	5.80E-02
		Total All	490.5	106.40	93.53	2,391.15	90.58	413.46	87.91	8.94E-02

1 All emissions are shown as the maximum 1-hour value

2 Logging winches cannot operate simultaneously with cementing units

Table 2-2: Discoverer and Associated Vessels Emission Units with Annual Emissions

		Rating		Maximum Fuel Consumption (MMBtu/yr)	PM_{10}	$PM_{2.5}$	NO_x	Maximum Emissions (ton/yr) SO_2	CO	VOC	Lead	HAPs
Frontier Discoverer												
FD-1	Generator Engine	1,325	hp	27,878	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02
FD-2	Generator Engine	1,325	hp	27,878	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02
FD-3	Generator Engine	1,325	hp	27,878	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02
FD-4	Generator Engine	1,325	hp	27,878	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02
FD-5	Generator Engine	1,325	hp	27,878	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02
FD-6	Generator Engine	1,325	hp	27,878	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02
FD-7	Propulsion Engine	7,200	hp	0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	0.00
FD-8	Em Generator	131	hp	7	2.55E-03	2.55E-03	1.30E-02	5.85E-06	7.16E-03	1.34E-03	1.06E-07	1.44E-05
FD-9	MLC Compressor	540	hp	5,413	0.13	0.13	2.69	4.32E-03	2.35	2.69	7.85E-05	0.01
FD-10	MLC Compressor	540	hp	5,413	0.13	0.13	2.69	4.32E-03	2.35	2.69	7.85E-05	0.01
FD-11	MLC Compressor	540	hp	0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	0.00
FD-12	HPU Engine	250	hp	2,951	0.08	0.08	4.09	2.35E-03	0.12	0.06	4.28E-05	0.00
FD-13	HPU Engine	250	hp	2,951	0.08	0.08	4.09	2.35E-03	0.12	0.06	4.28E-05	0.00
FD-14	Port Deck Crane	365	hp	4,237	0.03	0.03	4.75	3.38E-03	0.10	0.03	6.14E-05	0.00
FD-15	Starbd Deck Crane	365	hp	4,237	0.03	0.03	4.75	3.38E-03	0.10	0.03	6.14E-05	0.00
FD-16	Cementing Unit	335	hp	3,163	0.13	0.13	5.24	2.52E-03	0.29	0.09	4.59E-05	0.00
FD-17	Cementing Unit	335	hp	3,163	0.13	0.13	5.24	2.52E-03	0.29	0.09	4.59E-05	0.00
FD-18	Cementing Unit	147	hp	1,388	0.06	0.06	2.30	1.11E-03	0.13	0.04	2.01E-05	0.00
FD-19	Logging Winch[1]	128	hp	0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	0.00
FD-20	Logging Winch[1]	36	kW	0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	0.00
FD-21	Heat Boiler	7.97	MMBtu/hr	32,135	0.38	0.38	3.23	2.56E-02	1.24	0.02	1.45E-04	0.01
FD-22	Heat Boiler	7.97	MMBtu/hr	32,135	0.38	0.38	3.23	2.56E-02	1.24	0.02	1.45E-04	0.01
FD-23	Incinerator	276	lb/hr		0.53	0.45	0.32	0.16	1.99	0.19	1.36E-02	0.02
	Total while drilling			264,463	4.47	4.39	51.97	0.37	13.69	6.44	1.68E-02	0.15

Associated Fleets	Maximum Fuel Consumption (MMBtu/yr)	Fuel Use gal/yr	PM_{10}	$PM_{2.5}$	NO_x	Maximum Emissions (ton/yr) SO_2	CO	VOC	Lead	HAPs
Ice Management Fleet - Generic										
Diesel Engines	1,521,193	11,429,120	189	167	1698	167	647	107	2.21E-02	2.99
Incinerators			4.13	2.83	0.35	0.78	93.14	31.05	6.61E-02	7.78E-02
Total Ice Management Fleet	1,521,193	11,429,120	194	170	1,699	168	740	138	8.82E-02	3.07
Resupply Vessel - Generic	196.22	1,474	0.03	0.03	0.43	0.02	0.09	0.03	2.85E-06	3.86E-04
OSR Fleet										
OSR Main Ship Total	70,877	532,515	10.62	8.47	169.83	7.79	56.49	19.61	2.79E-02	1.71E-01
OSR Work Boats Total	51,819	389,332	0.77	0.77	39.39	5.23	1.72	0.80	7.51E-04	1.02E-01
Total OSR Fleet	122,696	921,846	11	9	209	13	58	20	2.86E-02	2.73E-01
Total All Fleet	1,644,085	12,352,440	205	179	1,908	181	798	159	1.17E-01	3.34
Total All	1,908,548	14,339,422	210	184	1960	181	812	165	1.34E-01	3.50

1 Logging winch emissions are included with cementing units

Table 2-3: Proposed Owner-Requested Restrictions

Compliance Condition	Restriction		How Calculated			How Documented
Operational Restrictions						
Season maximum drilling duration	168	days/ season	168 days/season x 24 hr/day =	4,032	hrs	First anchoring attached to last anchor removed, by clock
MLC compressors maximum use per season	63	days/ season	63 day/season x 24 hr/day x 2 engines x 540 hp/engine x 0.007 mBTU/hp-hr x 7.5 gal/mBTU=	85,882	gal/ season	Demonstrated using fuel consumption – dipstick on the combined MLC compressor consumption at day fuel tank
HPUs maximum use per season	63	days/ season	63 day/season x 24 hr/day x 2 engines x 250 hp/engine x 0.007 mBTU/hp-hr x 7.5 gal/mBTU=	39,760	gal/ season	Demonstrated using fuel consumption – dipstick on the combined HPU consumption at day fuel tank
Generator combined production maximum	71%		71%x 6 engines x 1325 hp x kW/1.340hp=	4,212	kW	Demonstrated by power meter - combined
Cementing & Logging units combined maximum	30%	per day (of cementing)	30% x (335 hp x 2 engines +147hp) x 0.007 mBTU/hp-hr x 24 hr/day x 7.5 gal/mBTU =	309	gal/ day	Demonstrated using fuel consumption – dipstick on the combined cementing/logging consumption at day fuel tank
Crane units combined maximum	38%	per season	Max Fuel Consumption	63,661	gal/ season	Demonstrated using fuel consumption – dipstick on the combined crane consumption at day fuel tank
Discoverer Incinerator limit	1525	lb/trash per day				
Discoverer Incinerator $PM_{2.5}$ limited to	7	lb/ton				Demonstrated by initial stack test
Discoverer Incinerator PM_{10} limited to	8.2	lb/ton				Demonstrated by initial stack test
Discoverer Incinerator SO_2 limited to	2.5	lb/ton				Demonstrated by initial stack test
Sulfur content on all stationary source engines on drilling vessel	0.0015%	by weight				Supplier documentation
Sulfur content on all ships except the Discoverer	0.19%	by weight				Supplier documentation

Table 2-3: Proposed Owner-Requested Restrictions (continued)

Compliance Condition	Restriction		How Calculated	How Documented
Operational Restrictions				
Ice management fleet fuel restriction while < 25 miles from drill site	1699	tons of NO_x /season	Fuel consumption (gallons) x stack test determined NOx emission factor (tons NOx per gallon fuel)	Demonstrated using fuel consumption – dipstick on both vessels measured daily
Anchor handler fuel restriction while < 25 miles from drill site	849	tons of NOx/season	Fuel consumption (gallons) x stack test determined NOx emission factor (tons NOx per gallon fuel)	Demonstrated using fuel consumption - dipstick on anchor handler measured daily
Ice management fleet capacity hourly $PM_{2.5}$ restriction	84.4	lb $PM_{2.5}$ / hour	(Propulsion engine power (kW) capacity (80% of design rating) x $PM_{2.5}$ emission factor (lb/kWh)) + (boiler design rate (btu/hr) x $PM_{2.5}$ emission factor (lb/Btu)) x 24 hours + incinerator capacity (lb/hr) x $PM_{2.5}$ emission factor (lb $PM_{2.5}$ /lb waste)	Propulsion emission factor by stack test, boiler and incinerator emission factors from this workbook. Compliance calculated prior to startup
Anchor handler capacity hourly $PM_{2.5}$ restriction	42.2	lb $PM_{2.5}$ / hour	(Propulsion engine power (kW) capacity (80% of design rating) x $PM_{2.5}$ emission factor (lb/kWh)) + (boiler design rate (btu/hr) x $PM_{2.5}$ emission factor (lb/Btu)) x 24 hours + incinerator capacity (lb/hr) x $PM_{2.5}$ emission factor (lb $PM_{2.5}$/lb waste)	Propulsion emission factor by stack test, boiler and incinerator emission factors from this workbook. Compliance calculated prior to startup
Ice management fleet capacity hourly PM_{10} restriction	96.0	lb PM_{10} / hour	(Propulsion engine power (kW) capacity (80% of design rating) x PM_{10} emission factor (lb/kWh)) + (boiler design rate (btu/hr) x PM_{10} emission factor (lb/Btu)) x 24 hours + incinerator capacity (lb/hr) x PM_{10} emission factor (lb PM_{10}/lb waste)	Propulsion emission factor by stack test, boiler and incinerator emission factors from this workbook. Compliance calculated prior to startup
Anchor handler capacity hourly PM_{10} restriction	48.0	lb PM_{10} / hour	(Propulsion engine power (kW) capacity (80% of design rating) x PM_{10} emission factor (lb/kWh)) + (boiler design rate (btu/hr) x PM_{10} emission factor (lb/Btu)) x 24 hours + incinerator capacity (lb/hr) x PM_{10} emission factor (lb PM_{10}/lb waste)	Propulsion emission factor by stack test, boiler and incinerator emission factors from this workbook. Compliance calculated prior to startup

Table 2-4: Proposed BACT Control Device Effectiveness

Compliance Condition	Restriction		Comments		Reference
Control Device Effectiveness					
Generator SCR NO_x control effectiveness	0.5	g/kW-hr	50-100% of capacity	CEM	D.E.C. Marine AB letter, October 9, 2008, initial stack test and CEM
Generator Oxidation Catalyst CO reduction efficiency	80%				D.E.C. Marine AB letter, October 9, 2008, and initial stack test
Generator Oxidation Catalyst VOC, HAPs, Formaldehyde reduction efficiency	70%				D.E.C. Marine AB letter, October 9, 2008
Generator Oxidation Catalyst PM_{10} reduction efficiency	50%				D.E.C. Marine AB email, February 9, 2009
Small engines (other than Tier 3 engines) Catalytic Diesel Particulate Filter (CDPF) CO, VOC, HAPs, Formaldehyde reduction efficiency	90%				CleanAIR CDPF guarantee
Small engines CDPF PM_{10} reduction efficiency	85%				California Air Resource Board, Currently Verified, January 2009, CleanAIR Systems PERMIT™

Emissions Unit: FD-1-6 Generator Engine **Make/Model:** Cat / D399 **Rating:** 1,325 hp

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.057	0.057	0.112	0.0016	0.200	0.017	2.9E-05

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
50%	50%	0.5 g/kW-hr	0%	80%	70%	0%

Rated fuel consumpt. MMBtu/hr	Capacity ORR	Max Actual fuel consumpt. MMBtu/hr	Hourly Emission Rate, lb/hr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
9.7	71%	6.91	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04

ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	Annual Emission Rate, ton/yr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
168	27,878	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04

Operational Restrictions

Generator combined production maximum 71%

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Control Device Effectiveness

		References
Generator SCR NOx control effectiveness	0.5 g/kW-hr	D.E.C. Marine AB letter, October 9, 2008, initial stack test and CEM
Generator Oxidation Catalyst CO reduction efficiency	80%	D.E.C. Marine AB letter, October 9, 2008, and initial stack test
Generator Oxidation Catalyst VOC, HAPs, Formaldehyde reduction efficiency	70%	D.E.C. Marine AB letter, October 9, 2008
Generator Oxidation Catalyst PM_{10} reduction efficiency	50%	D.E.C. Marine AB email, February 9, 2009

Emissions Factor References

PM_{10}	Caterpillar D399 SCAC Engine Data Sheet, 05/95
$PM_{2.5}$	100% PM_{10}
NO_x	D.E.C. Marine AB letter, 10/9/08
SO_2	Sulfur Content Calculation
CO	Caterpillar D399 SCAC Engine Data Sheet, 05/95
VOC	Caterpillar D399 SCAC Engine Data Sheet, 05/95
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

BACT Emission Limits and Test Methods

PM_{10}
Control Method: Oxidation Catalyst Control Efficiency: 50%
Uncontrolled emission rate: 251.2 g/hr 0.254 g/kW-hr Ref: Caterpillar D399 SCAC Engine Data Sheet, 05/95
Proposed BACT emission rate: 125.6 g/hr 0.127 g/kW-hr
Proposed emission test methods: EPA methods 1-4 & 5, at engine load >50% Interval: triplicate consecutive 1-hour tests.

NO_x
Control Method: SCR to 0.5 g/kW-hr
Uncontrolled emission rate: 7993.9 g/hr 8.084 g/kW-hr Ref: Caterpillar D399 SCAC Engine Data Sheet, 05/95
Proposed BACT emission rate: 0.5 g/kW-hr
Control efficiency: 94%
Proposed emission test methods: EPA methods 1-4 & 7E, at engine load >50% Interval: triplicate consecutive 1-hour tests.

CO
Control Method: Oxidation Catalyst Control Efficiency: 80%
Uncontrolled emission rate: 882.7 g/hr 0.893 g/kW-hr Ref: Caterpillar D399 SCAC Engine Data Sheet, 05/95
Proposed BACT emission rate: 176.54 g/hr 0.179 g/kW-hr
Proposed emission test methods: EPA methods 1-4 & 10, at engine load >50% Interval: triplicate consecutive 1-hour tests.

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
D399 Engines diesel heat rate	Caterpillar D399 SCAC Engine Data Sheet, 05/95	
237.5 g/kW-hr		
7350 Btu/hp-hr		
0.0073 MMBtu/hp-hr		

Emissions Unit: FD-8 Em Generator **Make/Model:** Caterpillar / 3304 **Rating:** 131 hp

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.696	0.696	3.553	0.0016	1.953	0.366	2.9E-05

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
0%	0%	0%	0%	0%	0%	0%

Rated fuel consumpt. MMBtu/hr	Use min/wk	Max Actual fuel consumpt. MMBtu/hr	Hourly Emission Rate, lb/hr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.9	20	0.3	0.21	0.21	1.09	4.88E-04	0.60	0.11	8.86E-06

ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	Annual Emission Rate, ton/yr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
168	7	2.55E-03	2.55E-03	1.30E-02	5.85E-06	7.16E-03	1.34E-03	1.06E-07

Operational Restrictions

Unit FD-8 (Emergency Generator) operation assumed for 20 min/week. Ref: Wright, Alistair email to Anthony Wilson, 1/21/09.

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Emissions Factor References

PM_{10}	Max of 13 test from EPA/600/8-90/057F
$PM_{2.5}$	100% PM_{10}
NO_x	Max of 13 test from EPA/600/8-90/057F
SO_2	Sulfur Content Calculation
CO	Max of 13 test from EPA/600/8-90/057F
VOC	Max of 13 test from EPA/600/8-90/057F
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
ICE Engines diesel heat rate	AP42 Table 3.3-1, 10/96	
7,000 Btu/hp-hr		
0.007 MMBtu/hp-hr		

Emissions Unit: FD-9-11 MLC Compressor **Make/Model:** Caterpillar / C-15 **Rating:** 540 hp

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.050	0.050	0.993	0.0016	0.868	0.993	2.9E-05

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
0%	0%	0%	0%	0%	0%	0%

Rated fuel consumpt. MMBtu/hr	Hourly Emission Rate, lb/hr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
3.6	0.18	0.18	3.55	5.71E-03	3.11	3.55	1.04E-04

ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	Annual Emission Rate, ton/yr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
63	5,413	0.13	0.13	2.69	4.32E-03	2.35	2.69	7.85E-05

Operational Restrictions

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Emissions Factor References

PM_{10}	Tier 3 emission limit
$PM_{2.5}$	100% PM_{10}
NO_x	Tier 3 emission limit
SO_2	Sulfur Content Calculation
CO	Tier 3 emission limit
VOC	Tier 3 emission limit
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

BACT Emission Limits and Test Methods

PM_{10}	Control Method: Integral design	Control Efficiency:	N/A	
	Uncontrolled & Controlled emission rate:	0.2 g/kW-hr	Ref:	Tier 3 emission limit
	Proposed emission test methods:	EPA methods 1-4 & 5, at engine load >50%	Interval:	triplicate consecutive 1-hour tests.
NO_x	Control Method: Integral design	Control Efficiency:	N/A	
	Uncontrolled & Controlled emission rate:	4.0 g/kW-hr	Ref:	Tier 3 emission limit
	Proposed emission test methods:	EPA methods 1-4 & 7E, at engine load >50%	Interval:	triplicate consecutive 1-hour tests.
CO	Control Method: Integral design	Control Efficiency:	N/A	
	Uncontrolled & Controlled emission rate:	3.5 g/kW-hr	Ref:	Tier 3 emission limit
	Proposed emission test methods:	EPA methods 1-4 & 10, at engine load >50%	Interval:	triplicate consecutive 1-hour tests.

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
Caterpillar C15 engines diesel heat rate	Caterpillar C15 Specification Sheet, LEHW7443-000, 2008	
26.9 gal/hr		
0.00663 MMBtu/hp-hr		

Emissions Unit: FD-12-13 HPU Engine **Make/Model:** Detroit/8V71 **Rating:** 250 hp

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.356	0.356	2.771	0.0016	0.844	0.418	2.9E-05

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
85%	85%	0%	0%	90%	90%	0%

Hourly Emission Rate, lb/hr

Rated fuel consumpt. MMBtu/hr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
2.0	0.10	0.10	5.41	3.11E-03	0.16	0.08	5.66E-05

Annual Emission Rate, ton/yr

ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
63	2,951	0.08	0.08	4.09	2.35E-03	0.12	0.06	4.28E-05

Operational Restrictions

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Control Device Effectiveness		**References**
Small engines (other than Tier 3 engines) Catalytic Diesel Particulate Filter (CDPF) CO, VOC, HAPs, Formaldehyde reduction efficiency	90%	CleanAIR CDPF guarantee
Small engines CDPF PM reduction efficiency	85%	California Air Resource Board Currently verified, January 2009, CleanAIR Systems PERMIT

Emissions Factor References

PM_{10}	Max of 4 test from EPA/600/8-90/057F
$PM_{2.5}$	100% PM_{10}
NO_x	Max of 4 test from EPA/600/8-90/057F
SO_2	Sulfur Content Calculation
CO	Max of 2 test from EPA/600/8-90/057F
VOC	Max of 2 test from EPA/600/8-90/057F
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

BACT Emission Limits and Test Methods

PM_{10}
- Control Method: CDPF — Control Efficiency: 85%
- Uncontrolled emission rate: 1.26 g/bhp-hr — 1.688 g/kW-hr — Ref: Max of 4 test from EPA/600/8-90/057F
- Proposed BACT emission rate: 0.189 g/bhp-hr — 0.253 g/kW-hr
- Proposed emission test methods: EPA methods 1-4 & 5, at engine load >50% — Interval: triplicate consecutive 1-hour tests.

NO_x
- Control Method: GCP & integral design — Control Efficiency: N/A
- Uncontrolled & Controlled emission rate: 9.8 g/bhp-hr — 13.145 g/kW-hr — Ref: Max of 4 test from EPA/600/8-90/057F
- Proposed emission test methods: EPA methods 1-4 & 7E, at engine load >50% — Interval: triplicate consecutive 1-hour tests.

CO
- Control Method: CDPF — Control Efficiency: 90%
- Uncontrolled emission rate: 2.99 g/bhp-hr — 4.007 g/kW-hr — Ref: Max of 2 test from EPA/600/8-90/057F
- Proposed BACT emission rate: 0.299 g/bhp-hr — 0.401 g/kW-hr
- Proposed emission test methods: EPA methods 1-4 & 10, at engine load >50% — Interval: triplicate consecutive 1-hour tests.

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
Detroit 8V-71N engines diesel heat rate	Detroit Diesel, Engine Performance Model: 8V-71N, 10/15/81	
0.415 lb/hp-hr		
0.0078 MMBtu/hp-hr		

Emissions Unit: FD-14-15 Deck Cranes **Make/Model:** Cat / D343 **Rating:** 365 hp

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.103	0.103	2.241	0.0016	0.473	0.138	2.9E-05

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
85%	85%	0%	0%	90%	90%	0%

Hourly Emission Rate, lb/hr

Max Actual fuel consumpt. MMBtu/hr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
2.8	0.04	0.04	6.20	4.41E-03	0.13	0.04	8.02E-05

Annual Emission Rate, ton/yr

Capacity ORR	ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
38%	168	4,237	0.03	0.03	4.75	3.38E-03	0.10	0.03	6.14E-05

Operational Restrictions

Crane units combined maximum 63,661 gal/season

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Control Device Effectiveness		**References**
Small engines (other than Tier 3 engines) Catalytic Diesel Particulate Filter (CDPF) CO, VOC, HAPs, Formaldehyde reduction efficiency	90%	CleanAIR CDPF guarantee
Small engines CDPF PM reduction efficiency	85%	California Air Resource Board Currently verified, January 2009, CleanAIR Systems PERMIT

Emissions Factor References

PM_{10}	Caterpillar D343 Engine Data Sheet, 05/95
$PM_{2.5}$	100% PM_{10}
NO_x	Caterpillar D343 Engine Data Sheet, 05/95
SO_2	Sulfur Content Calculation
CO	Caterpillar D343 Engine Data Sheet, 05/95
VOC	Caterpillar D343 Engine Data Sheet, 05/95
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

BACT Emission Limits and Test Methods

PM_{10}	Control Method:	CDPF	Control Efficiency: 85%			
	Uncontrolled emission rate:		129.8 g/hr	0.477 g/kW-hr	Ref:	Caterpillar D343 Engine Data Sheet, 05/95
	Proposed BACT emission rate:		19.47 g/hr	0.071 g/kW-hr		
	Proposed Emission test methods:		EPA methods 1-4 & 5, at engine load >50%		Interval:	triplicate consecutive 1-hour tests.
NO_x	Control Method:	GCP & integral design	Control Efficiency: N/A			
	Uncontrolled & Controlled emission rate:		2810.9 g/hr	10.319 g/kW-hr	Ref:	Caterpillar D343 Engine Data Sheet, 05/95
	Proposed emission test methods:		EPA methods 1-4 & 7E, at engine load >50%		Interval:	triplicate consecutive 1-hour tests.
CO	Control Method:	CDPF	Control Efficiency: 90%			
	Uncontrolled emission rate:		593.6 g/hr	2.179 g/kW-hr	Ref:	Caterpillar D343 Engine Data Sheet, 05/95
	Proposed BACT emission rate:		59.36 g/hr	0.218 g/kW-hr		
	Proposed Emission test methods:		EPA methods 1-4 & 10, at engine load >50%		Interval:	triplicate consecutive 1-hour tests.

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
D343 engines diesel heat rate	Caterpillar D343 Engine Data Sheet, 05/95	
245 g/kW-hr	100% loads at 2100 RPM value, T Prechamber Engines	
7576 Btu/hp-hr		
0.0076 MMBtu/hp-hr		

Emissions Unit: FD-16-17 Cementing Unit **Make/Model:** Detroit / 8V-71N **Rating:** 335 hp

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.542	0.542	3.310	0.0016	1.850	0.568	2.9E-05

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
85%	85%	0%	0%	90%	90%	0%

Rated fuel consumpt. MMBtu/hr	Hourly Emission Rate, lb/hr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
2.6	0.21	0.21	8.66	4.17E-03	0.48	0.15	7.58E-05

Capacity ORR	ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	Annual Emission Rate, ton/yr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
30%	168	3,163	0.13	0.13	5.24	2.52E-03	0.29	0.09	4.59E-05

Operational Restrictions

Cementing & Logging units combined maximum 30% per day (of Cementing)

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Control Device Effectiveness		**References**
Small engines (other than Tier 3 engines) Catalytic Diesel Particulate Filter (CDPF) CO, VOC, HAPs, Formaldehyde reduction efficiency	90%	CleanAIR CDPF guarantee
Small engines CDPF PM reduction efficiency	85%	California Air Resource Board Currently verified, January 2009, CleanAIR Systems PERMIT

Emissions Factor References

PM_{10}	Max of 8 test from EPA/600/8-90/057F
$PM_{2.5}$	100% PM_{10}
NO_x	Max of 8 test from EPA/600/8-90/057F
SO_2	Sulfur Content Calculation
CO	Max of 6 test from EPA/600/8-90/057F
VOC	Max of 6 test from EPA/600/8-90/057F
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

BACT Emission Limits and Test Methods

PM_{10}	Control Method: CDPF	Control Efficiency: 85%				
	Uncontrolled emission rate:	1.26 g/bhp-hr	1.688 g/kW-hr	Ref:	Max of 8 test from EPA/600/8-90/057F
	Proposed BACT emission rate:	0.189 g/bhp-hr	0.253 g/kW-hr		
	Proposed emission test methods:	EPA methods 1-4 & 5, at engine load >50%		Interval:	triplicate consecutive 1-hour tests.
NO_x	Control Method: GCP & integral design	Control Efficiency:		N/A	
	Uncontrolled & Controlled emission rate:	9.8 g/bhp-hr	13.145 g/kW-hr	Ref:	Max of 8 test from EPA/600/8-90/057F
	Proposed emission test methods:	EPA methods 1-4 & 7E, at engine load >50		Interval:	triplicate consecutive 1-hour tests.
CO	Control Method: CDPF	Control Efficiency: 90%			
	Uncontrolled emission rate:	2.99 g/bhp-hr	4.007 g/kW-hr	Ref:	Max of 6 test from EPA/600/8-90/057F
	Proposed BACT emission rate:	0.299 g/bhp-hr	0.401 g/kW-hr		
	Proposed emission test methods:	EPA methods 1-4 & 10, at engine load >50(		Interval:	triplicate consecutive 1-hour tests.

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
Detroit 8V-71N engines diesel heat rate	Detroit Diesel, Engine Performance Model: 8V-71N, 10/15/81	
0.415 lb/hp-hr		
0.0078 MMBtu/hp-hr		

Emissions Unit: FD-18 Cementing Unit **Make/Model:** GM 3-71 **Rating:** 147 hp

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.542	0.542	3.310	0.0016	1.850	0.568	2.9E-05

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
85%	85%	0%	0%	90%	90%	0%

Rated fuel consumpt. MMBtu/hr	Hourly Emission Rate, lb/hr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
1.1	0.09	0.09	3.80	1.83E-03	0.21	0.07	3.33E-05

Capacity ORR	ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	Annual Emission Rate, ton/yr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
30%	168	1,388	0.06	0.06	2.30	1.11E-03	0.13	0.04	2.01E-05

Operational Restrictions

Cementing & Logging units combined maximum 30% per day (of Cementing)

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Control Device Effectiveness		**References**
Small engines (other than Tier 3 engines) Catalytic Diesel Particulate Filter (CDPF) CO, VOC, HAPs, Formaldehyde reduction efficiency	90%	CleanAIR CDPF guarantee
Small engines CDPF PM reduction efficiency	85%	California Air Resource Board Currently verified, January 2009, CleanAIR Systems PERMIT

Emissions Factor References

PM_{10}	Max of 8 test from EPA/600/8-90/057F
$PM_{2.5}$	100% PM_{10}
NO_x	Max of 8 test from EPA/600/8-90/057F
SO_2	Sulfur Content Calculation
CO	Max of 6 test from EPA/600/8-90/057F
VOC	Max of 6 test from EPA/600/8-90/057F
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

BACT Emission Limits and Test Methods

PM_{10}	Control Method: CDPF	Control Efficiency: 85%			
	Uncontrolled emission rate:	1.26 g/bhp-hr	1.688 g/kW-hr	Ref:	Max of 8 test from EPA/600/8-90/057F
	Proposed BACT emission rate:	0.189 g/bhp-hr	0.253 g/kW-hr		
	Proposed emission test methods:	EPA methods 1-4 & 5, at engine load >50%		Interval:	triplicate consecutive 1-hour tests.
NO_x	Control Method: GCP & integral design	Control Efficiency:		N/A	
	Uncontrolled & Controlled emission rate:	9.8 g/bhp-hr	13.145 g/kW-hr	Ref:	Max of 8 test from EPA/600/8-90/057F
	Proposed emission test methods:	EPA methods 1-4 & 7E, at engine load >50		Interval:	triplicate consecutive 1-hour tests.
CO	Control Method: CDPF	Control Efficiency: 90%			
	Uncontrolled emission rate:	2.99 g/bhp-hr	4.007 g/kW-hr	Ref:	Max of 6 test from EPA/600/8-90/057F
	Proposed BACT emission rate:	0.299 g/bhp-hr	0.401 g/kW-hr		
	Proposed emission test methods:	EPA methods 1-4 & 10, at engine load >50		Interval:	triplicate consecutive 1-hour tests.

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
Detroit 8V-71N engines diesel heat rate	Detroit Diesel, Engine Performance Model: 8V-71N, 10/15/81	
0.415 lb/hp-hr		
0.0078 MMBtu/hp-hr		

AIR SCIENCES INC.	Air Sciences Inc.	PROJECT TITLE: Shell Offshore, Inc.	BY: S. Pryor	
		PROJECT NO: 180-15-1	PAGE: 8	OF: 14
	ENGINEERING CALCULATIONS	SUBJECT: Discoverer Emissions-AK OCS	DATE: May 18, 2009	

Emissions Unit: FD-19 Logging Winch **Make/Model:** Detroit / 4-71N **Rating:** 128 hp

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.542	0.542	3.310	0.0016	1.850	0.568	2.9E-05

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
85%	85%	0%	0%	90%	90%	0%

Hourly Emission Rate, lb/hr

Rated fuel consumpt. MMBtu/hr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
1.0	0.08	0.08	3.31	1.59E-03	0.18	0.06	2.90E-05

Annual Emission Rate, ton/yr

Capacity ORR	ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
30%	168	1,209	0.05	0.05	2.00	9.64E-04	0.11	0.03	1.75E-05

Operational Restrictions

Cementing & Logging units combined maximum 30%

Logging Units only operate when the cementing units are not operating

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Control Device Effectiveness		References
Small engines (other than Tier 3 engines) Catalytic Diesel Particulate Filter (CDPF) CO, VOC, HAPs, Formaldehyde reduction efficiency	90%	CleanAIR CDPF guarantee
Small engines CDPF PM reduction efficiency	85%	California Air Resource Board Currently verified, January 2009, CleanAIR Systems PERMIT

Emissions Factor References

PM_{10}	Max of 8 test from EPA/600/8-90/057F
$PM_{2.5}$	100% PM_{10}
NO_x	Max of 8 test from EPA/600/8-90/057F
SO_2	Sulfur Content Calculation
CO	Max of 6 test from EPA/600/8-90/057F
VOC	Max of 6 test from EPA/600/8-90/057F
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

BACT Emission Limits and Test Methods

PM_{10}
- Control Method: CDPF — Control Efficiency: 85%
- Uncontrolled emission rate: 1.26 g/bhp-hr — 1.688 g/kW-hr — Ref: Max of 8 test from EPA/600/8-90/057F
- Proposed BACT emission rate: 0.189 g/bhp-hr — 0.253 g/kW-hr
- Proposed emission test methods: EPA methods 1-4 & 5, at engine load >50% — Interval: triplicate consecutive 1-hour tests.

NO_x
- Control Method: GCP & integral design — Control Efficiency: N/A
- Uncontrolled & Controlled emission rate: 9.8 g/bhp-hr — 13.145 g/kW-hr — Ref: Max of 8 test from EPA/600/8-90/057F
- Proposed emission test methods: EPA methods 1-4 & 7E, at engine load >50 — Interval: triplicate consecutive 1-hour tests.

CO
- Control Method: CDPF — Control Efficiency: 90%
- Uncontrolled emission rate: 2.99 g/bhp-hr — 4.007 g/kW-hr — Ref: Max of 6 test from EPA/600/8-90/057F
- Proposed BACT emission rate: 0.299 g/bhp-hr — 0.401 g/kW-hr
- Proposed emission test methods: EPA methods 1-4 & 10, at engine load >50(— Interval: triplicate consecutive 1-hour tests.

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
Detroit 8V-71N engines diesel heat rate	Detroit Diesel, Engine Performance Model: 8V-71N, 10/15/81	
0.415 lb/hp-hr		
0.0078 MMBtu/hp-hr		

Emissions Unit: FD-20 Logging Winch **Make/Model:** John Deere/4024TF270 **Rating:** 36 kW

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.141	0.141	1.768	0.0016	1.296	1.768	2.9E-05

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
85%	85%	0%	0%	90%	90%	0%

Rated fuel consumpt.	Hourly Emission Rate, lb/hr						
MMBtu/hr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.3	7.14E-03	7.14E-03	5.95E-01	5.37E-04	4.37E-02	5.95E-02	9.76E-06

Capacity ORR	ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	Annual Emission Rate, ton/yr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
30%	168	407	4.32E-03	4.32E-03	3.60E-01	3.25E-04	2.64E-02	3.60E-02	5.91E-06

Operational Restrictions

Cementing & Logging units combined maximum 30%

Logging Units only operate when the cementing units are not operating

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Control Device Effectiveness		**References**
Small engines (other than Tier 3 engines) Catalytic Diesel Particulate Filter (CDPF) CO, VOC, HAPs, Formaldehyde reduction efficiency	90%	CleanAIR CDPF guarantee
Small engines CDPF PM reduction efficiency	85%	California Air Resource Board Currently verified, January 2009, CleanAIR Systems PERMIT

Emissions Factor References

PM_{10}	Tier 2 emission limit
$PM_{2.5}$	100% PM_{10}
NO_x	Tier 2 emission limit
SO_2	Sulfur Content Calculation
CO	Tier 2 emission limit
VOC	Tier 2 emission limit
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

BACT Emission Limits and Test Methods

PM_{10}	Control Method: CDPF & Integral Design	Control Efficiency: 85%	N/A	
	Uncontrolled emission rate:	0.6 g/kW-hr	Ref:	Tier 2 emission limit
	Proposed BACT emission rate:	0.09 g/kW-hr		
	Proposed emission test methods:	EPA methods 1-4 & 5, at engine load >50%	Interval:	triplicate consecutive 1-hour tests.
NO_x	Control Method: Integral Design	Control Efficiency: N/A	N/A	
	Uncontrolled & Controlled emission rate:	7.5 g/kW-hr	Ref:	Tier 2 emission limit
	Proposed emission test methods:	EPA methods 1-4 & 7E, at engine load >50%	Interval:	triplicate consecutive 1-hour tests.
CO	Control Method: CDPF & Integral Design	Control Efficiency: 90%	N/A	
	Uncontrolled emission rate:	5.5 g/kW-hr	Ref:	Tier 2 emission limit
	Proposed BACT emission rate:	0.55 g/kW-hr		
	Proposed emission test methods:	EPA methods 1-4 & 10, at engine load >50%	Interval:	triplicate consecutive 1-hour tests.

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
ICE Engines diesel heat rate	John Deere Model 4024TF270 Engine Performance, 06/04	
17.9 lb/hr		
0.007 MMBtu/hp-hr		

Emissions Unit: FD-21-22 Heat Boiler **Make/Model:** Clayton 200 Boiler **Rating:** 7.97 MMBtu/hr

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.024	0.024	0.201	0.0016	0.077	0.001	9.00E-06

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
0%	0%	0%	0%	0%	0%	0%

Rated fuel consumpt.	Hourly Emission Rate, lb/hr						
MMBtu/hr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
8.0	0.19	0.19	1.60	1.27E-02	0.62	0.01	7.17E-05

ORR	Max Actual fuel consumpt.	Annual Emission Rate, ton/yr						
days/yr	MMBtu/yr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
168	32,135	0.38	0.38	3.23	2.56E-02	1.24	0.02	1.45E-04

Operational Restrictions

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Emissions Factor References

PM_{10}	Clayton Industries, 8/2001
$PM_{2.5}$	100% PM_{10}
NO_x	Clayton Industries, 8/2001
SO_2	Sulfur Content Calculation
CO	Clayton Industries, 8/2001
VOC	Clayton Industries, 8/2001
Lead	AP42 Table 1.3-10. Emission Factors For Trace Elements From Distillate Fuel Oil Combustion Sources

BACT Emission Limits and Test Methods

PM_{10}	Control Method:	GCP & integral design	Control Efficiency: N/A		
	Uncontrolled & Controlled emission rate:	4.5 lb/day	0.024 lb/MMBtu	Ref:	Clayton Industries, 8/2001
	Proposed emission test methods:	EPA methods 1-4 & 5, at boiler load >50%		Interval:	triplicate consecutive 1-hour tests.
NO_x	Control Method:	GCP & integral design	Control Efficiency: N/A		
	Uncontrolled & Controlled emission rate:	38.5 lb/day	0.201 lb/MMBtu	Ref:	Clayton Industries, 8/2001
	Proposed emission test methods:	EPA methods 1-4 & 7E, at boiler load >50%		Interval:	triplicate consecutive 1-hour tests.
CO	Control Method:	GCP & integral design	Control Efficiency: N/A		
	Uncontrolled & Controlled emission rate:	14.8 lb/day	0.077 lb/MMBtu	Ref:	Clayton Industries, 8/2001
	Proposed emission test methods:	EPA methods 1-4 & 10, at boiler load >50%		Interval:	triplicate consecutive 1-hour tests.

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
ICE Engines diesel heat rate	AP42 Table 3.3-1, 10/96	
7,000 Btu/hp-hr		
0.007 MMBtu/hp-hr		

Emissions Unit: FD-23 Incinerator **Make/Model:** TeamTec/GS500C **Rating:** 276 lb/hr

Emissions Factors, lb/lb

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.0041	0.0035	0.0025	0.0013	0.0155	0.0015	1.07E-04

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
0%	0%	0%	0%	0%	0%	0%

Hourly Emission Rate, lb/hr

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
1.13	0.97	0.69	0.35	4.28	0.41	0.03

Annual Emission Rate, ton/yr

ORR days/yr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
168	0.53	0.45	0.32	0.16	1.99	0.19	1.36E-02

Operational Restrictions

Discoverer Incinerator 1525 lb/trash per day

[1] Sulfur content on all stationary source engines on drillship 0.0015% by wt.

Emissions Factor References

PM_{10}	ORR
$PM_{2.5}$	ORR
NO_x	AP42 Table 2.2-1, multiple hearth
SO_2	ORR
CO	AP42 Table 2.2-1, multiple hearth
VOC	AP42 Table 2.1-12, 10/96
Lead	AP42 Table 2.2-2 - Metals Emission Factors for Mass Burn and Modular Excess Air Combustors

BACT Emission Limits and Test Methods

PM_{10}	Control Method:	GCP & integral design	Control Efficiency: N/A		
	Uncontrolled & Controlled emission rate:	0.0041 lb/lb		Ref:	ORR
	Proposed emission test methods:	EPA methods 1-4 & 5, at engine load >50%		Interval:	triplicate consecutive 1-hour tests.
NO_x	Control Method:	GCP & integral design	Control Efficiency: N/A		
	Uncontrolled & Controlled emission rate:	0.0025 lb/lb		Ref:	AP42 Table 2.2-1, multiple hearth
	Proposed emission test methods:	EPA methods 1-4 & 7E, at engine load >50%		Interval:	triplicate consecutive 1-hour tests.
CO	Control Method:	GCP & integral design	Control Efficiency: N/A		
	Uncontrolled & Controlled emission rate:	0.0155 lb/lb		Ref:	AP42 Table 2.2-1, multiple hearth
	Proposed emission test methods:	EPA methods 1-4 & 10, at engine load >50%		Interval:	triplicate consecutive 1-hour tests.

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
ICE Engines diesel heat rate	AP42 Table 3.3-1, 10/96	
7,000 Btu/hp-hr		
0.007 MMBtu/hp-hr		

Emissions Units: Ice Management Fleet - Generic

Emissions Factors

	Units	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
ICE Engines	lb/MMBtu	0.249	0.22	5.876	0.2196	0.85	0.141	2.9E-05
Incinerators	lb/lb	0.0067	0.0046	0.0015	0.00125	0.15	0.05	1.1E-04

Control Efficiency

	PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
ICE Engines	0%	0%	0%	0%	0%	0%	0%
Incinerators	0%	0%	0%	0%	0%	0%	0%

	lb/hr	Rated fuel consumpt. MMBtu/hr	Hourly Emission Rate, lb/hr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
ICE Engines		377.28	93.99	83.00	2216.84	82.85	320.69	53.20	1.09E-02
[2] Incinerators	308		2.05	1.40	0.46	0.39	46.20	15.40	3.28E-02
Total		377.28	96.04	84.40	2217.31	83.23	366.89	68.60	4.37E-02

	ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	Annual Emission Rate, ton/yr PM_{10}	$PM_{2.5}$	NOx [3]	SO_2	CO	VOC	Lead
ICE Engines	168	1,521,193	189	167	1698	167	647	107	2.21E-02
[2] Incinerators	168		4.13	2.83	0.35	0.78	93.14	31.05	6.61E-02
Total		1,521,193	194	170	1699	168	740	138	8.82E-02

Operational Restrictions

[1] Sulfur content on all mobile sources 0.19% by wt.

[2] Assume 2 incinerators rated at 154 lb/hr & 154 lb/h 100% Use

[3] NOx operation restriction based on 38% of 168 days

Remaining Pollutants Operations Restriction calculated based on 100% of 168 days

ICE Emissions Factor References

PM_{10}	generic factors consistent w/Ice mgmt fleet ORRs
$PM_{2.5}$	generic factors consistent w/Ice mgmt fleet ORRs
NO_x	generic factors consistent w/Ice mgmt fleet ORRs
SO_2	AP42 Table 3.4-1, 10/96
CO	AP42 Table 3.4-1, 10/96
VOC	Corbett, Koehler. Revised: 05/03
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

Incinerator Emissions Factor References

PM_{10}	AP42 Table 2.1-12, 10/96 & Appendix B.1 2.1
$PM_{2.5}$	AP42 Table 2.1-12, 10/96 & Appendix B.1 2.1
NO_x	AP42 Table 2.1-12, 10/96
SO_2	AP42 Table 2.1-12, 10/96
CO	AP42 Table 2.1-12, 10/96
VOC	AP42 Table 2.1-12, 10/96
Lead	AP42 Table 2.2-2 - Metals Emission Factors for Mass Burn and Modular Excess Air Combustors

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
ICE Engines diesel heat rate	AP42 Table 3.3-1, 10/96	
7,000 Btu/hp-hr		
0.007 MMBtu/hp-hr		

Air Sciences Inc.	PROJECT TITLE: Shell Offshore, Inc.	BY: S. Pryor	
	PROJECT NO: 180-15-1	PAGE: 13	OF: 14
ENGINEERING CALCULATIONS	SUBJECT: Discoverer Emissions-AK OCS	DATE: May 18, 2009	

Emissions Units: Resupply Ship - Generic

Emissions Factors, lb/MMBtu

PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
0.31	0.31	4.41	0.2020	0.95	0.35	2.9E-05

Control Efficiency

PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
0%	0%	0%	0%	0%	0%	0%

Rated fuel consumpt. MMBtu/hr	Hourly Emission Rate, lb/hr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
2.0	0.63	0.63	9.01	0.41	1.94	0.72	5.93E-05

Use hr/day	Use days/yr	Max Actual fuel consumpt. MMBtu/yr	Annual Emission Rate, ton/yr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
12	8	196.22	0.03	0.03	0.43	0.02	0.09	0.03	2.85E-06

Operational Restrictions

[1] Sulfur content on all mobile sources 0.19% by wt.

Resupply Ship Operational 12 hr/day 8 days/year 96 hrs/yr

Emissions Factor References

PM_{10}	AP42 Table 3.3-1, 10/96
$PM_{2.5}$	100% PM_{10}
NO_x	AP42 Table 3.3-1, 10/96
SO_2	Sulfur Content Calculation
CO	AP42 Table 3.3-1, 10/96
VOC	AP42 Table 3.3-1, 10/96
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
ICE Engines diesel heat rate	AP42 Table 3.3-1, 10/96	
7,000 Btu/hp-hr		
0.007 MMBtu/hp-hr		

Emissions Units: OSR Fleet

Emissions Factors

	Units	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
OSR Main Ship ICE Propulsion Engines	lb/MMBtu	0.044	0.044	3.536	0.2020	0.190	0.257	2.90E-05
OSR Main Ship ICE Generators	lb/MMBtu	0.451	0.362	5.970	0.2196	0.85	0.141	2.90E-05
OSR Main Ship Incinerator	lb/lb	6.65E-03	4.55E-03	1.50E-03	1.25E-03	1.50E-01	5.00E-02	1.07E-04
OSR Work Boat ICE Propulsion Engines	lb/MMBtu	0.024	0.024	1.463	0.2020	0.049	0.025	2.90E-05
OSR Work Boat ICE Generators	lb/MMBtu	0.31	0.31	4.41	0.2020	0.95	0.35	2.90E-05

Control Efficiency

	PM_{10}	$PM_{2.5}$	NO_x	SO_2 [1]	CO	VOC	Lead
All OSR Sources	0%	0%	0%	0%	0%	0%	0%

	Rating	Max Actual fuel consumpt. MMBtu/hr	Hourly Emission Rate, lb/hr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
OSR Main Ship ICE Propulsion Engines		8.584	0.38	0.38	30.35	1.73	1.63	2.21	2.49E-04
OSR Main Ship ICE Generators		8.995	4.06	3.26	53.70	1.98	7.65	1.27	2.61E-04
OSR Main Ship Incinerator	125 lb/hr		0.83	0.57	0.19	0.16	18.75	6.25	1.33E-02
Total OSR Main Ship		*17.579*	*5.27*	*4.20*	*84.24*	*3.87*	*28.02*	*9.73*	*1.38E-02*
OSR Work Boat ICE Propulsion Engines		12.600	0.31	0.31	18.43	2.55	0.62	0.31	3.65E-04
OSR Work Boat ICE Generators		0.252	0.08	0.08	1.11	0.05	0.24	0.09	7.31E-06
Total OSR Work Boats		*12.852*	*0.38*	*0.38*	*19.54*	*2.60*	*0.85*	*0.40*	*3.73E-04*
Total OSR Fleet		**30.431**	**5.65**	**4.59**	**103.78**	**6.46**	**28.88**	**10.12**	**1.42E-02**

	Use hr/day	ORR days/yr	Max Actual fuel consumpt. MMBtu/yr	Annual Emission Rate, ton/yr PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead
Total OSR Main Ship	24	168	70,876.65	10.62	8.47	169.83	7.79	56.49	19.61	2.79E-02
Total OSR Work Boats	24	168	51,819.26	0.77	0.77	39.39	5.23	1.72	0.80	7.51E-04
Total OSR Fleet			**122,695.92**	**11.40**	**9.25**	**209.22**	**13.03**	**58.22**	**20.41**	**0.03**

Operational Restrictions

[1] Sulfur content on all mobile sources 0.19% by wt.

Emissions Factor References

All Sources — **SO_2** Sulfur Content Calculation

All ICE Engines — **Lead** L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines

OSR Main Ship ICE Propulsion Engines — **PM_{10}, NO_x, CO, VOC** Caterpillar 3608 Specification Sheet, DM5529, 10/06; **$PM_{2.5}$** 100% PM_{10}

OSR Main Ship ICE Generators — **NO_x, CO, VOC** AP42 Table 3.4-2, 10/96; **PM_{10}, $PM_{2.5}$** Corbett, Koehler. Revised: 05/03; **SO_2** AP42 Table 3.4-1, 10/96

OSR Main Ship Incinerator — **PM_{10}, $PM_{2.5}$, NO_x, CO, VOC** AP42 Table 2.1-12, 10/96; **Lead** AP42 Table 2.2-2 - Metals Emission Factors for Mass Burn and Modular Excess Air Combustors

OSR Work Boat ICE Propulsion Engines — **PM_{10}, NO_x, CO, VOC** Cummins Engine Model: QSB5.9-305 MCD Spec Sheet, 10/06; **$PM_{2.5}$** 100% PM_{10}

OSR Work Boat ICE Generators — **PM_{10}, NO_x, CO, VOC** AP42 Table 3.3-1, 10/96; **$PM_{2.5}$** 100% PM_{10}

Assumptions	References	Conversions
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.	1.340 hp/kW
133,098 Btu/gal		454 g/lb
0.1331 MMBtu/gal		3,600 sec/hour
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.	2,000 lb/ton
847.9 kg/m^3		2 wt. conversion of S to SO2
7.08 lb/gal		264 gal/m^3
ICE Engines diesel heat rate	AP42 Table 3.3-1, 10/96	
7,000 Btu/hp-hr		
0.007 MMBtu/hp-hr		
OSR Main Ship Propulsion (Cat/3608) diesel heat rate		
204.7 g/kW-hr		
6335 Btu/hp-hr		
0.0063 MMBtu/hp-hr		

ATTACHMENT E

Revised Impact Estimates

E.1 Emissions for modeling purposes

E.2 Revised application Sections 5, 6, and 7

Air Sciences Inc.	PROJECT TITLE: Shell Offshore, Inc.	BY: S. Pryor	
ENGINEERING CALCULATIONS	PROJECT NO: 180-15-1	PAGE: 1	OF: 15
	SUBJECT: Discoverer Emissions-AK OCS	DATE: May 18, 2009	

Frontier Discoverer Sources

Unit ID	Description	Make/Model	Rating		Max fuel consumpt. (MMBtu/hr)[1]	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	Notes
						Maximum Emissions (lb/hr)[1]					
FD-1	Generator Engine	Cat / D399	1,325	hp	6.91	0.20	0.20	0.77	1.10E-02	0.28	2, 3, 4
FD-2	Generator Engine	Cat / D399	1,325	hp	6.91	0.20	0.20	0.77	1.10E-02	0.28	2, 3, 4
FD-3	Generator Engine	Cat / D399	1,325	hp	6.91	0.20	0.20	0.77	1.10E-02	0.28	2, 3, 4
FD-4	Generator Engine	Cat / D399	1,325	hp	6.91	0.20	0.20	0.77	1.10E-02	0.28	2, 3, 4
FD-5	Generator Engine	Cat / D399	1,325	hp	6.91	0.20	0.20	0.77	1.10E-02	0.28	2, 3, 4
FD-6	Generator Engine	Cat / D399	1,325	hp	6.91	0.20	0.20	0.77	1.10E-02	0.28	2, 3, 4
FD-7	Propulsion Engine	MI / 6UEC65	7,200	hp	0.00	0.00	0.00	0.00	0.00E+00	0.00	5, 6
FD-8	Em Generator	Caterpillar / 3304	131	hp	0.31	0.21	0.21	1.09	4.88E-04	0.60	7
FD-9	MLC Compressor	Caterpillar / C-15	540	hp	3.58	0.18	0.18	3.55	5.71E-03	3.11	8
FD-10	MLC Compressor	Caterpillar / C-15	540	hp	3.58	0.18	0.18	3.55	5.71E-03	3.11	8
FD-11	MLC Compressor	Caterpillar / C-15	540	hp	0.00	0.00	0.00	0.00	0.00E+00	0.00	8
FD-12	HPU Engine	Detroit/8V71	250	hp	1.95	0.10	0.10	5.41	3.11E-03	0.16	9
FD-13	HPU Engine	Detroit/8V71	250	hp	1.95	0.10	0.10	5.41	3.11E-03	0.16	9
FD-14	Port Deck Crane	Cat / D343	365	hp	2.77	0.04	0.04	6.20	4.41E-03	0.13	9
FD-15	Starbd Deck Crane	Cat / D343	365	hp	2.77	0.04	0.04	6.20	4.41E-03	0.13	9
FD-16	Cementing Unit	Detroit / 8V-71N	335	hp	2.62	0.21	0.21	8.66	4.17E-03	0.48	9
FD-17	Cementing Unit	Detroit / 8V-71N	335	hp	2.62	0.21	0.21	8.66	4.17E-03	0.48	9
FD-18	Cementing Unit	GM 3-71	147	hp	1.15	0.09	0.09	3.80	1.83E-03	0.21	9
FD-19	Logging Winch	Detroit / 4-71N	128	hp	0.00	0.00	0.00	0.00	0.00E+00	0.00	9, 10
FD-20	Logging Winch	John Deere/4024TF270	36	kW	0.00	0.00	0.00	0.00	0.00E+00	0.00	10, 11
FD-21	Heat Boiler	Clayton 200 Boiler	7.97	MMBtu/hr	7.97	0.19	0.19	1.60	1.27E-02	0.62	
FD-22	Heat Boiler	Clayton 200 Boiler	7.97	MMBtu/hr	7.97	0.19	0.19	1.60	1.27E-02	0.62	
FD-23	Incinerator	TeamTec/GS500C	276	lb/hr		1.13	0.97	0.69	0.35	4.28	
Discoverer total while drilling					80.7	4.07	3.90	61.05	0.47	15.76	

Associated Fleets					Max fuel consumpt. (MMBtu/hr)[1]	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	Notes
						Maximum Emissions (lb/hr)[1]					
Ice Management Fleet - Generic											
ICE Engines					377.28	93.99	83.00	2,216.84	82.85	320.69	
Incinerators	154 lb/hr	154 lb/hr	308	lb/hr		2.05	1.40	0.46	0.39	46.20	12
Total Ice Management Fleet					**377.28**	**96.04**	**84.40**	**2,217.31**	**83.23**	**366.89**	
Resupply Ship - Generic					**2.04**	**0.63**	**0.63**	**9.01**	**0.41**	**1.94**	
OSR Fleet											
OSR Main Ship ICE Propulsion Engines					8.58	0.38	0.38	30.35	1.73	1.63	
OSR Main Ship ICE Generators					9.00	4.06	3.26	53.70	1.98	7.65	
OSR Main Ship Incinerator			125	lb/hr		0.83	0.57	0.19	0.16	18.75	
OSR Main Ship Total					*17.58*	*5.27*	*4.20*	*84.24*	*3.87*	*28.02*	
OSR Work Boat ICE Propulsion Engines					12.60	0.31	0.31	18.43	2.55	0.62	
OSR Work Boat ICE Generators					0.25	0.08	0.08	1.11	0.05	0.24	
OSR Work Boats Total					*12.85*	*0.38*	*0.38*	*19.54*	*2.60*	*0.85*	
Total OSR Fleet					**30.43**	**5.65**	**4.59**	**103.78**	**6.46**	**28.88**	
Total Fleet					409.75	102.33	89.62	2,330.10	90.11	397.71	
				Total All	490.46	106.40	93.53	2,391.15	90.58	413.46	

Notes

1 All emissions are the maximum 1-hour values
2 Units FD-1-6 (Generator Engines) instantaneous capacity restriction applied
3 Generator SCR NOx control effectiveness applied
4 Generator Oxidation Catalyst reduction efficiencies applied
5 Not used during drilling 0%
6 Any emissions from the propulsion engine associated with travel to and from drill sites (within 25 miles of the sites) will be negligible and are included in the ice management fleet allowance.
7 Unit FD-8 (Emergency Generator) operation assumed for 20 min/week. Ref: Wright, Alistair email to Anthony Wilson, 1/21/09.
8 Tier 3 engines
9 Small engines (other than the Tier 3 engines) CDPF PM & CO reduction efficiencies applied
10 Units FD-19 & 20 (Logging Winches) cannot operate simultaneously with cementing units, emissions combined with cementing uni 0%
11 Tier 2 engine
12 Assume 2 incinerators rated at 154 lb/hr & 154 lb/hr

Values in blue are input.
Values in black are calculated or linked

Emissions Summary for Screening Modeling Purposes

			PM_{10} Max 24-hr		$PM_{2.5}$ Max 24-hr		NO_x Max 24-hr		SO_2 [2] Max 1-hr		CO Max 1-hr	
Stack Identifier		**Comments**										
F-D Stack No.			**(lb/hr)**	**(g/sec)**	**(lb/hr)**	**(g/sec)**	**(lb/hr)**	**(g/sec)**	**(lb/hr)**	**(g/sec)**	**(lb/hr)**	**(g/sec)**
1	FD-1, 2, 3, 4, 5, 6	6 operating at 71%	1.18	0.15	1.18	0.15	4.64	0.59	6.62E-02	0.0083	1.66	0.21
	FD-7	Not used during drilling	0	0	0	0	0	0	0	0	0	0
	FD-8	20 min/wk	0.009	0.0011	0.009	0.0011	0.045	0.01	4.88E-04	0.0001	0.60	0.08
2	FD-9, 10	Operating at 100%	0.36	0.04	0.36	0.04	7.11	0.90	1.14E-02	0.001	6.22	0.78
	FD-11	Only used as backup for FD-9 & FD-10	0	0	0	0	0	0	0	0	0	0
3	FD-12, 13	Operating at 100%	0.21	0.03	0.21	0.03	10.81	1.36	6.23E-03	0.001	0.33	0.04
4	FD-16, 17, 18	Operating at 30%	0.16	0.02	0.16	0.02	6.33	0.80	1.02E-02	0.001	1.18	0.15
5a, 5b	FD-14, 15	Operating at 100%	0.09	0.01	0.09	0.01	12.39	1.56	8.82E-03	0.001	0.26	0.03
6	FD-21, 22	Operating at 100%	0.38	0.05	0.38	0.05	3.21	0.40	2.54E-02	0.003	1.23	0.16
7	FD-19, 20	Operating at 0%	0	0	0	0	0	0	0	0	0	0
8	FD-23	Operating at 1525 lb/trash per day	0.26	0.03	0.22	0.03	0.16	0.02	0.35	0.043	4.28	0.54
			2.63	**0.33**	**2.59**	**0.33**	**44.70**	**5.63**	**0.47**	**0.060**	**15.76**	**1.99**
Ice Management Fleet			96.0	12.10	84.4	10.63	2217.3	279.38	83.23	10.49	366.89	46.23
Resupply Ship		12 hr/day [1]	0.3	0.04	0.3	0.04	4.5	0.57	0.41	0.05	1.94	0.24
OSR Main Ship		24 hr/day	5.3	0.66	4.2	0.53	84.2	10.61	3.87	0.49	28.02	3.53
OSR Work Boats		24 hr/day	0.4	0.05	0.4	0.05	19.5	2.46	2.60	0.33	0.85	0.11
			102.0	**12.85**	**89.3**	**11.25**	**2325.6**	**293.02**	**90.1**	**11.35**	**397.7**	**50.11**
	maximum total when drilling		**104.64**	**13.18**	**91.90**	**11.58**	**2370.30**	**298.65**	**90.58**	**11.41**	**413.46**	**52.10**

[1] Craik, Keith email to R. Steen, 11/11/08.

[2] For 24-hour emission rate, the ORR of 1525 lb/trash is taken into account:

		SO_2 [2] Max 24-hr	
FD-23	Operating at 1525 lb/trash per day	0.08	0.01
Total F-D		**0.21**	**0.03**
maximum total when drilling		**90.31**	**11.38**

Source Release Parameters for Screening Modeling Purposes

Rig Sources

Source Description	Model Src ID	Source Type	Vertical or Horizontal?	Source Location X (m)	Source Location Y (m)	Rel Ht.[1] (m)	Stk Dia. (m)	Exit Temp. (deg K)	Exit Vel. (m/s)
Stack #1: 6 Main Drill Engines [2]	MAINENGS	POINT	Vertical	154.1	55.2	12.83	0.32	710	32.9
Stack #2: 2 MLC Compressors [3]	COMPENGS	POINT	Vertical	102.0	63.0	8.53	0.21	700	40.0
Stack #3: 2 HPU Engines [3]	HPPENGS	POINT	Vertical	79.0	65.0	6.10	0.18	700	40.0
Stack #4: 3 Cementing Units [4]	CEMENT	POINT	Vertical	95.0	67.0	6.10	0.18	800	46.6
Stack #5a: Crane Engine (port) [3]	CRANE_PT	POINT	Vertical	114	66.0	13.72	0.25	672	20.1
Stack #5b: Crane Engine (stbd) [3]	CRANE_SB	POINT	Vertical	70.1	43.7	13.72	0.25	672	20.1
Stack #6: 2 Heat Boilers [5]	HEATBOIL	POINT	Vertical	154.3	52.2	12.83	0.46	478	7.3
Stack #7: 1 Incinerator [3]	INCIN_D	POINT	Vertical	61.0	65.0	2.44	0.46	623	10.0

[1] Above main deck which is approximately 4.57 meters (15 feet) above the water surface.

[2] D399 Caterpillar Engine Data Sheet, 05/95 & D399 Stack Parameters Sheet

[3] Kulluk Permit R100CS-AK-07-01, June 2008

[4] Detroit Diesel Allison, Basic Engine Performance Model: 8V-71N, 10/15/81 & Detroit/8V-71N Stack Parameters Sheet; diameter from Kulluk Permit R100CS-AK-07-01, June 2008

[5] Clayton Industries, 8/2001

Fleet Sources

Source Description	Mod. Src. ID	Source Type	Ship Type	Stack Orientation	Rel. Ht. (m)	Stack Dia.[1] (m)	Exit Temp. (deg K)	Exit Vel.[1] (m/s)
Resupply [2]	KILABUK	POINT	Resupply	Vertical	15.24	0.18	700	40.0
Oil Spill Response (Kvichaks) [3a]	OILSPL3	POINT/VOLUMES	OSR Fleet (Kvichaks)	Vertical	3.35	0.15	694	32.9
Oil Spill Response (Nanuq) [3b]	OILSPL4	POINT/VOLUMES	OSR Fleet (Nanuq)	Vertical	15.24	0.76	644	40.0
Fennica/Nordica [4]	FENNICA2	POINT/VOLUMES	Secondary	Vertical	32.00	0.80	655	38.4
Vladimir Ignatjuk [5]	VLADIGN2	POINT/VOLUMES	Primary, Secondary	Vertical	24.38	0.79	668	33.2
Talagy 6	TALAGY	POINT/VOLUMES	Primary, Secondary	Vertical	25.91	0.80	594	43.7
Tor Viking II [7]	TOR_H	POINT/VOLUMES	Secondary	Horizontal	28.96	110.38	579	0.001
Odin Viking II [8]	ODIN_H	POINT/VOLUMES	Primary	Horizontal	28.96	94.61	579	0.001
Balder Viking [9]	BALD_H	POINT/VOLUMES	Secondary	Horizontal	28.96	110.38	579	0.001
Vidar Viking [10]	VIDAR_H	POINT/VOLUMES	Secondary	Horizontal	28.96	110.38	579	0.001

Fleet Sources, continued

Source Description	Source	Propulsion Engine	Max. Engine (kW)
Resupply [2]	Engine	---	---
Oil Spill Response (Kvichaks) [3a]	Engine	---	---
Oil Spill Response (Nanuq) [3b]	Engine	---	---
Fennica/Nordica [4]	Engine	2X Wartsila 16V32, 2X 12V32	6,000
Vladimir Ignatjuk [5]	Engine	4X Stork Werkspoor 8TM410	4,325
Talagy [6]	Engine	Sulzer 12 ZV 40/48	6,264
Tor Viking II [7]	Engine	2X MaK 8M32C, 2X 6M32C	3,840
Odin Viking II [8]	Engine	4X MaK 6M32C	2,880
Balder Viking [9]	Engine	2X MaK 8M32C, 2X 6M32C	3,840
Vidar Viking [10]	Engine	2X MaK 8M32C, 2X 6M32C	3,840

[1] Horizontal stacks adjusted per Alaska DEC recommendations to impeded vertical momentum (0.001 m/sec exit velocity), while allowing credit for buoyant rise from hot stacks. Adjustment to diameter is: 31.6 * (actual diameter in meters) * (square root of actual exit velocity in units of meters/sec).

[2] Resupply ship (Jim Kilabuk) configuration is taken from the Kulluk Permit R100CS-AK-07-01, June 2008.

[3a] OSR fleet configuration for the Kvichaks (34-foot boats) is from the Firebaugh Technical Memo.

[3a] OSR fleet configuration for the Nanuq is from the Firebaugh Technical Memo.

[4] Alaska Source Testing, LLC. Summary of Test Results Fennica/Nordica Icebreaker. June 28, 2007.

[5] TRC Environmental Corp. Emission Test Report - Vladimir Ignatjuk, Project No.150614. July 12, 2007.

[6] FEMCO-Management. Safety Quality Expertise – Fleet/AHTS “Talagy”.

[7] TRC Environmental Corp. Emission Test Report - Tor Viking II, Project No.150614. July 12, 2007.

[8] Viking Supply Ships AS Shipowners. AHTS Odin Viking II - Main Characteristics.

[9] Viking Supply Ships AS Shipowners. AHTS/Icebreaker Balder Viking - Main Characteristics.

[10] Viking Supply Ships AS Shipowners. AHTS/Icebreaker Vidar Viking - Main Characteristics.

Air Sciences Inc.	PROJECT TITLE: Shell Offshore, Inc.	BY: Tim Martin	
	PROJECT NO: 180-15-1	PAGE: 4	OF: 15
ENGINEERING CALCULATIONS	SUBJECT: Discoverer Emissions-AK OCS	DATE: May 18, 2009	

Fleet Sources, Stack Parameters for Loads Analysis - SCREEN3

Source Description	Load	Mod. Src. ID	Source Type	Stack Orientation	Rel. Ht. (m)	Stack Dia. [1] (m)	Exit Temp. (deg K)	Exit Vel. [1] (m/s)
Vladimir Ignatjuk [4]	80%	VLD2_080	POINT	Vertical	24.38	0.79	668	33.2
Vladimir Ignatjuk [4]	57%	VLD2_057	POINT	Vertical	24.38	0.79	638	25.9
Vladimir Ignatjuk [4]	35%	VLD2_035	POINT	Vertical	24.38	0.79	581	16.3
Fennica/Nordica [5]	80%	FEN2_080	POINT	Vertical	32.00	0.80	655	38.4
Fennica/Nordica [5]	57%	FEN2_057	POINT	Vertical	32.00	0.80	633	30.0
Fennica/Nordica [5]	35%	FEN2_035	POINT	Vertical	32.00	0.80	637	20.3
Tor Viking II [6]	80%	TORH_080	POINT	Horizontal	28.96	110.4	579	0.001
Tor Viking II [6]	57%	TORH_057	POINT	Horizontal	28.96	101.6	607	0.001
Tor Viking II [6]	35%	TORH_035	POINT	Horizontal	28.96	74.7	630	0.001

Fleet Sources, Inputs and Outputs for Loads Analysis - ISC-PRIME

Source Description	Actual NOx Emissions (lb/hr)	Normalized NOx Emissions (g/sec) [7]	Lowest Final Plume Ht. (m) [2]	Sigma Y (m)	Sigma Z [3] (m)	Max. ISC-PRIME Impact (ug/m3)	Load
Vladimir Ignatjuk [4]	83.6	1.000	24.43	46.51	9.21	110.7	80%
Vladimir Ignatjuk [4]	68.4	0.818	24.42	46.51	9.21	90.6	57%
Vladimir Ignatjuk [4]	29.6	0.354	24.40	46.51	9.21	39.3	35%
Fennica/Nordica [5]	96.5	1.000	32.02	46.51	12.76	78.4	80%
Fennica/Nordica [5]	66.6	0.690	32.02	46.51	12.76	54.1	57%
Fennica/Nordica [5]	49.0	0.508	32.01	46.51	12.76	39.8	35%
Tor Viking II [6]	13.8	1.000	28.97	46.51	11.34	89.4	80%
Tor Viking II [6]	5.16	0.374	28.97	46.51	11.34	33.4	57%
Tor Viking II [6]	2.61	0.189	28.97	46.51	11.34	16.9	35%

[1] Horizontal stacks adjusted per Alaska DEC recommendations to impeded vertical momentum (0.001 m/sec exit velocity), while allowing credit for buoyant rise from hot stacks. Adjustment to diameter is: 31.6 * (actual diameter in meters) * (square root of actual exit velocity in units of meters/sec).

[2] From SCREEN3 model output.

[3] TRC Environmental Corp. Emission Test Report - Vladimir Ignatjuk, Project No.150614. July 12, 2007.

[4] Alaska Source Testing, LLC. Summary of Test Results Fennica/Nordica Icebreaker. June 28, 2007.

[5] TRC Environmental Corp. Emission Test Report - Tor Viking II, Project No.150614. July 12, 2007.

[6] Normalized emissions are based on the emissions at each load point (100%, 75%, 50%, etc.) divided by the emissions from the maximum load point (100%).

Stack Parameters for Loads Analysis [2]

Source Description	Load	Mod. Src. ID	Source Type	Stack Orientation	Rel. Ht. [1] (m)	Stack Dia. (m)	Exit Temp. (deg K)	Exit Vel. (m/s)
Stack #1: 6 Main Drill Engines	100%	MAIN_100	POINT	vertical	12.83	0.32	710	32.9
Stack #1: 6 Main Drill Engines	75%	MAIN_075	POINT	vertical	12.83	0.32	663	26.4
Stack #1: 6 Main Drill Engines	50%	MAIN_050	POINT	vertical	12.83	0.32	606	21.0

Inputs and Outputs for Loads Analysis (NOx and PM_{10}) - ISC-PRIME [2]

	Actual Emissions (g/hr)		Normalized Emissions (g/sec) [3]		Max. ISC-PRIME Impact (ug/m3)		
Source Description	NOx	PM_{10}	NOx	PM_{10}	NOx	PM_{10}	Load
Stack #1: 6 Main Drill Engines	7993.9	251.2	1.000	1.000	64.7	64.7	100%
Stack #1: 6 Main Drill Engines	6159.8	133.8	0.771	0.533	56.5	39.0	75%
Stack #1: 6 Main Drill Engines	4360.5	79.1	0.545	0.315	45.6	26.4	50%

Inputs and Outputs for Loads Analysis (CO and SO_2) - ISC-PRIME [2]

	Actual Emissions (g/hr)		Normalized Emissions (g/sec)		Max. ISC-PRIME Impact (ug/m3)		
Source Description	CO	SO_2	CO	SO_2	CO	SO_2	Load
Stack #1: 6 Main Drill Engines	882.7	7.0	1.000	1.000	64.7	64.7	100%
Stack #1: 6 Main Drill Engines	710.1	5.1	0.804	0.730	58.9	53.5	75%
Stack #1: 6 Main Drill Engines	622.6	3.5	0.705	0.498	59.0	41.7	50%

[1] Above main deck which is approximately 4.57 meters (15 feet) above the water surface.

[2] Caterpillar D399 Engine Data Sheet, 05/95

[3] Normalized emissions are based on the emissions at each load point (100%, 75%, 50%, etc.) divided by the emissions from the maximum load point (100%).

Source Release Parameters for Screening Modeling Purposes

Fleet Sources

Source Description	Model Src ID	Source Type	Source Location X (m)	Source Location Y (m)	Rel Ht. (m)	Sigma-Y (m)	Sigma-Z (m)
Oil Spill Response Ships k,n *	OILSP01k,n	VOLUME	-1984.3	980.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP02k,n	VOLUME	-1984.3	930.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP03k,n	VOLUME	-1984.3	880.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP04k,n	VOLUME	-1984.3	830.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP05k,n	VOLUME	-1984.3	780.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP06k,n	VOLUME	-1984.3	730.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP07k,n	VOLUME	-1984.3	680.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP08k,n	VOLUME	-1984.3	630.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP09k,n	VOLUME	-1984.3	580.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP10k,n	VOLUME	-1984.3	530.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP11k,n	VOLUME	-1984.3	480.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP12k,n	VOLUME	-1984.3	430.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP13k,n	VOLUME	-1984.3	380.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP14k,n	VOLUME	-1984.3	330.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP15k,n	VOLUME	-1984.3	280.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP16k,n	VOLUME	-1984.3	230.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP17k,n	VOLUME	-1984.3	180.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP18k,n	VOLUME	-1984.3	130.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP19k,n	VOLUME	-1984.3	80.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP20k,n	VOLUME	-1984.3	30.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP21k,n	VOLUME	-1984.3	-20.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP22k,n	VOLUME	-1984.3	-70.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP23k,n	VOLUME	-1984.3	-120.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP24k,n	VOLUME	-1984.3	-170.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP25k,n	VOLUME	-1984.3	-220.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP26k,n	VOLUME	-1984.3	-270.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP27k,n	VOLUME	-1984.3	-320.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP28k,n	VOLUME	-1984.3	-370.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP29k,n	VOLUME	-1984.3	-420.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP30k,n	VOLUME	-1984.3	-470.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP31k,n	VOLUME	-1984.3	-520.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP32k,n	VOLUME	-1984.3	-570.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP33k,n	VOLUME	-1984.3	-620.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP34k,n	VOLUME	-1984.3	-670.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP35k,n	VOLUME	-1984.3	-720.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP36k,n	VOLUME	-1984.3	-770.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP37k,n	VOLUME	-1984.3	-820.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP38k,n	VOLUME	-1984.3	-870.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP39k,n	VOLUME	-1984.3	-920.0	3.38, 17.55	23.26	1.42, 6.38
Oil Spill Response Ships k,n *	OILSP40k,n	VOLUME	-1984.3	-970.0	3.38, 17.55	23.26	1.42, 6.38
Secondary Ice Management Fleet	BRK_B01	VOLUME	1222.3	2405.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B02	VOLUME	1222.3	2305.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B03	VOLUME	1222.3	2205.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B04	VOLUME	1222.3	2105.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B05	VOLUME	1222.3	2005.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B06	VOLUME	1222.3	1905.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B07	VOLUME	1222.3	1805.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B08	VOLUME	1222.3	1705.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B09	VOLUME	1222.3	1605.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B10	VOLUME	1222.3	1505.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B11	VOLUME	1222.3	1405.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B12	VOLUME	1222.3	1305.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B13	VOLUME	1222.3	1205.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B14	VOLUME	1222.3	1105.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B15	VOLUME	1222.3	1005.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B16	VOLUME	1222.3	905.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B17	VOLUME	1222.3	805.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B18	VOLUME	1222.3	705.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B19	VOLUME	1222.3	605.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B20	VOLUME	1222.3	505.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B21	VOLUME	1222.3	405.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B22	VOLUME	1222.3	305.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B23	VOLUME	1222.3	205.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B24	VOLUME	1222.3	105.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B25	VOLUME	1222.3	5.0	25.22	46.51	9.21

* Each type of oil spill response ship is explicitly modeled. K denotes the Kvichaks (34-foot boats) and N denotes the Nanuq.

Source Release Parameters for Screening Modeling Purposes, contd.

Fleet Sources

Source Description	Model Src ID	Source Type	Source Location X (m)	Source Location Y (m)	Rel Ht. (m)	Sigma-Y (m)	Sigma-Z (m)
Secondary Ice Management Fleet	BRK_B26	VOLUME	1222.3	-95.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B27	VOLUME	1222.3	-195.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B28	VOLUME	1222.3	-295.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B29	VOLUME	1222.3	-395.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B30	VOLUME	1222.3	-495.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B31	VOLUME	1222.3	-595.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B32	VOLUME	1222.3	-695.0	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B33	VOLUME	1222.3	-795	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B34	VOLUME	1222.3	-895	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B35	VOLUME	1222.3	-995	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B36	VOLUME	1222.3	-1095	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B37	VOLUME	1222.3	-1195	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B38	VOLUME	1222.3	-1295	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B39	VOLUME	1222.3	-1395	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B40	VOLUME	1222.3	-1495	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B41	VOLUME	1222.3	-1595	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B42	VOLUME	1222.3	-1695	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B43	VOLUME	1222.3	-1795	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B44	VOLUME	1222.3	-1895	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B45	VOLUME	1222.3	-1995	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B46	VOLUME	1222.3	-2095	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B47	VOLUME	1222.3	-2195	25.22	46.51	9.21
Secondary Ice Management Fleet	BRK_B48	VOLUME	1222.3	-2295	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A01	VOLUME	5022.3	4805	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A02	VOLUME	5022.3	4705	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A03	VOLUME	5022.3	4605	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A04	VOLUME	5022.3	4505	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A05	VOLUME	5022.3	4405	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A06	VOLUME	5022.3	4305	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A07	VOLUME	5022.3	4205	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A08	VOLUME	5022.3	4105	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A09	VOLUME	5022.3	4005	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A10	VOLUME	5022.3	3905	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A11	VOLUME	5022.3	3805	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A12	VOLUME	5022.3	3705	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A13	VOLUME	5022.3	3605	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A14	VOLUME	5022.3	3505	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A15	VOLUME	5022.3	3405	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A16	VOLUME	5022.3	3305	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A17	VOLUME	5022.3	3205	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A18	VOLUME	5022.3	3105	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A19	VOLUME	5022.3	3005	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A20	VOLUME	5022.3	2905	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A21	VOLUME	5022.3	2805	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A22	VOLUME	5022.3	2705	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A23	VOLUME	5022.3	2605	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A24	VOLUME	5022.3	2505	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A25	VOLUME	5022.3	2405	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A26	VOLUME	5022.3	2305	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A27	VOLUME	5022.3	2205	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A28	VOLUME	5022.3	2105	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A29	VOLUME	5022.3	2005	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A30	VOLUME	5022.3	1905	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A31	VOLUME	5022.3	1805	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A32	VOLUME	5022.3	1705	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A33	VOLUME	5022.3	1605	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A34	VOLUME	5022.3	1505	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A35	VOLUME	5022.3	1405	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A36	VOLUME	5022.3	1305	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A37	VOLUME	5022.3	1205	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A38	VOLUME	5022.3	1105	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A39	VOLUME	5022.3	1005	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A40	VOLUME	5022.3	905	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A41	VOLUME	5022.3	805	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A42	VOLUME	5022.3	705	25.22	46.51	9.21

Source Release Parameters for Screening Modeling Purposes, contd.

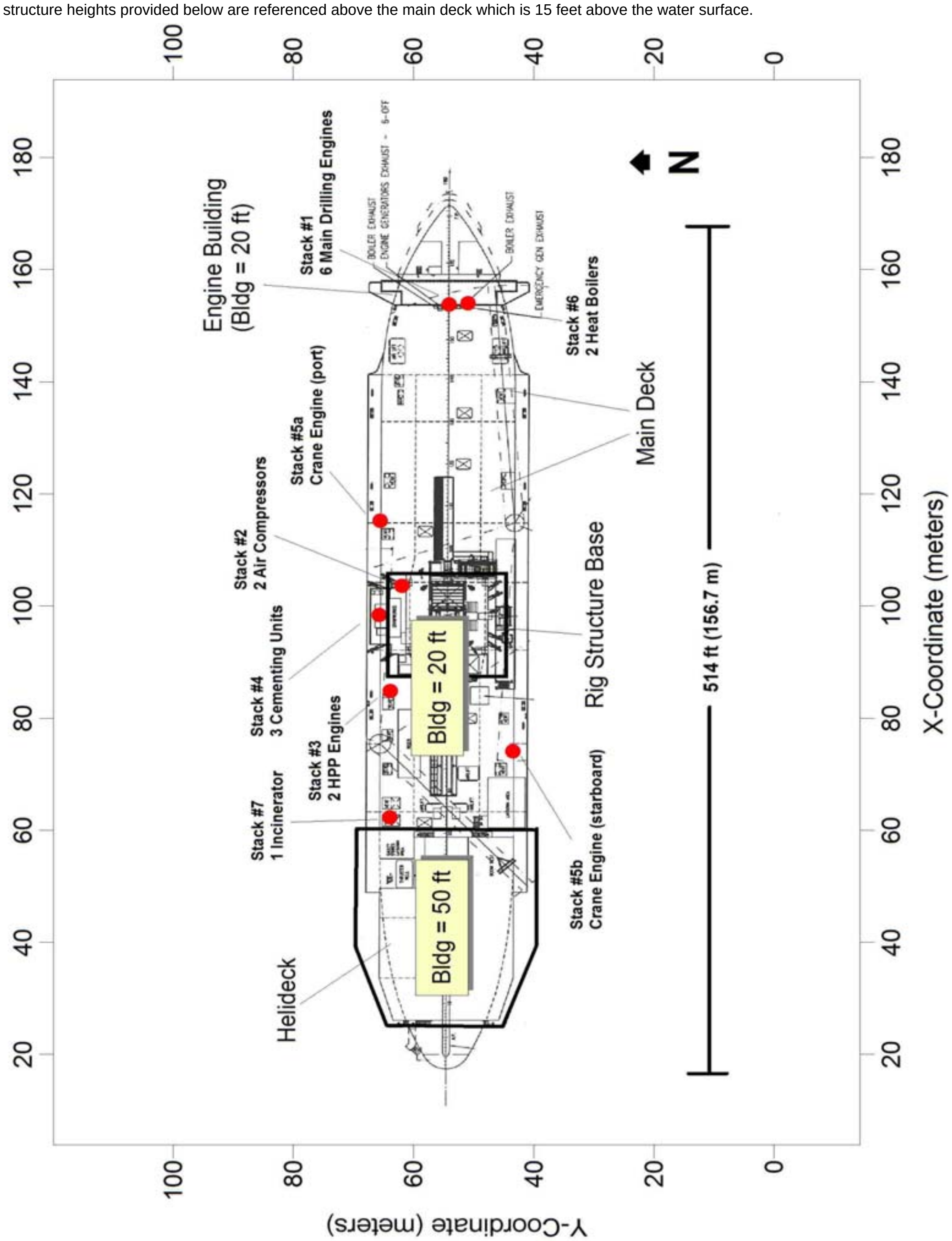
Fleet Sources

Source Description	Model Src ID	Source Type	Source Location X (m)	Source Location Y (m)	Rel Ht. (m)	Sigma-Y (m)	Sigma-Z (m)
Primary Ice Management Fleet	BRK_A43	VOLUME	5022.3	605	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A44	VOLUME	5022.3	505	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A45	VOLUME	5022.3	405	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A46	VOLUME	5022.3	305	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A47	VOLUME	5022.3	205	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A48	VOLUME	5022.3	105	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A49	VOLUME	5022.3	5	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A50	VOLUME	5022.3	-95	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A51	VOLUME	5022.3	-195	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A52	VOLUME	5022.3	-295	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A53	VOLUME	5022.3	-395	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A54	VOLUME	5022.3	-495	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A55	VOLUME	5022.3	-595	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A56	VOLUME	5022.3	-695	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A57	VOLUME	5022.3	-795	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A58	VOLUME	5022.3	-895	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A59	VOLUME	5022.3	-995	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A60	VOLUME	5022.3	-1095	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A61	VOLUME	5022.3	-1195	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A62	VOLUME	5022.3	-1295	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A63	VOLUME	5022.3	-1395	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A64	VOLUME	5022.3	-1495	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A65	VOLUME	5022.3	-1595	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A66	VOLUME	5022.3	-1695	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A67	VOLUME	5022.3	-1795	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A68	VOLUME	5022.3	-1895	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A69	VOLUME	5022.3	-1995	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A70	VOLUME	5022.3	-2095	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A71	VOLUME	5022.3	-2195	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A72	VOLUME	5022.3	-2295	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A73	VOLUME	5022.3	-2395	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A74	VOLUME	5022.3	-2495	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A75	VOLUME	5022.3	-2595	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A76	VOLUME	5022.3	-2695	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A77	VOLUME	5022.3	-2795	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A78	VOLUME	5022.3	-2895	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A79	VOLUME	5022.3	-2995	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A80	VOLUME	5022.3	-3095	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A81	VOLUME	5022.3	-3195	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A82	VOLUME	5022.3	-3295	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A83	VOLUME	5022.3	-3395	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A84	VOLUME	5022.3	-3495	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A85	VOLUME	5022.3	-3595	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A86	VOLUME	5022.3	-3695	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A87	VOLUME	5022.3	-3795	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A88	VOLUME	5022.3	-3895	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A89	VOLUME	5022.3	-3995	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A90	VOLUME	5022.3	-4095	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A91	VOLUME	5022.3	-4195	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A92	VOLUME	5022.3	-4295	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A93	VOLUME	5022.3	-4395	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A94	VOLUME	5022.3	-4495	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A95	VOLUME	5022.3	-4595	25.22	46.51	9.21
Primary Ice Management Fleet	BRK_A96	VOLUME	5022.3	-4695	25.22	46.51	9.21

Air Sciences Inc.	PROJECT TITLE: Shell Offshore, Inc.	BY: Tim Martin	
	PROJECT NO: 180-15-1	PAGE: 8	OF: 15
ENGINEERING CALCULATIONS	SUBJECT: Discoverer Emissions-AK OCS	DATE: May 18, 2009	

Configuration of Platform Equipment

* Building structure heights provided below are referenced above the main deck which is 15 feet above the water surface.



Building Information for ISC-BPIP Analysis

Structure Name	**Main Deck**		**Helideck**		**Rig Structure Base**		**Engine Housing**	
Height Above Water	4.57 m		19.81 m		10.67 m		10.67 m	
# Structure Corners	11		6		4		4	
Structure	**Coordinate**		**Coordinate**		**Coordinate**		**Coordinate**	
Corner #	X(m)	Y(m)	X(m)	Y(m)	X(m)	Y(m)	X(m)	Y(m)
1	15.7	55.3	59.0	40.5	81.6	66.0	154.1	47.5
2	32.6	67.8	38.5	40.5	81.6	44.0	154.1	62.5
3	141.6	67.8	23.6	45.0	104.1	44.0	158.5	62.5
4	141.8	66.0	23.6	64.8	104.1	66.0	158.5	47.5
5	158.8	62.5	38.5	69.8	---	---	---	---
6	172.3	55.0	59.0	69.8	---	---	---	---
7	158.8	47.0	---	---	---	---	---	---
8	143.4	44.3	---	---	---	---	---	---
9	141.6	42.3	---	---	---	---	---	---
10	47.5	42.3	---	---	---	---	---	---
11	32.6	42.3	---	---	---	---	---	---

Structure Name	**Re-Supply-T**		**Re-Supply-S**		**Re-Supply-B**	
Height Above Water	13.72 m		3.05 m		7.62 m	
# Structure Corners	11		6		4	
Structure	**Coordinate**		**Coordinate**		**Coordinate**	
Corner #	X(m)	Y(m)	X(m)	Y(m)	X(m)	Y(m)
1	63.0	-29.5	63.0	-12.0	63.0	-34.5
2	63.0	-15.5	63.0	28.0	63.0	-12.0
3	77.0	-15.5	77.0	28.0	77.0	-12.0
4	77.0	-29.5	77.0	-12.0	77.0	-34.5

Building Information for SCREEN3 Analyses

	Building Dimensions (m) [1]		
Source Description	Height	Max. Width	Min. Width
Oil Spill Response (Kvichaks)	3.05	4.88	3.66
Oil Spill Response (Nanuq)	13.72	15.24	15.24
Fennica/Nordica	27.43	26.00	21.34
Vladimir Ignatjuk	19.81	17.51	17.51
Talagy	19.81	17.25	13.72
Tor Viking II	24.38	18.00	15.24
Odin Viking II	24.38	16.90	16.90
Balder Viking	24.38	18.00	15.24
Vidar Viking	24.38	18.00	15.24

[1] Information derived from ships specifications and photographs (Ref: Firebaugh Technical Memo).

Air Sciences Inc.	PROJECT TITLE: Shell Offshore, Inc.	BY: S. Pryor
AIR SCIENCES INC.	PROJECT NO: 180-15-1	PAGE: 10 OF: 15
ENGINEERING CALCULATIONS	SUBJECT: Discoverer Emissions-AK OCS	DATE: May 18, 2009

Hourly Discoverer Maximum Emissions

Unit ID	Description	Rating		Max fuel consumpt. (MMBtu/hr) [1]	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead	Notes
					Maximum Emissions (lb/hr) [1]							
Frontier Discoverer												
FD-1	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04	2, 3, 4
FD-2	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04	2, 3, 4
FD-3	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04	2, 3, 4
FD-4	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04	2, 3, 4
FD-5	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04	2, 3, 4
FD-6	Generator Engine	1,325	hp	6.9	0.20	0.20	0.77	1.10E-02	0.28	0.04	2.01E-04	2, 3, 4
FD-7	Propulsion Engine	7,200	hp	0.0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	5
FD-8	Em Generator	131	hp	0.3	0.21	0.21	1.09	4.88E-04	0.60	0.11	8.86E-06	6
FD-9	MLC Compressor	540	hp	3.6	0.18	0.18	3.55	5.71E-03	3.11	3.55	1.04E-04	
FD-10	MLC Compressor	540	hp	3.6	0.18	0.18	3.55	5.71E-03	3.11	3.55	1.04E-04	
FD-11	MLC Compressor	540	hp	0.0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	5
FD-12	HPU Engine	250	hp	2.0	0.10	0.10	5.41	3.11E-03	0.16	0.08	5.66E-05	7
FD-13	HPU Engine	250	hp	2.0	0.10	0.10	5.41	3.11E-03	0.16	0.08	5.66E-05	7
FD-14	Port Deck Crane	365	hp	2.8	0.04	0.04	6.20	4.41E-03	0.13	0.04	8.02E-05	7
FD-15	Starbd Deck Crane	365	hp	2.8	0.04	0.04	6.20	4.41E-03	0.13	0.04	8.02E-05	7
FD-16	Cementing Unit	335	hp	2.6	0.21	0.21	8.66	4.17E-03	0.48	0.15	7.58E-05	7
FD-17	Cementing Unit	335	hp	2.6	0.21	0.21	8.66	4.17E-03	0.48	0.15	7.58E-05	7
FD-18	Cementing Unit	147	hp	1.1	0.09	0.09	3.80	1.83E-03	0.21	0.07	3.33E-05	7
FD-19	Logging Winch	128	hp	0.0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	7, 8
FD-20	Logging Winch	36	kW	0.0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	8
FD-21	Heat Boiler	7.97	MMBtu/hr	8.0	0.19	0.19	1.60	1.27E-02	0.62	0.01	7.17E-05	9
FD-22	Heat Boiler	7.97	MMBtu/hr	8.0	0.19	0.19	1.60	1.27E-02	0.62	0.01	7.17E-05	9
FD-23	Incinerator	276	lb/hr		1.13	0.97	0.69	0.35	4.28	0.41	0.03	
	Discoverer total while drilling			80.7	4.07	3.90	61.05	0.47	15.76	8.47	3.14E-02	

Hourly Fleet Maximum Emissions

		Max fuel consumpt. (MMBtu/hr) [1]	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead	Notes
			Maximum Emissions (lb/hr) [1]							
Ice Management Fleet - Generic										
ICE Engines		377.3	93.99	83.00	2,216.84	82.85	320.69	53.20	1.09E-02	
Incinerators	308 lb/hr		2.05	1.40	0.46	0.39	46.20	15.40	3.28E-02	10
Total Ice Management Fleet		*377.3*	*96.04*	*84.40*	*2,217.31*	*83.23*	*366.89*	*68.60*	*4.37E-02*	
Resupply Ship - Generic		2.0	0.63	0.63	9.01	0.41	1.94	0.72	5.93E-05	
OSR Fleet										
OSR Main Ship Total		17.6	5.27	4.20	84.24	3.87	28.02	9.73	1.38E-02	
OSR Work Boats Total		12.9	0.38	0.38	19.54	2.60	0.85	0.40	3.73E-04	
Total OSR Fleet		*30.4*	*5.65*	*4.59*	*103.78*	*6.46*	*28.88*	*10.12*	*1.42E-02*	
Total All Fleet		409.8	102.33	89.62	2,330.10	90.11	397.71	79.44	5.80E-02	
Total All		490.5	106.40	93.53	2,391.15	90.58	413.46	87.91	8.94E-02	

Notes

1 All emissions are the maximum 1-hour values
2 Units FD-1-6 (Generator Engines) instantaneous capacity restriction applied
3 Generator SCR NOx control effectiveness applied
4 Generator Oxidation Catalyst reduction efficiencies applied
5 Not used during drilling
6 Unit FD-8 (Emergency Generator) operation assumed for 20 min/week. Ref: Wright, Alistair email to Anthony Wilson, 1/21/09.
7 Small engines (other than the Tier 3 engines) CDPF PM, CO, VOC, HAPs reduction efficiency applied
8 Units FD-19 & 20 (Logging Winches) cannot operate simultaneously with cementing units, emissions combined with cementing units.
9 CO, VOC, HAPs & Lead emissions based on Fuel Oil Combustion Boilers EF
10 Assume 2 incinerators rated at 154 lb/hr & 154 lb/hr

Yearly Discoverer Maximum Emissions

Time at Drill Sites	168 days/yr	Unit FD-8		20 min/week	8 hrs/yr
	4032 hrs/yr	Units FD-9 through FD-11		63 days/yr	1512 hrs/yr
		Units FD-12 through FD-13		63 days/yr	1512 hrs/yr
		Units FD-14 & FD-15	38% of	168 days/year	1532 hrs/yr
		Unit FD-23	1525 lb/trash per day		

Unit ID	Rating		Max fuel consumpt. (MMBtu/yr)	Fuel Use gal/yr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead	HAPs	Notes
					Maximum Emissions (ton/yr)								
Frontier Discoverer													
FD-1	1,325	hp	27,878	209,457	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02	1, 2, 3
FD-2	1,325	hp	27,878	209,457	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02	1, 2, 3
FD-3	1,325	hp	27,878	209,457	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02	1, 2, 3
FD-4	1,325	hp	27,878	209,457	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02	1, 2, 3
FD-5	1,325	hp	27,878	209,457	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02	1, 2, 3
FD-6	1,325	hp	27,878	209,457	0.40	0.40	1.56	2.22E-02	0.56	0.07	4.04E-04	0.02	1, 2, 3
FD-7	7,200	hp	0	0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	0.00	4
FD-8	131	hp	7	55	2.55E-03	2.55E-03	1.30E-02	5.85E-06	7.16E-03	1.34E-03	1.06E-07	1.44E-05	5
FD-9	540	hp	5,413	40,673	0.13	0.13	2.69	4.32E-03	2.35	2.69	7.85E-05	0.01	6
FD-10	540	hp	5,413	40,673	0.13	0.13	2.69	4.32E-03	2.35	2.69	7.85E-05	0.01	6
FD-11	540	hp	0	0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	0.00	4, 6
FD-12	250	hp	2,951	22,169	0.08	0.08	4.09	2.35E-03	0.12	0.06	4.28E-05	0.00	7, 8
FD-13	250	hp	2,951	22,169	0.08	0.08	4.09	2.35E-03	0.12	0.06	4.28E-05	0.00	7, 8
FD-14	365	hp	4,237	31,831	0.03	0.03	4.75	3.38E-03	0.10	0.03	6.14E-05	0.00	7, 9
FD-15	365	hp	4,237	31,831	0.03	0.03	4.75	3.38E-03	0.10	0.03	6.14E-05	0.00	7, 9
FD-16	335	hp	3,163	23,765	0.13	0.13	5.24	2.52E-03	0.29	0.09	4.59E-05	0.00	7, 10
FD-17	335	hp	3,163	23,765	0.13	0.13	5.24	2.52E-03	0.29	0.09	4.59E-05	0.00	7, 10
FD-18	147	hp	1,388	10,428	0.06	0.06	2.30	1.11E-03	0.13	0.04	2.01E-05	0.00	7, 10
FD-19	128	hp	0	0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	0.00	7, 11
FD-20	36	kW	0	0	0.00	0.00	0.00	0.00E+00	0.00	0.00	0.00E+00	0.00	11
FD-21	7.97	MMBtu/hr	32,135	241,439	0.38	0.38	3.23	2.56E-02	1.24	0.02	1.45E-04	0.01	12
FD-22	7.97	MMBtu/hr	32,135	241,439	0.38	0.38	3.23	2.56E-02	1.24	0.02	1.45E-04	0.01	12
FD-23	276	lb/hr			0.53	0.45	0.32	0.16	1.99	0.19	1.36E-02	0.02	
Discoverer total while drilling			264,463	1,986,982	4.47	4.39	51.97	0.37	13.69	6.44	1.68E-02	0.15	

Yearly Fleet Maximum Emissions

Ice Management Fleet - For NOx only	38%	of	168 days/year	1532 hrs/yr
Ice Management Fleet - For all remaining pollutants	100%	of	168 days/year	4032 hrs/yr
Resupply Ship	12 hr/day		8 days/year	96 hrs/yr

		Max fuel consumpt. (MMBtu/yr)	Fuel Use gal/yr	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Lead	HAPs	Notes
				Maximum Emissions (ton/yr)								
Ice Management Fleet - Generic												
ICE Engines		1,521,193	11,429,120	189	167	1698	167	647	107	2.21E-02	2.99	13
Incinerators	308 lb/hr			4.13	2.83	0.35	0.78	93.14	31.05	6.61E-02	7.78E-02	13, 14
Total		*1,521,193*	*11,429,120*	*194*	*170*	*1,699*	*168*	*740*	*138*	*8.82E-02*	*3.07*	
Resupply Ship - Generic		196.22	1,474	0.03	0.03	0.43	0.02	0.09	0.03	2.85E-06	3.86E-04	15
OSR Fleet												
OSR Main Ship Total		70,877	532,515	10.62	8.47	169.83	7.79	56.49	19.61	2.79E-02	1.71E-01	
OSR Work Boats Total		51,819	389,332	0.77	0.77	39.39	5.23	1.72	0.80	7.51E-04	1.02E-01	16
Total		*122,696*	*921,846*	*11*	*9*	*209*	*13*	*58*	*20*	*2.86E-02*	*2.73E-01*	
Total All Fleet		1,644,085	12,352,440	205	179	1,908	181	798	159	1.17E-01	3.34	
Total All		1,908,548	14,339,422	210	184	1960	181	812	165	1.34E-01	3.50	

Notes

1 Units FD-1-6 (Generator Engines) instantaneous capacity restriction applied
2 Generator SCR NOx control effectiveness applied
3 Generator Oxidation Catalyst reduction efficiencies applied
4 Not used during drilling
5 Unit FD-8 (Emergency Generator) operation assumed for 20 min/week. Ref: Wright, Alistair email to Anthony Wilson, 1/21/09.
6 Units FD-9 through FD-11 (MLC Compressors) operational restriction applied
7 Small engines (other than the Tier 3 engines) CDPF PM, CO, VOC, HAPs reduction efficiency applied
8 Units FD-12 & FD-13 (HPU Engines) operational restriction applied
9 Units FD-14 & 15 (Cranes) operating restriction applied
10 Units FD-16, 17 & 18 (Cementing units) operating capacity restriction applied
11 Units FD-19 & 20 (Logging Winches) cannot operate simultaneously with cementing units, emissions combined with cementing units.
12 CO, VOC, HAPs & Lead emissions based on Fuel Oil Combustion Boilers EF
13 NOx emissions are calculated at 38% of 168 days/yr, Remaining are calculated at 100% of 168 days/yr
14 Assume 2 incinerators rated at 154 lb/hr & 154 lb/hr 100% Use
15 Resupply Ship maximun use 12 hr/day , 8 days/yr

Units	FD-1-6,each	FD-1-6,total	FD-7	FD-8	FD-9	FD-10	FD-11	FD-12	FD-13	FD-14	FD-15	FD-16	FD-17	FD-18	FD-19	FD-20	FD-21	FD-22	FD-23	TOTAL
											MMBtu/yr									
Fuel Consumption	27,878	167,270	0	7	5,413	5,413	0	2,951	2,951	4,237	4,237	3,163	3,163	1,388	0	0	32,135	32,135		
HAPs											ton/yr									
Acaldehyde	3.21E-03	1.92E-02	0.00	2.81E-06	2.08E-03	2.08E-03	0.00	1.13E-04	1.13E-04	1.62E-04	1.62E-04	1.21E-04	1.21E-04	5.32E-05	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	**2.42E-02**
Acenaphthene	5.94E-06	3.56E-05	0.00	5.21E-09	3.84E-06	3.84E-06	0.00	2.09E-07	2.09E-07	3.01E-07	3.01E-07	2.25E-07	2.25E-07	9.85E-08	0.00	0.00	2.55E-06	2.55E-06	0.00E+00	**5.00E-05**
Acenaphthylene	2.12E-05	1.27E-04	0.00	1.86E-08	1.37E-05	1.37E-05	0.00	7.47E-07	7.47E-07	1.07E-06	1.07E-06	8.00E-07	8.00E-07	3.51E-07	0.00	0.00	3.05E-08	3.05E-08	0.00E+00	**1.60E-04**
Acrolein	3.87E-04	2.32E-03	0.00	3.39E-07	2.50E-04	2.50E-04	0.00	1.36E-05	1.36E-05	1.96E-05	1.96E-05	1.46E-05	1.46E-05	6.42E-06	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	**2.92E-03**
Anthracene	7.82E-06	4.69E-05	0.00	6.86E-09	5.06E-06	5.06E-06	0.00	2.76E-07	2.76E-07	3.96E-07	3.96E-07	2.96E-07	2.96E-07	1.30E-07	0.00	0.00	1.47E-07	1.47E-07	0.00E+00	**5.94E-05**
Benzene	3.90E-03	2.34E-02	0.00	3.42E-06	2.53E-03	2.53E-03	0.00	1.38E-04	1.38E-04	1.98E-04	1.98E-04	1.48E-04	1.48E-04	6.47E-05	0.00	0.00	2.58E-05	2.58E-05	0.00E+00	**2.95E-02**
Benzo(a)anthracene	7.03E-06	4.22E-05	0.00	6.16E-09	4.55E-06	4.55E-06	0.00	2.48E-07	2.48E-07	3.56E-07	3.56E-07	2.66E-07	2.66E-07	1.17E-07	0.00	0.00	4.84E-07	4.84E-07	0.00E+00	**5.41E-05**
Benzo(a)pyrene	7.86E-07	4.72E-06	0.00	6.90E-10	5.09E-07	5.09E-07	0.00	2.77E-08	2.77E-08	3.98E-08	3.98E-08	2.97E-08	2.97E-08	1.30E-08	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	**5.94E-06**
Benzo(b)fluoranthene	4.14E-07	2.49E-06	0.00	3.63E-10	2.68E-07	2.68E-07	0.00	1.46E-08	1.46E-08	2.10E-08	2.10E-08	1.57E-08	1.57E-08	6.88E-09	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	**3.13E-06**
Benzo(b,k)fluoranthene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79E-07	1.79E-07	0.00E+00	**3.57E-07**
Benzo(g,h,l)perylene	2.04E-06	1.23E-05	0.00	1.79E-09	1.32E-06	1.32E-06	0.00	7.21E-08	7.21E-08	1.04E-07	1.04E-07	7.73E-08	7.73E-08	3.39E-08	0.00	0.00	2.73E-07	2.73E-07	0.00E+00	**1.60E-05**
Benzo(k)fluoranthene	6.48E-07	3.89E-06	0.00	5.69E-10	4.20E-07	4.20E-07	0.00	2.29E-08	2.29E-08	3.28E-08	3.28E-08	2.45E-08	2.45E-08	1.08E-08	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	**4.90E-06**
1,3-Butadiene	1.64E-04	9.81E-04	0.00	1.43E-07	1.06E-04	1.06E-04	0.00	5.77E-06	5.77E-06	8.28E-06	8.28E-06	6.18E-06	6.18E-06	2.71E-06	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	**1.24E-03**
Chrysene	1.48E-06	8.86E-06	0.00	1.29E-09	9.55E-07	9.55E-07	0.00	5.21E-08	5.21E-08	7.48E-08	7.48E-08	5.58E-08	5.58E-08	2.45E-08	0.00	0.00	2.87E-07	2.87E-07	0.00E+00	**1.17E-05**
Dibenz(a,h)anthracene	2.44E-06	1.46E-05	0.00	2.14E-09	1.58E-06	1.58E-06	0.00	8.60E-08	8.60E-08	1.23E-07	1.23E-07	9.22E-08	9.22E-08	4.05E-08	0.00	0.00	2.02E-07	2.02E-07	0.00E+00	**1.88E-05**
Ethylbenzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.68E-06	7.68E-06	0.00E+00	**1.54E-05**
Fluoranthene	3.18E-05	1.91E-04	0.00	2.79E-08	2.06E-05	2.06E-05	0.00	1.12E-06	1.12E-06	1.61E-06	1.61E-06	1.20E-06	1.20E-06	5.28E-07	0.00	0.00	5.84E-07	5.84E-07	0.00E+00	**2.42E-04**
Fluorene	1.22E-04	7.33E-04	0.00	1.07E-07	7.90E-05	7.90E-05	0.00	4.31E-06	4.31E-06	6.19E-06	6.19E-06	4.62E-06	4.62E-06	2.03E-06	0.00	0.00	5.40E-07	5.40E-07	0.00E+00	**9.24E-04**
Formaldehyde	4.93E-03	2.96E-02	0.00	4.33E-06	3.19E-03	3.19E-03	0.00	1.74E-04	1.74E-04	2.50E-04	2.50E-04	1.87E-04	1.87E-04	8.19E-05	0.00	0.00	3.98E-03	3.98E-03	0.00E+00	**4.53E-02**
Indeno(1,2,3-cd)pyrene	1.57E-06	9.41E-06	0.00	1.38E-09	1.02E-06	1.02E-06	0.00	5.53E-08	5.53E-08	7.94E-08	7.94E-08	5.93E-08	5.93E-08	2.60E-08	0.00	0.00	2.58E-07	2.58E-07	0.00E+00	**1.24E-05**
Naphthalene	3.55E-04	2.13E-03	0.00	3.11E-07	2.30E-04	2.30E-04	0.00	1.25E-05	1.25E-05	1.80E-05	1.80E-05	1.34E-05	1.34E-05	5.89E-06	0.00	0.00	1.36E-04	1.36E-04	0.00E+00	**2.95E-03**
Phenanthrene	1.23E-04	7.38E-04	0.00	1.08E-07	7.96E-05	7.96E-05	0.00	4.34E-06	4.34E-06	6.23E-06	6.23E-06	4.65E-06	4.65E-06	2.04E-06	0.00	0.00	1.27E-06	1.27E-06	0.00E+00	**9.32E-04**
Pyrene	2.00E-05	1.20E-04	0.00	1.75E-08	1.29E-05	1.29E-05	0.00	7.05E-07	7.05E-07	1.01E-06	1.01E-06	7.56E-07	7.56E-07	3.32E-07	0.00	0.00	5.13E-07	5.13E-07	0.00E+00	**1.52E-04**
Toluene	1.71E-03	1.03E-02	0.00	1.50E-06	1.11E-03	1.11E-03	0.00	6.03E-05	6.03E-05	8.66E-05	8.66E-05	6.47E-05	6.47E-05	2.84E-05	0.00	0.00	7.48E-04	7.48E-04	0.00E+00	**1.44E-02**
Xylenes	1.19E-03	7.15E-03	0.00	1.05E-06	7.71E-04	7.71E-04	0.00	4.20E-05	4.20E-05	6.04E-05	6.04E-05	4.51E-05	4.51E-05	1.98E-05	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	**9.01E-03**
o-Xylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32E-05	1.32E-05	0.00E+00	**2.63E-05**
Metals																				
Arsenic	6.83E-05	4.10E-04	0.00	1.80E-08	1.33E-05	1.33E-05	0.00	7.23E-06	7.23E-06	1.04E-05	1.04E-05	7.75E-06	7.75E-06	3.40E-06	0.00	0.00	6.43E-05	6.43E-05	2.80E-04	**8.99E-04**
Cadmium	1.53E-04	9.20E-04	0.00	4.03E-08	2.98E-05	2.98E-05	0.00	1.62E-05	1.62E-05	2.33E-05	2.33E-05	1.74E-05	1.74E-05	7.63E-06	0.00	0.00	4.82E-05	4.82E-05	6.98E-04	**1.90E-03**
Chromium	3.67E-05	2.20E-04	0.00	9.65E-09	7.12E-06	7.12E-06	0.00	3.88E-06	3.88E-06	5.57E-06	5.57E-06	4.16E-06	4.16E-06	1.82E-06	0.00	0.00	4.82E-05	4.82E-05	5.75E-04	**9.34E-04**
Lead	4.04E-04	2.43E-03	0.00	1.06E-07	7.85E-05	7.85E-05	0.00	4.28E-05	4.28E-05	6.14E-05	6.14E-05	4.59E-05	4.59E-05	2.01E-05	0.00	0.00	1.45E-04	1.45E-04	1.36E-02	**1.68E-02**
Mercury	8.64E-05	5.19E-04	0.00	2.27E-08	1.68E-05	1.68E-05	0.00	9.15E-06	9.15E-06	1.31E-05	1.31E-05	9.81E-06	9.81E-06	4.30E-06	0.00	0.00	4.82E-05	4.82E-05	3.59E-04	**1.08E-03**
Nickel	4.29E-05	2.58E-04	0.00	1.13E-08	8.34E-06	8.34E-06	0.00	4.54E-06	4.54E-06	6.53E-06	6.53E-06	4.87E-06	4.87E-06	2.14E-06	0.00	0.00	4.82E-05	4.82E-05	5.03E-04	**9.08E-04**
Total HAPs	**0.017**	**0.102**	**0.000**	**0.000**	**0.011**	**0.011**	**0.000**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.000**	**0.000**	**0.000**	**0.005**	**0.005**	**0.016**	**0.15**

Emission Factors, Conversions and Assumptions

Conversions

1.340 hp/kW	3600 sec/hour	2 wt. conversion of S to SO2
454 g/lb	2000 lb/ton	264 gal/m^3

Assumptions

			Reference
Diesel heat value	133,098 Btu/gal	0.1331 MMBtu/gal	Keiser, Ronald email to Chris Tengco, 01/26/09.
Diesel density	847.9 kg/m^3	7.08 lb/gal	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.

Diesel Heat Rates

				Reference
Caterpillar D399 engines	237.5 g/kW-hr	7,350 Btu/hp-hr	0.0073 MMBtu/hp-hr	Caterpillar D399 SCAC Engine Data Sheet, 05/95 100% load at 1200RPM value
Caterpillar D343 engines	244.8 g/kW-hr	7,576 Btu/hp-hr	0.0076 MMBtu/hp-hr	Caterpillar D343 Engine Data Sheet, 05/95 100% loads at 2100 RPM value, T Prechamber Engines
Caterpillar C15 engines		26.9 gal/hr	0.0066 MMBtu/hp-hr	Caterpillar C15 Specification Sheet, LEHW7443-000, 2008
Detroit 8V-71N engines		0.415 lb/hp-hr	0.0078 MMBtu/hp-hr	Detroit Diesel, Engine Performance Model: 8V-71N, 10/15/81
John Deere 4024TF270		17.9 lb/hr	0.0070 MMBtu/hp-hr	John Deere Model 4024TF270 Engine Performance, 06/04
Caterpillar 3608 engines	204.7 g/kW-hr	6,335 Btu/hp-hr	0.0063 MMBtu/hp-hr	Caterpillar 3608 Specification Sheet, DM5529, 10/06
ICE engines		7,000 Btu/hp-hr	0.0070 MMBtu/hp-hr	AP42 Table 3.3-1, 10/96

NOx Factors - converted at 133098 Btu/gal

Description	EF		EF		EF		Reference
Discoverer generator engines (Cat/D399)			0.5	g/kW-hr	0.112	lb/MMBtu	D.E.C. Marine AB letter, 10/9/08
Discoverer propulsion engine					3.2	lb/MMBtu	AP42 Table 3.4-1, 10/96
Discoverer emergency generator (Cat/3304)			11.28	g/bhp-hr	3.553	lb/MMBtu	Max of 13 test from EPA/600/8-90/057F
Discoverer MLC Compressors (Cat/C-15)			4.0	g/kW-hr	0.993	lb/MMBtu	Tier 3 emission limit
Discoverer HPU Engines			9.81	g/bhp-hr	2.771	lb/MMBtu	Max of 4 test from EPA/600/8-90/057F
Discoverer Cranes (Cat/D343)	2810.9	g/hr	1.70E-02	lb/hp-hr	2.241	lb/MMBtu	Caterpillar D343 Engine Data Sheet, 05/95
Discoverer Cementing & Logging 71 series engines			11.72	g/bhp-hr	3.310	lb/MMBtu	Max of 8 test from EPA/600/8-90/057F
Discoverer John Deere Logging Winch			7.5	g/kW-hr	1.768	lb/MMBtu	Tier 2 emission limit
Discoverer boilers			38.5	lb/day	0.201	lb/MMBtu	Clayton Industries, 8/2001
Discoverer Incinerator			5	lb/ton	0.0025	lb/lb	AP42 Table 2.2-1, multiple hearth
Ice Management Fleet factor			25	g/kW-hr	5.876	lb/MMBtu	generic factors consistent w/Ice mgmt fleet ORRs
All Other Incinerators			3	lb/ton	0.0015	lb/lb	AP42 Table 2.1-12, 10/96
Resupply Ship & OSR Work Boat Generators					4.41	lb/MMBtu	AP42 Table 3.3-1, 10/96
OSR Main Ship ICE Propulsion (Cat/3608)			13.62	g/kW-hr	3.536	lb/MMBtu	Caterpillar 3608 Specification Sheet, DM5529, 10/06
OSR Main Ship ICE Generators			25.4	g/kW-hr	5.970	lb/MMBtu	EPA Memo, D. Meyer, June 12, 2008
OSR Work Boat ICE Propulsion Engines			4.644	g/hp-hr	1.463	lb/MMBtu	Cummins Engine Model: QSB5.9-305 MCD Spec Sheet, 10/06

PM Factors

Description	EF		EF		EF		Reference
PM_{10}							
Discoverer generator engines (Cat/D399)	251.2	g/hr	4.18E-04	lb/hp-hr	0.057	lb/MMBtu	Caterpillar D399 SCAC Engine Data Sheet, 05/95
Discoverer propulsion engine					0.0573	lb/MMBtu	AP42 Table 3.4-2, 10/96
Discoverer emergency generator (Cat/3304)			2.21	g/bhp-hr	0.696	lb/MMBtu	Max of 13 test from EPA/600/8-90/057F
Discoverer MLC Compressors (Cat/C-15)			0.2	g/kW-hr	0.050	lb/MMBtu	Tier 3 emission limit
Discoverer HPU Engines			1.26	g/bhp-hr	0.356	lb/MMBtu	Max of 4 test from EPA/600/8-90/057F
Discoverer Cranes (Cat/D343)	129.8	g/hr	7.84E-04	lb/hp-hr	0.103	lb/MMBtu	Caterpillar D343 Engine Data Sheet, 05/95
Discoverer Cementing & Logging 71 series engines			1.92	g/bhp-hr	0.542	lb/MMBtu	Max of 8 test from EPA/600/8-90/057F
Discoverer John Deere Logging Winch			0.6	g/kW-hr	0.141	lb/MMBtu	Tier 2 emission limit
Discoverer boilers			4.5	lb/day	0.024	lb/MMBtu	Clayton Industries, 8/2001
Discoverer Incinerator			8.2	lb/ton	0.0041	lb/lb	ORR
Ice Management ICE Engines			1.06	g/kW-hr	0.249	lb/MMBtu	generic factors consistent w/Ice mgmt fleet ORRs
Ice Management & OSR Incinerators			13.3	lb/ton	0.0067	lb/lb	AP42 Table 2.1-12, 10/96 & Appendix B.1 2.1
Resupply Ship & OSR Work Boat Generators					0.31	lb/MMBtu	AP42 Table 3.3-1, 10/96
OSR Main Ship ICE Propulsion (Cat/3608)			0.17	g/kW-hr	0.044	lb/MMBtu	Caterpillar 3608 Specification Sheet, DM5529, 10/06
OSR Main Ship ICE Generators			1.92	g/kW-hr	0.451	lb/MMBtu	Corbett, Koehler. Revised: 05/03
OSR Work Boat ICE Propulsion Engines			0.077	g/hp-hr	0.024	lb/MMBtu	Cummins Engine Model: QSB5.9-305 MCD Spec Sheet, 10/06
$PM_{2.5}$							
All emissions units	100%	PM_{10}	except the following:				
Discover Incinerator			7	lb/ton	0.0035	lb/lb	ORR
Ice Management ICE Engines					0.22	lb/MMBtu	generic factors consistent w/Ice mgmt fleet ORRs
Ice Management & OSR Incinerators			9.1	lb/ton	0.0046	lb/lb	AP42 Table 2.1-12, 10/96 & Appendix B.1 2.1
OSR Main Ship ICE Generators			1.54	g/kW-hr	0.362	lb/MMBtu	EPA Ref: IVL

SO_2 Factors- (Diesel Fuel)	S content		EF		EF		Reference
All stationary source engines on drillship	0.0015%	by wt.	0.00003	lb/lb fuel	0.0016	lb/MMBtu	Calculation
All mobile sources	0.19%	by wt.	0.0038	lb/lb fuel	0.2020	lb/MMBtu	Calculation
Ice Mnge. ICE & OSR Main Ship ICE Gen.	0.19%	by wt.	8.09E-03 S	lb/hp-hr	0.2196	lb/MMBtu	AP42 Table 3.4-1, 10/96
Discoverer Incinerator			2.5	lb/ton	0.0013	lb/lb	ORR
All Other Incinerators			2.5	lb/ton	0.0013	lb/lb	AP42 Table 2.1-12, 10/96

CO Factors	EF		EF		EF		Reference
Discoverer generator engines (Cat/D399)	882.7	g/hr	1.47E-03	lb/hp-hr	0.200	lb/MMBtu	Caterpillar D399 SCAC Engine Data Sheet, 05/95
Disco Prop., Ice Mngt ICE, OSR Main Ship ICE Gen.					0.85	lb/MMBtu	AP42 Table 3.4-1, 10/96
Discoverer emergency generator (Cat/3304)			6.2	g/bhp-hr	1.953	lb/MMBtu	Max of 13 test from EPA/600/8-90/057F
Discoverer MLC Compressors (Cat/C-15)			3.5	g/kW-hr	0.868	lb/MMBtu	Tier 3 emission limit
Discoverer HPU Engines			2.99	g/bhp-hr	0.844	lb/MMBtu	Max of 2 test from EPA/600/8-90/057F
Discoverer Cranes (Cat/D343)	593.6	g/hr	3.59E-03	lb/hp-hr	0.473	lb/MMBtu	Caterpillar D343 Engine Data Sheet, 05/95
Discoverer Cementing & Logging 71 series engines			6.55	g/bhp-hr	1.850	lb/MMBtu	Max of 6 test from EPA/600/8-90/057F
Discoverer John Deere Logging Winch			5.5	g/kW-hr	1.296	lb/MMBtu	Tier 2 emission limit
Discoverer boilers			14.8	lb/day	0.077	lb/MMBtu	Clayton Industries, 8/2001
Discoverer Incinerator			31	lb/ton	0.0155	lb/lb	AP42 Table 2.2-1, multiple hearth
All Other Incinerators			300	lb/ton	0.1500	lb/lb	AP42 Table 2.1-12, 10/96
Resupply Ship & OSR Work Boat Generators					0.95	lb/MMBtu	AP42 Table 3.3-1, 10/96
OSR Main Ship ICE Propulsion (Cat/3608)			0.73	g/kW-hr	0.190	lb/MMBtu	Caterpillar 3608 Specification Sheet, DM5529, 10/06
OSR Work Boat ICE Propulsion Engines			0.155	g/hp-hr	0.049	lb/MMBtu	Cummins Engine Model: QSB5.9-305 MCD Spec Sheet, 10/06

VOC Factors	EF		EF		Reference
Discoverer generator engines (Cat/D399)	75.5	g/hr	0.017	lb/MMBtu	Caterpillar D399 SCAC Engine Data Sheet, 05/95
Discoverer propulsion engine			0.09	lb/MMBtu	AP42 Table 3.4-1, 10/96
Discoverer emergency generator (Cat/3304)	1.2	g/bhp-hr	0.366	lb/MMBtu	Max of 13 test from EPA/600/8-90/057F
Discoverer MLC Compressors (Cat/C-15)	4.0	g/kW-hr	0.993	lb/MMBtu	Tier 3 emission limit
Discoverer HPU Engines	1.5	g/bhp-hr	0.418	lb/MMBtu	Max of 2 test from EPA/600/8-90/057F
Discoverer Cranes (Cat/D343)	172.6	g/hr	0.138	lb/MMBtu	Caterpillar D343 Engine Data Sheet, 05/95
Discoverer Cementing & Logging 71 series engines	2.0	g/bhp-hr	0.568	lb/MMBtu	Max of 6 test from EPA/600/8-90/057F
Discoverer John Deere Logging Winch	7.5	g/kW-hr	1.768	lb/MMBtu	Tier 2 emission limit
Discoverer boilers	0.27	lb/day	0.001	lb/MMBtu	Clayton Industries, 8/2001
Discoverer Incinerator	3	lb/ton	0.0015	lb/lb	AP42 Table 2.1-12, 10/96
Ice Management & OSR Main Ship ICE Generators	0.6	g/kW-hr	0.141	lb/MMBtu	Corbett, Koehler. Revised: 05/03
All Other Incinerators	100	lb/ton	0.0500	lb/lb	AP42 Table 2.1-12, 10/96
Resupply Ship & OSR Work Boat Generators			0.35	lb/MMBtu	AP42 Table 3.3-1, 10/96
OSR Main Ship ICE Propulsion (Cat/3608)	0.99	g/kW-hr	0.257	lb/MMBtu	Caterpillar 3608 Specification Sheet, DM5529, 10/06
OSR Work Boat ICE Propulsion Engines	0.078	g/hp-hr	0.025	lb/MMBtu	Cummins Engine Model: QSB5.9-305 MCD Spec Sheet, 10/06

Air Sciences Inc.	PROJECT TITLE: Shell Offshore, Inc.	BY: S. Pryor	
ENGINEERING CALCULATIONS	PROJECT NO: 180-15-1	PAGE: 15	OF: 15
	SUBJECT: Discoverer Emissions-AK OCS	DATE: May 18, 2009	

HAPs Emission Factors -(from AP42)

ICE Engines Emission Factors

AP42 Table 3.3-2, Speciated Organic Compound Emission Factors For Uncontrolled Diesel Engines

Pollutant	EF lb/MMBtu
Acaldehyde	7.67E-04
Acenaphthene	1.42E-06
Acenaphthylene	5.06E-06
Acrolein	9.25E-05
Anthracene	1.87E-06
Benzene	9.33E-04
Benzo(a)anthracene	1.68E-06
Benzo(a)pyrene	1.88E-07
Benzo(b)fluoranthene	9.91E-08
Benzo(g,h,l)perylene	4.89E-07
Benzo(k)fluoranthene	1.55E-07
1,3-Butadiene	3.91E-05
Chrysene	3.53E-07
Dibenz(a,h)anthracene	5.83E-07
Fluoranthene	7.61E-06
Fluorene	2.92E-05
Formaldehyde	1.18E-03
Indeno(1,2,3-cd)pyrene	3.75E-07
Naphthalene	8.48E-05
Phenanthrene	2.94E-05
Pyrene	4.78E-06
Toluene	4.09E-04
Xylenes	2.85E-04

Boiler Emission Factors

AP42 Table 1.3-9, Emission Factors For Speciated Organic Compounds From Fuel Oil

Pollutant	EF lb/10^3 gal	EF lb/MMBtu
Acenaphthene	2.11E-05	1.59E-07
Acenaphthylene	2.53E-07	1.90E-09
Anthracene	1.22E-06	9.17E-09
Benzene	2.14E-04	1.61E-06
Benz(a)anthracene	4.01E-06	3.01E-08
Benzo(b,k)fluoranthene	1.48E-06	1.11E-08
Benzo(g,h,i)perylene	2.26E-06	1.70E-08
Chrysene	2.38E-06	1.79E-08
Dibenzo(a,h)anthracene	1.67E-06	1.25E-08
Ethylbenzene	6.36E-05	4.78E-07
Fluoranthene	4.84E-06	3.64E-08
Fluorene	4.47E-06	3.36E-08
Formaldehyde	3.30E-02	2.48E-04
Indo(1,2,3-cd)pyrene	2.14E-06	1.61E-08
Naphthalene	1.13E-03	8.49E-06
Phenanthrene	1.05E-05	7.89E-08
Pyrene	4.25E-06	3.19E-08
Toluene	6.20E-03	4.66E-05
o-Xylene	1.09E-04	8.19E-07

Incinerator Emission Factors

ICE Engines – Metals

Metal			lb/MMBtu
Arsenic	As		4.90E-06
Cadmium	Cd	11 lb/10^{12} Btu	1.10E-05
Chromium	Cr	0.35 lb/10^6 gal	2.63E-06
Lead	Pb		2.9E-05
Mercury	Hg	6.2 lb/10^{12} Btu	6.20E-06
Nickel	Ni	0.41 lb/10^6 gal	3.08E-06
Total HAPs			3.93E-03

Table 1.3-10. Emission Factors For Trace Elements From Distillate Fuel Oil Combustion Sources

Metal		EF lb/10^{12} Btu	EF lb/MMBtu
Arsenic	As	4	4.00E-06
Cadmium	Cd	3	3.00E-06
Chromium	Cr	3	3.00E-06
Lead	Pb	9	9.00E-06
Mercury	Hg	3	3.00E-06
Nickel	Ni	3	3.00E-06
Total HAPs			3.31E-04

Table 2.2-2 - Metals Emission Factors for Mass Burn and Modular Excess Air Combustors

Metal		lb/ton	lb/lb
Arsenic	As	4.37E-03	2.19E-06
Cadmium	Cd	1.09E-02	5.45E-06
Chromium	Cr	8.97E-03	4.49E-06
Lead	Pb	2.13E-01	1.07E-04
Mercury	Hg	5.60E-03	2.80E-06
Nickel	Ni	7.85E-03	3.93E-06
Total HAPs			1.25E-04

ICE Metal References

Arsenic	L & E Air Emissions from Sources of Arsenic and Arsenic Compounds, EPA-454/R-98-013, June 1998, Table 4-20, Distillate Oil Fired Turbine
Cadmium	L & E Air Emissions from Sources of Cadmium and Cadmium Compounds, EPA-454/R-93-040, Sept. 1993, Table 6-12, No. 2 Distillate Oil
Chromium	L & E Air Emissions from Sources of Chromium, EPA-450/4-84-007g, July 1984, Table 36, Distillate #2
Lead	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines
Mercury	L & E Air Emissions from Sources of Mercury and Mercury Compounds, EPA-454/R-97-012, Dec. 1997, Table 6-12, Distillate No. 2
Nickel	L & E Air Emissions from Sources of Nickel, EPA-450/4-84-007f, March 1984, Table 26, Distillate #2

Air Sciences Inc.	PROJECT TITLE: Shell Offshore, Inc.	BY: S. Pryor
ENGINEERING CALCULATIONS	PROJECT NO: 180-15-1	PAGE: 1 OF: 2
	SUBJECT: Fleet	DATE: May 18, 2009

Ice Management Fleet

Propulsion Engines	80%
Remaining Sources	100%

Unit ID	Description	Make/Model	Rating	Capacity	Fuel consumpt. (MMBtu/hr)	Fuel Use (gal/hr)	% of total fuel
Vladimir Ignatjuk (Primary ice management)							
VI-1	Main Propulsion	Wärtsilä / 9ZL	5,800 hp	80%	32.480	244.0	10.1%
VI-2	Main Propulsion	Wärtsilä / 9ZL	5,800 hp	80%	32.480	244.0	10.1%
VI-2	Main Propulsion	Wärtsilä / 9ZL	5,800 hp	80%	32.480	244.0	10.1%
VI-4	Main Propulsion	Wärtsilä / 9ZL	5,800 hp	80%	32.480	244.0	10.1%
VI-5	Electrical Generator		980 kW	100%	9.192	69.1	2.9%
VI-6	Electrical Generator		980 kW	100%	9.192	69.1	2.9%
VI-7	Heat Boiler		2.4 MMBtu/hr	100%	2.400	18.0	0.7%
VI-8	Hot Water Heater		0.54 MMBtu/hr	100%	0.540	4.1	0.2%
VI-9	Incinerator		66 lb/hr	100%			
	Vladimir Ignatjuk total				151.245	1,136.342	47.0%
Fennica/Nordica (Secondary ice management)							
FN-1	Main Prop Engine	Wärtsilä / 16V32	7,884 hp	80%	44.150	331.7	13.7%
FN-2	Main Prop Engine	Wärtsilä / 16V32	7,884 hp	80%	44.150	331.7	13.7%
FN-3	Main Prop Engine	Wärtsilä / 12V32	5,913 hp	80%	33.113	248.8	10.3%
FN-4	Main Prop Engine	Wärtsilä / 12V32	5,913 hp	80%	33.113	248.8	10.3%
FN-5	Auxiliary Engine		710 hp	100%	4.970	37.3	1.5%
FN-6	Em Generator		300 hp	100%	2.100	15.8	0.7%
FN-7	Heat Boiler		4.44 MMBtu/hr	100%	4.440	33.4	1.4%
FN-8	Heat Boiler		4.44 MMBtu/hr	100%	4.440	33.4	1.4%
FN-9	Incinerator		154 lb/hr	100%			
	Fennica/Nordica total				170.476	1280.8	53.0%
Ice Management Fleet					321.721	2,417.175	100.0%

Jim Kilabuk (Resupply Ship)

Unit ID	Description	Make/Model	Rating	Capacity	Fuel consumpt. (MMBtu/hr)
JK-1	Main Propulsion	EMD / V20 645	3,600 hp	0%	0.000
JK-2	Main Propulsion	EMD / V20 645	3,600 hp	0%	0.000
JK-3	Generator	Cat / D3406	292 hp	100%	2.044
JK-4	Generator	Cat / D3406	292 hp	0%	0.000
JK-5	HPU Engine	Cat / D343	300 hp	0%	0.000
JK-6	Bow Thruster	Cat / D343	300 hp	0%	0.000
	Jim Kilabuk total				2.044
Resupply Ship					2.044

Generic Ice Management

Primary Ice Management

Unit ID	Description	Make/Model	Rating	Capacity	Fuel consumpt. (MMBtu/hr)	Fuel Use (gal/hr)	% of total fuel
	Propulsion		28,400 hp	80%	159.040	1,194.9	45.7%
	Generator		2800 hp	100%	19.600	147.3	5.6%
	Heat Boiler		10 MMBtu/hr	100%	10.000	75.1	2.9%
	Incinerator		154 lb/hr	100%			
					188.640	1417.3	50.0%

Anchor handler

Unit ID	Description	Make/Model	Rating	Capacity	Fuel consumpt. (MMBtu/hr)	Fuel Use (gal/hr)	% of total fuel
	Propulsion		28,400 hp	80%	159.040	1,194.9	45.7%
	Generator		2800 hp	100%	19.600	147.3	5.6%
	Heat Boiler		10 MMBtu/hr	100%	10.000	75.1	2.9%
	Incinerator		154 lb/hr	100%			
					188.640	1417.3	50.0%
Ice Management Fleet					377.280	2,834.603	100.0%

Oil Spill Response Fleet

Nanuq (Main Oil Spill Response Vessel)		34-foot Oil Spill Response Work Boats	
1 Propulsion Engine	50%	Propulsion	100%
1 Electrical Generators	100%	Generator	100%
Remaining Prop & Generators	0%		
Incinerator	100%		

Unit ID	Description	Make/Model	Rating	Capacity	Fuel consumpt. (MMBtu/hr)
Nanuq (Main Oil Spill Response Vessel)					
N-1	Propulsion Engine	Cat/3608	2,710 hp	50%	8.584
N-2	Propulsion Engine	Cat/3608	2,710 hp	0%	0.000
N-3	Electrical Generator	Cat/3508	1,285 hp	100%	8.995
N-4	Electrical Generator	Cat/3508	1,285 hp	0%	0.000
N-5	Emergency Gen	John Deere	166 kW	0%	0.000
N-6	Incinerator	ASC / CP100	125 lb/hr	100%	
	Nanuq total				17.579
	Main Ship Propulsion Engines				8.584
	Main Ship Generators				8.995
Kvichak No. 1 34-foot Oil Spill Response Work Boat					
OSRK1-1	Propulsion		300 hp	100%	2.100
OSRK1-2	Propulsion		300 hp	100%	2.100
OSRK1-3	Generator		12 hp	100%	0.084
Kvichak No. 2 34-foot Oil Spill Response Work Boat					
OSRK2-1	Propulsion		300 hp	100%	2.100
OSRK2-2	Propulsion		300 hp	100%	2.100
OSRK2-3	Generator		12 hp	100%	0.084
Kvichak No. 3 34-foot Oil Spill Response Work Boat					
OSRK3-1	Propulsion		300 hp	100%	2.100
OSRK3-2	Propulsion		300 hp	100%	2.100
OSRK3-3	Generator		12 hp	100%	0.084
	3 34-foot OSR Work Boats total				12.852
OSR fleet total					30.431
	Work Boat Propulsion Engines		1800 hp		12.600
	Work Boat Generators		36 hp		0.252
					12.852

Warehouse in Barrow or Wainwright					**Reference**
Size	100	x	400	= 40000 ft^2	
Ceilings	25 ft				
Farenheit Tempature Increase			60		
Average insulation/Average leakage					
Heater Size	3.6 MMBtu/hr				http://www.heatershop.com/btu_calculator.htm

	Rating	
Heat Boiler	7.2 MMBtu/hr	Assume double the size

Maximum Emissions

Fuel Use		PM_{10}	NO_x	SO_2	CO	Lead	HAPs	
52.55	**gal/hr**	0.17	1.05	0.67	0.26	4.73E-10	2.16E-03	**lb/hr**
230,189.78	**gal/yr**	0.38	2.30	1.46	0.58	1.04E-09	4.72E-03	**ton/yr**

Emissions factors	**EF**		**EF**	**Reference**
Boilers <100 MMBtu/hr				
Filterable PM	2	$lb/10^3$ gal	0.01 lb/MMBtu	AP42 Table 1.3-1, 9/98
Condensable PM	1.3	$lb/10^3$ gal	0.01 lb/MMBtu	AP42 Table 1.3-2, 9/98
Total PM	3.3	$lb/10^3$ gal	0.02 lb/MMBtu	
NOx	20	$lb/10^3$ gal	0.15 lb/MMBtu	AP42 Table 1.3-1, 9/98
CO	5	$lb/10^3$ gal	0.04 lb/MMBtu	AP42 Table 1.3-1, 9/98
SO_2			0.09 lb/MMBtu	Calculation

Assumptions		**Reference**
Diesel heat rate		AP42 Table 3.3-1, 10/96
7,000	Btu/hp-hr	
0.007	MMBtu/hp-hr	
Diesel heat value		AP42, Appendix A
137,000	Btu/gal	
0.1370	MMBtu/gal	
Diesel density		AP42, Appendix A
845	kg/m^3	
7.05	lb/gal	
Sulfur Content		Royal Harris, Crowley
900	ppm	
0.09%	by wt.	
Heater use		Equivalent to 1/2 year of use at heater capacity
182.5	days/yr	

Conversions	
454	g/lb
264	gal/m^3
2	wt. conversion of S to SO_2
2000	lb/ton

HAPS

AP42 Table 1.3-9, Emission Factors For Speciated Organic Compounds From Fuel Oil Combustion

	EF	
Pollutant	lb/10^3 gal	lb/MMBtu
Acenaphthene	2.11E-05	1.54E-07
Acenaphthylene	2.53E-07	1.85E-09
Anthracene	1.22E-06	8.91E-09
Benzene	2.14E-04	1.56E-06
Benz(a)anthracene	4.01E-06	2.93E-08
Benzo(b,k)fluoranthene	1.48E-06	1.08E-08
Benzo(g,h,i)perylene	2.26E-06	1.65E-08
Chrysene	2.38E-06	1.74E-08
Dibenzo(a,h)anthracene	1.67E-06	1.22E-08
Ethylbenzene	6.36E-05	4.64E-07
Fluoranthene	4.84E-06	3.53E-08
Fluorene	4.47E-06	3.26E-08
Formaldehyde	3.30E-02	2.41E-04
Indo(1,2,3-cd)pyrene	2.14E-06	1.56E-08
Naphthalene	1.13E-03	8.25E-06
OCDD	3.10E-09	2.26E-11
Phenanthrene	1.05E-05	7.66E-08
Pyrene	4.25E-06	3.10E-08
1,1,1-Trichloroethane	2.36E-04	1.72E-06
Toluene	6.20E-03	4.53E-05
o-Xylene	1.09E-04	7.96E-07

Table 1.3-10. Emission Factors For Trace Elements From Distillate Fuel Oil Combustion Sources

		EF	
Metal		lb/10^{12} Btu	lb/MMBtu
Arsenic	As	4	2.92E-11
Beryllium	Be	3	2.19E-11
Cadmium	Cd	3	2.19E-11
Chromium	Cr	3	2.19E-11
Copper	Cu	6	4.38E-11
Lead	Pb	9	6.57E-11
Mercury	Hg	3	2.19E-11
Manganese	Mn	6	4.38E-11
Nickel	Ni	3	2.19E-11
Selenium	Si	15	1.09E-10
Zinc	Zn	4	2.92E-11
Total HAPs			2.99E-04

Barrow, AK

EPA Source ID	Discoverer ID	Tank capacity (m^3)	Tank capacity (ft^3)	Tank capacity (gal)	%	Tank Diameter (ft)	Tank Height (ft)	Max Tank Height (ft)	Avg Tank Height (ft)	Turnovers per Year	Net Throughput (gal/yr)
FD-24	21P	538	18999.29	142124.59	32%	35	19.75	19.75	19.75	5	667,108
FD-25	29P	267	9429.02	70533.95	16%	25	19.21	19.21	19.21	5	331,074
FD-26	29S	267	9429.02	70533.95	16%	25	19.21	19.21	19.21	5	331,074
FD-27	21S	179	6321.33	47286.81	11%	20	20.12	20.12	20.12	5	221,956
FD-28	22S	150	5297.20	39625.81	9%	20	16.86	16.86	16.86	5	185,997
FD-29	23S	150	5297.20	39625.81	9%	20	16.86	16.86	16.86	5	185,997
FD-30	24S	135	4767.48	35663.23	8%	20	15.18	15.18	15.18	5	167,397
				445394.15	100%	Engineering Judgement					2,090,604

EPA Source ID	Heated	Vertical or Horizontal	Shell Color/Shade	Shell Paint Condition	Roof Color/Shade	Roof Paint Condition	Roof Type	Roof Height	Roof Radius	Vacuum Setting (psig)	Pressure Setting (psig)
FD-24	No	Vertical	Red/Primer	Poor	Red/Primer	Poor	Dome	0	35.00	-0.03	0.03
FD-25	No	Vertical	Red/Primer	Poor	Red/Primer	Poor	Dome	0	25.00	-0.03	0.03
FD-26	No	Vertical	Red/Primer	Poor	Red/Primer	Poor	Dome	0	25.00	-0.03	0.03
FD-27	No	Vertical	Red/Primer	Poor	Red/Primer	Poor	Dome	0	20.00	-0.03	0.03
FD-28	No	Vertical	Red/Primer	Poor	Red/Primer	Poor	Dome	0	20.00	-0.03	0.03
FD-29	No	Vertical	Red/Primer	Poor	Red/Primer	Poor	Dome	0	20.00	-0.03	0.03
FD-30	No	Vertical	Red/Primer	Poor	Red/Primer	Poor	Dome	0	20.00	-0.03	0.03
	Assumed	Assumed	Worst Case	Worst Case	Worst Case	Worst Case	Assumed	Assumed	Default	Default	Default

EPA Source ID	Discoverer ID	Working Losses (lb/yr)	Breathing Losses (lb/yr)	Total Losses (lb/yr)
FD-24	21P	6.40	1.16	7.56
FD-25	29P	3.18	0.42	3.60
FD-26	29S	3.18	0.42	3.60
FD-27	21S	2.13	0.22	2.35
FD-28	22S	1.78	0.22	2.00
FD-29	23S	1.78	0.22	2.00
FD-30	24S	1.61	0.22	1.82
		20.06	2.88	22.93

Conversions

35.31 ft^3/m^3
7.48 gal/ft^3

Maximum Fuel Use

2,090,604 gal/yr — From Discoverer Chuckchi Emissions
168 days/yr

Bell 412 Helicopter

Use:	3 flights/day	1 min full power/landing or take off	6 min/day @ full power
	168 days/yr	16.8 hr/yr	

			Fuel Consmpt.		Expected Emissions				
			Max	Expected	(lb/landing/takeoff cycle)				
Description	**Make/Model**	**Rating**	**MMBtu/hr**		**PM_{10}**	**NO_x**	**SO_2**	**CO**	**VOC**
Helicopter	Pratt & Whitney PT6T Twin Pac	1800 SHP	17.59	1.76	0.40	3.02	0.44	13.54	6.78

			Fuel Consmpt.		Expected Emissions				
			Max	Expected	(ton/yr)				
Description	**Make/Model**	**Rating**	**MMBtu/yr**		**PM_{10}**	**NO_x**	**SO_2**	**CO**	**VOC**
Helicopter	Pratt & Whitney PT6T Twin Pac	1800 SHP	70921.69	295.51	0.10	0.76	0.11	3.41	1.71

	lb/landing/takeoff cycle	**Reference**
PM	0.4	AP42, Vol. II, Part II-Off Highway Mobile Sources, 2/80, Table II-1-10-Emissions for Military
NOx	3.02	Aircraft Landing/Takeoff Cycles: Helicopters, HH-3 Sea King/Jolly Green Giant
SOx	0.44	The HH-3 contains 2 T58-GE-5 engines, with horsepower range: 1,250 - 1,870 SHP (Ref: GE
CO	13.54	Aviation)
VOC	6.78	

Engine T58-GE-5 (used on Sea King Helicopter)			**Reference**
Fuel Rate-Approach	886 lb/hr	0.49 lb/hp-hr	AP42, Vol. II, Part II-Off Highway Mobile Sources, Table II-1-8
Heat Rate	0.0098 MMBtu/hp-hr		

Jet Propulsion-5 Fuel Specifications			**Reference**
Heat Value	135,000 Btu/gal	0.1350 MMBtu/gal	AP42 Appendix A, Kerosene
Density	6.8 lb/gal		US Marine Corps, Characteristics Of Fuels
Sulfur	0.05% by wt.	Range 0.02-0.05%/by weight	AP42 Appendix A, Kerosene
SO2	0.05 lb/MMBtu		Calculation

Conversions	
454	g/lb
264	gal/m^3
2000	lb/ton
2	wt. conversion of S to SO2

Air Sciences Inc.	PROJECT TITLE: Shell Offshore, Inc.	BY: S. Pryor		
ENGINEERING CALCULATIONS	PROJECT NO: 180-15-7	PAGE: 1	OF: 1	SHEET: 4
	SUBJECT: Jim Kilibuk	DATE: May 13, 2009		

Jim Kilabuk (Resupply Ship)

Unit ID	Description	Make/Model	Rating	Capacity	Fuel consumpt. (MMBtu/hr)	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC
						Max Actual Emissions (lb/hr)					
JK-1	Main Propulsion	EMD / V20 645	3,600 hp	80%	20.16	9.10	7.30	120.35	4.43	17.14	2.84
JK-2	Main Propulsion	EMD / V20 645	3,600 hp	80%	20.16	9.10	7.30	120.35	4.43	17.14	2.84
JK-3	Generator	Cat / D3406	292 hp	100%	2.04	0.92	0.74	12.20	0.45	1.74	0.29
JK-4	Generator	Cat / D3406	292 hp	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JK-5	HPU Engine	Cat / D343	300 hp	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JK-6	Bow Thruster	Cat / D343	300 hp	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Jim Kilabuk total				42.36	19.12	15.33	252.91	9.30	36.01	5.97

8 trips/yr 4 hr/trip 32 hr/yr

Unit ID	Description	Make/Model	Rating	Capacity	Fuel consumpt. (MMBtu/yr)	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC
						Max Actual Emissions (ton/yr)					
JK-1	Main Propulsion	EMD / V20 645	3,600 hp	80%	645.12	0.15	0.12	1.93	0.07	0.27	0.05
JK-2	Main Propulsion	EMD / V20 645	3,600 hp	80%	645.12	0.15	0.12	1.93	0.07	0.27	0.05
JK-3	Generator	Cat / D3406	292 hp	100%	65.41	0.01	0.01	0.20	0.01	0.03	0.00
JK-4	Generator	Cat / D3406	292 hp	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JK-5	HPU Engine	Cat / D343	300 hp	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JK-6	Bow Thruster	Cat / D343	300 hp	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Jim Kilabuk total				1,355.65	0.31	0.25	4.05	0.15	0.58	0.10

Emissions factors	EF	EF	Reference
PM			
PM_{10}	1.92 g/kW-hr	0.45 lb/MMBtu	EPA Reference: IVL
$PM_{2.5}$	1.54 g/kW-hr	0.36 lb/MMBtu	EPA Reference: IVL
NOx	25.40 g/kW-hr	5.97 lb/MMBtu	Dan Meyer EPA Memo, June 12, 2008
SO_2			
S content	0.19% by wt.	0.220 lb/MMBtu	AP42 Table 3.4-1, 10/96
CO		0.85 lb/MMBtu	AP42 Table 3.4-1, 10/96
VOC	0.60 g/kW-hr	0.14 lb/MMBtu	EPA Reference: IVL

Assumptions	Reference
Diesel heat value	Keiser, Ronald email to Chris Tengco, 01/26/09.
133,098 Btu/gal	
0.1331 MMBtu/gal	
Diesel density	SCANRAFF-Vladimir Ignatjuk Certificate of Quality. 09/19/04.
847.9 kg/m^3	
7.08 lb/gal	
ICE engines diesel heat rate	AP42 Table 3.3-1, 10/96
7,000 Btu/hp-hr	
0.007 MMBtu/hp-hr	

Conversions

454 g/lb
264 gal/m^3
2000 lb/ton
2 wt. conversion of S to SO2
1.34 hp/kW

Response Materials for Attachment A, Comment D.3.

SECTION 5

AMBIENT IMPACTS

…Shell no longer is basing its application on an ambient air boundary associated with a safety zone, although the safety zone is likely to become a part of the exploration program. Thus, compliance is demonstrated at and beyond the hull of the Discoverer. Owner-requested restrictions limiting operation of the sources are taken into account in the analysis. This impact analysis demonstrates how the *Discoverer* and associated fleets are modeled in accordance with these regulations as provided in Shell's Frontier Discoverer Alaska Outer Continental Shelf (OCS) Exploratory Drilling Program Air Quality Impact Modeling Protocol (dated November 12, 2008) provided to EPA Region 10.

Table 5-1: Summary of Applicable Standards

Pollutant	Averaging Time	NAAQS [1] (µg/m^3)	PSD Class II Increment (µg/m^3)
Nitrogen Dioxide (NO_2)	Annual	100	25
Particulate Matter ($PM_{2.5}$)	24-hour	35	NA
	Annual	15	NA
Particulate Matter (PM_{10})	24-hour	150	30
	Annual	50	17
Sulfur Dioxide (SO_2)	3-hour	1,300	512
	24-hour	365	91
	Annual	80	20
Carbon Monoxide (CO)	1-hour	40,000	NA
	8-hour	10,000	NA
Ozone (O_3)	8-hour	0.075 (ppm)	NA
Lead (Pb)	3-month	0.15	NA
	Quarterly	1.5	NA

[1] National Ambient Air Quality Standards

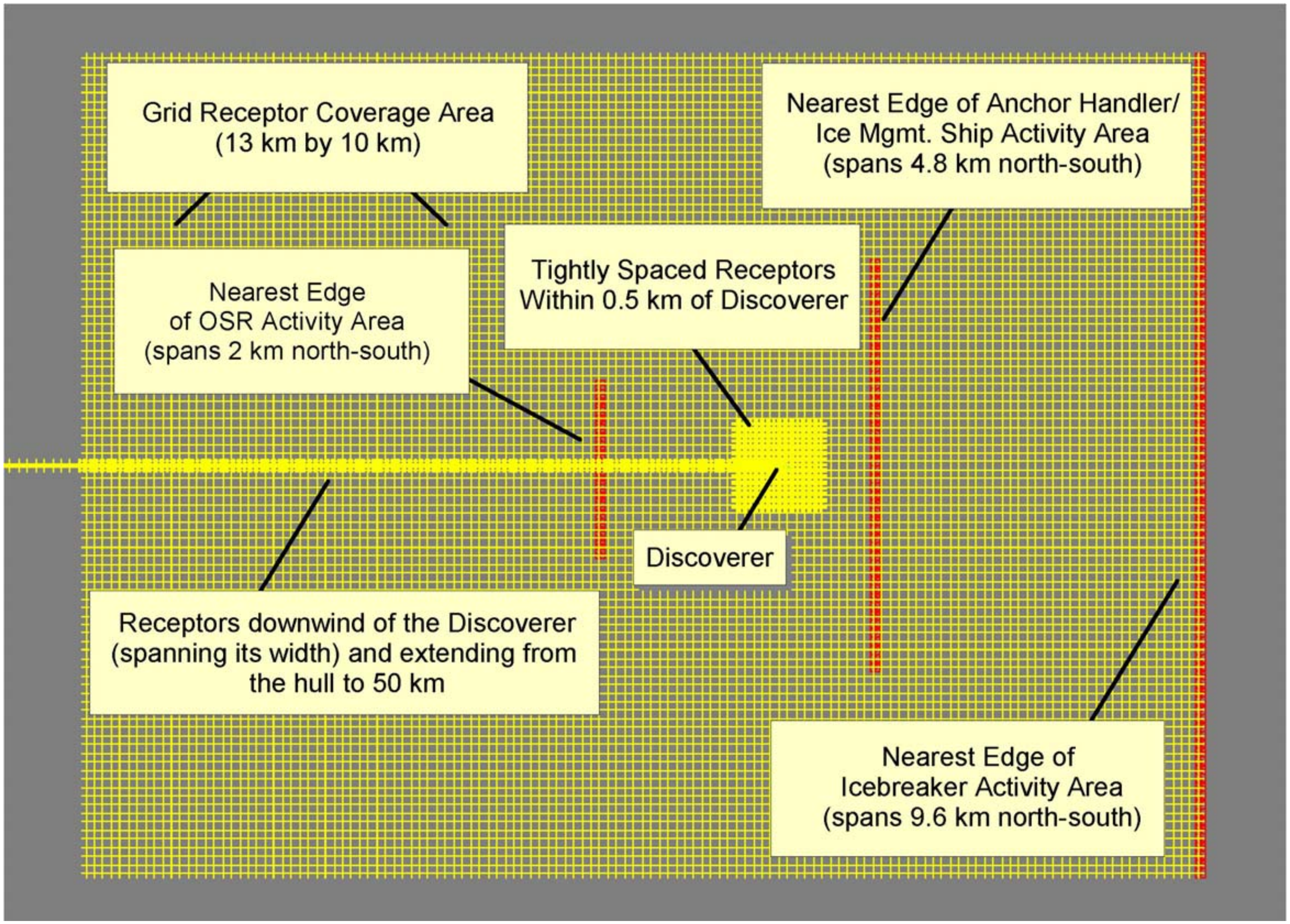
NA not applicable

New Receptor Configuration – No Exclusion Zone

5.5 Ambient Air Boundary and Receptors

…To capture maximum screening impacts from the *Discoverer* and its associated fleet, receptors are placed every 100 meters throughout a 13-kilometer by 10-kilometer area covering all activity areas upwind and downwind of the *Discoverer*. Receptors are spaced around the hull of the Discoverer every 10 meters and within approximately 500 meters of the Discoverer receptors are spaced every 25 meters. In addition, a high resolution line of receptors is placed downwind of the *Discoverer* spanning the width of the *Discoverer* (three receptors spaced every 15 meters spanning north-south). Receptors on this line (located directly downwind of the *Discoverer)* are spaced: every 25 meters between the exclusion zone and 8 kilometers from the *Discoverer*, every 100 meters from 8 kilometers to 50 kilometers, and every 500 meters to 50 kilometers. All maximum impact locations are captured by this high resolution line. Receptor locations for the worst-case modeling scenario are shown on Figure 5-1.

Figure 5-1: Source and Receptor Locations for Worst-Case Impact Scenario



Response Materials for Attachment A, Comment D.4.

5.4 Physical Characterization of the Emission Units

5.4.2 Volume Source Characterization of Supporting Fleets

In a January 26, 2009, memo from Shell representatives to EPA Region 10,[1] a detailed description of the volume source characterization of the support fleets was provided and based on subsequent discussions with EPA, the following characterization of the support fleets is utilized in the modeling analysis.

The ice management and OSR fleets are characterized in the air quality impact analysis using an elevated line source (series of adjacent volume sources) at the nearest edge of anticipated activity to the *Discoverer*. This configuration is worst-case since, in reality, the ice management fleet will be breaking up ice at and beyond (e.g., further away from the *Discoverer*) the nearest edge of anticipate ice management activity. The line source characterization is designed to simulate the effect of mobile sources moving around and emitting plumes which rise and form a layer of emissions above ground (e.g., smearing in space of a plume from a moving ship) which is then advected downwind towards the *Discoverer*. This design simulates the effect of ice management fleet under its highest emitting scenario, which is a continual churning up of one-year ice drifting toward the *Discoverer*.

Determination of Effective Emission Heights for Volume Sources

According to Section 1.2 in the User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume II - Description of Model Algorithms (EPA-454/95-003b, September 1995), the effective emissions height for elevated volume sources needs to be assigned. The plume heights for the fleet emissions are estimated using SCREEN3 (an alternate screening model that provides a printout of plume rise) which accounts for the mechanical and buoyant lift from the ship's stacks. Per EPA's request, as provided in Section 2.11, Shell has compiled a list of potential ships which could be used for ice management and anchor handling activities. The stack characteristics of the main propulsion engines for each ship are used with the SCREEN3 algorithms to define the plume height for the ice management fleet emissions (in ISC-PRIME) as shown on Appendix B, Page 3. Building downwash information related to these sources in provided on Appendix B, Page 9.

Note that some of the ice management ships have horizontal stacks which are modeled in accordance with Alaska DEC's recommendations. Alaska DEC's recommended adjustments

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[1] Martin, Tim, Air Sciences Inc. [Technical memo Herman Wong, EPA Region 10]. Description of Volume Source Characterization of Icebreaker Fleets, Shell *Discoverer* Chukchi Sea Permit Application. January 26, 2009.

provide for the retention of buoyancy while addressing the impediment to the vertical momentum of the release.

The following procedure was utilized to model horizontally emitting stacks:

- Set the actual stack velocity (V_{actual}), in meters per second, to an adjusted stack exit velocity ($V_{adjusted}$) of 0.001 meter per second.
- To conserve volumetric flow, determine an adjusted stack diameter ($D_{adjusted}$) by adjusting the actual stack inside diameter (D_{actual}), in meters, to account for buoyancy of the plume by using the following equation:
- $D_{adjusted} = 31.6(D_{actual})(V_{actual})^{0.5}$

Use the adjusted parameters, $V_{adjusted}$ and $D_{adjusted}$, in the modeling analysis.

These source characteristics and building dimension information were used as inputs to SCREEN3 to obtain an estimate of final plume rise. Per EPA's request, the worst-case final plume rise values were determined by considering the single, worst-case meteorological condition of 20 meters per second, and D stability, Appendix E provides the SCREEN3 output for each of the ice management ships.

The ice management fleet will be managing ice upwind of the *Discoverer* given the mobile nature of the fleets, the plumes from the fleets will rise and spread out at some height. The final plume rise for each ship was chosen to represent the height of the volume sources for ISC-PRIME. The final plume height for the generic ice management and anchor handler fleet was conservatively chosen as the lowest plume rise value for any ship at 1,000 meters upwind of the *Discoverer*, which the closest location of any ship to *the Discoverer* (see Table 5-4).

In reality, the support ships will typically be located much further away than 1,000 meters from the *Discoverer* and much higher plume rise values would be appropriate. Based on the data highlighted in Table 5-4, the lowest final plume rise for the primary and secondary ice management ships is 25.22 meters (based on worst-case plume rise from the Vladimir Ignatjuk) and is used to define the volume source release heights for the ice management fleet in ISC-PRIME.

Table 5-4: Summary of SCREEN3 Output for Plume Rise

	Minimum Plume Rise from SCREEN3								
Downwind Distance(m)	OSR Fleet Kvichaks	OSR Fleet Nanuq	Fennica/ Nordica	Vladimir Ignatjuk	Talagy	Tor Viking II	Odin Viking II	Balder Viking	Vidar Viking
100	3.38	15.37	32.02	24.43	25.98	28.97	28.97	28.97	28.97
200	3.38	15.76	32.10	24.58	26.19	29.02	29.00	29.02	29.02
300	3.38	16.37	32.22	24.82	26.53	29.07	29.01	29.07	29.07
400	3.38	17.17	32.39	25.15	26.99	29.07	29.01	29.07	29.07
500	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
600	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
700	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
800	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
900	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
1,000	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
1,100	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
1,200	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
1,300	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
1,400	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
1,500	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
1,600	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
1,700	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
1,800	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
1,900	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
2,000	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
2,100	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
2,200	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
2,300	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
2,400	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
2,500	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
2,600	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
2,700	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
2,800	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
2,900	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
3,000	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
3,500	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
4,000	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
4,500	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
5,000	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
5,500	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
6,000	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
6,500	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
7,000	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
7,500	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
8,000	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
8,500	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
9,000	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
9,500	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07
10,000	3.38	17.55	32.51	25.22	27.44	29.07	29.01	29.07	29.07

Determination of the Volume Sources Spacing and Dimensions

For each ship, the elevated line source is divided into a series of volume sources and each volume source is assigned initial X, Y, and Z dimensions following Section 1.2 in the User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume II - Description of Model Algorithms (EPA-454/95-003b dated September 1995).

The line source for the primary and secondary ice management ships is composed of a series of adjacent squares with 100 meters on each side. EPA has suggested that the volume sources could be spaced based on the size of the ice management ships which are generally around 100 meters long. The line source for the OSR fleet is composed of a series of adjacent squares, each 50 meters on side. The OSR fleet vessels could potentially range in size from 34-foot (~10 meter) boats, to the Nanuq which is roughly 100 meters in length. The line source of the OSR fleet is composed of a series of adjacent squares which represent both the larger and the smaller ships so a fleet average of approximately 50 meters is used to represent the OSR fleet.

The impacts from the OSR fleet are based on modeling the emissions from both the smaller craft (Kvichaks) and the larger Nanuq as separate sources. For comparison, the stacks of the 34-foot craft are 11 feet above the water while the stack of the Nanuq is approximately 50 feet above the water. The final plume rise values for each ship type are provided in Table 5-4.

Initial dispersion for volume sources is characterized by two parameters, σy (sigma Y) and σz (sigma Z). For the ice management and anchor handling fleet, the sigma Y value for each volume source is determined by dividing the physical horizontal dimension of the volume, 100 meters, by 2.15 as recommended in the ISC User's Guide. The sigma Y value for each volume of the OSR fleet is 50 meters, divided by 2.15. Thus, the sigma Y values for the OSR fleet and ice management fleet used as input to the ISC-PRIME model are 46.5 and 23.3 meters, respectively. EPA has recommended that Shell utilize the minimum sigma Z values following guidance from the ISC User's Guide. Following this methodology, the sigma Z value for an elevated source on or adjacent to a building is the building height divided by 2.15. Table 5-5 lists minimum sigma Z values for both the OSR and ice management fleets. Based on this table, the sigma Z values for the OSR fleet's Kvichaks and Nanuq are 1.42 and 6.38 meters, respectively. The minimum sigma Z value for the management fleet is 9.21 meters (Vladimir Ignatjuk and Talagy).

Table 5-5: Minimum Sigma Z Values from SCREEN3

Source Name	SCREEN3 Model ID	Minimum Sigma Z
OSR Fleet (Kvichaks)	OILSPL3	1.42
OSR Fleet (Nanuq)	OILSPL4	6.38
Fennica/Nordica	FENNICA2	12.76
Vladimir Ignatjuk	VLADIGN2	9.21
Talagy	TALAGY	9.21
Tor Viking II	TOR_H	11.34
Odin Viking II	ODIN_H	11.34
Balder Viking	BALD_H	11.34
Vidar Viking	VIDAR_H	11.34

A listing of the assumed locations and source characteristics for the primary and secondary ice management ships and the OSR fleet are provided on Pages 5, 6 and 7 of Appendix B.

Response Materials for Attachment A, Comment D.7.b.

5.7 PSD Modeling Assessment Phases – Preliminary Analysis and Full Impact Analysis

…The results of the preliminary analysis determine whether a full impact analysis (facility plus competing regional sources) for a particular pollutant is necessary. If the ambient impacts from the preliminary analysis are greater than the PSD Significant Impact Levels (SILs) shown in Table 5-6 then the extent of the Significant Impact Area (SIA) of the proposed project is to be determined.

Table 5-6: Summary of Significant Impact Levels and Related Significant Areas

Pollutant	Averaging Time	PSD Class II SIL (µg/m³)	Screening Model Max. SIA (kilometers)
Nitrogen Dioxide (NO_2)	Annual	1	50.0
Particulate Matter ($PM_{2.5}$)	24-hour Annual	NA NA	NA NA
Particulate Matter (PM_{10})	24-hour Annual	5 1	50.0 13.8
Sulfur Dioxide (SO_2)	3-hour 24-hour Annual	25 5 1	7.0 50.0 8.6
Carbon Monoxide (CO)	1-hour 8-hour	2,000 500	Not significant Not Significant

SIL Significant Impact Level
SIA Significant Impact Area
NA not applicable

Initially, the SIA is determined for every relevant averaging time for a particular pollutant. The final SIA for that pollutant is the largest area for each of the various averaging times. According to the EPA's Draft New Source Review Workshop Manual (EPA, 1990), the SIA is a circular area with a radius extending from the source to: (1) the most distant point where approved dispersion modeling predicts a significant ambient impact will occur, or (2) a modeling receptor distance of 50 kilometers, whichever is less. Therefore, a SIA cannot be greater than 50 kilometers for any pollutant. In addition, the Guideline on Air Quality Models (40 CFR 51, Appendix W), indicates that traditional steady-state models (e.g., ISC-PRIME) are applicable for transport distances of 50 km or less. 50 km is the useful distance to which most steady-state Gaussian plume models are considered accurate for setting emission limits. From Table 5-6, the SIAs for NO_2, PM_{10}, and SO_2 are 50 kilometers.

The full impact analysis expands the preliminary impact analysis by considering emissions from both the proposed project as well as other sources in the SIA (the competing sources). The full impact analysis may also consider other sources outside the SIA that could cause significant impacts in the SIA of the proposed source. The results from the full impact analysis are used to demonstrate compliance with NAAQS and PSD increments. The source inventory for the cumulative NAAQS analysis includes all nearby sources that have significant impacts within the proposed source SIA, while the source inventory for the cumulative PSD increment analysis is limited to increment-affecting sources (new sources and changes to existing sources that have occurred since the applicable increment baseline date).

The full impact analysis is limited to receptor locations within the proposed project's SIA. The modeling results from the NAAQS cumulative impact analysis are added to representative ambient background concentrations, and the total concentrations are compared to the NAAQS. However, the modeled air quality impacts for all increment-consuming sources are directly compared to the PSD increments to determine compliance (without consideration of ambient background concentrations).

Emissions of lead are insignificant and were not evaluated.

Response Materials for Attachment A, Comment E.3.

Table 6-2 provides a representative estimate of regional background concentrations in remote locations of the Alaska OCS where there are no significant pollution sources. The Wainwright monitored concentrations will be updated with data through April 2009 for verification of the results herein.

Table 6-2: Baseline Concentrations

Pollutant	Averaging Time	Monitored Concentrations Wainwright (1) ($\mu g/m^3$)
NO_2	Annual (2)	3.8
$PM_{2.5}$	24-hour	8.7
	Annual (2)	2.0
PM_{10}	24-hour	9.5
	Annual (2)	4.0
SO_2	3-hour	18.2
	24-hour	10.4
	Annual (2)	---
CO	1-hour	1049.3
	8-hour	537.2

1 Wainwright data provided is for November 2008 through February 2009; Values to updated as more data become available.

2 The annual average values are conservatively based on the monthly maximum values from November 2008 through February 2009.

NA Not applicable

Response Materials for Attachment A, Comment D.4.

SECTION 7

IMPACT MODELING RESULTS

7.1 Worst-Case Concentration Impacts

The *Discoverer* drilling impact summary of Table 7-1 is developed from the individual source impacts and background concentrations (for NAAQS) for all applicable averaging times. Because the modeling scenario defines the worst-case annual impact, Shell's Chukchi Sea exploratory drilling program will comply with the NAAQS and PSD increments. The modeling results and associated calculations for the annual impacts are provided in Table 7-2. Results and associated calculations for both short-term and annual impacts are summarized in Table 7-3. All electronic modeling files and associated calculations are provided in the CD.

Table 7-1: Summary of Screening Maximum Estimated Short-Term and Annual Concentrations all Sources Combined

Pollutant	Averaging Time	NAAQS[1] (µg/m³)	Screening Model Max. Impact Plus Background[2] (µg/m³)	PSD Class II Increment (µg/m³)	Screening Model Max. Impact No Background[3] (µg/m³)
Nitrogen Dioxide (NO_2)	Annual	100	24.0	25	20.2
Particulate Matter ($PM_{2.5}$)	24-hour	35	34.3	NA	NA
	Annual	15	3.7	NA	NA
Particulate Matter (PM_{10})	24-hour	150	36.8	30	27.3
	Annual	50	5.8	17	1.8
Sulfur Dioxide (SO_2)	3-hour	1,300	67.7	512	49.5
	24-hour	365	38.2	91	27.8
	Annual	80	2.1	20	2.1
Carbon Monoxide (CO)	1-hour	40,000	1,429.3	NA	NA
	8-hour	10,000	879.2	NA	NA

[1] National Ambient Air Quality Standards

[2] Maximum modeled impacts plus background concentrations are compared to the NAAQS.

[3] Maximum modeled impacts only (no background concentrations included) are compared to the PSD Increments.

NA Not applicable

Table 7-2: Impact Scenarios Used to Define Screening Maximum Annual Impacts from All Sources and Multiple Sequential Wells

Pollutant	Model Run	Impact Category	Max. Impact Location X(m)	Max. Impact Location Y(m)	Modeled 1-Hour Impact [1]	Persistence Factor	Emiss. Adjust [2]	Conc. (μg/m³)
NO_2 [3]	All Sources	At or Beyond Hull	-2134.3	55.0	1043.0	0.10	0.1726	13.5
	No xxd [2]	At or Beyond Hull	-2134.3	55.0	311.3	0.10	0.2877	6.7
							Total Annual NO_2 Impact (μg/m³) >	*20.2*
Pollutants	**Model Run**	**Impact Category**	**Max. Impact Location X(m)**	**Max. Impact Location Y(m)**	**Modeled 1-Hour Impact [1]**	**Persistence Factor**	**Emiss. Adjust [2]**	**Conc. (μg/m³)**
$PM_{2.5}$	All Sources	At or Beyond Hull	-2309.3	55.0	40.0	0.10	0.1726	0.7
	No xxd [2]	At or Beyond Hull	-2309.3	55.0	33.8	0.10	0.2877	1.0
							Total Annual $PM_{2.5}$ Impact (μg/m³) >	*1.7*
Pollutants	**Model Run**	**Impact Category**	**Max. Impact Location X(m)**	**Max. Impact Location Y(m)**	**Modeled 1-Hour Impact [1]**	**Persistence Factor**	**Emiss. Adjust [2]**	**Conc. (μg/m³)**
PM_{10}	All Sources	At or Beyond Hull	-2309.3	55.0	43.8	0.10	0.1726	0.8
	No xxd [2]	At or Beyond Hull	-2309.3	55.0	37.7	0.10	0.2877	1.1
							Total Annual PM_{10} Impact (μg/m³) >	*1.8*
Pollutant	**Model Run**	**Impact Category**	**Max. Impact Location X(m)**	**Max. Impact Location Y(m)**	**Modeled 1-Hour Impact [1]**	**Persistence Factor**	**Emiss. Adjust [2]**	**Conc. (μg/m³)**
SO_2	All Sources	At or Beyond Hull	-2084.3	40.0	46.3	0.10	0.1726	0.8
	No xxd [2]	At or Beyond Hull	-2084.3	40.0	43.9	0.10	0.2877	1.3
							Total Annual SO_2 Impact (μg/m³) >	*2.1*

Assume 168 days per drilling season and 63 days of operation per season for HPU engines, air compressors, and resupply, ice management ships (NOx only) at each location.

1 Modeled 1-hour impacts for both sets of model runs (i.e., A) all sources, and B) no HPUs, compressors, cranes, or resupply and ice management ships (NOx only; also called "No_xxd" run) which results in the highest combined impact after emissions adjustments are made.

2 Annual emissions adjustment to modeled hourly emissions to account for duration of drilling season.

For ice management annual NOx compliance limit, ice management activity is assumed for 63 days per season. Thus, model run with all sources is adjusted by 63 days/365 days (i.e., 0.1726) and model run with no HPUs, compressors, cranes, or resupply and ice management ships is adjusted by (168 days - 63 days)/365 days (i.e., 0.2877). For all other pollutants, the ice management annual compliance limit is based on 168 days per season. Thus, model run with all sources is adjusted by 63 days/365 days (i.e., 0.1726) and model run with no HPUs, compressors, cranes, or resupply ships is adjusted by (168 days - 63 days)/365 days (i.e., 0.2877).

3 Assume that $NO_2 = NO_x * 0.75$.

Table 7-3: Combined Screening Maximum Impacts from All Sources and Multiple Sequential Wells

Pollutant	Averaging Period	Max. Modeled 1-Hour Impact at or Beyond Hull	Persistence Factor	Emis. Adj.[1]	Concentration (μg/m³) Total No Background	Background	Total w/ Background	PSD Class II Increment (μg/m³)	Comply?	NAAQS (μg/m³)	Comply?	Sig. Monitoring Concentration (μg/m³)	Exceed?
NO_2 [2]	Annual	See Calculations in Table 7-2			20.2	3.8	24.0	25	Yes	100	Yes	14	Yes
$PM_{2.5}$	24-Hour	42.6	0.6	1	25.6	8.7	34.3	---	---	35	Yes	---	---
	Annual	See Calculations in Table 7-2			1.7	2.0	3.7	---	---	15	Yes	---	---
PM_{10}	24-Hour	45.5	0.6	1	27.3	9.5	36.8	30	Yes	150	Yes	10	Yes
	Annual	See Calculations in Table 7-2			1.8	4.0	5.8	17	Yes	50	Yes	---	---
SO_2	3-Hour	49.5	1.0	1	49.5	18.2	67.7	512	Yes	1,300	Yes	---	---
	24-Hour	46.4	0.6	1	27.8	10.4	38.2	91	Yes	365	Yes	13	Yes
	Annual	See Calculations in Table 7-2			2.1	---	2.1	20	Yes	80	Yes	---	---
CO	1-Hour	380.0	1.0	1	380.0	1049.3	1429.3	---	---	40,000	Yes	---	---
	8-Hour	380.0	0.9	1	342.0	537.2	879.2	---	---	10,000	Yes	575	No

Assume 168 days per drilling season and 63 days of operation per drilling season for HPU engines, air compressors, cranes, and resupply and ice management ships (NOx only).

[1] Annual emissions adjustment to modeled hourly emissions; assume 168 days per season and the HPUs, compressors, cranes and resupply and ice management ships (NOx only) are limited to 63 days per season. Ice management is limited to 168 days per season for $PM_{2.5}$, PM_{10}, SO_2, and CO.
Short term emissions assume 24 hour per day operations.

[2] Assume that $NO_2 = NO_x * 0.75$.

Note that the worst-case impacts in Table 7-3 are also compared to the significant monitoring concentration thresholds. For any criteria pollutant that Shell proposes to emit in significant quantities, continuous monitoring data may be required as part of the air quality analysis. The permitting agency has discretionary authority to exempt a permit applicant from this data requirement if, 1) the highest modeled ambient impacts, or 2) the existing ambient pollutant concentrations are less than the significant monitoring concentration listed in Table 7-3. Existing ambient background NO_2, PM_{10} and SO_2 concentrations and maximum modeled impacts exceed the significant monitoring thresholds. As part of the Wainwright monitoring program, these pollutants along with other criteria pollutants, including ozone, are being gathered for use in the ambient impact analysis. Note that ozone monitoring is required since the project has NOx emissions (ozone precursor emissions) greater than 100 tons per year.

7.2 Source Contribution Analyses at Maximum Impact Location

EPA has asked that Shell provide a breakdown of individual source contributions. A source contribution analysis for 24-hour average $PM_{2.5}$ and annual average NO_2 is provided in Table 7-4. These pollutants and averaging times are presented since these are the highest impacts relative to the applicable ambient standards. Maximum impacts for annual NO_2 are driven by poorer dispersing engines (HPU engines and cementing units) on the *Discoverer* and the OSR and ice management fleet while the 24-hour $PM_{2.5}$ impacts are dominated by the incinerator on the *Discoverer*.

Table 7-4: Discoverer Source Contributions at the Screening Maximum Impact Locations

Source Description	Model Source ID	Impact Contribution (%)	
		Annual NO_2	24-Hour $PM_{2.5}$
Stack #1: 6 Main Drill Engines	MAINENGS	3	10
Stack #2: 2 Air Compressors	COMPENGS	4	0.5
Stack #3: 2 HPU Engines	HPPENGS	9	21
Stack #4: 3 Cementing Units	CEMENT	14	8
Stack #5a: Crane Engine (port)	CRANE_PT	0	0
Stack #5b: Crane Engine (stbd)	CRANE_SB	7	3
Stack #6: 2 Heat Boilers	HEATBOIL	5	11
Stack #7: 1 Incinerator	INCIN_D	0.4	36
Resupply Ship	KILABUK	2	0
Oil Spill Response Ships	OILSPL01-40	18	0
Ice Management (Secondary)	BRK_B01-48	27	8
Ice Management (Primary)	BRK_A01-96	12	2
	Total >	100	100

7.3 Impacts from the Ice Management and Anchor Handler Fleet

EPA has asked that Shell provide a table showing the maximum concentration impacts from both the primary and the secondary ice management ships and its locations. As expected, if the impacts from all source operations show compliance with the ambient standards as shown in Table 7-3 above, then the impacts from each of the ice management ships individually will also be less than the ambient standards. The maximum impacts from the primary ice management fleet and secondary ice management fleet are provided below in Table 7-5 and 7-6, respectively, and impacts are well below the PSD increment and NAAQS thresholds.

Table 7-5: Maximum Impacts from Primary Ice Management Ship

Pollutant	Averaging Period	Coordinate of Max. Impact Receptor X (m)	Coordinate of Max. Impact Receptor Y (m)	Max. Modeled 1-Hr Impact (μg/m³)	Persistence Factor	Emission Adjustment [1]	Concentration (μg/m³) Max. Modeled Impact (μg/m³)	Concentration (μg/m³) Background	Concentration (μg/m³) Total No Background	Concentration (μg/m³) Total w/ Background	PSD Class II Increment [2] (μg/m³)	PSD Class II Increment [2] Comply?	NAAQS [3] (μg/m³)	NAAQS [3] Comply?
NO_2	Annual	4,800.0	-4,500.0	252.9	0.1	0.1726	3.3	3.8	3.3	7.1	25	Yes	100	Yes
$PM_{2.5}$	24-Hour	4,800.0	-4,500.0	9.6	0.6	1	5.8	8.7	5.8	14.5	---	---	35	Yes
	Annual	4,800.0	-4,500.0	9.6	0.1	0.4603	0.4	2.0	0.4	2.4	---	---	15	Yes
PM_{10}	24-Hour	4,800.0	-4,500.0	11.0	0.6	1	6.6	9.5	6.6	16.1	30	Yes	150	Yes
	Annual	4,800.0	-4,500.0	11.0	0.1	0.4603	0.5	4.0	0.5	4.5	17	Yes	50	Yes
SO_2	3-Hour	4,800.0	-4,500.0	9.5	0.9	1	8.5	18.2	8.5	26.7	512	Yes	1,300	Yes
	24-Hour	4,800.0	-4,500.0	9.5	0.6	1	5.7	10.4	5.7	16.1	91	Yes	365	Yes
	Annual	4,800.0	-4,500.0	9.5	0.1	0.4603	0.4	---	0.4	0.4	20	Yes	80	Yes
CO	1-Hour	4,800.0	-4,500.0	41.9	1.0	1	41.9	1049.3	41.9	1091.2	---	---	40,000	Yes
	8-Hour	4,800.0	-4,500.0	41.9	0.9	1	37.7	537.2	37.7	574.9	---	---	10,000	Yes

[1] For short-term impacts assume 24-hour day operations (adjustment = 1) for annual impacts assume 63 days per drilling season for NOx (adjustment = 63 days/365 days) and and 168 days per drilling season for $PM_{2.5}$, PM_{10}, and SO_2 (adjustment = 168 days/365 days).

[2] Impacts without background concentrations are compared to the PSD increments.

[3] Impacts including background concentrations are compared to the NAAQS.

Table 7-6: Maximum Impacts from Secondary Ice Management Ship

Pollutant	Averaging Period	Coordinate of Max. Impact Receptor X (m)	Y (m)	Max. Modeled 1-Hr Impact (µg/m³)	Persistence Factor	Emission Adjustment [1]	Concentration (µg/m³) Max. Modeled Impact (µg/m³)	Background	Total No Background	Total w/ Background	PSD Class II Increment [2] (µg/m³)	Comply?	NAAQS [3] (µg/m³)	Comply?
NO_2	Annual	1000.0	-2100.0	505.8	0.1	0.1726	6.5	3.8	6.5	10.3	25	Yes	100	Yes
$PM_{2.5}$	24-Hour	1000.0	-2100.0	19.3	0.6	1	11.6	8.7	11.6	20.3	---	---	35	Yes
	Annual	1000.0	-2100.0	19.3	0.1	0.4603	0.9	2.0	0.9	2.9	---	---	15	Yes
PM_{10}	24-Hour	1000.0	-2100.0	21.9	0.6	1	13.2	9.5	13.2	22.7	30	Yes	150	Yes
	Annual	1000.0	-2100.0	21.9	0.1	0.4603	1.0	4.0	1.0	5.0	17	Yes	50	Yes
SO_2	3-Hour	1000.0	-2100.0	19.0	0.9	1	17.1	18.2	17.1	35.3	512	Yes	1,300	Yes
	24-Hour	1000.0	-2100.0	19.0	0.6	1	11.4	10.4	11.4	21.8	91	Yes	365	Yes
	Annual	1000.0	-2100.0	19.0	0.1	0.4603	0.9	---	0.9	0.9	20	Yes	80	Yes
CO	1-Hour	1000.0	-2100.0	83.7	1.0	1	83.7	1049.3	83.7	1133.0	---	---	40,000	Yes
	8-Hour	1000.0	-2100.0	83.7	0.9	1	75.3	537.2	75.3	612.5	---	---	10,000	Yes

1 For short-term impacts assume 24-hour day operations (adjustment = 1) for annual impacts assume 64 days per drilling season for NOx (adjustment = 63 days/365 days) and and 168 days per drilling season for $PM_{2.5}$, PM_{10}, and SO_2 (adjustment = 168 days/365 days).

2 Impacts without background concentrations are compared to the PSD increments.

3 Impacts including background concentrations are compared to the NAAQS.

7.4 Worst-Case Screening Impacts at Nearest Villages on Chukchi Coast

Based on Figure 1-1, the nearest coastal villages to the existing Shell leases are Wainwright and Point Lay, which are approximately 110 and 100 kilometers away from the nearest Shell leases, respectively. Worst-case impacts from the proposed project using the screening analysis are provided in Table 7-7 and are well below the NAAQS and PSD increments at these locations.

Table 7-7: Worst-Case Screening Impacts at Nearest Villages on Chukchi Coast

Pollutant	Averaging Period	Concentration ($\mu g/m^3$): Max. Modeled [1]: Wainwright	Concentration ($\mu g/m^3$): Max. Modeled [1]: Point Lay	Concentration ($\mu g/m^3$): Background	Concentration ($\mu g/m^3$): Total No Background	Concentration ($\mu g/m^3$): Total w/ Background	PSD Class II Increment [2] ($\mu g/m^3$)	Comply?	NAAQS [3] ($\mu g/m^3$)	Comply?	Shell Impact % NAAQS
NO_2	Annual	2.8	3.0	3.8	3.0	6.8	25	Yes	100	Yes	3
$PM_{2.5}$	24-Hour	4.5	4.8	8.7	4.8	13.5	---	---	35	Yes	14
	Annual	0.3	0.4	2.0	0.4	2.4	---	---	15	Yes	2
PM_{10}	24-Hour	5.1	5.4	9.5	5.4	14.9	30	Yes	150	Yes	4
	Annual	0.4	0.4	4.0	0.4	4.4	17	Yes	50	Yes	1
SO_2	3-Hour	7.5	8.0	18.2	8.0	26.2	512	Yes	1,300	Yes	1
	24-Hour	4.5	4.7	10.4	4.7	15.1	91	Yes	365	Yes	1
	Annual	0.3	0.4	---	0.4	0.4	20	Yes	80	Yes	0.5
CO	1-Hour	34.7	36.9	1049.3	36.9	1086.2	---	---	40,000	Yes	0.1
	8-Hour	31.2	33.2	537.2	33.2	570.4	---	---	10,000	Yes	0.3

[1] The nearest villages to Shell's Chukchi leases are Wainwright (~110 km away) and Point Lay (~100 km away).

[2] Total impact without background is compared to the PSD increments.

[3] Total impact with background is compared to the NAAQS.

Response Materials for Attachment A, Comment F.1.

SECTION 8

ADDITIONAL IMPACT ANALYSES

8.4 Ozone Analysis

Ozone is an air pollutant formed through complex chemical reactions of nitrogen oxide (NOx) and volatile organic compound (VOC) emissions during periods of conducive weather conditions. Ozone is more readily formed when it is sunny and hot and the air is stagnant. Conversely, ozone production is more limited when it is cloudy, cool, rainy, and windy. For these reasons, ozone concentrations are generally the highest during the summer.

The majority of tropospheric ozone formation occurs when nitrogen oxides (NOx), carbon monoxide (CO) and volatile organic compounds (VOCs), react in the atmosphere in the presence of sunlight. NOx, CO, and VOCs are called ozone precursors.

The chemical reactions involved in tropospheric ozone formation are a series of complex cycles in which carbon monoxide and VOCs are oxidized to water vapor and carbon dioxide. The reactions involved in this process are illustrated below with CO but similar reactions occur for VOC as well. Oxidation begins with the reaction of CO with the hydroxyl radical. The hydrogen atom formed by this reacts rapidly with oxygen to give a peroxy radical HO_2

$$OH + CO \rightarrow H + CO_2$$

$$H + O_2 \rightarrow HO_2$$

Peroxy radicals then go on to react with NO to give NO_2 which is photolysed (indicated by hv) to give atomic oxygen and through reaction with oxygen a molecule of ozone:

$$HO_2 + NO \rightarrow OH + NO_2$$

$$NO_2 + hv \rightarrow NO + O$$

$$O + O_2 \rightarrow O_3$$

The net effect of these reactions is:

$$CO + 2O_2 \rightarrow CO_2 + O_3$$

This cycle involving HO_x and NO_x is terminated by the reaction of OH with NO_2 to form nitric acid or by the reaction of peroxy radicals with each other to form peroxides. The chemistry involving VOCs is much more complex but the same reaction of peroxy radicals oxidizing NO to NO_2 is the critical step leading to ozone formation. [2]

[2] http://en.wikipedia.org/wiki/Tropospheric_ozone

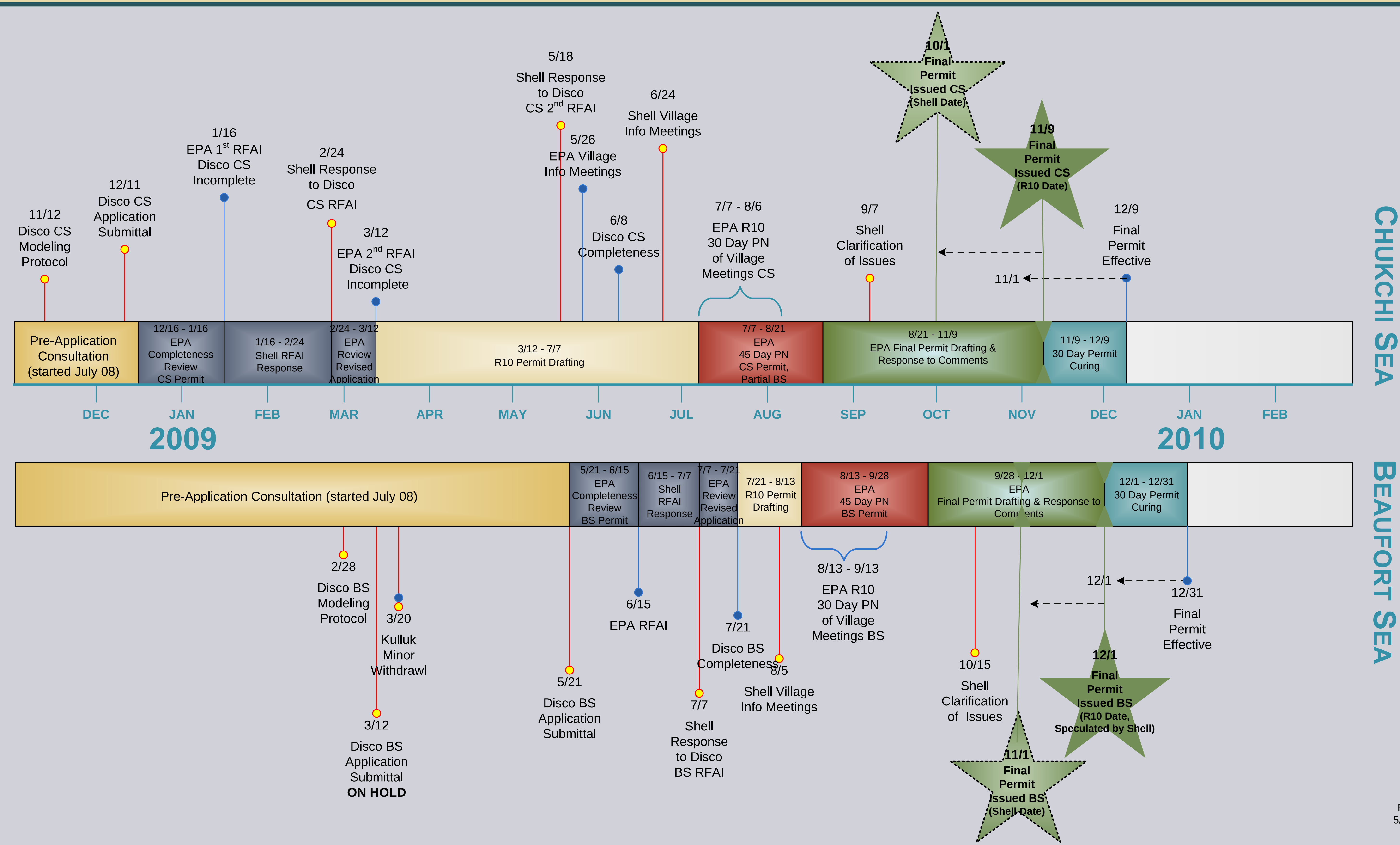
ATTACHMENT F

Shell EPA PSD Air "Major Source" Permits:

Semi-Parallel Processing Schedule

SHELL EPA PSD AIR "MAJOR SOURCE" PERMITS:

Semi-Parallel Processing Schedule (using R10 proposed permit issuance dates; to be mutually optimized to occur earlier as shown)



Revised
5/18/2009