

CHAPTER 4 ENVIRONMENTAL CONSEQUENCES

GENERAL METHODOLOGY FOR ESTABLISHING IMPACT THRESHOLDS AND MEASURING EFFECTS BY RESOURCE

General Analysis Method

Impact analyses and conclusions are based on data from existing literature, information, and insights provided by NPS, FAA, other agency experts, and NPS's professional judgment. A very large amount of data was produced and examined for this analysis, using a wide variety of metrics related to sound, noise, and other subjects. All available data and other relevant factors (context, duration, timing) were carefully considered in making impact determinations in this EIS.

Items Specific to Meeting NPS Criteria for NEPA Analysis

When developing impact criteria and thresholds for NEPA documents, the NPS follows NPS Director's Order 12, Conservation Planning, Environmental Impact Analysis and Decision Making, to develop park (and/or project) specific impact criteria and thresholds, taking into consideration the type of proposed action and context, intensity, duration, and timing of potential impacts. Because impact analyses must consider all of these factors, a given action may have a variety of impacts (for example, major adverse localized impacts in some areas, and moderate beneficial impacts in others). Thresholds and other criteria for each impact topic evaluated in this EIS were developed to determine relative differences in impacts among Alternatives solely for this project. They represent a means to evaluate impacts of this project as required by NEPA, and as such, they are not necessarily applicable to all GCNP projects or to similar projects in other parks. Figure 4.1 outlines the NPS impact analysis process.

Effects of Alternatives were analyzed by evaluating existing impacts of Alternative A (No Action/Current Conditions), then comparing anticipated impacts of Action Alternatives (E, F, and NPS Preferred) to Alternative A's existing impacts. Impacts are presented and compared to Alternative A for Base Year and Ten-Year Forecast Peak and Off-Peak Seasons (see below for definitions).

METHODOLOGY

For each impact topic described in Chapter 3, the following impact assessment methodology was followed for each Alternative

1. Define Issues of Concern

Issues were developed based on public and internal scoping and tribal consultation described in Chapters 1 and 5.

2. Identify Area of Potential Effect

Unless otherwise specified for an individual impact topic, Area of Potential Effect for this EIS is generally the Special Flight Rules Area for direct effects, and the entire study area³³ for cumulative effects. However, for substantial restoration of natural quiet, the Area of Potential Effect is Grand Canyon National Park, not the entire SFRA or study area, and only up to 17,999 feet MSL (73 Federal Register 55130).

Direct effects of Alternatives primarily include impacts of air-tour and air-tour-related aircraft, which vary by Alternative below 18,000 feet MSL in the SFRA. Effects of other aircraft below 18,000 feet within the SFRA do not vary by Alternative and are included in the analysis. Effects of other noise sources, including all ground-based noise sources and aircraft above and outside the SFRA are included only in Cumulative Effects analysis (see below).

3. Identify Mitigation Measures

Action Alternative mitigation measures to manage aircraft impacts are described in Chapter 2. Impact analysis considers mitigation measures reasonably implemented before assessing impacts

³³ As described in Chapter 1's Scope of Analysis and shown on Map 1.2, the rectangular study area encompasses the park, the Special Flight Rules Area, and lands beyond

4. Identify Environmental Consequences

Environmental Consequences (Impacts or Effects) are described using the following bulleted items.

- **Timeframe**

Evaluation considered a change in air-tour noise impacts over time resulting from actions proposed in the Alternatives such as changes in air-tour routes, air-tour operations, and/or implementation of quiet-technology incentives or requirements. For each Alternative, analysis includes impact assessment during Base Year and Ten-Year Forecast. In addition, in the Action Alternatives, analysis considers seasonal changes in air-tour routes or route use. Therefore, impacts were considered during an Alternative's Peak and Off-Peak Season. Peak and Off-Peak Season vary by Alternative, as shown below, with the exception of Alternative A, No Action/Current Conditions, which does not have Peak and Off-Peak Seasons

Under Alternative A, all routes are open and can be used year-round. Historically fewer operations occur in winter, but some winter high-use days approach Peak Day.³⁴ Because there are no seasonal differences in management of air-tours under Alternative A, only Peak Day was included in Alternative A's impact analysis (Peak Day could theoretically occur any time of year because, in Alternative A, no management constraints limit or prevent use)

- **Base Year** 2005 is the Base Year used for noise modeling in this EIS. The best available data as of the end of 2005 is used as the base for noise modeling for the Alternatives. Since 2005, the 2005 database has been checked against data from subsequent years, and although there are some differences, given all factors contributing to those differences, the 2005 database has proven consistent enough to continue as a reasonable base for evaluating impacts of Alternatives in this EIS

- **Ten-Year Forecast** Ten-Year Forecast is the best estimate of what will occur ten years after implementing each Alternative, starting from the Base Year scenario. For the Ten-Year Forecast, growth in aircraft operations was assumed as explained in Appendix D. Also, full implementation of each Alternative's action elements is assumed to be achieved in the Ten-Year Forecast (for example, full conversion to quiet-technology aircraft if that is an Alternative element)

- **Peak Season** Because Action Alternatives (E, F, and NPS Preferred) propose different seasonal changes to routes, Alternatives are analyzed for different Peak Seasons. Alternative A (No Action/Current Conditions) does not contain, and is not analyzed for, Peak and Off-Peak Seasons

Alternative	Peak Season
E	July 1- September 15
F	February 1-November 30
NPS Preferred	May 1-October 31

- **Off-Peak Season** Because Action Alternatives (E, F, and NPS Preferred) propose different seasonal changes to routes, Alternatives are analyzed for different Off-Peak Seasons. Alternative A (No Action/Current Conditions) does not contain, and is not analyzed for, Peak and Off-Peak Seasons

Alternative	Off-Peak Season
E	September 16-June 30
F	December 1-January 31
NPS Preferred	November 1-April 30

³⁴ Peak Day Noise analysis for this EIS is based on a 12-hour time period of 7 a.m. to 7 p.m. on the Peak Day, the day with the highest total number of air-tour and air-tour-related operations. Based on a review of the best available data at the time EIS noise modeling analysis began, Peak Day occurred August 8, 2005, with a total 635 operations. This day forms the basis for Base Year analyses for the Alternatives. Data for subsequent years was checked to ensure use of 2005 Peak Day as the basis for Base Year analysis was still reasonable

Effects were characterized based on

- **Direct Effect** Caused by an action and occurs in the same time and place as the action
- **Indirect Effect** Caused by an action but occurs later in time or farther away but still reasonably foreseeable
- **Beneficial Effect** Generally a positive change in resource condition, a positive change in visitor experience, or a change that moves a resource or visitor experience toward a desired condition (consistent with the purpose and/or management objectives of the affected park land or other area)
- **Adverse Effect** Generally a change that moves the resource or visitor experience away from a desired condition or that detracts from visitor experience or resource condition. More specific descriptions of adverse and beneficial impacts may be provided for individual Impact Topics
- **Impact Intensity** Uses four intensity thresholds, **negligible**, **minor**, **moderate**, and **major** as defined for each impact topic and explained below in Impact Intensity Threshold and shown in Table 4.1
- **Duration** Considers length of time a resource would be affected by an event or related series of events. Duration (**short or long term**) varies by impact topic and is addressed in each
- **Timing** Considers sensitive time periods or seasons, sensitive time(s) of day, how often impact would occur, and whether impact is recurring
- **Area** **Marble Canyon, East End, Central, and West End** as shown on Map 3.2
- **Context** Generally refers to an impact's geographical extent, whether **regional** or **localized**, but also whether it would occur in a location sensitive to such impacts. Generally, regional impacts in this EIS are associated with a large part of the park or SFRA. Localized impacts are generally associated with specific sites or flight routes. If definitions vary from these, they are discussed under that impact topic
 - **Management Zone** Park Management Zones are an important part of Context (see above) for some Impact Topics. Park Management Zones considered in this EIS are **Wilderness**, **Non-Wilderness**, and **Developed** (as described in Chapter 3). In general, impact analyses consider that, in the Developed Zone (about 2% of the park), more noise sources are present and more noise impact (from all sources, including aircraft) are accepted than in Wilderness and Non-Wilderness Zones, based on each Management Zone's objectives
- **Cumulative Effect** As described in CEQ's regulation 1508.7 as follows
 - Cumulative impacts are impacts that result from incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions
 - Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time

Each cumulative impact analysis is additive, considering the overall impact of each Alternative when combined with effects of other past, present, and reasonably foreseeable future actions—in and outside the Area of Potential Effect. Thus, it was

necessary to identify other ongoing or reasonably foreseeable future projects at GCNP and, if applicable, the surrounding region. Because the scope of this project is relatively large, the geographic and temporal scope of the cumulative analysis is similarly large. The geographic scope for this analysis includes actions in and adjacent to park boundaries, while the temporal scope includes projects in a range of generally ten years (except Ethnographic Resources which considers a longer period). Given this, projects were identified for conducting cumulative effects analysis, and are listed in Appendix G

Cumulative effects analysis includes noise from aircraft flying 18,000 feet and above, aircraft flying below 18,000 feet but outside the SFRA, non-aircraft noise sources, and impacts of Alternatives

The park area affected by non-aircraft noise sources is localized to areas of human use, primarily Developed Zone areas (2% of the park), and a small component from vehicles on remote roads, motorboats on the Colorado River, and area mining activities. Aircraft flights above and outside the SFRA are the primary cumulative noise source impacting most of the SFRA

SOUND METRICS AND NOISE MODELING FOR ALL ALTERNATIVES

Noise was characterized based on the following metrics.

The FAA's Integrated Noise Model (INM) was used to predict effects of Alternatives regarding Soundscape and noise impacts. For additional information on metrics and modeling see Appendix D.

- **Percent Time Audible (%TA)** **Also known as Audibility.** Percent of time during the 12-hour day used in this analysis (7 a.m. to 7 p.m.) that aircraft sounds can be heard by humans and other animals with normal hearing. Percent Time Audible refers to potential for a human or animal to detect presence of sound, and provides information primarily related to duration of aircraft noise impacts

The extent to which aircraft sounds are actually heard on the ground depends on amplitude (sound pressure level) and sound structure (its frequency content and temporal pattern); hearing ability and attention of the animal or human; and other simultaneous sounds (ambient conditions). Since aircraft sound can be heard at or below ambient conditions, the Percent Time Audible metric is even sensitive to distant noise. However, because Percent Time Audible says nothing about how loud the aircraft is, Percent Time Audible is used in conjunction with Average Sound Level (L_{Aeq12}) and Percent Time Above (%TALA) metrics (both described below) to provide additional insight into the nature of the noise and its potential impacts.

Percent Time Audible was also used to assess restoration of natural quiet to GCNP's Soundscape. Substantial Restoration of Natural Quiet is defined by the NPS to mean 50% or more of the park will achieve natural quiet (no aircraft audible) 75 to 100% of the day, each and every day. All Alternatives must meet Public Law 100-91 provisions to substantially restore natural quiet in the park. However, Substantial Restoration of Natural Quiet is a determination rather than a metric value that lends itself to an impact intensity level definition, and is applicable only to GCNP, not other lands in the SFRA or study area. The amount of Substantial Restoration of Natural Quiet achieved by an Alternative is not reported in terms of negligible, minor, moderate, or major impact intensity level. In addition Percent Time Audible was only calculated within the GCNP boundary

- **Average Sound** **Also known as Equivalent Sound Level.** The logarithmic average, on an energy basis, of aircraft sound pressure levels in decibels (dBA) over the 12-hour day used in this

Level (L_{Aeq12})

analysis. Average Sound Level takes into account number of aircraft operations, their time-varying sound levels, and their duration. It provides information primarily related to energy intensity of aircraft noise impacts (in lay terms, loudness). However, occasional loud sound levels may heavily influence (increase) Average Sound Level. Long periods without aircraft sounds may also influence (decrease) Average Sound Level values. The values must be used cautiously. The Average Sound Level metric does not take ambient sound levels into account and only provides a measure of sound levels emitted by aircraft operations by themselves. Average Sound Level is used in conjunction with Percent Time Audible and Percent Time Above to gain fuller insight into the nature of the noise and its potential impacts

- **Distance**
in Meters

Distance (**also known as Slant Distance**) relates primarily to **proximity** of aircraft to a location or point of interest on the ground, such as a visitor attraction site or wildlife habitat, not to the relationship of distance and sound levels. Distance impacts include visual aspects such as how big or how close an aircraft appears to visitors or wildlife on the ground, with related issues of disturbance, seclusion, solitude, and privacy

Distance measures also provide important information about opportunities for air-tour visitors to view specific ground features. (Ground points of interest, known as Location Points, are shown on Map 3.2). **Distances shown in analysis are for Peak Season only.** For routes that change during Off-Peak Season, Distances for routes not in use during Off-Peak Season would be greater than 2,000 meters

- **Percent Time Above**

35, 45, and 55 dBA (%TALA35, %TALA45, and %TALA55, respectively)
Percentage of time during the 12-hour day used in this analysis that aircraft sounds exceed 35, 45, and 55 dBA, respectively. The 10 dBA increments generally represent a ten-fold increase in number of aircraft (assuming roughly the same amount of noise for each aircraft), and a perceived doubling in loudness. Percent Time Above metrics are used in conjunction with Average Sound Level and Percent Time Audible to gain fuller insight into the nature of the noise and its potential impacts

Two types of noise-modeling analyses were performed for this EIS, 1) Contour Analysis (Percent Time Audible and Average Sound Level), and 2) representative Location Point Analysis (for all metrics).

- **Contour Analysis**

Produced maps presenting SFRA flight tracks and key features, with data values in colored contours for the entire park and and/or SFRA as shown in each map's legend; data tables summarize contour data by Management Zone (Developed, Non-Wilderness, and Wilderness). Contour Analysis was not performed for Marble Canyon, East End, Central, and West End and SFRA (see Appendix D for further information on INM modeling)

- **Location Point Analysis**

NPS identified 127 individual points (shown on Map 3.2 and Table 3.2) to represent noise-sensitive areas for park resources or visitor experiences, or as part of a ten-kilometer grid to ensure sufficient locations throughout the park were included in noise modeling. For further information on noise modeling see Appendix D

Both Contour and Location Point Analysis include Percent Time Audible and Average Sound Level. Percent Time Above is only computed for Location Point Analysis. Because ambient data outside GCNP is limited, and calculations of Percent Time Audible require ambient values as inputs, Percent Time Audible is only calculated for the area inside GCNP. Calculations of Average Sound Level require noise source data as inputs (mostly aircraft in this EIS), so Average Sound Level is calculated for the entire SFRA.

- 1 • **Dual-Zone System** Noise modeling for this EIS uses a Dual-Zone System (Audibility and Noticeability),³⁵
 2 for Percent Time Audible calculations, which generally addresses different objectives for
 3 different Management Zones. Specifically, for Noticeability Zone (approximately 66% of
 4 the park), natural ambient sound levels were used directly in computing Percent Time
 5 Audible in the noise model. For areas in the Noticeability Zone (approximately 34% of
 6 the park), 10 dB were added to natural ambient sound levels in the noise model to
 7 account for factors such as increased visitor activity and presence of non-natural sound
 8 sources. For reasons explained in the Federal Register Notice described in the footnote,
 9 when NPS and FAA agreed to use the Dual-Zone System for modeling at GCNP, most of
 10 the Developed Zone (including South and North Rim developed areas), GCNP's West
 11 End, and Marble Canyon are within the Noticeability Zone

12
 13 The Dual-Zone System was used in calculations to assess whether natural quiet has been
 14 substantially restored to GCNP. When interpreting modeling results, NPS takes into
 15 account that the overall definition of Substantial Restoration of Natural Quiet is based on
 16 audibility and natural ambient sound levels (natural Soundscape), not noticeability

17 18 **Development of Impact Intensity Thresholds**

19
 20 To identify possible consequences of noise exposure, NPS reviewed noise standards accepted by the American
 21 National Standards Institute (ANSI) and the Environmental Protection Agency (EPA), the entire body of relevant
 22 peer-reviewed scientific literature, park management objectives and mandates (GMP, NPS Management Policies,
 23 etc.), natural ambient and other sound data measured at Grand Canyon, and public scoping comments. NPS also
 24 consulted applicable agencies, scientists, subject-matter and resource experts, and affiliated tribes.

25
 26 Consistent with CEQ regulations (40 CFR 1502.22), and NPS Director's Order 12, Conservation Planning,
 27 Environmental Impact Analysis and Decision Making (Sections 4.4 and 4.5), and considering the review described
 28 above, the NPS determined that

- 29 • The current state of scientific knowledge is incomplete or unavailable for some effects of aircraft noise on
 30 Impact Topics evaluated in this EIS. For example numerous studies document responses of visitors and wildlife
 31 to loud noise events. However chronic exposure to less obvious (less loud) noise sources is less understood.
 32 Also evidence of behavioral responses to noise is insufficient to be decisively interpreted or dismissed
- 33 • Impact analysis methodology is essential in evaluating reasonably foreseeable significant adverse impacts on
 34 the human environment
- 35 • Simple comparisons of noise metric values do not provide enough information to understand differences in
 36 impacts among Alternatives sufficient to make reasoned decisions based on best available science

37
 38 After considering the above bulleted items, and incorporating theoretical approaches and research methods generally
 39 accepted in the scientific community, NPS used professional judgment regarding consequences requiring
 40 management action to develop impact intensity threshold descriptions and select specific values for the quantitative
 41 framework shown in Table 4.1. For all Impact Topics except Socioeconomics (to which noise modeling does not
 42 apply), NPS applied noise modeling and other data to threshold descriptions to make determinations on Alternative
 43 A (No Action/Current Conditions) impact levels, then used a similar approach to evaluate changes in impacts for
 44 Action Alternatives compared to Alternative A.

45
 46 The quantitative framework in Table 4.1 is only one part of the impact intensity determination process. While this
 47 framework is integrated into impact intensity threshold descriptions as applicable for individual Impact Topics, it is
 48 impossible to develop a single framework that works equally well in all situations all the time. Therefore, final
 49 impact intensity determinations may differ from a strict adherence to the framework if, in NPS professional
 50 judgment, the preponderance of evidence from all available information in relation to context, duration, or timing

³⁵ Audibility/Noticeability zones for noise modeling are not the same as park Management Zones. The Dual-Zone System is explained in 64 Federal Register 3969, Notice Change in Noise Evaluation Methodology for Air-tour operations Over Grand Canyon National Park, and in Appendix D. A map of Dual-Zones for noise modeling is in Appendix D, Fig. 1

indicates a different impact level or a range of levels, such as situations where not all metrics indicate the same impact intensity level.

Multiple metrics and approaches are considered as appropriate for each impact topic and situation to provide the most reasonably complete description of noise and other impacts. Potential for interactive effects of metrics grouped together are examined, in addition to values of individual metrics. Scientific literature most closely related to individual species and specific situations was also re-evaluated to see if any adjustment to impact intensity level indicated by the framework was warranted considering the particular context, duration, or timing involved.

To estimate level and length of time a resource or visitor may be affected by aircraft noise, Percent Time Audible in combination with Average Sound Levels were the primary metrics evaluated. Distance was also a factor (except in Soundscapes and Socioeconomics where Distance does not apply). In addition, analyses considered the qualitative response a resource or visitor would likely have to the sound environment. Both the metrics and this assessment of response were used to determine level of impact.

There were many cases when metrics did not all clearly indicate the same level of impact (negligible, minor, moderate, or major). In such cases, a hierarchy was generally applied relating to a metric's importance level in eliciting visitor or resource response, tempered by professional judgment related to metric values in specific situations. Percent Time Audible was usually given more weight in determining impact level because it generally better indicates amount of time a resource or visitor is exposed to conditions outside natural conditions (i.e., impacted at some level) than Average Sound Level (usually second in the hierarchy), or Distance (usually third in the hierarchy). Metrics indicating Percent Time Above certain decibel levels were usually considered to help clarify information provided by the other metrics.

For areas outside GCNP, but in the SFRA where Percent Time Audible was not assessed, Average Sound Level was normally considered more important in determining impact intensity level than Distance.

TABLE 4.1 NPS QUANTITATIVE IMPACT ANALYSIS FRAMEWORK

Metric ^a	Negligible	Minor	Moderate	Major
Percent Time Audible (Aircraft) during a 12-hour Day ^{bc}	Less than or equal to 5%	Greater than 5% and less than or equal to 10%	Greater than 10% and less than or equal to 25%	Greater than 25%
Average Sound Level (L_{Aeq12}) Energy Average of Aircraft Sound Levels during a 12-hour Day ^d	Less than or equal to 15 dBA	Greater than 15 dBA and less than or equal to 25 dBA	Greater than 25 dBA and less than or equal to 35 dBA	Greater than 35 dBA
Distance between Points of Interest on the Ground and Aircraft Routes	Greater than or equal to 2,000 meters	Less than 2,000 meters and greater than or equal to 1,000 meters	Less than 1,000 meters and greater than or equal to 500 meters	Less than 500 meters

^aSee text above for definitions of these metrics

^bPercent Time Audible and Average Sound Level consider a 12-hour time period (7 a.m. to 7 p.m.)

^cThe framework for negligible, minor, moderate, and major in terms of Percent Time Audible was selected for reasons which include 1) Substantial Restoration of Natural Quiet at GCNP depends on park percent in which aircraft are audible less than or equal to 25% of a 12-hour day (the breakpoint between moderate and major impact levels); 2) 5% Percent Time Audible translates to an average of one flight per hour for the entire 12-hour day using an average of three minutes audibility per flight (the breakpoint between Negligible and Minor impact levels); and 3) 10% Percent Time Audible is a reasonable minor/moderate breakpoint considering the other two breakpoints and all above information sources

^dSpecific Average Sound Levels values were selected in the framework for reasons which include 1) accepted EPA and ANSI standards (Acoustical Society of America 2002, Crocker 1997) recommend levels at and below 35 dBA (breakpoint between moderate and major impact levels) for numerous indoor settings where there is a reasonable expectation for quiet (classrooms, theaters), and for outdoor rural settings; 2) increments of 10 dBA in Average Sound Level are consistent with a ten-fold increase in number of aircraft (assuming roughly the same amount of noise for each aircraft), and a perceived doubling of loudness

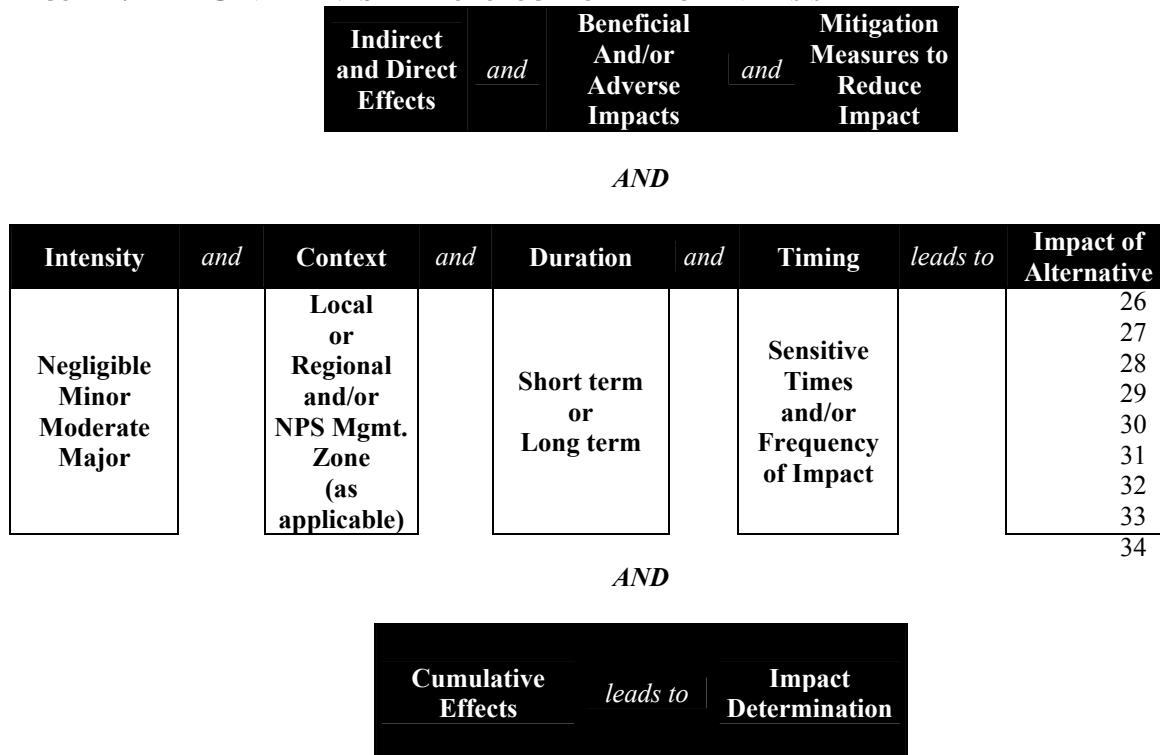
Summary

Impacts are presented in the most reasonably accurate manner available. As appropriate, different impact intensity descriptions are presented for different locations, contexts, or time periods. Impacts are not averaged over large areas or long periods unless specifically stated. For example, moderate to major adverse impacts might occur beneath flight routes at the same time moderate to major beneficial impacts occur in portions of Flight-Free Zones, and impacts may be quite different during different time periods.

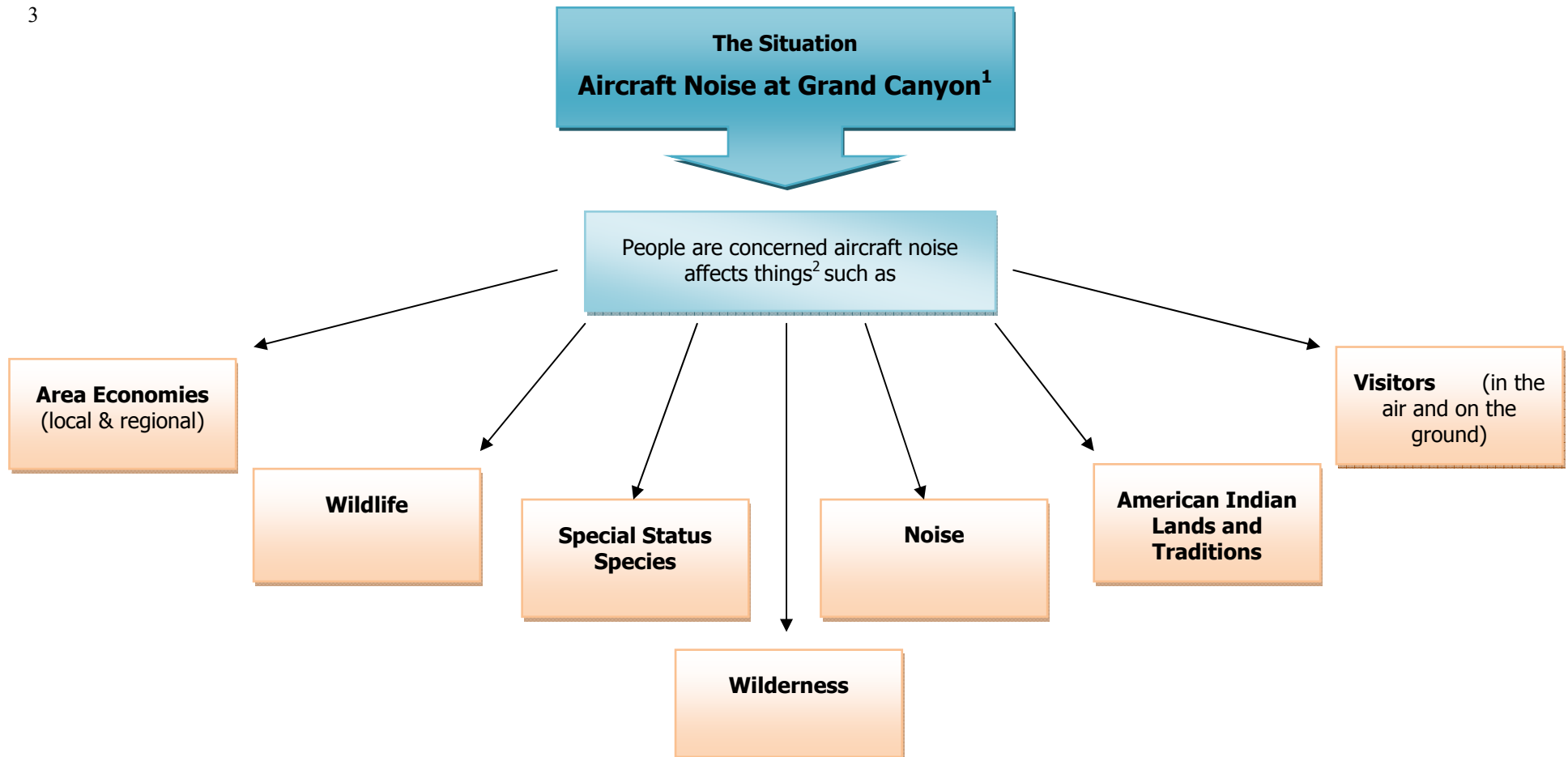
The NPS equates the term *major impacts* (or effects) to the term *significant* as used in NEPA and its implementing regulations. The NPS thus distinguishes between proposed actions and associated effects requiring EIS preparation versus those that require only an Environmental Assessment.

All available data were comprehensively examined to make impact determinations for each impact topic using standard NPS impact analysis methods outlined in Figure 4.1 to Figure 4.5. Criteria or conditions considered in determining magnitude of impact were developed based on guidance from the NPS Intermountain Regional Office Environmental Quality Division, the NPS Natural Resource Program Center's Natural Sounds Program, and park planning and resource staffs' best professional judgment. Likewise, intensity determined for each impact topic was based on all available data.

FIGURE 4.1 GENERAL NPS METHODOLOGY FOR IMPACT ANALYSIS



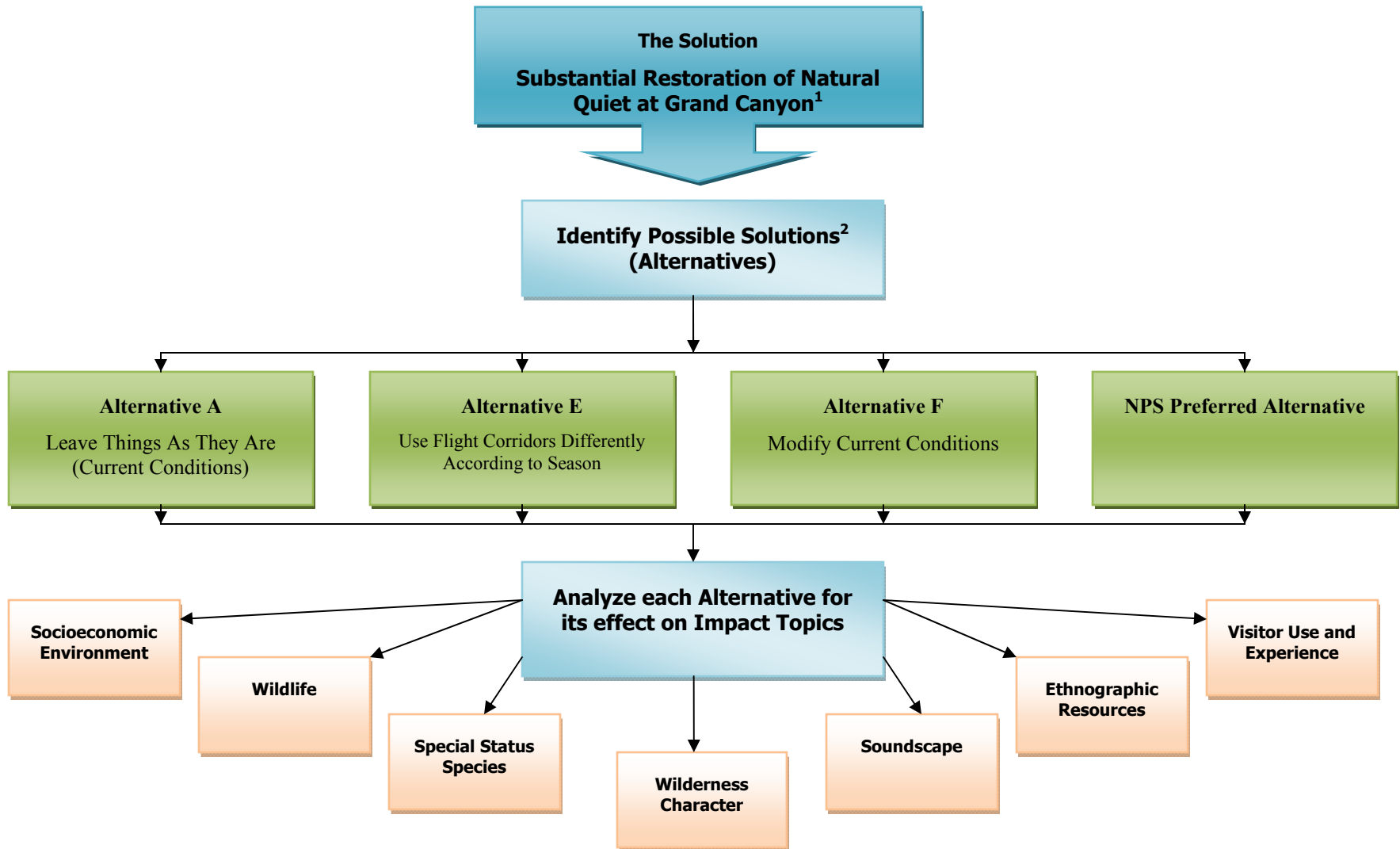
1 **FIGURE 4.2 THE EIS PROCESS STEP ONE**
 2
 3



¹ In an EIS the affected location is called the *Area of Potential Effect* or the *Study Area*. In this EIS, the Study Area is larger than Grand Canyon National Park. See Map 1.2

² Things potentially affected by the situation are called *Impact Topics* listed in the next Figure, and are determined as described in Chapter 1

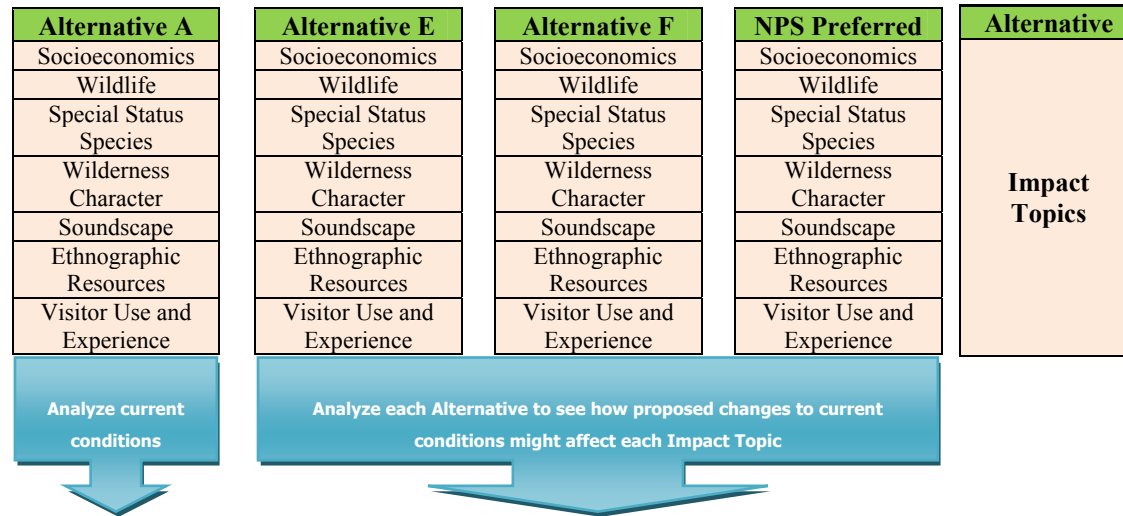
FIGURE 4.3 THE EIS PROCESS STEP TWO



¹As directed by law and policy; see Chapter 1 and Appendix A

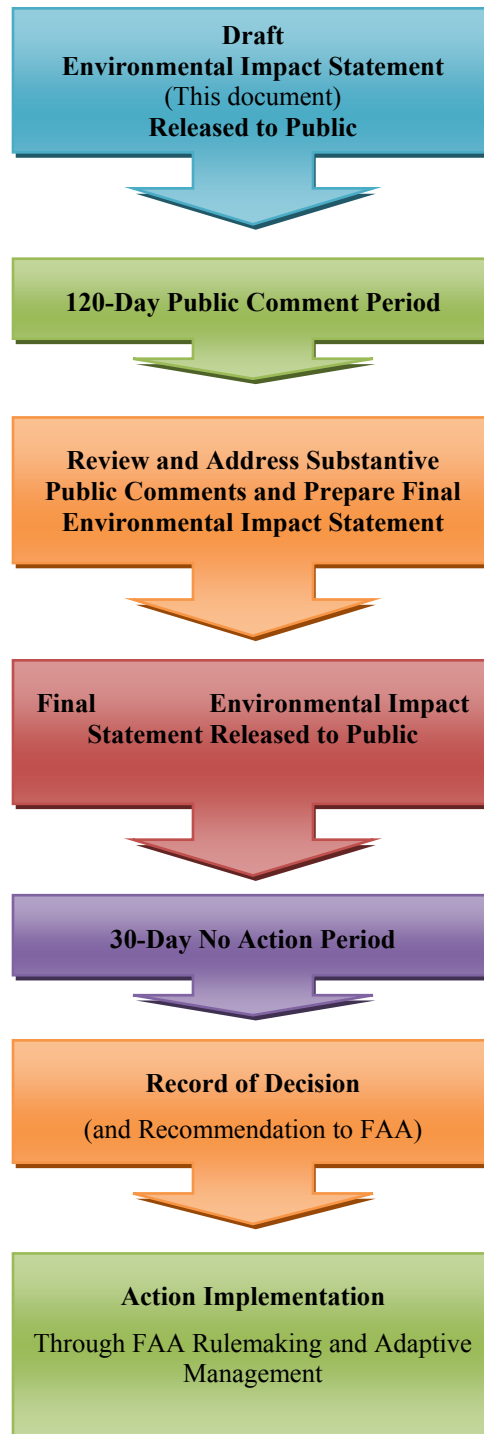
²Alternatives are derived from public scoping, consultation, and subject-matter experts as described in Chapters 2 and 5

1 **FIGURE 4.4 THE EIS PROCESS STEP THREE**



In this EIS, Impact Topics under Each Alternative are Analyzed by											
Effects	Direct		Metrics	Percent Time Audible		Time Frame	Peak Season				
	Indirect			Average Sound Level			Off-Peak Season				
	Beneficial			Distance							
	Adverse			Percent Time Above							
Intensity	Negligible		Area	Marble Canyon		Factors in this table are combined and assessed to reach a conclusion about each Alternative's combined effects, as shown in Figure 4.1 and summarized in Table 2.6					
	Minor			East End							
	Moderate			Central							
	Major			West End							
Duration	Short Term		Management Zone	Developed							
	Long Term			Non-Wilderness							
Context	Localized	Wilderness									
	Regional	Cumulative Impacts	Alternative impacts plus impacts from other past, present, and reasonably foreseeable future actions								
Timing	Sensitive Times and/or Frequency of Impact	Time Frame	Base Year	Peak and Off-Peak Season Change in Alternatives E, F, and NPS Preferred							
			Ten-Year Forecast								
Each Term Above Is Defined In Each Alternative		Definition of Each Term Above Remains the Same for All Alternatives									
All Above Terms are Defined in this Methodology Section											

FIGURE 4.5 THE EIS PROCESS STEP FOUR



SOUNDSCAPE

General Methodology

Soundscape

Methods and impact thresholds used for Soundscapes analysis in this EIS were developed specifically for circumstances at GCNP, and are not necessarily intended to be used or set precedents for use, in other national parks. In the thresholds below, all aspects of aircraft noise intensity and duration including, but not limited to, aircraft Percent Time Audible and Average Sound Level are included in the term *aircraft noise intensity*.

Because Soundscapes are recognized as a resource throughout the national park system, for the purpose of this EIS these thresholds apply to other NPS-managed lands within the SFRA boundary, including NPS lands in Lake Mead National Recreation Area, Glen Canyon National Recreation Area, and Grand Canyon-Parashant National Monument. The conclusion for this section addresses overall impact to all NPS units in the SFRA in addition to Grand Canyon National Park.

Soundscape impact analysis is presented 1) by Zone (Developed, Non-Wilderness, Wilderness) emphasizing Contour Analysis data in GCNP, 2) by Area (Marble Canyon, East End, Central, West End) emphasizing Location Point data in the SFRA, 3) for NPS Units in the SFRA but Outside GCNP, 4) Cumulative Impacts, and 5) Conclusion.

A summary of impacts across Alternatives is provided at the end of Soundscapes in Summary of Impacts, All Alternatives, Soundscape.

All metrics modeled in noise analysis were reviewed and considered even if not listed in threshold definitions.

NPS Impact Intensity Threshold Descriptions

General Methodology

Soundscape

Threshold Levels

Soundscape

<i>Negligible</i>	Aircraft noise rarely audible, aircraft audible less than or equal to 5% of the 12-hour day used in this analysis. Natural sounds predominate
	Average aircraft noise intensity in a specific area less than or equal to 15 dBA
<i>Minor</i>	Aircraft noise audible for a small portion of applicable time periods, aircraft audible greater than 5% and less than or equal to 10% of the 12-hour day
	Average aircraft noise intensity in a specific area greater than 15 dBA and less than or equal to 25 dBA
<i>Moderate</i>	Aircraft noise audible for an intermediate portion of applicable time periods, aircraft audible greater than 10% and less than or equal to 25% of the 12-hour day
	Average aircraft noise intensity in a specific area greater than 25 dBA and less than or equal to 35 dBA
<i>Major</i>	Aircraft noise audible for a large portion of applicable time periods, aircraft audible greater than 25% of the 12-hour day
	Average aircraft noise intensity in a specific area greater than 35 dBA

Type of Impact

Soundscape

<i>Adverse</i>	Impacts detract from achieving substantial restoration of natural quiet, increase aircraft noise intensity, and/or duration of aircraft noise events
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Beneficial Impacts contribute toward achieving substantial restoration of natural quiet, decrease aircraft noise intensity, and/or duration of aircraft noise events

Context

Soundscape

Regional Impacts affect majority of the park or SFRA, or multiple backcountry use areas, attraction sites, trails, or flight routes

Localized Impacts affect a small area, such as a single backcountry use area, a specific attraction site, a specific trail, or flight route

Park Management Zone Non-natural sound has greatest intensity of impact in NPS areas in the Wilderness Zone, then Non-Wilderness Zone, and least in the Developed Zone. For example, an Average Sound Level consistent with the moderate intensity level definition in the Wilderness Zone may be considered a minor intensity impact in the Developed Zone while the same level in the Non-Wilderness Zone may be considered minor-to-moderate, depending on other factors including duration and timing

Duration

Soundscape

Short Term Impacts associated with individual, infrequent, and/or non-repetitive actions impact Soundscape only during and shortly after specified actions

Long Term Impacts persist well beyond completion of individual actions, generally impacting Soundscape longer than the day action occurs. Related actions frequent or repetitive over more than a few days would also be considered long-term impacts

Timing Frequency of occurrence and time of day can be important considerations in assessing Soundscape impacts. Seasonality and sensitive time periods are described in impact topics where most relevant (Visitor Use and Experience, Wildlife), and not in Soundscape analysis

Background Information

Soundscape

In national park units, Soundscape is the aggregate of all sounds in an area; it is the park's total acoustic environment. In a national park setting, Soundscape can be composed of both natural ambient sound and a variety of human-made sounds. Natural Soundscapes are composed completely of natural sounds without the presence of human-made sounds (NPS 2006b). The NPS recognizes the natural Soundscape of each national park unit as an inherent resource, and manages this resource to "restore degraded Soundscapes to the natural conditions wherever possible, and protect natural Soundscapes from degradation due to noise" (NPS 2006b).

This section describes potential noise impacts of the Alternatives using various noise metrics to determine the extent to which each Alternative would 1) achieve and improve substantial restoration of natural quiet, and 2) result in impacts to Soundscape in NPS units in the study area.

The NPS considers a park's natural Soundscape to be a resource just like other natural and cultural resources found in a park. Soundscapes have their own inherent value that is susceptible to impacts from air-tours. Soundscapes can also serve as a guide to evaluating impacts to other park resources such as wildlife, cultural resources, and visitor experience. Noise modeling results for each Alternative were used to determine level of impact aircraft overflights might have on Soundscapes of NPS lands in the SFRA.

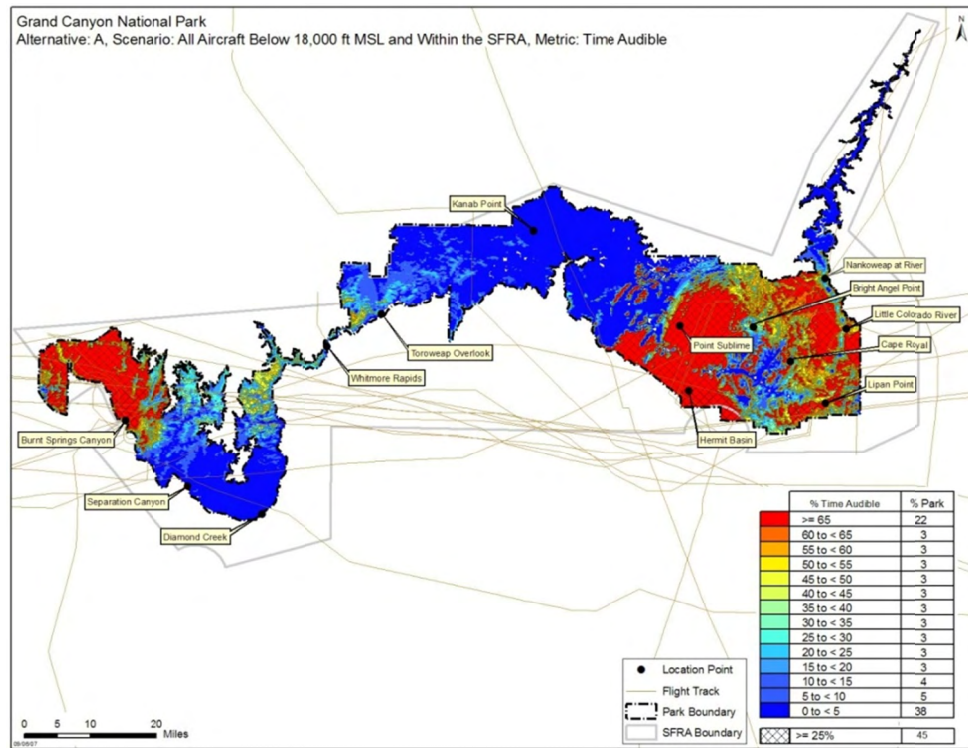
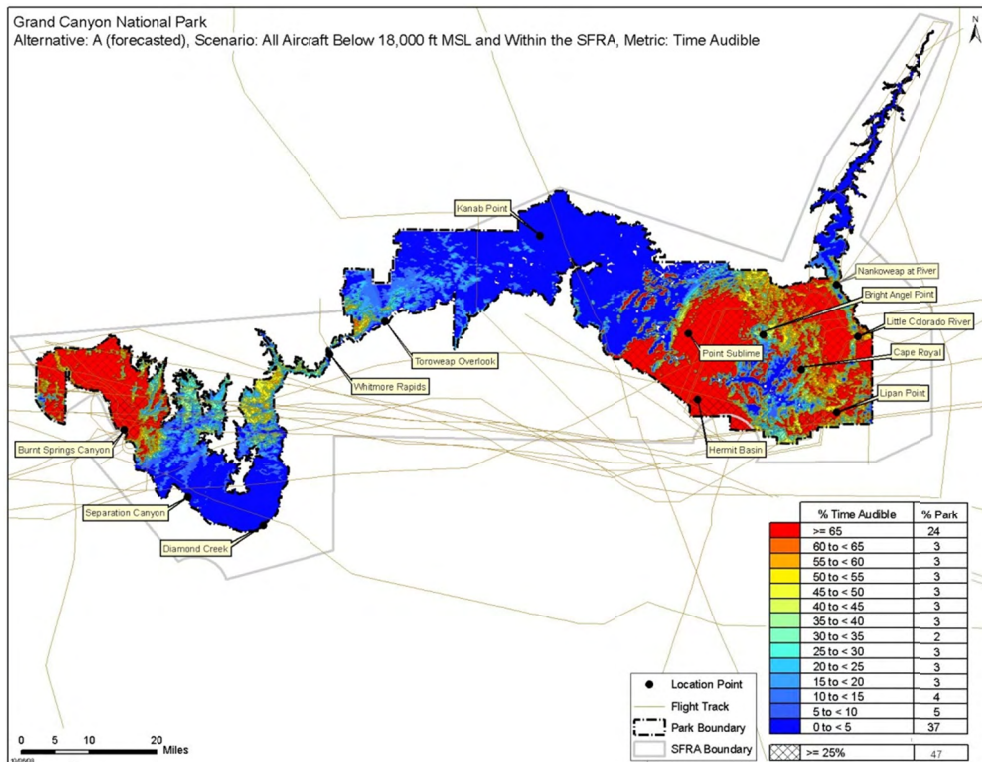
FIGURE 4.6 ALTERNATIVE A PERCENT TIME AUDIBLE BASE YEAR**FIGURE 4.7 ALTERNATIVE A PERCENT TIME AUDIBLE TEN-YEAR FORECAST**

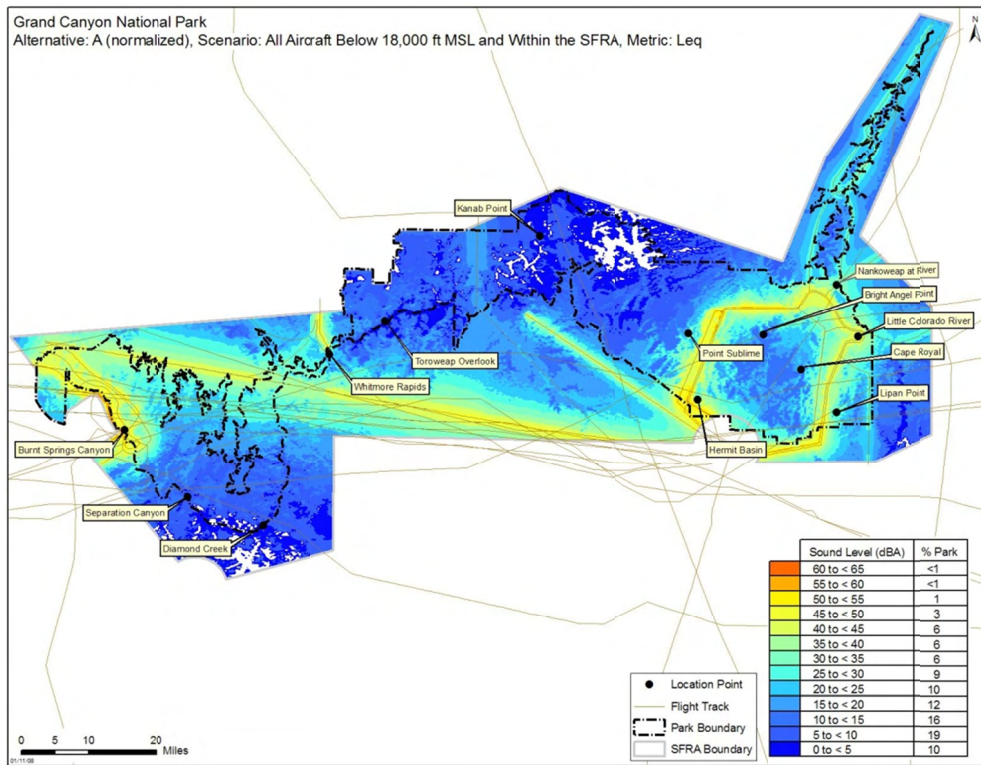
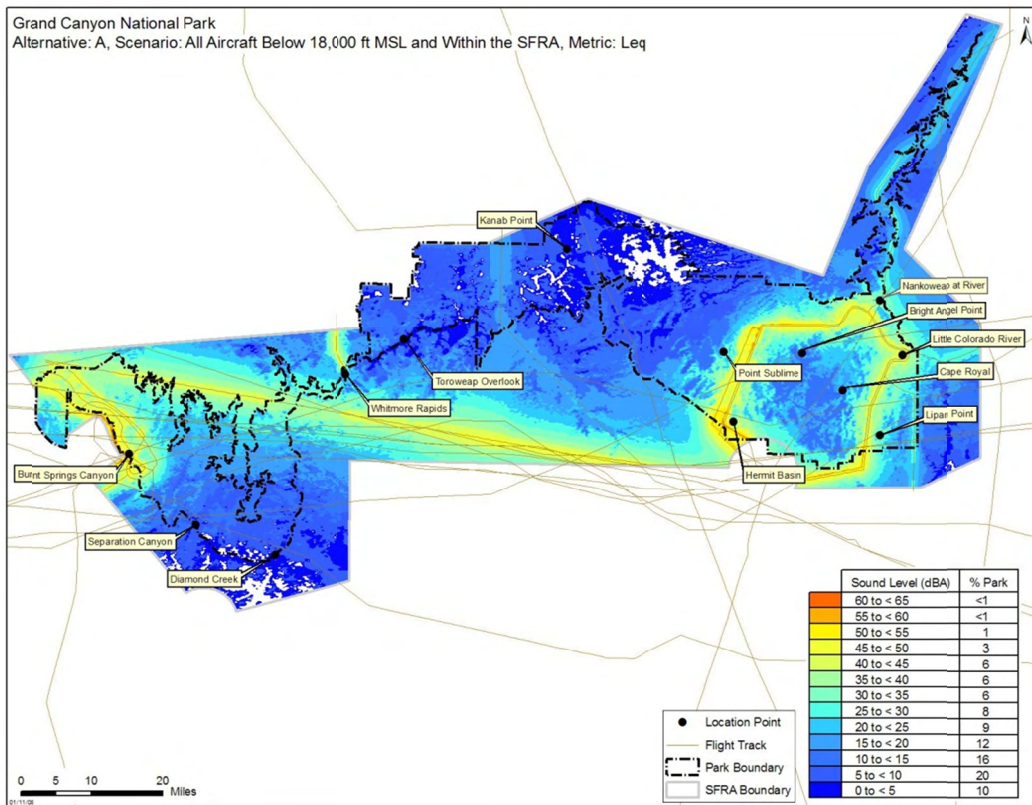
FIGURE 4.8 ALTERNATIVE A AVERAGE SOUND LEVEL BASE YEAR**FIGURE 4.9 ALTERNATIVE A AVERAGE SOUND LEVEL TEN-YEAR FORECAST**

TABLE 4.2 ALTERNATIVE A PERCENT TIME AUDIBLE CONTOUR ANALYSIS RESULTS^{abc}

Percent Time Audible	Base Year (Percent of Zone)				Ten-Year Forecast (Percent of Zone)			
	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP
Percent Park Restored				55%				53%
≥ 25	88%	79%	43%	45%	90%	80%	45%	47%
10 to < 25	6%	8%	10%	10%	5%	7%	10%	10%
5 to < 10	1%	3%	6%	5%	1%	2%	6%	5%
> 0 to < 5	5%	11%	40%	38%	5%	11%	39%	37%

^aDue to rounding differences, totals shown in this table may differ from Appendix D by up to 2%

^bBecause limited ambient data were available outside GCNP, contours for Percent Time Audible were computed only within GCNP boundaries; Average Sound Level contours were computed in the entire SFRA

^cColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

TABLE 4.3 ALTERNATIVE A AVERAGE SOUND LEVEL CONTOUR ANALYSIS RESULTS^{ab}

Average Sound Level	Base Year (% of Zone)					Ten-Year Forecast (% of Zone)				
	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP	In SFRA	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP	In SFRA
≥ 35	10%	21%	15%	16%	15%	24%	33%	22%	23%	14%
25 to < 35	55%	37%	12%	14%	15%	74%	57%	26%	28%	21%
15 to < 25	33%	28%	21%	22%	27%	2%	10%	38%	37%	41%
> 0 to < 15	3%	14%	48%	46%	40%	0%	1%	13%	13%	24%

^aDue to rounding differences, totals shown in this table may differ from Appendix D by up to 2%

^bColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

ALTERNATIVE A NO ACTION/CURRENT CONDITION SOUNDSCAPE

Alternative A would continue all aspects of current management for general aviation and air-tour operations in the SFRA and, under NEPA, serves as the baseline against which to compare Action Alternatives. Alternative A would achieve Substantial Restoration of Natural Quiet in 55% of the park 75 to 100% of the day Base Year, and 53% of the park Ten-Year Forecast, as shown in Table 4.2 and 4.3.

Alternative A noise modeling mapped results (all aircraft below 18,000 feet MSL and in the SFRA scenario) for Percent Time Audible and Average Sound Level are shown on Figures 4.6 through 4.9. Tables 4.2 and 4.3 present Contour Analysis results computed for Percent Time Audible and Average Sound Level, respectively, for Alternative A. Table 4.4 presents Location Point results computed for all metrics for Alternative A. Unless otherwise stated, Alternative A metric values discussed in the text are taken from these figures and tables. NOTE: Blank areas in contour maps indicate where aircraft noise was not audible or below 0 dBA.

Developed Zone (about 2% of GCNP) Alternative A Soundscape

With exception of a very small area at Tuweep, all GCNP Developed Zone areas are in the East End. Audibility calculations for the Developed Zone added 10 dBA to natural ambient sound levels due to the Dual-Zone System explained further in Chapter 4, Methodology. As such, analysis considers Developed Zone management objectives which accept presence of many non-natural sound sources (increased background ambient sound levels) including most of the park's visitors and their activities, presence of paved roads and motorized transportation, and developed

facilities. **Alternative A is not analyzed for Peak and Off-Peak Season because there are no seasonal route changes in this Alternative.**

TABLE 4.4 ALTERNATIVE A LOCATION POINT RESULTS^{ab}

Location Point Grouping		Base Year					Ten-Year Forecast				
		TAUD ^c	L _{Aeq12} ^d	TALA35 dBA ^e	TALA45 dBA ^e	TALA55 dBA ^e	TAUD	L _{Aeq12}	TALA35 dBA	TALA45 dBA	TALA55 dBA
Marble Canyon	Max	3%	24 dBA	1%	0%	0%	3%	25 dBA	2%	0%	0%
	Median	2%	14 dBA	0%	0%	0%	2%	16 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
East End	Max	100%	49 dBA	100%	51%	5%	100%	49 dBA	100%	57%	5%
	Median	64%	28 dBA	5%	0%	0%	67%	29 dBA	6%	0%	0%
	Min	0%	6 dBA	0%	0%	0%	0%	7 dBA	0%	0%	0%
Central	Max	22%	27 dBA	4%	0%	0%	25%	27 dBA	5%	0%	0%
	Median	1%	10 dBA	0%	0%	0%	1%	10 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
West End	Max	93%	47 dBA	71%	29%	4%	95%	48 dBA	81%	33%	5%
	Median	19%	22 dBA	1%	0%	0%	21%	23 dBA	1%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
All Location Points	Max	100%	49 dBA	100%	51%	5%	100%	49 dBA	100%	57%	5%
	Median	9%	17 dBA	0%	0%	0%	10%	18 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%

^aBecause limited ambient data were available outside GCNP, contours for Percent Time Audible were computed only in GCNP boundaries; Average Sound Level (L_{Aeq12}) contours were computed in the entire SFRA

^bMax refers to maximum Location Point value for a Location Point grouping for each respective specific metric; conversely, Min refers to minimum Location Point value. Median characterizes the central tendency of the results. That is, 50% of results are above the median; 50% below. The median, as opposed to the arithmetic mean, is more appropriate for data not normally distributed

^cTAUD = Percent Time Audible

^dL_{Aeq12} = Average Sound Level

^eTALA35 dBA, TALA45 dBA, and TALA55 dBA = Percent of time during the 12-hour day used in this analysis that aircraft sounds exceed 35, 45, and 55 dBA, respectively

*Developed Zone
Base Year*

Alternative A

Soundscape

Average Sound Level would generally be greater than 25 dBA in 65% of the Developed Zone (25 to 35 dBA in 55% of the Developed Zone, and greater than 35 dBA in 10%). Percent Time Audible would generally be greater than 25% of the day in 88% of the Developed Zone, and 10 to 25% Percent Time Audible in 6% of the Developed Zone. Thus the majority of the Developed Zone would experience moderate to major adverse impacts due to amount of air-tour activity in both Zuni Point and Dragon Corridors. Although major adverse impacts would occur, effects would be a mix of short and long term given amount of visitor activity and presence of non-natural sound sources.

Developed Zone

Alternative A

Soundscape

Ten-Year Forecast

Because Alternative A includes growth in operations, but does not include quiet-technology incentives or conversion requirements, adverse impacts would increase to 98% of the Developed Zone experiencing Average Sound Level greater than 25 dBA, and 95% of the Developed Zone with air-tour aircraft Percent Time Audible greater than 10% of the day (areas with moderate to major adverse impacts). This would represent a minor to moderate adverse change in impacts due to forecasted increase in air-tour operations from Base Year to Ten-Year Forecast.

Non-Wilderness Zone (4% of GCNP) Alternative A Soundscape

Almost all Non-Wilderness Zone areas are located in East End (exceptions are a few Central area dirt road corridors). A portion of the Non-Wilderness Zone is in the Dual-Zone area where 10 dBA is added to natural ambient sound levels for audibility calculations; this portion is generally close to Developed Zone areas with motorized noise sources, although there is a strip of Non-Wilderness Zone on Marble Canyon's east side. The majority of the Non-Wilderness Zone is in the area where natural ambient sound levels are used directly as the basis for audibility calculations in this EIS, consistent with Non-Wilderness Zone management objectives that call for mostly natural conditions to prevail in the Zone.

Non-Wilderness Zone Alternative A Soundscape *Base Year*

Average Sound Level would generally be greater than 25 dBA in 58% of the Non-Wilderness Zone (25 to 35 dBA in 37%, and greater than 35 dBA in 21%). Percent Time Audible would generally be greater than 25% of the day in 79% of the Non-Wilderness Zone, and 10 to 25% Percent Time Audible in 8% of the Non-Wilderness Zone (areas with moderate to major adverse impacts). Thus the majority of the Non-Wilderness Zone would experience moderate to major adverse impacts due to amount of air-tour activity in Zuni Point and Dragon Corridors. Although long-term major adverse impacts would occur, some effects would be short term given amount of visitor activity and presence of non-natural sound sources in some of the Zone.

Non-Wilderness Zone Alternative A Soundscape *Ten-Year Forecast*

Because Alternative A includes growth in operations but does not include quiet-technology incentives or conversion requirements, adverse impacts would increase to 90% of the Non-Wilderness Zone with Average Sound Level greater than 25 dBA, and 87% of the Non-Wilderness Zone with air-tour aircraft Percent Time Audible greater than 10% of the day (areas with moderate to major adverse impacts). This would represent a minor to moderate adverse change in impact due to forecasted increase in air-tour operations from Base Year to Ten-Year Forecast.

Wilderness Zone (about 94% of GCNP) Alternative A Soundscape

In the Wilderness Zone, results vary to a greater degree than in Developed and Non-Wilderness Zones due to the Wilderness Zone's increased size and geographic extent compared to the others. Most of the Wilderness Zone is in the area where natural ambient sound levels are used directly in audibility calculations in the Dual-Zone System acoustic approach to noise modeling. Exceptions are West End and Marble Canyon.

Wilderness Zone Alternative A Soundscape *Base Year*

Average Sound Level would generally be greater than 25 dBA in 27% of the Wilderness Zone (25 to 35 dBA in 12%, and greater than 35 dBA in 15%). Percent Time Audible would generally be greater than 25% of the day in 43% of the Wilderness Zone, and 10 to 25% Percent Time Audible in 8% of the Wilderness Zone (areas with moderate to major adverse impacts). Thus, percentage of the Wilderness Zone experiencing moderate to major adverse impacts would be almost half, and impacts would mostly be concentrated in East and West Ends as shown in Figures 4.6 to 4.9. In the Wilderness Zone, major adverse impacts would mostly be long-term with reduced visitor use and absence of non-natural sound sources in the Zone.

Wilderness Zone Alternative A Soundscape *Ten-Year Forecast*

Because Alternative A includes growth in operations, but does not include quiet-technology incentives or conversion requirements, adverse impacts would increase to 48% of the Zone with Average Sound Level greater than 25 dBA, and 55% of the Wilderness Zone with air-tour aircraft Percent Time Audible greater than 10% of the day (areas with moderate to major adverse impacts). This would represent a negligible to minor adverse change in impacts due to forecasted increase in air-tour operations from Base Year to Ten-Year Forecast.

Marble Canyon Alternative A Soundscape

Marble Canyon's west side is located in the Wilderness Zone; its east side is in the Non-Wilderness Zone. It is also entirely in the Dual-Zone noticeability area in which 10 dBA is added to natural ambient sound levels in calculating Percent Time Audible (see Chapter 4, Methodology).

Marble Canyon Alternative A Soundscape Base Year

Localized long- and short-term impacts would generally be negligible to minor adverse (based on Figures 4.6 to 4.9, Average Sound Level would generally be less than 15 dBA and Percent Time Audible less than 5%). Location Points range zero to 3% Percent Time Audible, and Average Sound Level zero to 24 dBA.

Marble Canyon Alternative A Soundscape Ten-Year Forecast

Localized long- and short-term impacts would generally be negligible to minor adverse (based on Figures 4.6 to 4.9, Average Sound Level would generally be less than 15 dBA and Percent Time Audible less than 5%). Results would increase negligibly (no increase in median Percent Time Audible and one to 2 dBA in median Average Sound Level) Base Year to Ten-Year Forecast.

East End Alternative A Soundscape

Under Alternative A, greatest exposure to noise and visual impacts would continue East End, which contains over half the Peak Day air-tour operations. East End includes all three Management Zones: Developed, Non-Wilderness, and Wilderness, and heavily-used air-tour routes in Zuni Point and Dragon Corridors for both short-loop tours and the long-loop tour between Zuni Point and Dragon Corridors over North Rim. Also, most of East End's land area is contained in Bright Angel Flight-free Zone.

East End Alternative A Soundscape Base Year

Although the majority of East End Location Points do not experience Average Sound Level greater than 35 dBA, several Location Points (**96-mile Camp, The Basin, Eremita Mesa, Ten X Meadow, and Tower of Ra**) show Average Sound Level as high as 45 to 55 dBA, and Percent Time Audible 5 to 50% of the day. Air-tour aircraft in locations away from the river (represented by the **Little Colorado River** and **Nankoweap Mesa** Location Points) Percent Time Audible would be 34 to 87% of the day with Average Sound Level 43 dBA. Close to the river, as represented by the **Nankoweap River** Location Point, these effects would be less, with aircraft Average Sound Level of 34 dBA and Percent Time Audible approximately 7%. Areas beneath Zuni Point and Dragon Corridor routes and Black-1A/Green-1A over North Rim would experience nearly continuous noise at 52 to almost 100% Percent Time Audible, with Average Sound Level at 28 to 49 dBA. Amid Bright Angel Flight-free Zone, represented by **Grid Location Points 12 and 13**, air-tour operations would have negligible impact on natural Soundscape with Percent Time Audible of less than one percent, and aircraft Average Sound Level 12 to 13 dBA.

East End Location Points Percent Time Audible range zero to almost 100% with Average Sound Level 6 to 49 dBA. Average Sound Level for individual aircraft events would not exceed 35 dBA for most locations; however, at some locations, aircraft events would exceed 35 dBA 100% of the day, 45 dBA 51% of the day, and 55 dBA 5% of the day. Areas under and near East End air-tour routes would experience long-term major adverse impacts (Average Sound Level greater than 40 dBA with Percent Time Audible greater than 50%). Areas amid Bright Angel Flight-free Zone would experience negligible to minor adverse impacts.

East End Alternative A Soundscape Ten-Year Forecast

East End areas would see negligible increases in impacts (3% increase in median Percent Time Audible and one dBA in median Average Sound Level) Base Year to Ten-Year Forecast.

Central Alternative A Soundscape

The Central area is in the Wilderness Zone, with exception of a few Non-Wilderness Zone dirt road corridors, and a very small Developed Zone area at Tuweep. The Central area is entirely in the Dual-Zone System audibility area in which natural ambient sound levels are used directly in Percent Time Audible calculations. This area comprises most of the Toroweap/Shinumo Flight-free Zone, and is transected by two general-aviation corridors.

Central Alternative A Soundscape Base Year

Central area Location Points range zero to 22% Percent Time Audible with Average Sound Level zero to 27 dBA. Average Sound Level for the loudest individual aircraft events would exceed 35 dBA 4% of the day. Localized long- and short-term impacts would be negligible to moderate adverse (based on Figures 4.6 to 4.9, Average Sound Level would generally be less than 10 dBA and Percent Time Audible less than 5%).

Central Alternative A Soundscape Ten-Year Forecast

Central area Location Point results would increase negligibly (3% increase in median Percent Time Audible and no increase in median Average Sound Level) Base Year to Ten-Year Forecast.

West End Alternative A Soundscape

West End is in the Wilderness Zone, and entirely in the Dual-Zone System noticeability area in which 10 dBA is added to natural ambient sound levels in Percent Time Audible calculations. West End impacts depend on proximity to Blue Direct and Blue-2/Green-4.

West End Alternative A Soundscape Base Year

Location Points range zero to 93% Percent Time Audible with Average Sound Level zero to 47 dBA. Average Sound Level for individual aircraft events would not exceed 35 dBA for most locations; however, at some locations, aircraft events would exceed 35 dBA 71% of the day, 45 dBA 29% of the day, and 55 dBA 4% of the day. Beneath West End air-tour routes (Green-4, Blue-2, and Blue Direct South), represented by Location Points **Burnt Springs Canyon, Bat Cave, and Grid Location Point 33**, there would be high Percent Time Audible of air-tour aircraft 70 to 93% of the day, and Average Sound Level would be high at 42 to 47 dBA. Under Brown routes (**Whitmore Rapids and Parashant Wash** Location Points), and further west along the river, would be less affected with Percent Time Audible at 12%, and Average Sound Level 21 to 33 dBA. Areas under Blue Direct North and South, including **Grid Location Points 28 and 32**, would have a Percent Time Audible 14% to 44% and Average Sound Level 17 to 27 dBA.

In the **northern West End** near air-tour routes, localized long- and short-term impacts would be major adverse (Figures 4.6 to 4.9), Average Sound Level would be greater than 40 dBA with Percent Time Audible greater than 65%). In the southern West End (mostly Sanup Flight-free Zone), localized long-term impacts would be negligible to minor adverse (Figures 4.6 to 4.9). Average Sound Level would be 10 to 20 dBA with Percent Time Audible less than 20%).

West End Alternative A Soundscape Ten-Year Forecast

Because Alternative A includes growth in operations but does not include quiet-technology incentives or conversion requirements, **West End area** adverse impacts would increase a negligible amount (2% in median Percent Time Audible, and one dBA in Average Sound Level) from Base Year to Ten-Year Forecast.

NPS Units in the SFRA outside Grand Canyon National Park Alternative A Soundscape

For park lands directly under and within five miles of Blue Direct routes (Lake Mead National Recreation Area and Grand Canyon-Parashant National Monument) and other busy GCNP air-tour corridors, adverse impacts would be

considered major adverse Base Year (Average Sound Level would range 40 to 50 dBA) with negligible increases Ten-Year Forecast.

Cumulative Impacts

Alternative A

Soundscape

Other than air-tour aircraft sounds, impacts on Soundscape result from sounds of high-altitude aircraft above 18,000 feet MSL and, to a lesser degree, aircraft below 18,000 feet MSL and outside the SFRA. Throughout GCNP, these aircraft produce Average Sound Level 22 to 31 dBA. Audibility of high-altitude aircraft varies throughout the park as presented below. Noise from other sources (vehicles, building noise) is mostly concentrated in the Developed Zone (2% of the park), although there is a small component added primarily from vehicles on remote roads, motorboats on the Colorado River, and mining activities. Especially in terms of Percent Time Audible, though, noise generated by aircraft above and outside the SFRA contributes the most non-natural noise over most of the SFRA and overwhelms any localized cumulative benefits realized under the Alternatives.

At Location Points in Marble Canyon and nearby areas, noise from aircraft above and outside the SFRA Percent Time Audible is 16 to 36% of the day. At East End Location Points, except those close to the river, aircraft above and outside the SFRA are audible 27 to 71% of the day. At Central Location Points, noise from aircraft above and outside the SFRA is audible 16 to 65% of the day. At West End Location Points, noise from aircraft above and outside the SFRA is audible 12 to 51% of the day. Average Sound Level from aircraft above and outside the SFRA would generally be less than 30 dBA in all areas.

Cumulative noise from aircraft flying over 18,000 feet, as well as aircraft flying below 18,000 feet but outside the SFRA's lateral extents, would have minor to moderate localized short-term adverse impacts in the entire SFRA; however, long-term impacts would be major adverse (aircraft Percent Time Audible would generally be greater than 25%). There are no areas in GCNP where the natural Soundscape would not be adversely affected by aircraft noise at least some of the time. When effects of air-tour aircraft in Alternative A are added to these effects, overall, there would be a long-term moderate to major adverse cumulative impact in the study area.

Conclusion

Alternative A

Soundscape

Under Alternative A, a range of aircraft Average Sound Level and Percent Time Audible would affect GCNP Soundscapes. Alternative A would achieve Substantial Restoration of Natural Quiet in 55% of the park 75 to 100% of the day Base Year; which would decrease slightly to 53% of the park Ten-Year Forecast due to increases in air-tour operations (a negligible change in impacts).

Because Alternative A includes growth in operations, but no quiet-technology conversion requirements, noise impacts would increase Base Year to Ten-Year Forecast in all Zones and areas. However, increases in impacts would generally be negligible. Near busy air-tour corridors, such as those in East End, changes might not be discernable as some affected areas already experience close to 100% audibility. However, for areas where Percent Time Audible is less than, but close to 25%, future increases might jeopardize achievement of substantial restoration of natural quiet.

Conclusion by Zone Ten-Year Forecast

Alternative A

Soundscape

Wilderness Zone (94% of GCNP); area of moderate to major adverse impacts would be 48 to 55% of the Zone.

Non-Wilderness Zone (about 4% of GCNP); area of moderate to major adverse impacts would be 87 to 90% of the Zone.

Developed Zone (about 2% of GCNP); area of moderate to major adverse impacts would be 95 to 98% of the Zone.

Conclusion by Area

Alternative A

Soundscape

In Marble Canyon, Central areas, and West End's southern portion, localized long- and short-term impacts would generally be negligible to minor adverse (Average Sound Level would often be less than 15 dBA and Percent Time Audible less than 5%). Greatest exposure to noise impacts would occur under and near East and West End heavily-used air-tour routes where long- and short-term major adverse impacts would occur Base Year and Ten-Year

Forecast (aircraft Average Sound Level 40 to 50 dBA, and Percent Time Audible greater than 65%). Away from routes amid Flight-free Zones, impacts would be negligible to minor adverse.

Cumulative Impacts

Alternative A

Soundscape

Cumulative impacts from all actions would be long term moderate to major adverse due primarily to high aircraft Percent Time Audible levels.

ALTERNATIVE E

ALTERNATING SEASONAL USE

SOUNDSCAPE

Alternative E, Alternating Seasonal Use, would maximize park area in Flight-free Zones, and seasonally alternate use of Zuni Point and Dragon Corridor routes.

Base Year Peak Season, Alternative E would achieve Substantial Restoration of Natural Quiet in 75% of the park 75 to 100% of the day. This represents moderate beneficial change in impacts with a 20% increase in park area restored as shown in Table 4.23 compared to Alternative A. Base Year Off-Peak Season Alternative E would achieve Substantial Restoration of Natural Quiet in 78% of the park as shown in Table 4.23. This represents moderate beneficial change in impacts with a 23% increase in park area restored compared to Alternative A.

Ten-Year Forecast Peak Season Substantial Restoration of Natural Quiet would be achieved in 84% of the park as shown in Table 4.24. This represents major beneficial change in impacts with a 31% increase in park area restored compared to Alternative A. Ten-Year Forecast Off-Peak Season Substantial Restoration of Natural Quiet would be achieved in 86% of the park as shown in Table 4.24. This represents major beneficial changes in impacts compared to Alternative A with a 33% increase in park area restored.

Mapped results of noise modeling for Alternative E for Percent Time Audible and Average Sound Level are shown in Figures 4.10 through 4.17. Table 4.5 through 4.10 present Contour Analysis and Location Point results computed for Alternative E Peak and Off-Peak Seasons, respectively, and includes comparisons with Alternative A, No Action/Current Condition.

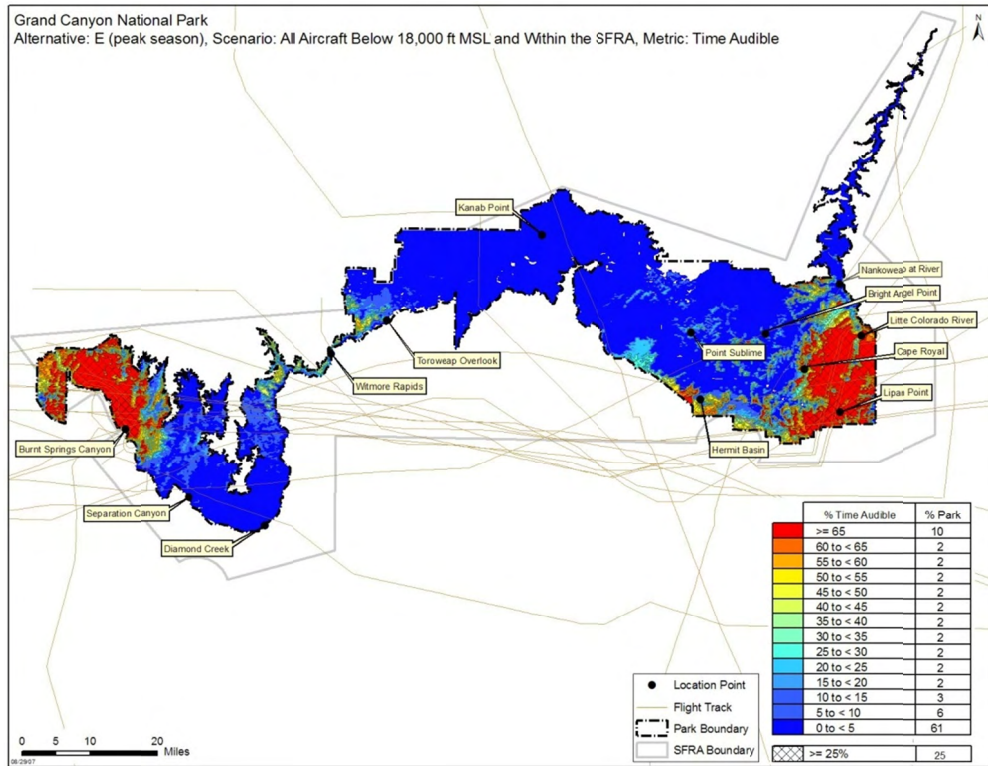
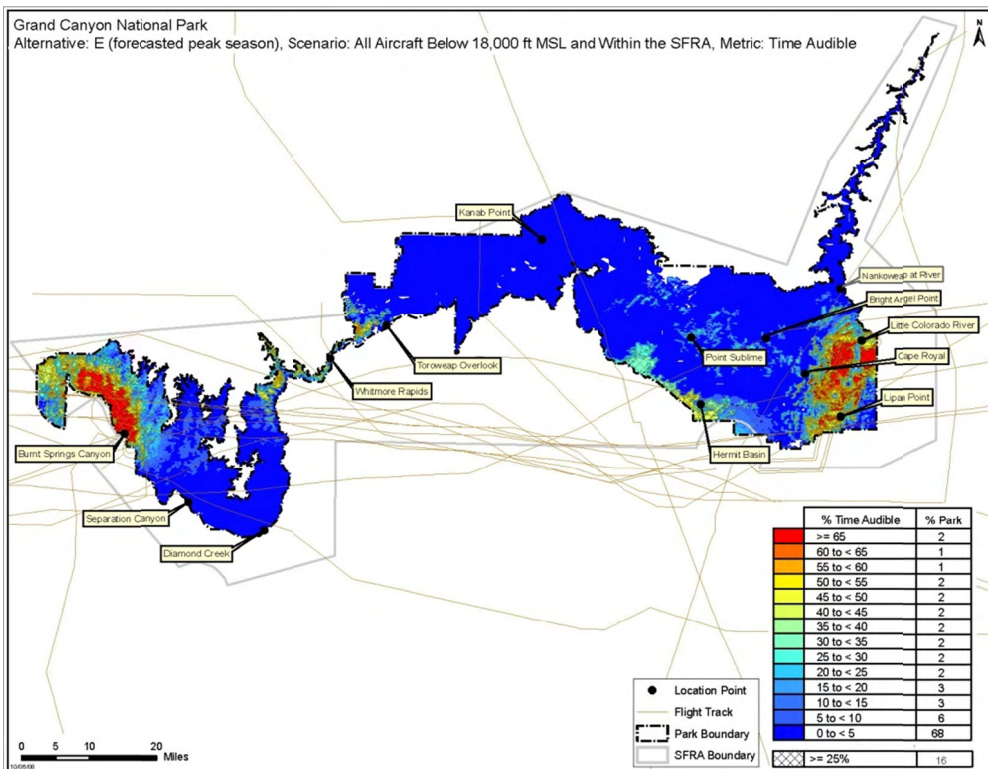
FIGURE 4.10 ALTERNATIVE E PERCENT TIME AUDIBLE BASE YEAR PEAK SEASON**FIGURE 4.11 ALTERNATIVE E PERCENT TIME AUDIBLE TEN-YEAR FORECAST PEAK SEASON**

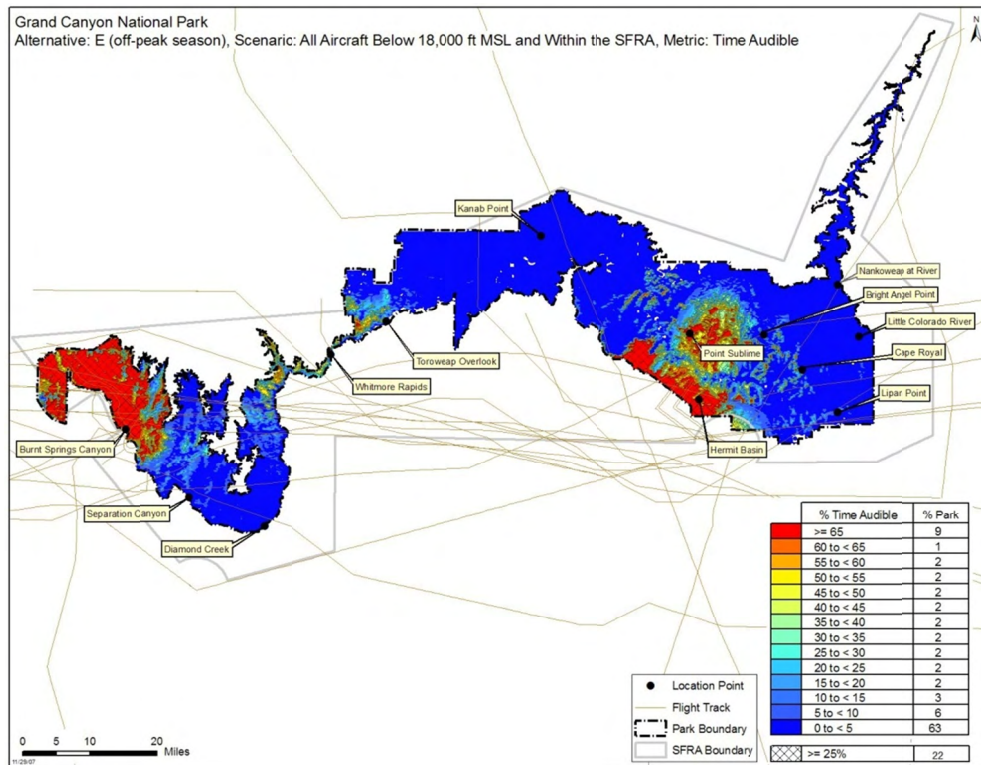
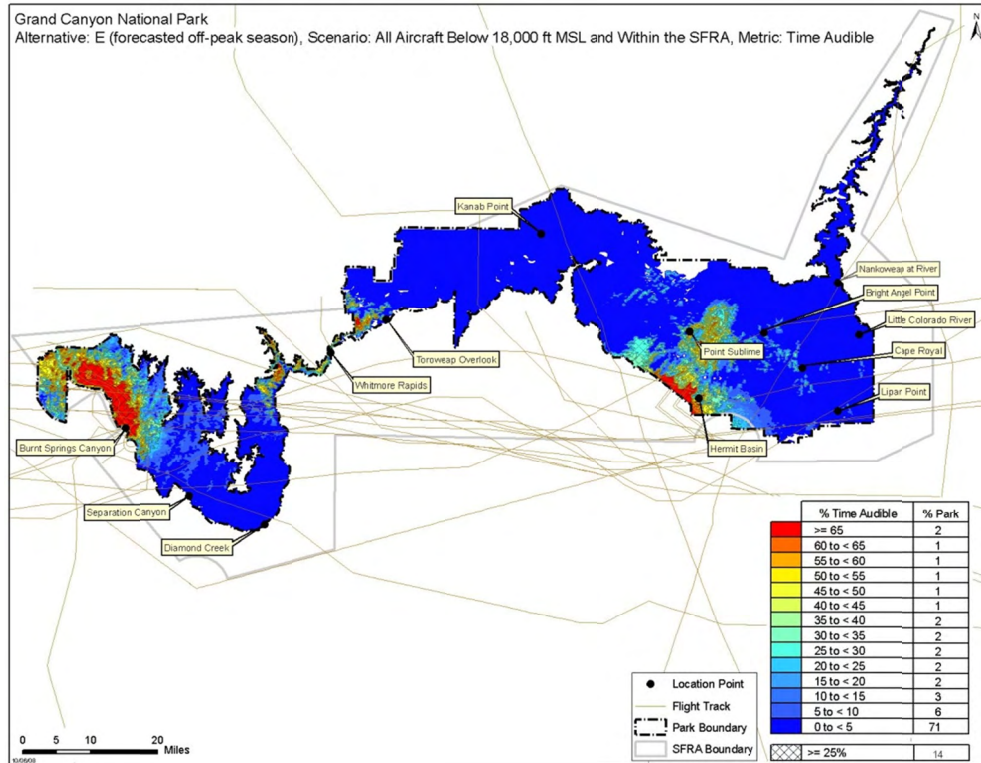
FIGURE 4.12 ALTERNATIVE E PERCENT TIME AUDIBLE BASE YEAR OFF-PEAK SEASON**FIGURE 4.13 ALTERNATIVE E PERCENT TIME AUDIBLE TEN-YEAR FORECAST OFF-PEAK SEASON**

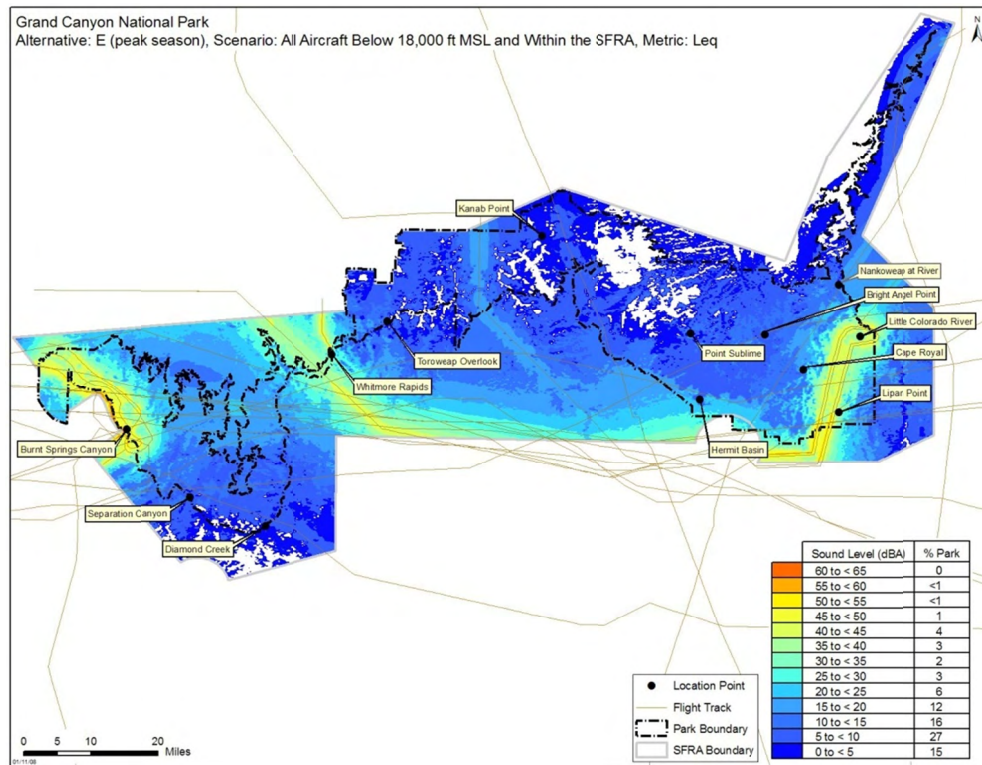
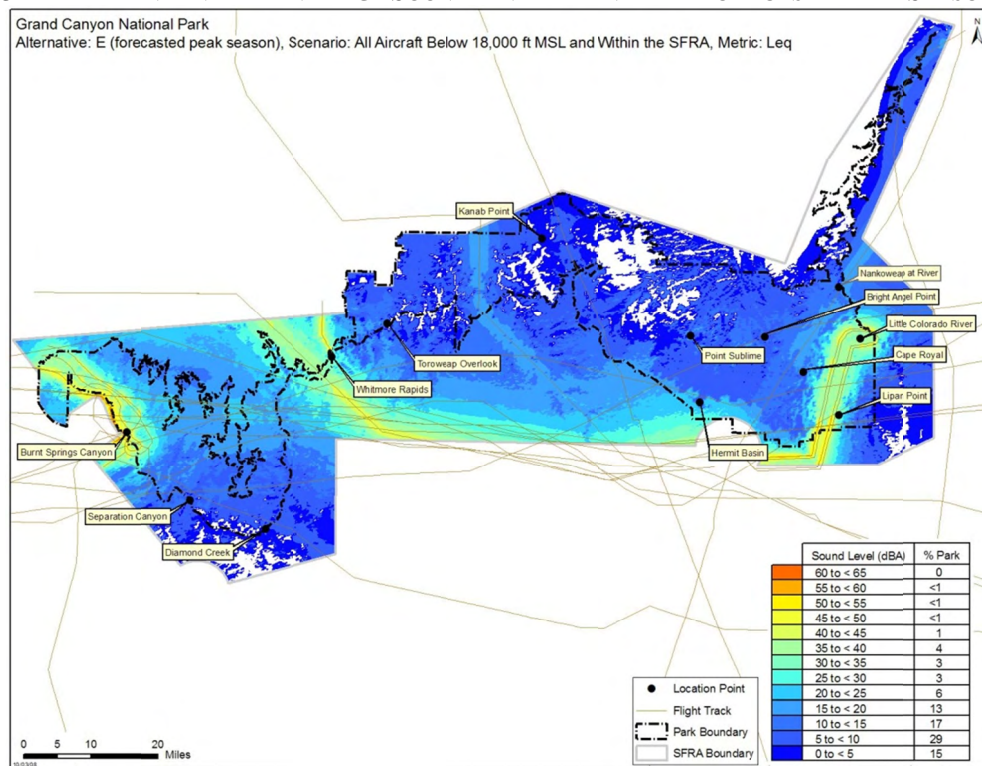
FIGURE 4.14 ALTERNATIVE E AVERAGE SOUND LEVEL BASE YEAR PEAK SEASON**FIGURE 4.15 ALTERNATIVE E AVERAGE SOUND LEVEL TEN-YEAR FORECAST PEAK SEASON**

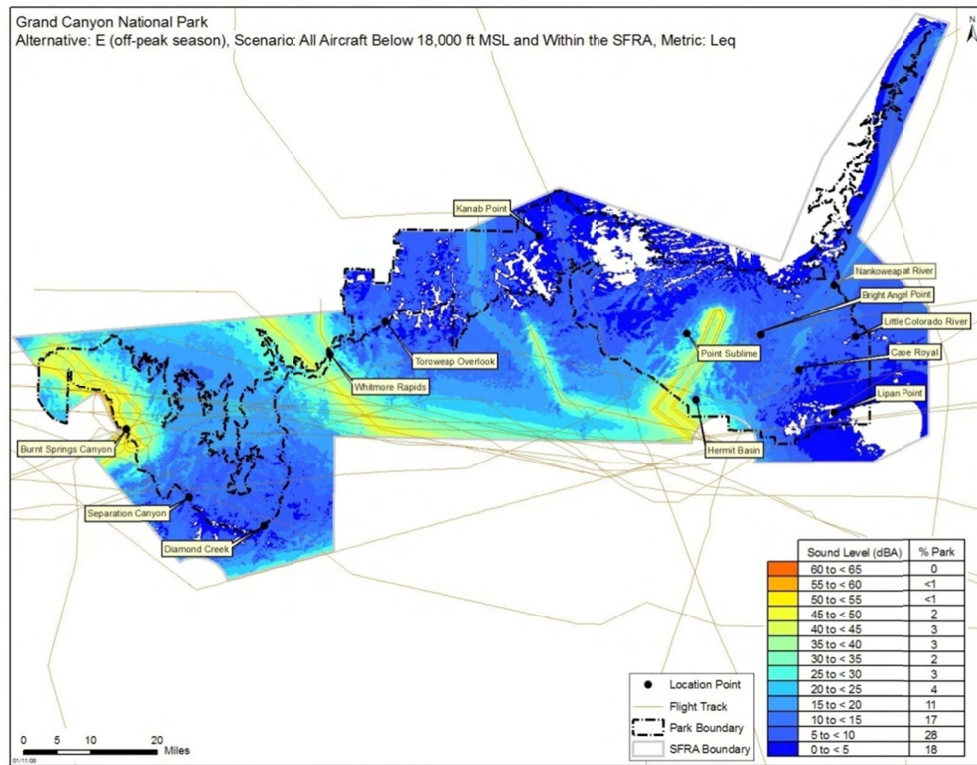
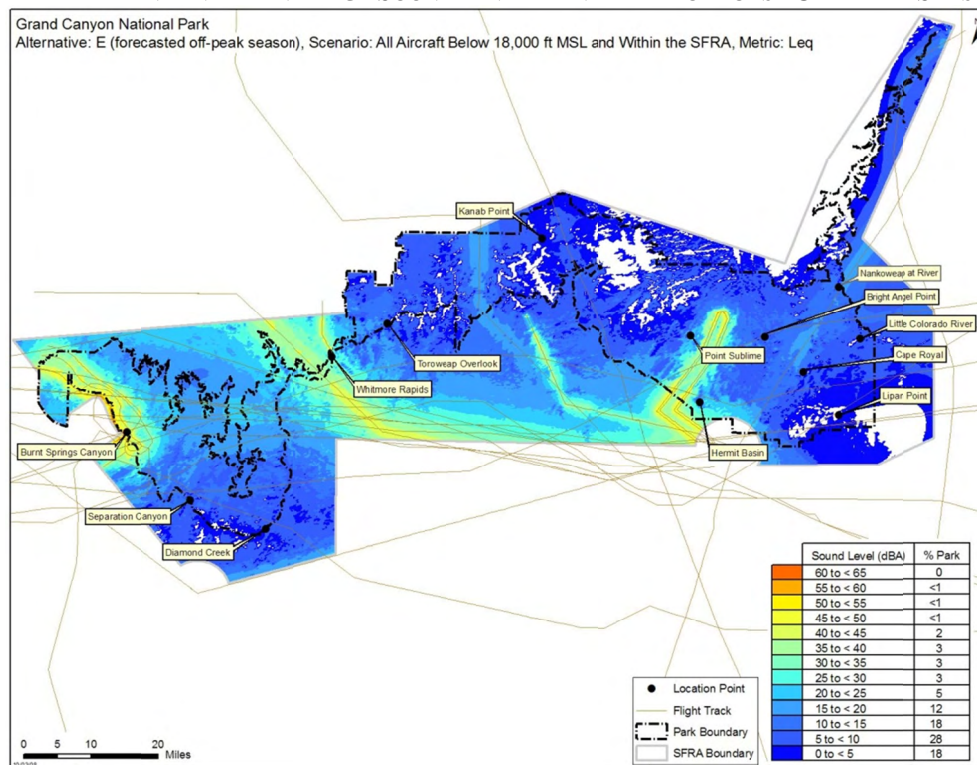
FIGURE 4.16 ALTERNATIVE E AVERAGE SOUND LEVEL BASE YEAR OFF-PEAK SEASON**FIGURE 4.17 ALTERNATIVE E AVERAGE SOUND LEVEL TEN-YEAR FORECAST OFF-PEAK SEASON**

TABLE 4.5 ALTERNATIVE E PERCENT TIME AUDIBLE CONTOUR ANALYSIS RESULTS
PEAK SEASON^{abc}

Percent Percent Time Audible	Base Year (Percent of Zone)				Ten-Year Forecast (Percent of Zone)			
	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP
Percent Park Restored				75%				84%
≥ 25	52%	52%	23%	25%	26%	21%	16%	16%
10 to < 25	17%	13%	7%	7%	32%	18%	8%	8%
5 to < 10	15%	5%	6%	6%	16%	15%	6%	6%
> 0 to < 5	16%	31%	63%	61%	25%	44%	69%	68%
Percent of Zone Difference in Percent Time Audible Contour Results with Alternative A								
≥ 25	36%	27%	20%	21%	64%	59%	29%	30%
10 to < 25	-11%	-5%	4%	3%	-27%	-12%	3%	2%
5 to < 10	-14%	-2%	0%	0%	-15%	-13%	0%	-1%
> 0 to < 5	-11%	-20%	-23%	-23%	-20%	-33%	-30%	-30%

^aDue to rounding differences, totals in this table may differ from Appendix D by up to 2%

^bBecause limited ambient data were available outside GCNP, contours for Percent Time Audible were computed only in GCNP boundaries; Average Sound Level contours were computed in the entire SFRA

^cColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

TABLE 4.6 ALTERNATIVE E AVERAGE SOUND LEVEL CONTOUR ANALYSIS RESULTS^{ab}

Average Sound Level	Base Year (Percent of Zone)					Ten-Year Forecast (Percent of Zone)				
	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP	In SFRA	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP	In SFRA
≥ 35	7%	6%	8%	8%	8%	5%	5%	6%	6%	6%
25 to < 35	12%	13%	5%	6%	9%	7%	10%	5%	5%	9%
15 to < 25	59%	41%	16%	18%	24%	62%	38%	18%	19%	24%
> 0 to < 15	22%	39%	60%	59%	51%	25%	47%	62%	61%	51%
Percent of Zone Difference in Average Sound Level Contour Results with Alternative A										
≥ 35	3%	15%	7%	7%	7%	19%	27%	16%	17%	8%
25 to < 35	43%	24%	7%	8%	7%	67%	47%	21%	23%	11%
15 to < 25	-26%	-13%	5%	4%	3%	-61%	-29%	20%	18%	16%
> 0 to < 15	-20%	-25%	-12%	-13%	-11%	-25%	-46%	-48%	-48%	-27%

^aDue to rounding differences, totals in this table may differ from Appendix D by up to 2%

^bColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

1 **TABLE 4.7 ALTERNATIVE E LOCATION POINT RESULTS PEAK SEASON ^a**

Location Point Grouping		Base Year					Ten-Year Forecast				
		TAUD ^b	L _{Aeq12} ^c	TALA 35 dBA ^d	TALA 45 dBA ^d	TALA 55 dBA ^d	TAUD	L _{Aeq12}	TALA 35 dBA	TALA 45 dBA	TALA 55 dBA
Marble Canyon	Max	1%	13 dBA	0%	0%	0%	1%	13 dBA	0%	0%	0%
	Median	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
East End	Max	88%	53 dBA	54%	15%	5%	66%	51 dBA	46%	12%	4%
	Median	17%	13 dBA	0%	0%	0%	10%	12 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	1 dBA	0%	0%	0%
Central	Max	15%	18 dBA	0%	0%	0%	16%	19 dBA	0%	0%	0%
	Median	1%	7 dBA	0%	0%	0%	1%	8 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
West End	Max	92%	47 dBA	70%	28%	4%	84%	46 dBA	65%	23%	4%
	Median	5%	18 dBA	0%	0%	0%	4%	19 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
All Location Points	Max	92%	53 dBA	70%	28%	5%	84%	51 dBA	65%	23%	4%
	Median	1%	11 dBA	0%	0%	0%	1%	10 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
Difference in Location Points Results with Alternative A											
Marble Canyon	Max	2%	11 dBA	1%	0%	0%	2%	12 dBA	1%	0%	0%
	Median	1%	14 dBA	0%	0%	0%	2%	16 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	2 dBA	0%	0%	0%
East End	Max	12%	-4 dBA	46%	36%	0%	34%	-2 dBA	54%	45%	1%
	Median	47%	15 dBA	5%	0%	0%	58%	17 dBA	6%	0%	0%
	Min	0%	6 dBA	0%	0%	0%	0%	6 dBA	0%	0%	0%
Central	Max	8%	9 dBA	4%	0%	0%	9%	9 dBA	4%	0%	0%
	Median	0%	3 dBA	0%	0%	0%	1%	3 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
West End	Max	1%	0 dBA	1%	0%	0%	12%	2 dBA	17%	10%	1%
	Median	14%	4 dBA	0%	0%	0%	17%	4 dBA	1%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
All Location Points	Max	8%	-4 dBA	30%	23%	0%	16%	-2 dBA	36%	3400%	100%
	Median	7%	5 dBA	0%	0%	0%	9%	8 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%

^aMax refers to maximum Location Point value for a Location Point grouping for each respective specific metric; conversely, Min refers to minimum Location Point value. The median characterizes the central tendency of the results. That is, 50% of results are above the median; 50% are below. The median, as opposed to the arithmetic mean, is more appropriate for data not normally distributed

^bTAUD = Percent Time Audible

^cL_{Aeq12} = Average Sound Level

^dTALA35 dBA, TALA45 dBA, and TALA55 dBA = Percent of time during the 12-hour day used in this analysis that aircraft sounds exceed 35, 45, and 55 dBA, respectively

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3
4

TABLE 4.8 ALTERNATIVE E PERCENT AUDIBLE CONTOUR ANALYSIS RESULTS
OFF-PEAK SEASON^{abc}

Percent Percent Time Audible	Base Year (Percent of Zone)				Ten-Year Forecast (Percent of Zone)			
	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP
% Park Restored				78%				86%
≥ 25	31%	26%	22%	22%	17%	14%	14%	14%
10 to < 25	17%	13%	7%	8%	32%	18%	6%	7%
5 to < 10	14%	10%	6%	6%	13%	11%	5%	6%
> 0 to < 5	36%	49%	64%	63%	35%	53%	72%	71%
% of Zone Difference in TAUD Contour Results with Alternative A								
≥ 25	57%	53%	21%	23%	73%	66%	31%	32%
10 to < 25	-11%	-5%	3%	3%	-27%	-12%	4%	3%
5 to < 10	-13%	-8%	0%	0%	-13%	-9%	0%	0%
> 0 to < 5	-32%	-38%	-24%	-25%	-31%	-42%	-34%	-34%

^aDue to rounding differences, totals in this table may differ from Appendix D by up to 2%

^bBecause limited ambient data were available outside GCNP, contours for Percent Time Audible were computed only in GCNP boundaries; Average Sound Level contours were computed in the entire SFRA

^cColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

TABLE 4.9 ALTERNATIVE E AVERAGE SOUND LEVEL CONTOUR ANALYSIS RESULT OFF-PEAK
SEASON^{ab}

Average Sound Level	Base Year (Percent of Zone)					Ten-Year Forecast (Percent of Zone)				
	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP	In SFRA	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP	In SFRA
≥ 35	0%	1%	8%	7%	8%	0%	0%	5%	5%	6%
25 to < 35	6%	11%	5%	5%	9%	5%	11%	5%	5%	10%
15 to < 25	48%	26%	15%	15%	21%	48%	23%	17%	17%	23%
> 0 to < 15	45%	55%	64%	63%	53%	46%	58%	64%	64%	53%
Percent of Zone Difference in Average Sound Level Contour Results with Alternative A										
≥ 35	10%	20%	8%	8%	6%	24%	32%	17%	18%	8%
25 to < 35	49%	26%	7%	8%	6%	70%	46%	21%	23%	11%
15 to < 25	-15%	3%	7%	6%	6%	-47%	-13%	22%	19%	18%
> 0 to < 15	-43%	-41%	-16%	-18%	-12%	-46%	-58%	-51%	-51%	-28%

^aDue to rounding differences, totals in this table may differ from Appendix D by up to 2%

^bColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

1 **TABLE 4.10 ALTERNATIVE E LOCATION POINT RESULTS OFF-PEAK SEASON^a**

Location Point Grouping		Base Year					Ten-Year Forecast				
		TAUD ^b	L _{Aeq12} ^c	TALA35 dBA ^d	TALA45 dBA ^d	TALA55 dBA ^d	TAUD	L _{Aeq12}	TALA35 dBA	TALA45 dBA	TALA55 dBA
Marble Canyon	Max	1%	13 dBA	0%	0%	0%	1%	13 dBA	0%	0%	0%
	Median	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
East End	Max	93%	46 dBA	34%	10%	3%	78%	44 dBA	29%	7%	2%
	Median	1%	8 dBA	0%	0%	0%	1%	9 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
Central	Max	25%	26 dBA	1%	0%	0%	20%	24 dBA	1%	0%	0%
	Median	1%	8 dBA	0%	0%	0%	1%	8 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
West End	Max	96%	48 dBA	82%	32%	5%	88%	46 dBA	74%	24%	4%
	Median	5%	19 dBA	0%	0%	0%	4%	20 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	1 dBA	0%	0%	0%
All Location Points	Max	96%	48 dBA	82%	32%	5%	88%	46 dBA	74%	24%	4%
	Median	2%	9 dBA	0%	0%	0%	1%	10 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
Difference in Location Points Results with Alternative A											
Marble Canyon	Max	2%	11 dBA	1%	0%	0%	2%	12 dBA	1%	0%	0%
	Median	1%	14 dBA	0%	0%	0%	2%	16 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	2 dBA	0%	0%	0%
East End	Max	7%	3 dBA	66%	41%	2%	21%	6 dBA	71%	50%	3%
	Median	63%	20 dBA	5%	0%	0%	66%	19 dBA	6%	0%	0%
	Min	0%	6 dBA	0%	0%	0%	0%	7 dBA	0%	0%	0%
Central	Max	-3%	1 dBA	3%	0%	0%	6%	3 dBA	4%	0%	0%
	Median	0%	2 dBA	0%	0%	0%	1%	2 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
West End	Max	-3%	0 dBA	-11%	-4%	0%	8%	2 dBA	8%	9%	2%
	Median	14%	3 dBA	0%	0%	0%	17%	3 dBA	1%	0%	0%
	Min	0%	-4 dBA	0%	0%	0%	0%	-1 dBA	0%	0%	0%
All Location Points	Max	4%	2 dBA	18%	19%	0%	12%	3 dBA	26%	33%	2%
	Median	7%	7 dBA	0%	0%	0%	9%	8 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%

^aMax refers to maximum Location Point value for a Location Point grouping for each respective specific metric; conversely, Min refers to minimum Location Point value. The median characterizes the central tendency of the results. That is, 50% of results are above the median; 50% are below. The median, as opposed to the arithmetic mean, is more appropriate for data not normally distributed

^bTAUD = Percent Time Audible

^cL_{Aeq12} = Average Sound Level

^dTALA35 dBA, TALA45 dBA, and TALA55 dBA = Percent of time during the 12-hour day used in this analysis that aircraft sounds exceed 35, 45, and 55 dBA, respectively

Developed Zone (about 2% of GCNP) Alternative E**Soundscape**

With exception of a very small Developed Zone area at Tuweep, all GCNP Developed Zone areas are in East End. Developed Zone audibility calculations added 10 dBA to natural ambient sound levels due to the Dual-Zone System acoustic approach explained in Chapter 4, Methodology. As such, analysis considers Developed Zone management objectives which accept presence of many non-natural sound sources (increased background ambient sound levels) including most of the park's visitors and their activities, presence of paved roads and motorized transportation, and developed facilities.

*Developed Zone**Alternative E**Soundscape**Base Year Peak Season*

Average Sound Level would generally be 25 dBA or more in 19% of the Developed Zone; that is, Average Sound Level would be 25 to 35 dBA in 12% of the Zone (moderate adverse impact) and greater than 35 dBA in 7% of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more in 69% of the Zone; that is Percent Time Audible of 10 to 25% in 17% of the Zone (moderate adverse impact) and greater than 25% in 52% of the Zone (major adverse impact). This would represent a reduction of 46% in area with Average Sound Level 25 dBA or more, and a reduction of 25% in area of 10% or more Percent Time Audible compared to Alternative A (a 25 to 46% reduction in areas of moderate to major adverse impact), resulting in a moderate to major beneficial change in impacts compared to Alternative A.

*Developed Zone**Alternative E**Soundscape**Base Year Off-Peak Season*

Average Sound Level would generally be greater than 25 dBA in 6% of the Developed Zone; that is, Average Sound Level would be 25 to 35 dBA in 6% of the Zone (moderate adverse impact) and no areas greater than 35 dBA in the Zone (no areas of major adverse impact in terms of Average Sound Level). Percent Time Audible would generally be 10% or more of the day in 48% of the Zone; that is 10 to 25% Percent Time Audible in 17% of the Zone (moderate adverse impact) and Percent Time Audible greater than 25% in 31% of the Zone (major adverse impact). This would represent a reduction of 59% in area with Average Sound Level of 25 dBA or more, and a reduction of 46% in area of 10% or more Percent Time Audible compared to Alternative A (a 46 to 59% reduction in areas of moderate to major adverse impact), resulting in a major beneficial change in impacts compared to Alternative A.

*Developed Zone**Alternative E**Soundscape**Ten-Year Forecast Peak Season*

Average Sound Level would generally be greater than 25 dBA in 12% of the Developed Zone; that is, Average Sound Level would be 25 to 35 dBA in 7% of the Zone (moderate adverse impact), and greater than 35 dBA in 5% of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more in 58% of the Zone; that is, 10 to 25% Percent Time Audible in 32% of the Zone (moderate adverse impact), and greater than 25% Percent Time Audible in 26% of the Zone (major adverse impact). This would represent a reduction of 86% in area with Average Sound Level of 25 dBA or more, and a reduction of 37% in area of 10% or more Percent Time Audible compared to Alternative A (a 37 to 86% reduction in areas of moderate to major adverse impact), resulting in a major beneficial change in impacts compared to Alternative A.

*Developed Zone**Alternative E**Soundscape**Ten-Year Forecast Off-Peak Season*

Average Sound Level would generally be greater than 25 dBA in 5% of the Developed Zone; that is, Average Sound Level would be 25 to 35 dBA in 5% of the Zone (moderate adverse impact), and no areas in the Zone would be greater than 35 dBA (no areas of major adverse impact). Percent Time Audible would generally be 10% or more in 49% of the Zone; that is, 10 to 25% Percent Time Audible in 32% of the Zone (moderate adverse impact), and greater than 25% Percent Time Audible in 17% of the Zone (major adverse impact). This would represent a reduction of 94% in area with Average Sound Level of 25 dBA or more, and a reduction of 46% in area of 10% or more Percent Time Audible compared to Alternative A (a 10 to 94% reduction in areas of moderate to major adverse impact), resulting in a moderate to major beneficial change in impacts compared to Alternative A.

Non-Wilderness Zone (6% of GCNP) Alternative E Soundscape

Almost all Non-Wilderness Zone areas are located in East End (exceptions are a few Central area dirt road corridors). A portion of the Non-Wilderness Zone is in the Dual-Zone System area where 10 dBA is added to natural ambient sound levels for audibility calculations; this portion is generally close to Developed Zone areas with motorized noise sources, although there is a strip of Non-Wilderness Zone on Marble Canyon's east side. The majority of the Non-Wilderness Zone is in the area where natural ambient sound levels are used directly as the basis for audibility calculations, consistent with Non-Wilderness Zone management objectives that call for mostly natural conditions to prevail in the Zone.

Non-Wilderness Zone Alternative E Soundscape *Base Year Peak Season*

Average Sound Level would generally be 25 dBA or more in 19% of the Zone; that is, Average Sound Level would be 25 to 35 dBA in 13% of the Zone (moderate adverse impact), and greater than 35 dBA in 6% of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more of the day in 65% of the Zone; that is, 10 to 25% Percent Time Audible in 13% of the Zone (moderate adverse impact), and greater than 25% Percent Time Audible in 52% of the Zone (major adverse impact). This would represent a reduction of 39% in area with Average Sound Level of 25 dBA or more, and a reduction of 47% in area of 10% or more Percent Time Audible compared to Alternative A (a 39 to 47% reduction in areas of moderate to major adverse impact), resulting in a major beneficial change in impacts compared to Alternative A.

Non-Wilderness Zone Alternative E Soundscape *Base Year Off-Peak Season*

Average Sound Level would generally be greater than 25 dBA in 12% of the Zone; that is, Average Sound Level would be 25 to 35 dBA in 11% of the Zone (moderate adverse impact), and greater than 35 dBA in one percent of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more of the day in 39% of the Zone; that is, 10 to 25% Percent Time Audible in 13% of the Zone (moderate adverse impact), and greater than 25% Percent Time Audible in 26% of the Zone (major adverse impact). This would represent a reduction of 46% in area with Average Sound Level of 25 dBA or more, and a reduction of 48% in area of 10% or more Percent Time Audible compared to Alternative A (a 46 to 48% reduction in areas of moderate to major adverse impact), resulting in a major beneficial change in impacts compared to Alternative A.

Non-Wilderness Zone Alternative E Soundscape *Ten-Year Forecast Peak Season*

Average Sound Level would generally be greater than 25 dBA in 15% of the Zone; that is, Average Sound Level would be 25 to 35 dBA in 10% of the Zone (moderate adverse impact), and greater than 35 dBA in 5% of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more in 39% of the Zone; that is, 10 to 25% Percent Time Audible in 18% of the Zone (moderate adverse impact), and greater than 25% Percent Time Audible in 21% of the Zone (major adverse impact). This would represent a reduction of 74% in area with Average Sound Level of 25 dBA or more, and a reduction of 47% in area of 10% or more Percent Time Audible compared to Alternative A (a 47 to 74% reduction in areas of moderate to major adverse impact), resulting in a major beneficial change in impacts compared to Alternative A.

Non-Wilderness Zone Alternative E Soundscape *Ten-Year Forecast Off-Peak Season*

Average Sound Level would generally be greater than 25 dBA in 11% of the Zone; that is, Average Sound Level would be 25 to 35 dBA in 11% of the Zone (moderate adverse impact), and no areas of the Zone would be greater than 35 dBA (no areas of major adverse impact in the Zone). Percent Time Audible would generally be 10% or more in 32% of the Zone; that is, 10 to 25% Percent Time Audible in 18% of the Zone (moderate adverse impact), and greater than 25% Percent Time Audible in 14% of the Zone (major adverse impact). This would represent a reduction of 78% in area with Average Sound Level of 25 dBA or more, and a reduction of 61% in area of 10% or more Percent Time Audible compared to Alternative A (a 61 to 78% reduction in areas of moderate to major adverse impact), resulting in a major beneficial change in impacts compared to Alternative A.

Wilderness Zone (94% of GCNP) Alternative E Soundscape

In the Wilderness Zone, results vary to a greater degree than in Developed and Non-Wilderness Zones due to the Wilderness Zone increased size and geographic extent as compared to the others. Most of the Wilderness Zone is in the area where natural ambient sound levels are used directly in audibility calculations in the Dual-Zone System acoustic approach to noise modeling. Exceptions are West End and Marble Canyon.

Wilderness Zone Alternative E Soundscape *Base Year Peak Season*

Average Sound Level would generally be 25 dBA or more in 13% of the Zone; that is, Average Sound Level would be 25 to 35 dBA in 5% of the Zone (moderate adverse impact), and greater than 35 dBA in 8% of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more in 30% of the Zone; that is, one to 25% Percent Time Audible in 7% of the Zone (moderate adverse impact), and greater than 25% Percent Time Audible in 23% of the Zone (major adverse impact). This would represent a 37% reduction in area with Average Sound Level of 25 dBA or more and a reduction of 32% in area of 10% or more Percent Time Audible compared to Alternative A (a 32 to 37% reduction in areas of moderate to major adverse impact), resulting in a major beneficial change in impacts compared to Alternative A.

Wilderness Zone Alternative E Soundscape *Base Year Off-Peak Season*

Average Sound Level would generally be greater than 25 dBA in 13% of the Zone; that is, Average Sound Level would be 25 to 35 dBA in 5% of the Zone (moderate adverse impact) and greater than 35 dBA in 8% of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more of the day in 29% of the Zone; that is 10 to 25% Percent Time Audible in 7% of the Zone (moderate adverse impact) and greater than 25% Percent Time Audible in 22% of the Zone (major adverse impact). This would represent a reduction of 15% in area with Average Sound Level of 25 dBA or more and a reduction of 24% in area of 10% or more Percent Time Audible compared to Alternative A (a 15 to 24% reduction in areas of moderate to major adverse impact), resulting in a moderate beneficial change in impacts compared to Alternative A.

Wilderness Zone Alternative E Soundscape *Ten-Year Forecast Peak Season*

Average Sound Level would generally be greater than 25 dBA in 11% of the Zone; that is, Average Sound Level would be 25 to 35 dBA in 5% of the Zone (moderate adverse impact) and greater than 35 dBA in 6% of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more of the day in 24% of the Zone; that is, 10 to 25% Percent Time Audible in 8% of the Zone (moderate adverse impact) and greater than 25% Percent Time Audible in 16% of the Zone (major adverse impact). This would represent a reduction of 37% in area with Average Sound Level of 25 dBA or more and a reduction of 32% in area of 10% or more Percent Time Audible compared to Alternative A (a 32 to 37% reduction in areas of moderate to major adverse impact), resulting in a major beneficial change in impacts compared to Alternative A.

Wilderness Zone Alternative E Soundscape *Ten-Year Forecast Off-Peak Season*

Average Sound Level would generally be greater than 25 dBA in 10% of the Zone; that is, Average Sound Level would be 25 to 35 dBA in 5% of the Zone (moderate adverse impact) and greater than 35 dBA in 5% of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more of the day in 20% of the Zone; that is, 10 to 25% Percent Time Audible in 6% of the Zone (moderate adverse impact) and greater than 25% Percent Time Audible in 14% of the Zone (major adverse impact). This would represent a reduction of 38% in area with Average Sound Level of 25 dBA or more and a reduction of 35% in area of 10% or more Percent Time Audible compared to Alternative A (a 35 to 38% reduction in areas of moderate to major adverse impact), resulting in a major beneficial change in impacts compared to Alternative A.

Marble Canyon Alternative E Soundscape

Marble Canyon's west side is in the Wilderness Zone; it's east side in the Non-Wilderness Zone. It is also entirely in the Dual-Zone System noticeability area in which 10 dBA is added to natural ambient sound levels in calculating Percent Time Audible (Chapter 4, Methodology). Seasonal use of Dragon and Zuni Point Corridors would not affect

this area. In Marble Canyon, based on Figures 4.10 to 4.17, air-tour aircraft Average Sound Level would be barely audible at less than 15 dBA), due to Bright Angel Flight-free Zone being substantially enlarged by extending its boundary north to include all of Marble Canyon.

Marble Canyon

Alternative E

Soundscape

All Scenarios

Marble Canyon Location Points Percent Time Audible range zero to one percent, and Average Sound Level zero to 13 dBA Peak and Off-Peak Seasons. Results would be nearly identical (within Percent Time Audible of one percent and one dBA Average Sound Level) Base Year to Ten-Year Forecast. These values represent negligible impacts and negligible to minor beneficial changes in impacts compared to Alternative A.

East End

Alternative E

Soundscape

Under Alternative E, as in Alternative A, greatest exposure to noise and visual impacts would continue East End. However, air-tour sounds would be reduced beneath Dragon Corridor when closed Peak Season and conversely, beneath Zuni Point Corridor when closed Off-Peak Season. This would result in a major beneficial change in impacts compared to Alternative A. Alternative E curfews would benefit Soundscape in all East End Management Zones.

East End

Alternative E

Soundscape

Base Year Peak Season

East End Location Points would range zero to 88% Percent Time Audible (median 17%), and zero to 53 dBA (median 13 dBA). At some locations, aircraft events would exceed 35 dBA for 54% of the day, 45 dBA for 15% of the day, and 55 dBA for 5% of the day. Because this represents a 47% reduction in median Percent Time Audible and a 12% reduction in maximum Percent Time Audible, this would be a moderate to major beneficial change in East End impacts compared to Alternative A. Localized long- and short-term adverse impacts would be major in areas near Zuni Point Corridor, and comparable to Alternative A (from Figures 4.10 to 4.17, Average Sound Level would be 40 to 50 dBA, Percent Time Audible would be greater than 75%). Impacts would be negligible to minor in areas near Dragon Corridor; a major beneficial change in impacts compared to Alternative A. Although the majority of Location Points do not experience Average Sound Level greater 35 dBA, two Location Points (**Grid Location Point 14 and Temple Butte**) show Average Sound Level as high as 45 to 55 dBA with Percent Time Audible 5 to 10%.

East End

Alternative E

Soundscape

Base Year Off-Peak Season

East End Location Points would range zero to 93% Percent Time Audible (median 1%), and zero to 46 dBA (median 8 dBA). At some locations, aircraft events would exceed 35 dBA for 34% of the day, 45 dBA for 10% of the day, and 55 dBA for 3% of the day. Because this represents a 63% reduction in median Percent Time Audible and a 7% reduction in maximum Percent Time Audible, this would be a minor to major beneficial change in East End impacts compared to Alternative A. Localized long- and short-term adverse impacts would be major in areas near Dragon Corridor and comparable to Alternative A (from Figures 4.10 to 4.17, Average Sound Level would be 40 to 50 dBA, Percent Time Audible would be greater than 75%). Impacts would be negligible to minor adverse in areas near Zuni Point Corridor, a major beneficial change in impacts compared to Alternative A. Although the majority of Location Points do not experience Average Sound Level greater 35 dBA, three Location Points (**96-mile Camp, Eremita Mesa, and Tower of Ra**) show Average Sound Level as high as 45 to 55 dBA with Percent Time Audible 5 to 10% of the day.

East End

Alternative E

Soundscape

Ten-Year Forecast Peak Season

East End Location Points would range zero to 66% Percent Time Audible (median 10%); a 20% reduction in maximum Percent Time Audible Base Year to Ten-Year Forecast, and a 5% reduction in median Percent Time Audible Base Year to Ten-Year Forecast, because Alternative E includes quiet-technology incentives and conversion requirements. Average Sound Level would range one to 51 dBA (median 12 dBA), within one dBA of Average Sound Level Base Year. This represents a 58% reduction in median Percent Time Audible, and a 34% reduction in maximum Percent Time Audible. Impacts would be negligible to minor adverse under and near Dragon Corridor (a major beneficial change from Alternative A); major adverse under and near Zuni Point

Corridor (a negligible change from Alternative A); negligible across North Rim (a moderate to major beneficial change from Alternative A); and negligible to minor adverse away from active routes and amid Bright Angel Flight-free Zone (a negligible change from Alternative A).

East End *Alternative E* *Soundscape*

Ten-Year Forecast Off-Peak Season

East End Location Points Percent Time Audible would range zero to 78% (median one percent), and Average Sound Level zero to 44 dBA (median 9 dBA). Compared to Base Year Off-Peak Season, this represents no change in median Percent Time Audible but a 15% reduction in maximum Percent Time Audible; this also represents negligible change in median and Average Sound Level (changes of one and 2 dBA). This represents a 66% reduction in median Percent Time Audible, and a 21% reduction in maximum Percent Time Audible, due in large part to Alternative E quiet-technology conversion requirements. Impacts would be major adverse under and near Dragon Corridor (a negligible change from Alternative A); negligible to minor adverse under and near Zuni Point Corridor (a major beneficial change from Alternative A); negligible across North Rim (a moderate to major beneficial change from Alternative A); and negligible to minor adverse away from active routes and amid Bright Angel Flight-free Zone (a negligible change from Alternative A).

Central **Alternative E** **Soundscape**

The Central area is located in the Wilderness Zone, with exception of a few Non-Wilderness Zone dirt road corridors, and a very small Developed Zone area at Tuweep. The Central area is entirely in the Dual-Zone System audibility area in which natural ambient sound levels are used directly in calculations of Percent Time Audible. This area comprises most of the Toroweap/Shinumo Flight-free Zone, and is transected by two general-aviation corridors.

Central *Alternative E* *Soundscape*

Base and Ten-Year Forecast Peak Season

Base Year **Central area Location Points** range zero to 15% Percent Time Audible (median one percent), and Average Sound Level zero to 18 dBA (median 7 dBA). Impacts would be negligible to minor adverse, a minor beneficial change in impacts compared to Alternative A. Results are nearly identical (one percent and one dBA) Ten-Year Forecast. Modified Blue Direct routes contribute to slightly lower Average Sound Level and Percent Time Audible.

Central *Alternative E* *Soundscape*

Base Year and Ten-Year Forecast Off-Peak Season

Central area Location Points Percent Time Audible range zero to 25% (median one percent), and Average Sound Level zero to 26 dBA (median 8 dBA). These increases over Peak Season results are due to increased operations on the modified Blue Direct route Off-Peak Season. There would be negligible changes in impacts Base Year to Ten-Year Forecast. Impacts would range from negligible to moderate adverse with negligible change in impacts compared to Alternative A Base Year Off-Peak Season.

West End **Alternative E** **Soundscape**

West End is located in the Wilderness Zone and entirely in the Dual-Zone System noticeability area in which 10 dBA is added to natural ambient sound levels in Percent Time Audible calculations. Impacts to West End areas tend to be much localized, depending on proximity to Blue Direct and Blue-2/Green-4 routes. Blue-2/Green-4 would be the same as under Alternative A. Blue Direct North would be moved east and shortened over GCNP, and Blue Direct South would be eliminated.

West End *Alternative E* *Soundscape*

Base Year and Ten-Year Forecast Peak Season

West End Location Points Percent Time Audible ranges zero to 92% (median 5%), and Average Sound Level zero to 47 dBA (median 18 dBA). At some locations, aircraft events would exceed 35 dBA for 70% of the day, 45 dBA for 28% of the day, and 55 dBA for 4% of the day. Peak Season Ten-Year Forecast, Average Sound Level would be essentially unchanged from Base Year, but maximum Percent Time Audible would be reduced 8% due to Alternative E quiet-technology conversion requirements. Median Percent Time Audible would be