United States Department of the Interior

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To: Peter Taylor
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From: NPS Natural Sounds and Night Skies Division

Subject: Comments on the noise analysis in the USFS South Fowl Lake Snowmobile Access EIS

Date: August 21, 2012

Summary Conclusions

- The indicators chosen by USFS are good ones for describing impacts; however, the ambient sound data used to assess the spatial limit of noise impacts could be augmented to better reflect natural ambient levels and potential impacts in the project area.
- Royal Lake ambient sound level data from March 3-7, 2011 and a prior Copper-Nickel study suggest that 34 dBA may not be representative of the natural ambient at this site because of instrument limitations. However, if USFS deems 34 dBA as appropriately representative, the EIS should disclose this as well as the fact that it might in fact under-represent impacts. The SFL EIS could make use of voluntary consensus standards, pursuant to OMB Circular A-119, in support of the noise analysis and criteria used to evaluate functional impacts of noise exposure.
- The secondary placement of a frequency-specific geographic noise model in Appendix G seems counter-intuitive, since spectral noise models are typically preferred to simplified approaches when appropriate noise source spectra exists.
- Some parts of noise propagation analysis used in the USFS South Fowl Lake Snowmobile Access EIS (SFL EIS) appears subject to unnecessary error and could be improved via use of a validated noise model that better conforms to available standards.

Comment [A1]: These items are addressed through use of the NMSim model and revised ambient sound levels as recommended later in the document by NPS.

Background

The US Forest Service (USFS) Superior National Forest (SNF) unit initiated an interagency agreement and a work order with the National Park Service (NPS) Natural Sounds and Night Skies Division (NSNSD) to fulfill the instructions of the Snowmobile EIS Appeal Reviewing Officer. Specifically, NSNSD was asked to evaluate the existing analysis, sampling techniques, technology, and data analysis and resultant technical conclusions drawn regarding acoustics effects in the project area. If NSNSD determines that the existing acoustics analysis is insufficient to provide reasonable technical estimations of acoustics effects, NSNSD was asked to provide any new information needed, including the results of any supplemental noise models the NPS would run to estimate impacts for the South Fowl project.

The SFL EIS noise analysis seeks to evaluate the effects of snowmobile in the project area, and parts of the Boundary Waters Canoe Area Wilderness (BWCAW) that are near the project area. This NSNSD report focuses on the portions of the SFL EIS that addressed noise exposure estimation.

Chapter 3

Analysis methods and affected environment

The USFS analysis considered four factors of a sound event: 1) type (spectral composition), 2) volume, 3) frequency of occurrence, and 4) duration. USFS found that the type and frequency of occurrence of sound events will not vary by alternative and instead focused on volume and duration. Therefore, in Section 3.2.2, page 3-5, the SFL EIS focuses on two indicators, described below:

Indicator 1: Volume and Area of Sound. A-weighted noise levels and areas of impact are very widely used for evaluating noise impacts, and these metrics are strongly supportable.

Indicator 2: Duration of Sound. This is a widely used measure of noise exposure, which the NPS calls "Time Audible" (TAud). NSNSD agrees that change in duration of snowmobile sound above natural ambient is a potentially useful metric.

Both of these indicators relate to current acoustic conditions; specifically, the ambient sounds that are present in winter when snowmobiles are in operation. The use of the 5-day median daytime sound level in Section 3.2.4, page 3-12 is shorter than the NPS standard, and may not be a reasonable proxy for the natural ambient sound level if unusual conditions were present during the monitoring (e.g., periods of extreme wind speeds, heavy storms, or higher than normal visitor use). It is also important to clarify the median being used; it is not a median of all the daytime 1-second values (L_{eq1s}), but rather a median of the daytime 16-hour L_{eq}s. This definition of daytime median results in a level 5dBA higher than the NPS standard, and is likely to underestimate impacts to the natural ambient. Addition of another metric such as n-percent exceeded sound levels could help to better represent the variation of ambient sound levels in the project vicinity.

Comment [A2]: The L_{10}, L_{50} and L_{90} ambient sound levels identified by the NPS are discussed in Appendix A and summarized in the Supplemental Information Report (SIR).

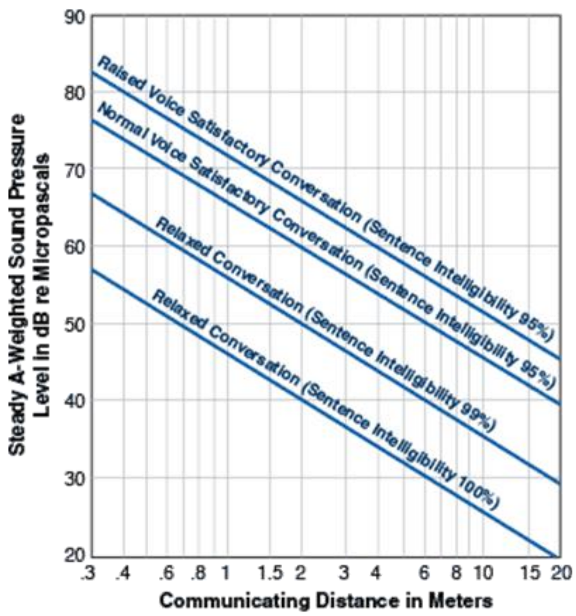
Environmental consequences are described in terms of audibility, zone of decay to ambient, areas above ambient, and duration of audibility for each alternative. Chapter 3 contains data for all the alternatives in both tabular and graphical form. A comparison of the audibility impacts between several alternatives is shown in figure 3-6. Total areas of wilderness where snowmobile noise may exceed ambient are calculated in Table 3-2. Duration of audibility for each alternative is displayed in Tables 3-3 and 3-4, and Figures 3-12 and 3-13. The methods and assumptions for the audibility calculations are described in Appendices C and D.

Potential Indicators. The following metrics have substantial scientific support and offer USFS additional options for quantifying impacts. Their value for the SFL EIS is dependent upon USFS land use objectives and is therefore a matter for USFS professional judgment. Audibility may be a primary driver in the BWCAW, while metrics such as speech interference may have greater relevance in project areas closer to the snowmobile trails (outside of the BWCAW).

- Lost auditory alerting distance or listening area reduction. This indicator applies to humans and wildlife.

Examples of reduction in Auditory Awareness to Increases in Ambient Levels				
dBA Ambient Increase	3	6	10	20
Percent Reduction in Listening Area	50%	75%	90%	99%
Percent Reduction in Alerting Distance	30%	50%	70%	90%

- Speech interference: as ambient levels increase, speakers must either raise their voice, or reduce the distance to the listener. The following figure, published by the EPA[1], gives maximum distances for several types of conversation in the presence of various ambient levels.



Appendix C

C-1 Analysis Methods and Field Data Collection Methods

Field data is used to analyze the effects of snowmobile sound in the project area. This includes the four factors of sound identified in Chapter 3 and the Court Order: 1) type, 2) volume, 3) frequency of

[1] Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, EPA, 1974

Comment [A3]: As the Park Service states, the use of these possible indicators are "dependent on USFS land use objectives and is therefore a matter for USFS professional judgment." The indicators used in the South Fowl FEIS along with discussion on relevant management direction (or "land use objectives") specific to the Superior National Forest and BWCAW such as Forest Plan Wilderness Management Areas is considered adequate for considering impacts of the project.

This is consistent with the Appeal Reviewing Officer Letter which states that while the Superior NF was instructed to obtain expert review on the technical acoustic analysis, the Forest has the expertise to estimate impacts to wilderness (ARO Letter page 13). Consideration of the use of these indicators is relevant to the experience of people and impacts to wilderness.

As stated in other responses to Park Service advice, we have implemented advice from the Park Service related to the technical acoustic analysis such as using the ambient sound levels identified by the Park Service and the NMSim Nord 2000 model for the discussion in the SIR.

occurrence, and 4) duration. The general procedures appear sound with the provision that the equipment should be adequate to capture and produce representative snowmobile sound. The Extech HD600 sound level meter appears adequate for Type 2 measurement, as long as the meter is set to the appropriate range and the sound levels to be measured fall within its range of measurement, which is claimed to range from 30 to 130 decibels (dB).

C-2 Royal River Sound Test

The January/February 2009 sound tests are potentially useful as they can show how sound from specific snowmobiles may impact sensitive receiver sites under the chosen test conditions. Four tests were conducted with USFS personnel at nine listening points along the Royal River. The first test was a baseline test of the existing ambient sound with no snowmobile noise added. Two of three following tests were conducted with a Ski-Doo Skandik 550 running on the Little John and North Fowl Lakes. The remaining test was a reproduction of snowmobile noise on the proposed South Fowl Lake trail. The South Fowl Lake trail reproduction was produced using a Galls StreetThunder megaphone. It is unclear whether this megaphone is capable of producing the low frequency portion of the snowmobile noise spectrum. Although a datasheet with a frequency response for a StreetThunder megaphone could not readily be found, comparison to other products, including a Galls StreetThunder 100 Watt siren loudspeaker with a reported frequency response of 450-6000 Hz (±10 dB), indicates that such devices typically fall off sharply around 500 Hz. In Appendix G, USFS finds 500 Hz important as the frequency that "carried snowmobile sound the greatest distance and would show the greatest impacts from snowmobile use."

The "Standard HD600 Data Logger" plots on pages C-17 through C-35 suggest the sound level meter was limited by the noise floor of the Extech HD600, evident by the consistent 40dBA (approximate) level in the plots. This possibility is further corroborated by notes on pages C-22, C-26, C-31, C-32, and C-34 mentioning audible snowmobile sound that did not register on the HD600, and by March 2011 measurements using a Larson Davis Model 831, which is capable of capturing lower sound levels than the HD600.

C-4 Noise propagation modeling

It is stated in the earliest NPS aircraft noise model validation study that only through computer modeling is it practical to assess natural quiet, i.e. no audibility, over the large and geographically complex area of the Grand Canyon [Miller, N. 2003]. For calculation of audibility, the NPS and FAA have agreed on the use of one-third (1/3) octave spectral modeling and the d' metric. This approach accounts for aspects of perception and propagation that are frequency dependent.

The SFL EIS project area contains moderate geographic complexity which will result in some amount of terrain shielding. Therefore, it is reasonable to use the spreadsheet model in Appendix C-4 to establish an upper bound for maximum impact area, NPS would recommend in that case that the EIS sufficiently acknowledge that the analysis may lack terrain influenced detail. The effect, if any, that the absence of terrain level analysis could have, would be to potentially overestimate impacts. However, if a geographic information system (GIS)-based computer noise model such as NMSim program with the Nord2000 option is available to calculate the times and areas of audibility over the project area, that is certainly an option that would strengthen the analysis results.

Comment [A4]: The NPS ran the NMSim model for the South Fowl Project and provided the analysis to the SNF. The SNF used the model as explained in Appendix A.

Appendix D

Frequency and duration of audible snowmobile noise

In order to assess audibility of a noise source, it is important to accurately characterize the ambient sound level. If A-weighted snowmobile noise levels exceed the ambient sound level, then it is reasonable to assume that snowmobile noise may be audible. However, snowmobile noise may still be audible when the overall level is below that of the ambient, depending on the spectrum of each.

Results

Based on a detailed analysis of the ambient sound level data in Appendix G and comparison to Volume 3-Chapter 5 of the Minnesota Environmental Quality Board Regional Copper-Nickel Study, the ambient levels described in section IV (B) on page D-19 may be an overestimation of the true ambient levels at the Royal River and the BWCAW (see Appendix G discussion below). This higher ambient would then underestimate the acoustic impacts of snowmobiles.

Comment [A5]: The SNF has used the ambient sound level identified by NPS as discussed in the SIR and Appendix A.

Methods used to estimate area of impacts

In Figure D-7, the displayed zone of audibility is based on simplified assumptions that may be reasonable but should be validated. Visual assessments indicate that the areas and durations of audibility could be improved in accuracy by use of a more advanced geographic noise model. For example, with the assumed ambient sound level and the hill to the south of the Alternative 2 trail, the zone of audibility on the south side of the hill is probably largely exaggerated. Similarly, the zone of audibility to the north of Alternatives 3 and 4 may not accurately represent the effect of hilly terrain and atmospheric conditions. Consequently, NSNSD suggests that the GIS calculated areas of impact from snowmobile noise could be refined using more accurate noise models such as the NPS NMSim program. This recommendation affects Figure D-7, as well as Tables D-3 through D-5.

Comment [A6]: The NPS ran the NMSim model for the South Fowl Project and provided the analysis to the SNF. The results of NMSim modeling are presented in Appendix A and the SIR.

Appendix G

Methods used to estimate ambient sound levels

Table G-2 proposes ambient sound levels as a baseline for assessing potential noise impacts in the project area. The table displays overall (24 hour), daytime (0700-2300) and nighttime (2300-0700) equivalent continuous sound levels (LAeq) and the median of those levels. In addition, daily minimum (fast response) A-weighted sound levels (LAFminimum) are provided. Average wind data from a nearby station was used for the analysis, but second-by-second data was unavailable. Because of this, periods of high wind exceeding a set threshold may not have been excluded from the data (ANSI S12.18 Section 6.7, ANSI S12.18 Section 4.4.1.1).

Table G-2 shows that the median daytime A-weighted equivalent continuous sound level between the hours of 0700-2300, March 3-7, 2011, was 34 decibels (dBA) at the edge of Royal Lake. As might be expected, the LAeq is strongly influenced by infrequent high level events; in this case, more than 90% of ambient sound levels fell below 34 dBA. Assuming the March 3-7 measurements are representative of winter sound levels, use of a 34 dBA level is likely to underestimate impacts to the natural ambient. The typical median hourly 50- and 90-percent exceeded sound levels (L_{50} and L_{90}) measured between 0700-2300 are considerably lower and could arguably serve as better proxies for the natural ambient. A draft ANSI standard for the residual sound in quiet areas is currently in revision following an initial ballot of the accredited standards committees. While it should be noted that it may not be the same as the natural ambient, the residual sound can be loosely defined per existing standard ANSI S12.9 Part 1 as the all-encompassing sound when all uniquely identifiable discrete sound sources are eliminated. Similar to ANSI S12.9 Part 1, the new draft standard specifies that the residual sound level for any given time period shall be determined from measured hourly 90th percentile sound levels or other percentile sound levels required by the authority with jurisdiction.

NSNSD has reprocessed the March 3-7, 2011 sound level meter data to obtain the hourly 10-, 50-, and 90-percent exceeded levels (L_{10}, L_{50} and L_{90}) for the chosen impact period of 0700-2300. The median hourly L_{10}, L_{50} and L_{90} values are displayed in the table below. The noise floor of the sound level meter was reported at its previous calibration to be approximately 17.2 dBA. Because the lowest sound levels, as represented by L_{90} values, fell below this level on two of the five days, it is reasonable to conclude that a small percentage of the sound levels were lower than the chosen sound level meter, microphone, and preamp combination was able to measure. Therefore, some of the measured L_{90} values at the Royal Lake site may be higher than the actual residual sound level, as defined by ANSI S12.9 Part 1.

2011 Royal Lake/South Fowl Lake Sound Monitoring						March 2011
Day 0700-2300	3-Mar	4-Mar	5-Mar	6-Mar	7-Mar	Overall (dBA)
L10	38.1	37.7	25.6	26.9	21.6	33.2
L50	33.2	29.1	18.3	17.8	19.4	23.4
L90	24.2	23.6	17.1	16.9	18.3	18.2

Notwithstanding, other ambient measurement data exists to confirm the reasonableness of the March 3-7, 2011 data. Volume 3-Chapter 5 of the Minnesota Environmental Quality Board Regional Copper-Nickel Study found that winter L_{50} values in a region near the Royal Lake ranged from 24 to 32 dBA, while winter L_{90} values were 15 to 19 dBA. Based on this study, the USFS-measured median hourly L_{50} and L_{90} values of 23 and 18 dBA at the Royal Lake site seem reasonable and may be assumed to be representative, even if the actual L_{90} may be slightly lower. If USFS believes that its March 3-7, 2011 measurements were not representative and a higher ambient level such as 34 dBA is appropriate, then the USFS South Fowl EIS should explain to the public why the higher ambient level was chosen.

Comment [A7]: The SIR and Appendix A discuss these figures.

In its Acoustical Sampling & Analysis Guide, NSNSD recommends a minimum 25 day sampling period and use of the percent time audible of extrinsic noise to form an estimate of the natural ambient sound level (L_{Nat}). If A is the percent time audible, then the L_{Nat} estimate will be $L_{50+A/2}$. For example, if extrinsic sounds are audible 28% of the time, then the natural ambient would correspond to the L_{64} ($L_{50 + (28/2)}$) value. Therefore, if USFS is not able to estimate the percent time audible of extrinsic noise, then in light of the ANSI standard, the closest reasonable proxy for USFS to use would be L_{90}.If however, USFS is able to estimate the percent time audible and it is found to be minor or negligible at the Royal Lake site, then it would be reasonable for USFS to use the median hourly L_{50} value of 23 dBA. The NSNSD Acoustical Sampling & Analysis Guide is available at http://science.nature.nps.gov/im/monitor/protocols/Acoustical%20Sampling%20&%20Analysis%20Guide%202008-12-02%20v1.0%20FINAL.doc

Comment [A8]: The NMSim model runs used the L50 value of 23 dBA. Rationale for use of this value is in Appendix A. The NPS reviewed the value selected and rationale as discussed on page 14.

Methods used as an alternative analysis of snowmobile noise

The SPreAD-GIS model is proposed in Appendix G to validate or modify the analysis in section 3.2 of the SFL EIS. The iterative approach for SPreAD-GIS use described on page G-3 is reasonable assuming the input parameters are correct and any assumptions used are adequately disclosed. . Specifically, given that SPreAD-GIS model runs are reported to be time consuming, an iterative approach to determine which 1/3 octave produces the greatest area of audibility is logical. However, in determining which input values "carried snowmobile sound the farthest," it is important that the SPreAD-GIS excess noise output is used and not the baseline noise propagation result. It is also important that the chosen 1/3 octave source levels and 1/3 octave ambient level inputs are correct for each iteration.

Based on a review of Table G-3, on page G-5, it appears that the 1/3 octave ambient values are not low enough in comparison to the measured median hourly L_{50} of 23 dBA. However, the snowmobile 1/3 octave band level of 64 dB at 500 Hz appears reasonable when compared to Table 17, page 63 of the 2006 Yellowstone over-snow vehicle modeling report. The net result is that an incorrect ambient level choice can be expected to inject errors into the iterative approach. Choice of an ambient level that is too high may result in underestimated impacts in the project area.

The EIS does not explain why the geographic information system (GIS)-based noise model in Appendix G was used as a the secondary model and the spreadsheet approach chosen as the primary but ? USFS has reported that SPreAD-GIS model runs are lengthy and may be difficult to complete successfully. USFS offers caution on page G-1 that the model output is not the final answer in evaluating noise impacts since there are limitations in the model. A careful inspection of the methods of the GIS-based model and comparison to available standards provide additional important clues on the potential limitations of this model.

The following are observations of the SPreAD-GIS analysis in Appendix G and a discussion of whether its use by USFS is recommended for validation or modification of the analysis in section 3.2 of the SFL EIS. An examination of the historical origins of SPreAD-GIS is an important step for understanding how SPreAD-GIS makes geographic noise predictions, because very little information exists to validate its use and its ability to accurately calculate geographic noise contours. For example, no SPreAD-GIS validation studies are known, very few references to its use appear in the peer-reviewed literature, and only one standard relevant for noise modeling is cited in the SPreAD-GIS v2.0 user guide.

According to the user guide and Dr. Sarah Reed, SPreAD-GIS v2.0 is based on simplified workbook tables from a 1980 publication by the USFS San Dimas Technology & Development Center (SDTDC) [http://leopold.wilderness.net/pubs/67.pdf] and not based on the more extensive Acoustic Detection Range Prediction Model (ADRPM) software formulas from which the workbook was adapted. The 1980 workbook formulas were intended for calculation of acoustic detectability between 400 and 2,000 Hz at single locations and not for calculation of A-weighted sound levels. SPreAD-GIS v2.0 does not include the inherent capability to calculate A-weighted sound levels.

Extension of SPreAD-GIS v2.0 capabilities down to 125 Hz was related by Dr. Sarah Reed to be based on extrapolation of the workbook table values between 400 and 2,000 Hz in the 1980 publication and other references such as ANSI S1.26. It is reasonable to conclude that because the 1980 workbook tables were a simplified adaptation of ADRPM software formulas to a tabular workbook approach and because USFS SDTDC briefly made available (circa 1998) a Sun LINUX workstation version (analogous to ADRPM) functional from 40 to 10,000 Hz [http://www.fs.fed.us/t-d/pubs/html/98231308/98231308.html], the extrapolation of the simplified 1980 workbook tables to an geospatial software implementation wasn't originally intended.

It could also be concluded that if the USFS SDTCD Sun LINUX software algorithms were based on ADRPM software, their adaptation to a geospatial implementation with a broader frequency range (than the 1980 workbook) could be more ideal; however, Dr. Reed indicated that at the time of SPreAD-GIS development, the Sun LINUX software code from USFS SDTDC was not available. It is unclear whether the authors of SPreAD-GIS referenced a sufficient number of acoustical propagation standards (such as ISO 9613) or worked with qualified technical experts to ensure a sufficiently accurate acoustical propagation analysis comparable to ADRPM and other noise prediction programs. It is also important to consider the effect of partial (individual) frequency band level calculations in comparison to a more complete (additive) frequency analysis for calculation of A-weighted sound levels. According to a German paper by Datakustik's Head of R&D, the standard deviation of the energetic sum of n equal levels with equal standard deviation decreases by $1/\sqrt{n}$ as the total number of levels is increased [Probst, 2002]. This equation also applies, in theory, to the energetic sum of octave band levels in forming an A-weighted sound level. Dr. Probst also clarifies in the paper that in order to correctly represent the statistical uncertainty of the attenuation value D_i, it should not include systematic deviations caused by source and receiver height errors, ground absorption inaccuracies, or inaccurate knowledge of acoustically relevant geometry. While NPS has not been able to determine anything conclusively, it is possible that these systematic errors may be present in SPreAD-GIS.NPS recommends that the EIS disclose that:

1) if SPreAD-GIS is used only at a single frequency, this may result in greater sound pressure level uncertainty than if individual 1/3 octave bands are energetically summed to form an A-weighted sound level identified as a primary indicator in Chapter 3., and
2) Because portions of SPreAD-GIS calculation (other than atmospheric absorption) are based on tabulated workbook values and not algorithms published in modern standards, SPreAD-GIS may produce discontinuities or step-like errors.

Furthermore, NPS is uncertain of the handling of the following scenarios which would require further investigation in order to rule them out as sources of error:

1. SPreAD-GIS may not adequately consider that downwind attenuation due to ground effect is determined primarily by the ground surfaces near the source and near the receiver, as described in ISO 9613-2 section 7.3.
2. SPreAD-GIS may not consider source and receiver height as needed to accurately assess the extent of the source and receiver regions where ground effect occurs. The SPreAD-GIS plots in Appendix G show anomalous predicted levels that are suspicious. By contrast, examples plots are provided below, including Figure G-11a and an alternative geographic noise prediction by NMSim-Nord2000 for Alternative 2.

a. Table G-3 indicates that the SPreAD-GIS model was run at a single 1/3 octave band frequency (500 Hz) which will very likely result in greater sound pressure level uncertainty than if a sufficient number of 1/3 octave band results are energetically summed to produce an overall A-weighted sound level identified as a primary indicator in Chapter 3.

b. In Figures G-1 through G-12a, the model calculations appear to incorrectly assume exposed ground and water representative of a summer condition and not a typical Minnesota winter condition when snow covers all ground features, including frozen lake surfaces. This could occur if ground effect was calculated based on National Land Cover Dataset (NLCD) layers.

c. In Figures G-4a through G-12a (not b), the contours extending across the southern bay of North Fowl Lake extend farther north than would be considered reasonable, even during a summer condition. The presumed reason is an improper calculation of ground effect that greatly overestimates the extent (distance) of ground interaction and/or does not consider the independent ground effects at source and receiver.

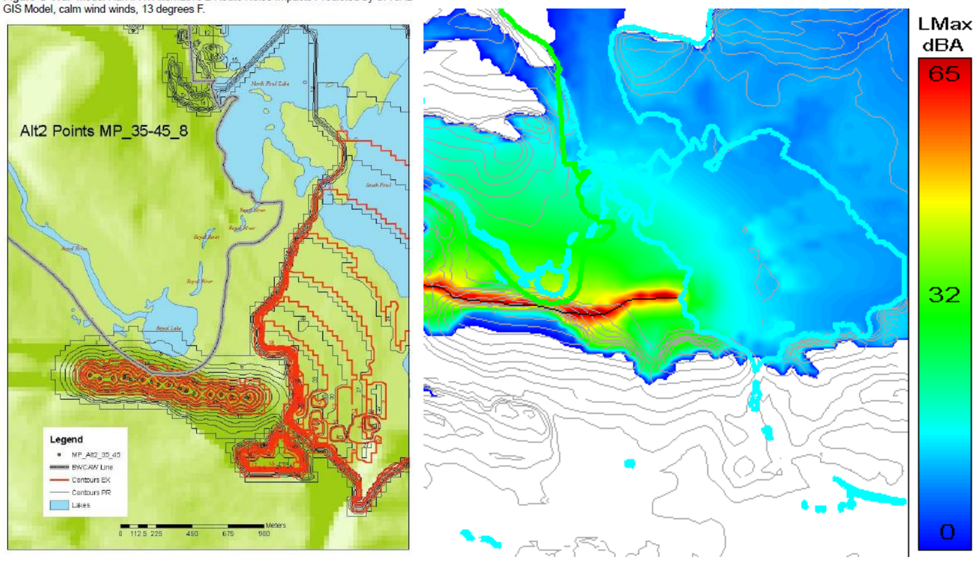
d. In Figures G-4a through G-12a (not b), the contours extend south with little or no attenuation into a sheltered ravine (forming a thumb) at the lower southeast corner of the plot. There is insufficient attenuation due to the diffractive loss expected as sound propagates around the nearby ridges, approximately 900 meters to the southeast of the easternmost noise source location. The presumed reason is an improper calculation of terrain screening that does not adequately consider acoustically relevant terrain geometry such as multiple barriers, lateral attenuation around ridges, and/or complex ground profiles such as depressions and ravines although NPS has not had time to rule out other possible explanations

e. In Figures G-4a through G-12a (not b), there is a predicted rapid increase in sound levels with increasing distance from the source, resulting in an approximate 60 meter wide band of contours that extends from 450 meters north of the easternmost source an additional 2000 meters north and even across water, where there are no significant sources of attenuation other than conventional spherical spreading and atmospheric losses. Again, the rapid increase in sound levels over 60 meters is extremely suspect, however, NPS has not had the opportunity to explore and rule out other plausible explanations. In Figures G-7a through G-9a (not b), the displayed contours north of Royal Lake are strangely square in shape. NPS has not had the opportunity to identify the cause with any certainty, but this could be due to a number of different reasons including a low resolution GIS layer or an improper calculation of ground effects near the Royal River.

f. In Figures G-1 through G-12a, SPreAD-GIS results show strange jumps and steps which are difficult to physically justify and thereby may reveal potential errors or it could just be a limitation in the resolution. NPS has not had the opportunity to confirm the cause. The SPreAD-GIS and NMSim-Nord2000 example plots below show different sound levels and use a different graphical approach for display of noise levels, but they can be compared in terms of expected attenuation over distance. Both are set up to show noise levels only down to 0 dB. The plots highlight some of the aforementioned anomalies of the SPreAD-GIS results at 500 Hz. In Figure G-11a (shown on left), black noise contours surrounding expected Alt 2 snowmobile noise source locations drop off too rapidly from the reported 66 dB (at 50 feet) to 0 dB over Royal Lake, approximately 275 meters north of the noise source. NMSim-Nord2000 (shown on right) predicts a level of approximately 39 dBA over Royal Lake, at roughly equivalent distances.

Approximately 1800 meters to the north (and 1200 meters north of Royal Lake), SPreAD-GIS predicts a rapid increase in sound levels to 15 dB. NMSim-Nord2000 does not show any increase and instead predicts a level of 17 dBA, 22 decibels below the Royal Lake value of 37 dBA. A 15 dB increase where an approximate 20 dB of attenuation is expected indicates that SPreAD-GIS values could be off by substantial amounts. The reasons for the rise in sound levels with increasing distance are unknown. To the east of the easternmost noise source location, SPreAD-GIS predicts a drop to approximately 12 dB in 250 meters and then a rise to 36 dB 350 meters to the east the source. This rapid rise in sound levels continues in an apparent 60 meter wide band 2000 meters to the north, described in point (e) above. Such a rapid change in sound levels is highly questionable but NPS has not had the opportunity to further explore or rule out any explanations. In general, NMSim-Nord2000 does not show an increase of sound levels to the east and northeast of the proposed Alternative 2 trail. The results produced by NMSim-Nord2000 do not exhibit the same physical anomalies produced by SPreAD-GIS.

Figure G-11a: Model Run #11. Alternative 2 Route Noise Impacts Predicted by SPreAD GIS Model, calm wind winds, 13 degrees F.



Discussion with USFS staff suggested that single frequency SPreAD-GIS calculations were time consuming and a broader frequency analysis could increase time requirements considerably. Consequently, NPS recommends that the South Fowl EIS disclose the above mentioned potential limitations. In the future, should USFS choose to continue to model noise impacts in this area in order to monitor or manage adaptively, NPS recommends that USFS use NMSim with the Nord2000 option. That said, while some aspects of the SPreAD GIS results are definitely unusual and even defy explanation in some instances, NPS cannot conclude that the model results are invalid without further consideration into other plausible explanations. Again, NPS recommends that the EIS be very clear about the potential limitations of the SPreAD results. It is widely accepted that noise modeling, like measurements, can benefit from the specification of performance, design, or operations provided by voluntary consensus standards. OMB Circular A-119 "directs agencies to use voluntary consensus standards in lieu of government-unique standards except where inconsistent with law or otherwise impractical." Considering that NMSim was developed for NPS, and has been used in a number of other EIS impact analyses and management plans, it may be a more appropriate choice for another land management agency such as USFS.

Proposed methods to improve impact analysis of snowmobile noise

In order to reduce apparent errors and strengthen the analysis, NSNSD recommends USFS consider augmenting the existing analysis with updated ambient noise levels and a noise model that better complies with existing standards. Using the NPS NMSim program with the Nord2000 calculation option, NSNSD has provided USFS with 10 second noise levels and audibility values across the project area for Alternatives 1-4. The NMSim Visualizer enables export in ESRI ASCII format for Arc GIS processing.

Model	Sources	Tracks/	Weather	Comments

		Trails		
Nord2000	(1) 2-stroke SM	Alts 1-4	No wind, default turbulence values	10 sec runs with 139x100 resolution
Nord2000	(1) 2-stroke SM	Alts 1-4	6 mph S wind, 1m roughness length	10 sec runs with 139x100 resolution
Nord2000	(1) 2-stroke SM and (1) 4-stroke SM	Alts 1-4	No wind, default turbulence values, and trees	10 sec runs with 139x100 resolution
Nord2000	(1) 2-stroke SM and (1) 4-stroke SM	Alts 1-4	6 mph S wind, 1m roughness length	10 sec runs with 139x100 resolution

All NMSim-Nord2000 models were run with the following atmospheric conditions: 67% relative humidity, -10.6 °C (13 °F), a thermal gradient of -6.5 °C/1000 meters, a roughness length of 1.0 meter, and Nord2000 default thermal and kinetic turbulence values. In addition, ground effect was calculated with a flow resistivity assuming the entire project area was covered with loose granular snow. Snowmobile source levels were taken from Table 17, page 63 of the 2006 Yellowstone over-snow vehicle modeling report and a 2012 measurement of 4-stroke snowmobile 15 mph pass-by noise in Yellowstone National Park. Measurements were made according to SAE J1161. All but the 15 mph data for the 4-stroke snowmobile were taken from the 2006 report.

For NMSim audibility calculations, NSNSD chose the following ambient spectrum from the March 2011 Royal Lake measurement. The spectrum was considered to be a reasonable representation of the median hourly L_{50} at that site and therefore likely to constitute a reasonable estimate of the natural ambient sound level where the percent time audible of extrinsic noise is small.

Frequency (Hz)	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**
1/3 Octave Spectra	17.9	18.0	20.5	22.7	22.8	20.3	20.0	17.7	19.5	18.6	15.8	14.6

Frequency (Hz)	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**	**6300**	**8000**	**0**	**dBA**
1/3 Octave Spectra	13.9	10.8	9.7	8.6	8.3	8.2	7.9	7.8	8.0	7.9	7.9	7.6	23.4

Comments by Richard Horonjeff

New Information in 03 November 2011 Letter to Kristen Marttila

Mr. Horonjeff reaffirms a 26 October 2011 letter recommendation that a qualified expert be retained by USFS for guiding the performance and interpretation of sound level measurements and modeling procedures in low-ambient environments. NSNSD has substantial experience measuring low sound levels and modeling noise sources over complex terrain. NSNSD believes that the NMSim-Nord2000 modeled noise levels and audibility values for the project area and the reprocessed ambient sound level data above should provide USFS with the tools it needs to accurately analyze and judge the acoustic impact assessments in the SLF EIS.

NSNSD agrees with Mr. Horonjeff's comment that the true ambient sound levels may have been lower than the noise floor of the Extech HD600 device utilized for data presented in Appendix C. This possibility is confirmed by the March 2011 data shown in Table G-2. Mr. Horonjeff is not precisely correct, however, that the top three rows of cells in Table G-2 contain median L_{50} sound level values. Rather, they contain equivalent-continuous sound levels (LAeq) for each day and the median of the LAeq values. Consequently, the values in Mr. Horonjeff's Table 1, page 5, are believed to reflect approximate noise floor corrected LAeq values. NSNSD acknowledges work with Mr. Horonjeff on a potentially useful noise floor subtraction method for overcoming instrument limitations in quiet environments [Horonjeff, R. 2002], but NSNSD does not currently use such a method in its acoustical sampling protocol.

As stated in its sampling protocol, NSNSD has converged on a minimum 25 day ambient sampling period in order to adequately capture natural ambient variation and to reduce measurement uncertainty. While NSNSD agrees with Mr. Horonjeff that a measurement period longer than 5 days would increase confidence, NSNSD believes that the existence of corroborating data from the nearby Copper-Nickel study decreases the likelihood that the March 2011 data represents an atypical or unusual sample. NSNSD believes that if USFS chooses to disclose the hourly 10-, 50-, and 90-percent exceeded levels (L_{10}, L_{50} and L_{90}) for the chosen impact period of 0700-2300, this will provide additional valuable information on the range of observed sound levels at the Royal Lake measurement site. NSNSD also agrees with Mr. Horonjeff that choice of a 34 dBA ambient value may not be truly protective of the natural environment in winter, particularly if it is typical that the actual natural ambient sound level falls below 34 dBA more than 90% of the time, as NSNSD found for the March 3-7, 2011 Royal Lake measurement.

Comment [A9]: These are discussed in Appendix A.

NSNSD believes that it has given USFS the information and tools it requires to validate and ensure that the impact assessments in the SFS EIS are adequate. NSNSD believes that use of NMSim-Nord2000 modeled noise levels and audibility values for the project area and the reprocessed ambient sound level data should greatly reduce potential criticism due to non-standard analysis methods or practices.

References

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USFS San Dimas Equipment Development Center Publication 67 “Predicting Impact of Noise on Recreationalists”, USFS and EPA, April 1980 [http://leopold.wilderness.net/pubs/67.pdf]

The Superior National Forest also asked the NPS to review a draft of Appendix A Sound Impact Summary and the Supplemental Information Report in order to have an acoustic expert review the information for accuracy from a technical acoustics standpoint. The following comments were received from Kurt Fistrup (NSNSD staff) on 2/27/13 and were considered as discussed below:

I have reviewed Appendix A as you requested, and offer the following comments:

Appendix A, general comment
The most substantial difference between the FEIS and NSNS noise modeling was due to the NSNS finding that ambient sound levels were more than 10 dB lower than assumed in the FEIS. Less substantial differences may be due to differences between the implementations of sound propagation algorithms in SPreAD-GIS and NMSim. The FEIS analysis also utilized field listening tests to measure the distances at which snowmobile noise was audible. These results were unaffected by modeling assumptions.

Appendix A, page 1, 2nd bullet
It is premature to conclude the SPreAD-GIS propagation model may be invalid. Four possible causes for the seemingly anomalous mapping results are:
1. The figure is somewhat cluttered, and the NSNS reviewer may not have interpreted it correctly.
2. The SPreAD-GIS model output was not translated accurately in the map output.
3. There were anomalies in the SPreAD-GIS inputs that caused the anomalous outputs.
4. The implementation of sound propagation algorithms in SPreAD-GIS is flawed.
It seems unlikely that a flaw in implementing the propagation algorithm sufficient to explain the apparent anomalies in the noise mapping results could have gone undetected by the developer.

page 2, first two paragraphs
It is fair to claim that differences between the L50 and the L54, L55, L58, or L59 will be small, quite possibly less than the +/- 1 dB tolerance for ANSI Type 1 sound level meters. I assume that the L50 was used because it is not trivial to reprocess the data to obtain the other exceedance measures.

Figure 3-6 discussion
Given the conspicuous difference in the noise radii for Alt2 versus Alt3 and Alt4, and the role this plays in the conclusion that there is no difference among alternatives in noise exposure in the BWCAW, I recommend reiterating that the analysis assumed lower speeds in Alt2 than in the other alternatives (specify the speeds for each alternative).

Figures A-1 to A-4
Figure A-1 represents noise from all anticipated snowmobile traffic, while Figures A-2 through A-4 portrays the noise from the Alternative transportation routes only (no lake traffic). Direct comparisons between the no action and proposed alternatives (see the last sentence on page 14 of Appendix A) would be facilitated if all four figures portrayed either noise from the transportation routes or noise from all traffic.

page 17, bullets
As written, these bullets seem contradictory. One resolution to this apparent contradiction would be state that the audibility analysis in the FEIS was based on field listening trials to measure the radius of

Comment [A10]: The SIR discusses this point and the NMSim model runs presented in the SIR and Appendix A uses the ambient sound levels identified by the NPS.

Comment [A11]: We understand from this comment that the maps from SPreAD-GIS show anomalous results but the NPS is not saying that the anomalies invalidate the SPreAD-GIS model; rather the NPS has not determined the cause of the anomalies. This was also discussed in the NPS report of August 2012. Rather than further investigate the anomalies, the SNF chose to have the NPS run the NMSim model to improve the technical accuracy of the modeling.

Comment [A12]: Comment noted. The NMSim model runs and discussion in the SIR and Appendix A utilize the L50 ambient sound level as the natural ambient sound level. This is adequate based on the discussion on page 6, this comment and the discussion on pages 1-2 of Appendix A .

Comment [A13]: Page 3-15 of the FEIS explains that the audible distance varies between Alternative 2 and Alternatives 3 and 4 due to different operating speeds. We have added a footnote to Appendix A noting this.

We also note that while snowmobile noise is audible inside the BWCAW under all alternatives as shown in Figure 3-6, there is a difference between alternatives in noise impacts to the BWCAW. Alternative 2 adds an incremental impact through increasing snowmobile sound levels in a portion of the wilderness near the route as shown in Figure 3-10.

Comment [A14]: We recognize this could be a useful way to present the information in Appendix A. However, this would also clutter Figures A-2 through A-4 and the incremental impact of the routes created by the project might be less clear.

We included some additional Figures in the SIR to better highlight the differences between No Action and Alternative 2. This comparison is presented in the SIR since Alternative 2 is the only alternative that increases impacts to the BWCAW above No Action.

audibility, rather than SPreAD-GIS modeling. Therefore, differences between the FEIS and NSNS noise modeling do not pertain directly to the FEIS audibility analysis.
If the NSNS modeling predicts that snowmobile noise would be above ambient levels for 8000 feet of trail compared with 2000 feet of trail in the FEIS anslysis, then it is safe to assume that the NSNS modeling would have predicted a duration of audibility that was approximately four times as long as the duration predicted by the FEIS modeling, if those models had been employed to predict audibility.

The SIR Review repeats the widely cited rule of thumb that a 10 dB increase in noise level repesents a doubling of perceived loudness. This statement is not correct for transportation noise, especially at the low levels discussed in the FEIS. It is reasonable to retain this statement, given its ubiquity. I recommend balancing it by noting that community annoyance doubles with every 5.5 dB increase in noise (ANSI S12.9/part 4). For sounds that are masked by noise, every 3 dB increase in noise causes a 50% reduction in the area from which those sounds can be heard (Barber et al 2010, Trends in Ecology and Evolution).

Comment [A15]: We have clarified and updated the duration discussion in Appendix A and the SIR to address these points and better use the NMSim model outputs. The NMSim model outputs were used to estimate duration of audible and above ambient snowmobile sound at the point of greatest impact inside the BWCAW (rather than estimate the number of feet of trail from which a snowmobile may be audible or above ambient).

Comment [A16]: The Abstract to ANSI 12.9/part 4 states that the annoyance analysis methods described therein cannot be applied to "address the effects of intrusive sound on people in areas of short-term use such as parks and wilderness areas". However we understand that the 10 dB increase 'rule of thumb' could be qualified with the 5.5 dB increase resulting in a doubling in annoyance as a more accurate statement for transportation noise.

The listening area metric was not added since other indicators were chosen by the Forest Service for the analysis (see comment on page 2).