CHAPTER 4

ENVIRONMENTAL CONSEQUENCES

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4. ENVIRONMENTAL CONSEQUENCES

Chapter 4 of this environmental impact statement assesses and compares the potential environmental consequences of the alternatives described in Chapter 2.

In addition to providing an assessment of direct and indirect impacts of each alternative, this chapter also contains a cumulative effects assessment, which outlines the resulting effects on each resource when added to the effects of past, present, and reasonably foreseeable actions within each resource area's region of influence.

For a summary of the major findings documented in this Chapter, see Chapter 2, Table 2–12, which is the summary table of environmental consequences.

The National Aeronautics and Space Administration (NASA) Sounding Rockets Program (SRP) operations at Poker Flat Research Range (PFRR) consist principally of a series of suborbital rocket flights followed by recovery actions.

In general, each SRP launch at PFRR typically entails the following programmatic components that could result in environmental effects and are therefore considered within this Chapter of the environmental impact statement (EIS):

1. Preflight activities, including receiving, storing, and inspecting rockets and assembling the scientific payload;

2. Assembling rockets and scientific payload to make up the launch vehicle, transporting the launch vehicle to the launch pad, mounting the vehicle to the launcher, and pointing the launcher;

3. Releasing small meteorological balloons, which have payloads recording data on upper-atmospheric weather conditions;

4. Series launching of two small test rockets nearby for radar and telemetry checkout/calibration;

5. The actual launching of the sounding rocket and surface-to-surface flight, lasting a matter of minutes;

6. Immediate post-flight activities, including, in some cases, recovery of the payload and spent stages, and storing of the launch equipment; and

7. Longer-term closure activities, such as removing identified spent stages and payloads from downrange impact sites, and restoring these sites to their original condition.

How Impacts are Described in this EIS

Project-related environmental impacts are described by their type, context, intensity, and duration for each affected resource area. The levels of impacts and their specific definitions vary based on the resource that is being evaluated. For example, the scale at which an impact may occur (local, regional, etc.) would be different for wetland impacts as compared to economic resources. Moreover, an otherwise minor impact occurring within a sensitive area could be considered major given the environmental context.

Table 4–1 provides a general overview of how potential impacts are evaluated in this EIS. Specific considerations that are only applicable to a resource area are described within its respective section.

Table 4–1. Evaluation Criteria for Analyzing Environmental Impacts

Type of Impact	
Adverse	The impact would result in some level of environmental degradation.
Beneficial	The impact would result in some level of environmental improvement.
Context of Impact	
Local	The impact would not extend beyond the immediate vicinity of the action causing the effect.
Regional	The impact would occur over a larger geographic scale, such as an ecoregion.
Global	The impact would occur at the global level.
Intensity of Impact (how much)	
Major	Substantial impact on or change in a resource area that is easily defined, noticeable, and/or calculable but may not be measurable, or exceeds a threshold level that may threaten the integrity of one or more resource components.
Moderate	Noticeable change in a resource occurs, but the integrity of the resource remains intact.
Minor	The impact is at the lowest levels of detection (barely measurable and with no perceptible consequences) or would result in only a minor change in a resource.
Negligible	Impact is at the lowest level of measurement or is so low as to be immeasurable and has no perceptible consequences.
Duration of Impact (how long)	
Long-Term	The impact would likely persist for a period greater than the medium-term impact and, depending on the specific resource and project type, would likely extend beyond the life of the project.
Medium-Term	The impact would only occur for specific, relatively brief periods during the project life, interrupted by periods of no impacts (for example, during recovery operations).
Short-Term	The impact would extend for short periods much less than the overall project life (for example, during launch operations).

Assumptions

The characteristics (*e.g.,* launch vehicle, trajectory, and payload) and frequency of missions conducted at PFRR are highly dependent upon the scientific objectives of the sponsoring researcher and NASA's scientific priorities. Therefore, it is not possible to assess every possible mission scenario that could be proposed for PFRR in the next 10 years.

Accordingly, NASA made certain assumptions regarding the types of rocket, payload, and recovery operations that would most likely occur; these were based primarily upon past experience, interviews with key personnel, and best professional judgment. These assumptions are detailed in Appendices F and G; however, the key overarching assumptions for assessing impacts are listed below:

- Future launches from PFRR would consist primarily of two- and four-stage rockets (the Terrier-Improved Orion [T-IO] and the Black Brant [BB] XII);
- Launch frequency would average four launches per year, not exceeding eight in any given year;
- Launch trajectories would be similar to those flown over the past 10 years;
- Launches would occur during winter months (December–April); and
- Recovery operations would occur during non-winter months (May–September) unless necessitated by a safety requirement or scientific need.

Additional assumptions that are only useful for assessing the effects on a particular resource area are presented in its respective methodology section.

It is important for the reader of this *Environmental Impact Statement for the Sounding Rockets Program at Poker Flat Research Range (PFRR EIS)* to recognize that recovery efforts would only be undertaken if a post-launch (or post-report in the case of an existing stage or payload identified by a person or group not related to PFRR operations) search flight resulted in the positive identification of NASA SRP associated hardware. In the case of newly launched hardware, recent searches have resulted in the identification of approximately half of the known items. This success rate is expected to increase as location devices are improved; however, the reader should not assume that all downrange flight hardware would be found in every case. Therefore, the most reliable (and conservative) product of the assumptions outlined in Appendix F is an estimated quantification of fuel usage (and resulting air emissions) of recovery-related vehicles. Estimates of flight times (and fuel usage) associated with both search and recovery would be considered conservative in that greater emissions would occur when conducting both activities. This would also be the case for noise, in which removal activities would generate more human-induced sounds into the natural environment. However, when other resource areas, such as the wilderness values of special use lands, are considered, these scenarios may underestimate impacts in that it is likely not all hardware would be removed. Therefore, a range of potential outcomes could result, and the reader should be aware that when appropriate, these ranges are presented for consideration.

How Probability is Considered

The analysis of several key resource areas, including wildlife, land use, and safety, rely heavily on numerical probabilities of flight hardware landing within a particular area of interest. During both pre-mission planning and in real time during the launch sequence, NASA calculates the estimated impact points for the sounding rocket stages and the payloads based on information known about the launch (*e.g.*, azimuth, payload weight, direction, and wind speed). While these calculations provide NASA's best estimates of where these items are expected to impact the Earth, there is a level of uncertainty associated with these estimates because of the large number of variables associated with each launch (explained in more detail in Chapter 2, Section 2.1). These variations become even more pronounced the higher the payload or spent stage is launched.

Each mission employs a specific trajectory and it is not practical to estimate potential future impacts from each specific past mission. Evaluation of past launch data, however, can identify trends and areas most likely to be affected by future launches, resulting in a more focused analysis. For this EIS, typical impact locations were established at seven different distances from the PFRR launch site, covering a range of possible launch vehicles, to determine the probability of a spent stage or payload landing within a number of potential areas of concern (see Appendix G) and to develop search and recovery scenarios (see Appendix F). These impact points represent composite points for a number of rocket launches from PFRR over the years. They are not intended to represent the predicted impact points for all future NASA SRP launches from PFRR, but are intended to show where future launches are most likely to occur and to graphically illustrate the typical uncertainty, or dispersion, associated with the most common vehicles. The distances established are as follows:

- 2 kilometers (1.2 miles) – 1st stage of BB IX or BB XII
- 13 kilometers (8.1 miles) – 1st stage of T-IO or 2nd stage of BB XII
- 55 kilometers (35 miles) – Orion
- 200 kilometers (120 miles) – 2nd stage of Mark 12 T-IO
- 300 kilometers (180 miles) – 2nd stage of BB IX or BB X
- 350 kilometers (220 miles) – 3rd stage of BB XII or 2nd stage of Mark 70 T-IO
- 1,000 kilometers (620 miles) – 4th stage of BB XII

These areas are shown below in **Figure 4–1**. More information regarding this methodology is contained within Appendix G.

How this Chapter is Organized

Similar to Chapter 3 of this EIS, Chapter 4 is organized by resource area. For each resource, a brief introduction is provided, followed by a summary of the analytical methodology and specific assumptions used to support the analysis, and then concluding with a presentation of impacts for each alternative. Where relevant, impacts of each alternative on a resource are presented by the phase of operations to which they correspond (*e.g.*, launch or search and recovery).

Consideration of Non-Winter Launches

For some resource areas, a general discussion of potential impacts occurring from non-winter launches is presented. Although non-winter launches have not occurred within recent years, and are not expected to occur, the potential for their proposal cannot be completely discounted. Therefore, a high-level assessment of potential effects and necessary considerations is provided as a means to identify relevant issues that would need to be addressed should the need for such an operation arise. Given only the cursory level of assessment of potential effects in this *PFRR EIS*, especially those related to wildfire, any future proposals for non-winter launches would require more focused, mission-specific National Environmental Policy Act (NEPA) assessment, as appropriate.

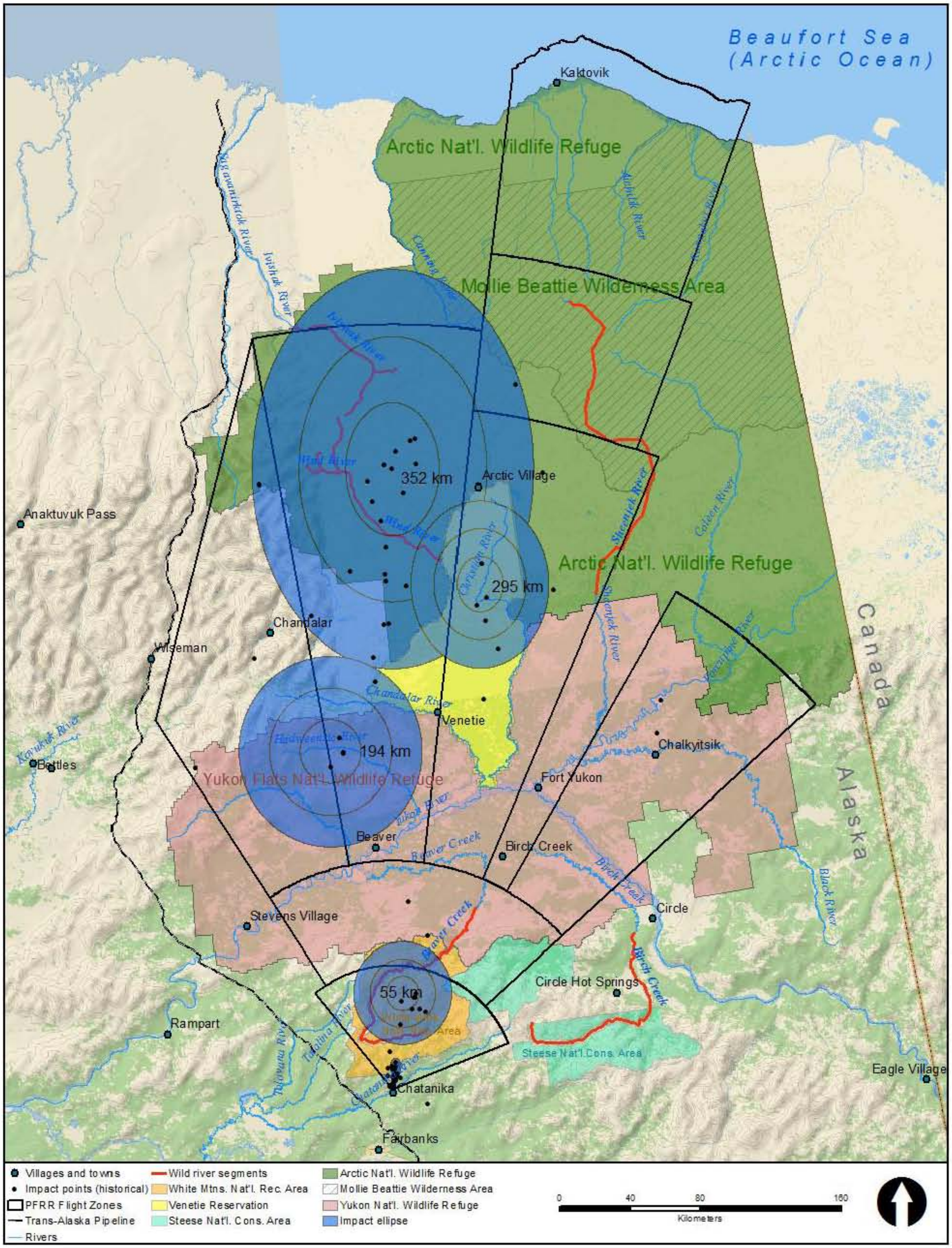


Figure 4–1. Typical Landing Areas Established for Analysis of Impacts

4.1 AIR QUALITY

This section describes potential impacts on air quality in and around PFRR and under the launch corridor as a result of the alternatives.

4.1.1 Methodology

Under the Clean Air Act (CAA), emissions of stationary sources are regulated through emission standards for certain categories of sources and permitting programs for new and modified sources. Emissions from mobile sources (*e.g.,* cars and trucks) are regulated through standards for fuel production and vehicle efficiency. Mobile sources such as sounding rockets; however, are not regulated by the CAA.

PFRR activities that may affect air quality include conducting routine site operations (*e.g.,* heating of buildings, use of electricity), use of employee vehicles and delivery vehicles, rocket launches, and search and recovery activities. Emissions from ongoing, routine activities at PFRR were quantified based on recent fuel and electricity use (see Chapter 3, Section 3.1). Emissions from sounding rocket launches were quantified for vehicles that are expected to be used the most frequently in the future. Emissions from rocket launches vary depending on the launch vehicle, but typically include emissions of carbon dioxide, carbon monoxide, nitrogen dioxide, aluminum oxide, and other particulate matter. Emissions from launches analyzed in this *PFRR EIS* were estimated assuming up to four launches of BB XII rockets (see **Table 4–2**) and four launches of T-IO rockets (see **Table 4–3**) per year. Although other launch vehicles may be used at PFRR, the number of launches and amount of emissions in any year are expected to be less than the total emissions from this combination.

Table 4–2. Black Brant XII Rocket Launch Air Pollutant Emissions (kilograms)

Pollutant	Stage 1[a] (Talos) (0.2 to 1.9 km)	Stage 2[a] (Taurus) (4.2 to 6.3 km)	Stage 3[b, c] (Black Brant V) (10.6 to 58.9 km)	Stage 4[b, c] (Nihka) (96.0 to 153.5 km)	Total
Carbon dioxide	469	175	14	9	667
Carbon monoxide	465	333	228	66	1,092
Lead	22	11	0	0	33
Hydrogen chloride	0	0	187	67	254
Aluminum oxide	0	0	357	106	463
Sulfur	0	0	1	1	2
Other	0	0	4	2	6

a. Emissions from Stages 1 and 2 are to the lower atmosphere.
b. Emissions from Stages 3 and 4 are to the upper atmosphere.
c. Aluminum oxide would be emitted as particulate matter.
Note: To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.
Key: km=kilometers.
Source: NASA 2000a.

Table 4–3. Terrier-Improved Orion Rocket Launch Air Pollutant Emissions (kilograms)

Pollutant	Stage 1[a] (Terrier) (0 to 1.5 km)	Stage 2[b] (Orion) (10 to 52 km)	Total
Carbon dioxide	160	44	204
Carbon monoxide	228	50	278
Lead	10	0	10
Hydrogen chloride	0	64	64
Aluminum oxide[c]	0	31	31
Sulfur	0	1	1
Copper	0	1	1
Other	0	0	0

a. Emissions from Stage 1 are to the lower atmosphere.
b. Emissions from Stage 2 are to the upper atmosphere.
c. Aluminum oxide would be emitted as particulate matter.
Note: To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.
Key: km=kilometers.
Source: NASA 2000.

Emissions from search and recovery activities were based on the estimated number of helicopter and airplane flights per year for each alternative; flight time required for search and recovery in various areas, as described in Appendix F; typical emissions for hourly operation of this equipment; and emissions for landing and takeoff operations. Aircraft emission rates were obtained from the Federal Aviation Administration's EDMS [Emissions and Dispersion Modeling System] program for aircraft emissions **(FAA 2010)**. Emissions for truck transport and fuel delivery operations during recovery operations were based on miles traveled and emission rates obtained from the U.S. Environmental Protection Agency's (EPA) Mobile 6.2 emission factor model for vehicles **(USEPA 2003)**.

For the evaluation of magnitude of air quality impacts, major impacts would be any that result in concentrations that exceed ambient standards and result in degradation of air quality in a nonattainment area.[1] Moderate impacts would be any that result in an increase in ambient concentrations of more than 10 percent of the ambient standard; or an increase in toxic pollutant concentrations above a guideline level. For mobile source emissions, a moderate impact would equate to an increase in emissions greater than 250 tons (230 metric tons) per year for any criteria pollutant. This value is used by the EPA in its New Source Review standards as an indicator for impact analysis for listed new major stationary sources in attainment areas. No similar regulatory threshold is available for mobile source emissions. Lacking any mobile source emissions thresholds, the 250-ton-per-year (230-metric-ton-per-year) per year major stationary source threshold was used to equitably assess and compare mobile source emissions.

[1] A nonattainment area is an area that the U.S. Environmental Protection Agency has determined does not meet one or more of the National Ambient Air Quality Standards for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may meet the standards for some pollutants, but not for others.

Minor impacts would be any that result in increases of pollutant that are less than the levels specified as moderate impacts, but greater than negligible impacts, which are immeasurable.

For the evaluation of duration of air quality impacts, short-term impacts would be any that occur for brief periods that are much less than the total project life, such as from rocket launches. Medium-term impacts would be any that occur for relatively brief periods less than the total project life but may occur repeatedly, such as from search and recovery operations. Long-term impacts would be any that occur for periods longer than medium-term and as long as the life of the project or longer, such as emissions from routine operations at PFRR or the impact from ozone-depleting substances.

4.1.2 No Action Alternative

4.1.2.1 *Launch Operations*

Emissions from a sounding rocket in the lower atmosphere occur over a few seconds. When launches occur during the winter, which is normally the case at PFRR and is assumed to be the case for new launches from PFRR over the next 10 years, the winds are typically from the northeast from 6.4 to 8.0 kilometers per hour (4 to 5 miles per hour) **(NASA 2000a)**. These winds are not strong enough to result in pollutant concentrations high enough to be of concern at sensitive receptors 1.6 kilometers (1 mile) or more to the south (Chatanika Lodge and F.E. Gold Camp). Emissions of a launch of a BB XII or a T-IO would result in emissions of particulate matter (primarily aluminum oxide), carbon monoxide, and carbon dioxide, as shown in Tables 4–2 and 4–3. The BB XII launch vehicle has the highest emissions of the sounding rockets used at PFRR. Other vehicles used at PFRR would have lower emissions and lower impacts on nearby receptors. Based on this analysis, launching any sounding rocket shown in Chapter 2, Figure 2–2, from PFRR would result in ground-level air pollutant concentrations below the ambient air quality standards.

Emissions from daily activities at PFRR include the operation of heating and ventilation systems, occasional operation of generators, use of various vehicles to move equipment, and employee vehicles. Estimated annual emissions from these activities are presented in Chapter 3 and are expected to be similar under all the alternatives. Annual emissions from rocket launches are presented in **Table 4–4**, assuming up to 4 BB XII launches and 4 T-IO launches per year. Although other launch vehicles may be used, the total emissions are not expected to exceed the total associated with these launch vehicles.

Air quality impacts from PFRR routine operations would be regional in scope, adverse, however minor and long-term in duration. Impacts from rocket launches would be global in scope, adverse, and minor and short-term in duration.

Annual emissions from recovery activities would be limited to attempted recovery of up to one payload under the No Action Alternative, as discussed in Appendix F. Annual emissions from search and recovery operations are presented in Table 4–4. Impacts from search and recovery operations would be regional in scope and adverse; however, minor and medium-term in duration.

Table 4–4. No Action Alternative Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation a	Launches b	Search and Recovery[c]	Total
Carbon monoxide	15	5.5	0.2	21
Nitrogen dioxide	6.9	0	<0.1	6.9
PM_{10}	0.2	0	<0.1	0.2
$PM_{2.5}$	<0.1	0	<0.1	0.2
Sulfur dioxide	<0.1	0	<0.1	<0.1
Lead	0	0.2	0	0.2
VOCs	NR	0	<0.1	<0.1
Hydrogen chloride	0	1.3	0	1.3
Aluminum oxide	0	2.0	0	2.0
Sulfur	0	<0.1	0	<0.1
Copper	0	<0.1	0	<0.1
Other	NR[d]	<0.1	NR[d]	<0.1

a. Excludes emissions from rocket launches. Emissions are from Chapter 3.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes up to eight launches per year, recovery of up to one payload, and no recovery of new or existing spent stages.
d. Various toxic air pollutants would be emitted from fossil fuel combustion, but these emissions would be small.

Key: NR=not reported; PFRR=Poker Flat Research Range; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; VOCs=volatile organic compounds.

Note: To convert metric tons to tons, multiply by 1.1023.

4.1.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.1.3.1 *Launch Operations*

Under Alternative 1, air quality impacts from PFRR routine operations would be the same as those projected for the No Action Alternative. Impacts from rocket launches would also be the same as those projected for the No Action Alternative.

4.1.3.2 *Search and Recovery*

Impacts from search and recovery activities would be larger than those projected for the No Action Alternative because additional search and recovery activities would be undertaken, as described in Appendix F. On average, attempts would be made to recover approximately two payloads and 10 spent stages each year under Alternative 1, as discussed in Appendix F. Emissions from search and recovery operations are presented in **Table 4–5**. These impacts would continue to be regional, adverse, minor and medium-term in duration.

Table 4–5. Alternative 1 Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation[a]	Launches[b]	Search and Recovery[c]	Total
Carbon monoxide	15	5.5	3.4	24
Nitrogen dioxide	6.9	0	0.13	7.0
PM_{10}	0.2	0	<0.1	0.2
$PM_{2.5}$	0.2	0	<0.1	0.2
Sulfur dioxide	<0.1	0	<0.1	<0.1
Lead	0	0.2	0	0.2
VOCs	NR	0	0.2	<0.2
Hydrogen chloride	0	1.3	0	1.3
Aluminum oxide	0	2.0	0	2.0
Sulfur	0	<0.1	0	<0.1
Copper	0	<0.1	0	<0.1
Other	NR[d]	<0.1	NR[d]	<0.1

a. Excludes emissions from rocket launches. Emissions are from Chapter 3.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes up to eight launches per year, recovery of up to two payloads, recovery of 10 new spent stages and 5 existing spent stages, and search only for 10 spent stages.
d. Various toxic air pollutants would be emitted from fossil fuel combustion, but these emissions would be small.

Note: To convert metric tons to tons, multiply by 1.1023.

Key: NR=not reported; PFRR=Poker Flat Research Range; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; VOCs=volatile organic compounds.

4.1.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.1.4.1 *Launch Operations*

Annual emissions under Alternative 2 are presented in **Table 4–6**. Under Alternative 2, air quality impacts from PFRR routine operations would be the same as those projected for the No Action Alternative and Alternative 1. Impacts from rocket launches would also be the same as those projected for the No Action Alternative and Alternative 1.

4.1.4.2 *Search and Recovery*

Impacts from search and recovery activities would be larger than those projected for the No Action Alternative or Alternative 1 because additional search and recovery activities would be undertaken, as described in Appendix F. On average, 4 payloads and 16 spent stages would be recovered each year under Alternative 2, as discussed in Appendix F. These impacts would be regional, adverse, minor and medium-term in duration.

Table 4–6. Alternative 2 Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation[a]	Launches[b]	Search and Recovery[c]	Total
Carbon monoxide	15	5.5	4.6	25
Nitrogen dioxide	6.9	0	0.2	7.1
PM_{10}	0.2	0	<0.001	0.2
$PM_{2.5}$	0.2	0	<0.001	0.2
Sulfur dioxide	<0.1	0	<0.1	<0.1
Lead	0	0.2	0	0.2
VOCs	NR	0	0.25	0.25
Hydrogen chloride	0	1.3	0	1.3
Aluminum oxide	0	2.0	0	2.0
Sulfur	0	<0.1	0	<0.1
Copper	0	<0.1	0	<0.1
Other	NR[d]	<0.1	NR[d]	<0.1

a. Excludes emissions from rocket launches. Emissions are from Chapter 3.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes up to eight launches per year, recovery of four payloads, recovery of 16 new spent stages and 10 existing spent stages, and search only for 4 spent stages.
d. Various toxic air pollutants would be emitted from fossil fuel combustion, but these emissions would be small.

Note: To convert metric tons to tons, multiply by 1.1023.

Key: NR=not reported; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; VOCs=volatile organic compounds.

4.1.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

4.1.5.1 *Launch Operations*

Restricted trajectories would not change the projected air quality impacts associated with continued routine operations at PFRR or future launches. Therefore, air quality impacts under Alternative 3 would be the same as those described under Alternative 1 in Section 4.1.3 since Alternatives 1 and 3 would have the same number of future launches.

4.1.5.2 *Search and Recovery*

Restricted trajectories would not change the projected air quality impacts associated with search and recovery activities. Air quality impacts under Alternative 3 would be the same as those described under Alternative 1 in Section 4.1.3 since Alternatives 1 and 3 would have the same number of search and recovery activities.

4.1.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

4.1.6.1 *Launch Operations*

Restricted trajectories would not change the projected air quality impacts associated with continued routine operations at PFRR or future launches. Projected air quality impacts under Alternative 4 would be the same as those described under Alternative 2 in Section 4.1.4 since Alternatives 2 and 4 would have the same number of future launches.

4.1.6.2 *Search and Recovery*

Restricted trajectories would not change the projected air quality impacts associated with search and recovery activities. Projected air quality impacts under Alternative 4 would be the same as those described under Alternative 2 in Section 4.1.4 since Alternatives 2 and 4 would have the same number of search and recovery activities.

4.1.7 Summer Launches

Although it is anticipated that launches and initial search operations would occur during winter months and recovery operations would occur during summer months, there could be summer launches from PFRR, as discussed in Chapter 2, Section 2.1.2.4. With regard to potential air quality impacts, regardless of when the launches occurred, impacts would continue to be global, adverse, minor, and short-term in duration.

4.2 GLOBAL ATMOSPHERE

This section deals with the impact on the Earth's atmosphere of gases, liquids, and solids emitted from rockets and payloads of various NASA SRP launch vehicles during flight. This discussion is extracted or summarized from the *Final Supplemental Environmental Impact Statement for Sounding Rocket Program (SRP SEIS)* **(NASA 2000a)** with appropriate modifications to focus on launches from PFRR. Greenhouse gas emissions are included within this section.

The following definitions and typical altitude ranges are used to describe the Earth's atmosphere **(NASA 2000a)**:

- Lower Atmosphere:
  - Free Troposphere – 2 to 10 kilometers (1.3 to 6.2 miles)
  - Atmospheric Boundary Layer – 0 to 2 kilometers (0 to 1.3 miles)
- Upper Atmosphere:
  - Ionosphere – 80 to 1,000 kilometers (50 to 620 miles)
  - Mesosphere – 50 to 80 kilometers (31 to 50 miles)
  - Stratosphere – 10 to 50 kilometers (6.2 to 31 miles)

4.2.1 Methodology

The exhaust products from rocket launches are estimated by thermodynamic calculation; this is usually performed by computer models or by direct measurement when rocket motors are fired in a stationary location on the ground. In either case, once the relative proportions of each chemical species in the exhaust are known, the rocket's trajectory can then be applied to determine the mass of a particular compound or element that would be emitted at a particular altitude during flight **(NASA 2000a)**. In general, emissions into the atmosphere from sounding rocket launches include halogens (chlorine), particulates (aluminum oxide), carbon monoxide, carbon dioxide, nitrogen oxides, and trace metals **(NASA 2000a)**.

Possible emissions from payloads include exhaust products from any pyrotechnic devices, constituents of batteries, and chemical releases. The impacts of releases from pyrotechnic devices or constituents of batteries are several orders of magnitude smaller than those of chemical releases and are not addressed here **(NASA 2000a)**. Greenhouse gas emissions would be considered moderate if greater than 25,000 metric tons (28,000 tons) of carbon dioxide equivalent direct emissions, the Council on Environmental Quality (CEQ) level above which further analysis is recommended **(Sutley 2010)**. Major impacts could be considered to be several orders of magnitude greater than for a moderate impact. Minor impacts would be any that result in increases of greenhouse gases that are less than the levels specified as moderate impacts, but greater than negligible impacts, which are immeasurable. Major and moderate impacts of ozone-depleting emissions are not readily quantified. For the purpose of this assessment, minor impacts are those that are quantifiable, and negligible emissions are immeasurable.

For the evaluation of duration of atmospheric impacts, short-term impacts would be any that occur for brief periods that are much less than the total project life, such as from rocket launches. Medium-term impacts would be any that occur for relatively brief periods less than the total project life but may occur repeatedly, such as from search and recovery operations. Long-term impacts would be any that occur for periods longer than medium-term and as long as the life of the project or longer, such as routine operations at PFRR or the impact from ozone-depleting substances or greenhouse gases that accumulate in the atmosphere.

4.2.2 No Action Alternative

4.2.2.1 *Lower Atmosphere*

At the time of launch, the atmospheric boundary layer (from 0 to 2 kilometers [0 to 1.3 miles]) may or may not be stable and may have an inversion or a strong wind condition. Thus, the initial launch rocket plume may move in an unforeseen direction **(NASA 2000a)**.

The potential environmental impacts in the boundary layer include the following **(NASA 2000a)**:

- Formation of "smog" due to entrainment of atmospheric nitrogen into the exhaust plume, leading to formation of nitric acid and tropospheric ozone;
- Deposition of hydrogen chloride in the boundary layer and subsequent evolution from surfaces near the launch site;
- Disposal and/or deposition of trace heavy metals and organics in the boundary layer, such as lead and sulfur; and
- Diffusion of exhaust particles, such as aluminum oxide, into the boundary layer.

The potential environmental impacts in the free troposphere (from 2 to 10 kilometers [1.3 to 6.2 miles]) include the following **(NASA 2000a)**:

- Formation of high-altitude clouds, which could lead to localized weather modification;
- Adsorption of water-soluble acids such as hydrogen chloride, resulting in localized acid rain; and
- Photochemical oxidation of carbon monoxide to carbon dioxide, and nitrogen oxides to nitric acid and ozone.

The lower atmosphere receives the launch vehicle rocket exhaust emissions from all first stages, plus many second stages in three- and four-stage launch vehicles. The first, or boost, stage usually contains more propellant than the second stage, the second stage more than the third, and so on. Thus, the lower atmosphere receives most of the rocket exhaust emissions from a given launch vehicle (**Figures 4–2** and **4–3**) **(NASA 2000a)**.

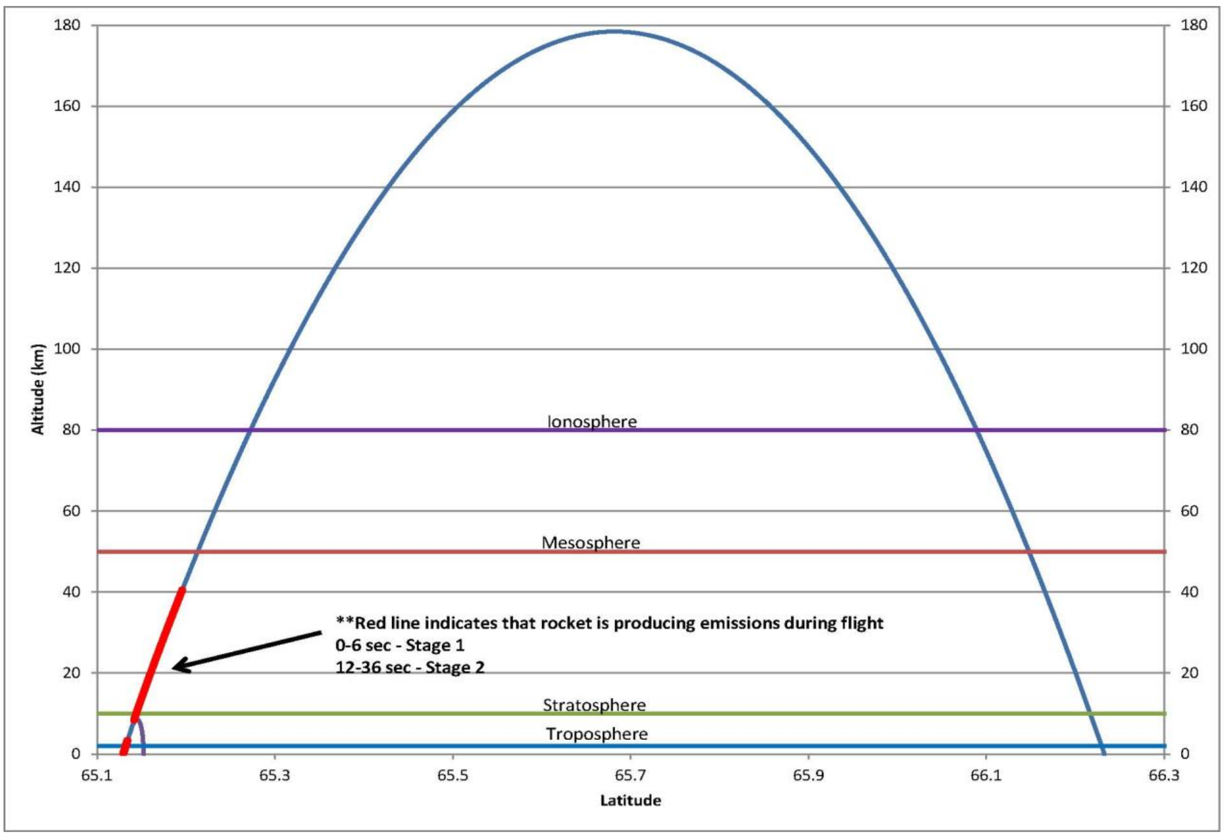


Figure 4–2. Emissions along a Representative Terrier-Improved Orion Trajectory

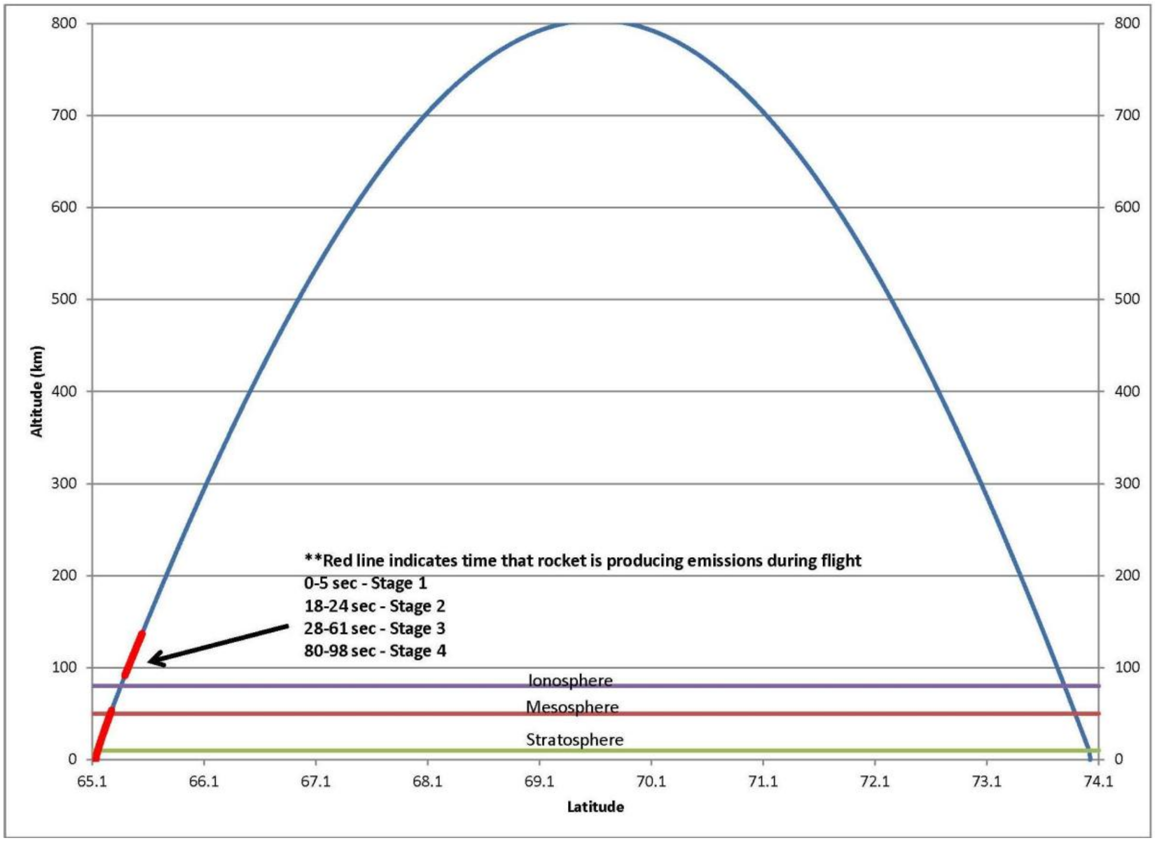


Figure 4–3. Emissions along a Representative Black Brant XII Trajectory

Estimated lower atmosphere exhaust emissions for the two most common launch vehicles used at PFRR are presented in **Table 4–7**. Three criteria pollutants regulated under the National Ambient Air Quality Standards set by the EPA under the CAA are emitted by SRP launch vehicles at low altitudes: lead, carbon monoxide, and particulates (aluminum oxide) **(NASA 2000a)**.

Table 4–7. Poker Flat Research Range Projected Average Annual Lower Atmosphere (<10 kilometers) Rocket Exhaust Emissions (kilograms) for Sounding Rockets

Launch Vehicle	Altitude Range (km)	Hydrogen Chloride	Aluminum Oxide	Carbon Monoxide	Carbon Dioxide	Element	Other	Total
BB XII (1st & 2nd stage [Talos and Taurus] engines)	0–1.9	0	0	3,192	2,576	132 (Lead)	0	5,900
T-IO (1st stage [Terrier] engine)	0–1.5	0	0	912	640	40 (Lead)	0	1,592
Total for up to 8 vehicles	–	0	0	4,104	3,216	172	0	7,492

Key: BB=Black Brant; km=kilometers; T-IO=Terrier-Improved Orion.
Note: Emission represent up to four BB XII launches and four T-IO launches per year. To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.
Source: NASA 2000a.

Test rockets also emit into the atmospheric boundary layer. Typical lower atmosphere rocket exhaust emissions from test rockets used at PFRR are presented in **Table 4–8**.

Table 4–8. Poker Flat Research Range Projected Average Annual Lower Atmosphere (<10 kilometers) Rocket Exhaust Emissions (kilograms) from Test Rockets

Launch Vehicle	Typical Altitude Range (km)	Carbon Monoxide	Carbon Dioxide	Lead	Methane	Total
70 mm Test Rocket[a]	0–0.6	2.7	1.6	0.039	0.020	4.4
Supporting 4 launches[b]		108	64	1.6	0.8	176
Supporting 8 launches[b]		216	128	3.1	1.6	352

a. Calculations based on two 70-milimeter Test Rockets launched per countdown night.
b. Each sounding rocket launch supported assumed to require 10 nights counting down.
Note: To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.
Source: NASA 2000a.

4.2.2.2 *Upper Atmosphere*

With two-, three- and four-stage launch vehicles, such as the T-IO, BB X, and BB XII, apogees into the ionosphere would be reached. At lower levels of the upper atmosphere (the mesosphere and stratosphere), there are emissions from upper-stage rockets and attitude control system (ACS) fluid jets **(NASA 2000a)**. Some payloads would employ chemical releases to obtain the requisite scientific information; these releases typically take place at the highest altitudes (hundreds of kilometers above the Earth).

Launches

Typical average annual upper-stage rocket exhaust emissions for NASA launch vehicles used at PFRR are presented in **Table 4–9**. Emissions from most of the launch vehicles are confined to the stratosphere. Potential environmental impacts in the upper atmosphere include the following **(NASA 2000a)**:

- Thermal radiation changes due to emissions of water and carbon dioxide and other species into the very thin atmosphere above 50 kilometers (31 miles) in the mesosphere and ionosphere;
- Changes in the ionization level at and above 90 kilometers (56 miles) in the ionosphere, affecting radio wave transmission, due to hydrogen chloride emissions;
- Contribution to global warming due to carbon dioxide emissions (discussed in Section 4.2.2.3 of this EIS); and
- Contribution to depletion of the ozone layer in the stratosphere due to emissions of hydrogen chloride and particulate aluminum oxide, both of which enter into reactions, which can lead to ozone depletion.

Table 4–9. Poker Flat Research Range Projected Average Annual Upper Atmosphere (>10 kilometers) Rocket Exhaust Emissions (kilograms) for Sounding Rockets

Launch Vehicle	Altitude Range (km)	Hydrogen Chloride	Aluminum Oxide	Carbon Monoxide	Carbon Dioxide	Element	Other	Total
Black Brant XII (3rd & 4th stage [Black Brant V and Nihka] engines)	10–153	1,016	1,852	1,416	92	0	24	4,400
Terrier-Improved Orion (2nd stage [Orion] engine)	10–52	256	124	200	176	4 (Cu)	0	760
Total for up to 8 vehicles	–	1,272	1,976	1,616	268	4	24	5,160

Key: Cu=copper; km=kilometers.
Note: Emission represent up to four Black Brant XII launches and four Terrier-Improved Orion launches per year. To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.

The stratosphere is the main region of ozone production in the Earth's atmosphere. Concentrations vary with the time and place as ozone is continually created and destroyed in complex reactions. The most destructive species leading to stratospheric ozone depletion are believed to be chlorine and bromine. The principal terrestrial sources are industrial chlorinated compounds and emissions from active volcanoes. Rocket emissions directly in the stratosphere are also a contributor **(NASA 2000a)**. Annual stratospheric chlorine releases associated with NASA launches at PFRR are projected to be, at most, about four 10 thousandths of a percent (0.0004 percent) of all industrial sources in the United States, estimated to be approximately 300,000 metric tons (330,000 tons) annually **(NASA 2000a)**. It is expected that there may be a very small, temporary local stratospheric ozone reduction effect in the wake of SRP upper-stage rockets, but no global effects (minor, long-term impacts).For certain observations of deep space phenomena, it is necessary to align optical instruments accurately using an ACS using directed jets of compressed fluids. These jets may use nitrogen, freons, argon, or neon. All of these are permanent gases found naturally in the atmosphere except freons. Freons contain chlorine, which is known to contribute to ozone depletion in the stratosphere. Most of these releases are above 50 kilometers (31 miles), outside the ozone formation zone, and would not create adverse impacts.

Tracer Releases

Historically, tracer releases from sounding rocket payloads at PFRR have been primarily TMA [trimethylaluminum] at altitudes of 80 to 200 kilometers (50 to 120 miles) **(NASA 2000a)**. Quantities of TMA released are typically small, approximately several kilograms. Although it is a liquid at sea level, TMA vaporizes very quickly when released in the low-pressure environment in the upper atmosphere. The TMA reacts spontaneously with oxygen to produce carbon dioxide, water vapor, and aluminum oxide. A byproduct of the reaction is a white light that can be seen from the ground. At ground level, the material burns vigorously because of the high oxygen concentration; however, the reaction is much slower at high altitudes. A complete description of TMA is provided in Chapter 2, Section 2.1.2.2 of this *PFRR EIS*.

Other tracers that have been used in the past (or could be used in the future) are metals. The most common are lithium and barium. To enable these releases, the metal tracer is mixed with thermite in a payload canister vessel. Thermite is a mixture of iron oxide (rust) and aluminum powder. Thermite, when ignited, burns at several thousand degrees and produces enough heat to vaporize the metal tracer. The products of the thermite reaction are iron and aluminum oxide.

Potential environmental effects from high-altitude tracer releases would be minimal. Carbon dioxide and water vapor occur naturally in the atmosphere, although usually not at those altitudes. Aluminum oxide occurs naturally in the upper atmosphere due to deposition by the steady influx of small meteorites that ablate at those heights. The aluminum oxide from the rocket releases is a small fraction of the total aluminum oxide deposited by natural processes. Some of the tracer metals also occur naturally because of meteor ablation, such as lithium, but some, such as barium, do not. All of the releases diffuse rapidly, and the concentrations are quickly reduced.

Other potential impacts of high-altitude tracer releases identified in the *SRP SEIS* **(NASA 2000a)** include visible light emissions that could be observed or that could contaminate non-participating astronomical observations, release of trace amounts of hazardous materials into the biosphere, temporary perturbations of the ionosphere causing temporary disruptions of communications links, modification of trace element concentrations in the upper atmosphere, and contamination of nearby spacecraft by released materials **(NASA 2000a)**.

4.2.2.3 *Climate Change*

Carbon dioxide and other gases in the atmosphere act like glass in a greenhouse, letting the Sun's rays through, but trapping some of the heat that would otherwise be radiated back into space. Emissions of carbon dioxide and other greenhouse gases are believed to affect the Earth's radiative balance and to result in changes in global climate. Activities on Earth are emitting about 26 billion metric tons (29 billion tons) of carbon dioxide per year into the atmosphere (average for 2000–2005) **(IPCC 2007)**. Total U.S. emissions of carbon dioxide are estimated to be 5.45 billion metric tons (6.01 billion tons) per year **(DOE 2011)**. Emissions of carbon dioxide associated with launches, normal operations, and search and recovery activities are presented in **Table 4–10**. Annual emissions of carbon dioxide associated with NASA launches at PFRR, including the continued heating and electrical requirements associated with year-round operation of the PFRR launch site (see Chapter 3, Section 3.1.1), are projected to be, at most, about 4 one hundred thousandths of a percent (0.00004 percent) of total U.S. emissions of carbon dioxide and are not considered substantial. However, scientific uncertainty limits the ability to assess directly attributable effects of greenhouse gases on climate change from selected individual actions. Therefore, NASA provides only a qualitative conclusion concerning these impacts. The No Action Alternative would likely create impacts that increase climate change, which would be global, adverse, minor, and long-term.

Table 4–10. No Action Alternative Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Carbon Dioxide Equivalent Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation[a]	Launches[b]	Search and Recovery[c]	Total
Carbon dioxide (equivalents)[d]	2,100	3.5	14	2,120

a. Excludes emissions from rocket launches.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes up to eight launches per year, recovery of up to four payloads, and no recovery of new or existing spent stages.
d. Carbon dioxide equivalents include emissions of carbon dioxide and other greenhouse gases multiplied by their global warming potential (**Solomon *et al.* 2007**).

Note: To convert metric tons to tons, multiply by 1.1023.

4.2.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.2.3.1 *Lower Atmosphere*

Impacts from rocket launches under Alternative 1 would be the same as those described under the No Action Alternative.

4.2.3.2 *Upper Atmosphere*

Impacts from rocket launches under Alternative 1 would be the same as those described under the No Action Alternative.

4.2.3.3 *Climate Change*

Launch Operations

Under Alternative 1, air quality impacts from PFRR routine operations would be the same as those projected for the No Action Alternative. Impacts from rocket launches would also be the same as those projected for the No Action Alternative.

Search and Recovery

Impacts from search and recovery activities would be larger than those projected for the No Action Alternative because additional search and recovery activities would be undertaken, as described in Appendix F. Carbon dioxide equivalent emissions from search and recovery operations are presented in **Table 4–11**. Similar to the No Action Alternative, the impact on climate change from the emission of greenhouse gases associated with all of the PFRR activities would be minor and long-term.

Table 4–11. Alternative 1 Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Carbon Dioxide Equivalent Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation[a]	Launches[b]	Search and Recovery[c]	Total
Carbon dioxide (equivalents)[d]	2,100	3.5	62	2,166

a. Excludes emissions from rocket launches.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes recovery of up to four payloads, recovery of eight new spent stages and six existing spent stages, and search only for 12 spent stages.
d. Carbon dioxide equivalents include emissions of carbon dioxide and other greenhouse gases multiplied by their global warming potential (**Solomon et al. 2007**).
Note: To convert metric tons to tons, multiply by 1.1023.

4.2.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.2.4.1 *Lower Atmosphere*

Impacts from rocket launches under Alternative 2 would be the same as those described under the No Action Alternative.

4.2.4.2 *Upper Atmosphere*

Impacts from rocket launches under Alternative 2 would be the same as those described under the No Action Alternative.

4.2.4.3 *Climate Change*

Launch Operations

Annual emissions under Alternative 2 are presented in **Table 4–12**. Under Alternative 2, air quality impacts from PFRR routine activities would be the same as those projected for the No Action Alternative. Impacts from rocket launches would also be the same as those projected for the No Action Alternative.

Search and Recovery

Impacts from search and recovery activities would be larger than those projected for the No Action Alternative or Alternative 1 because additional search and recovery activities would be undertaken, as described in Appendix F. Similar to the No Action Alternative, the impact on climate change from emissions of greenhouse gases from PFRR activities would be long-term.

Table 4–12. Alternative 2 Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Carbon Dioxide Equivalent Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation[a]	Launches[b]	Search and Recovery[c]	Total
Carbon dioxide (equivalents)[d]	2,100	3.5	100	2,204

a. Excludes emissions from rocket launches. Emissions are from Chapter 3.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes recovery of 4 payloads, and 16 spent stages.
d. Carbon dioxide equivalents include emissions of carbon dioxide and other greenhouse gases multiplied by their global warming potential.

Note: To convert metric tons to tons, multiply by 1.1023.

4.2.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts from the continued operation of PFRR, rocket launches and search and recovery under Alternative 3 would be the same as those described under Alternative 1.

4.2.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts from the continued operation of PFRR, rocket launches and search and recovery under Alternative 4 would be the same as those described under Alternative 2.

4.2.7 Summer Launches

Although it is anticipated that launches and initial search operations would occur during winter months and recovery operations would occur during summer months, there could be summer launches from PFRR, as discussed in Chapter 2, Section 2.1.2.4. With regard to potential global atmosphere impacts, regardless of when the launches occurred, impacts would be global, adverse, minor, and long-term in duration.

4.3 WATER RESOURCES

This section describes potential impacts on surface and groundwater resources as a result of the alternatives.

4.3.1 Methodology

Determination of water resource impacts is based on an analysis of the potential for launch and search and recovery activities to affect surface water or groundwater quality as defined by applicable laws and regulations; wetland disturbance, degradation, or loss; and Wild and Scenic River corridor disturbance. Considered in this analysis is activity-related introduction of contaminants into surface water or groundwater resources; and physical alterations or disturbances of overland surface water flows and groundwater recharge.

Attribute criteria for analyzing potential impacts on surface water and groundwater are presented in **Table 4–13**.

It should be noted that complete National Wetlands Inventory or comparable coverage for PFRR and other adjacent areas of interest—necessary to delineate and analyze potential NASA SRP wetland impacts—were not available. To assess the potential for wetland impacts, analysis was conducted based on PFRR ecoregion surface hydrology and wetland attribute information (see Chapter 3, Section 3.3.4 “Ecoregions”).

Table 4–13. Evaluation Criteria for Analyzing Water Resource Impacts

Attribute	Evaluation Criteria	
	Surface Waters	**Groundwater**
Type		
Adverse	The impact would result in some level of impairment, degradation, or disturbance to water resources.	
Beneficial	The impact would result in some level of environmental improvement to water resources.	
Water Quality		
Context		
Global	Effect would have worldwide implications on the quality and/or quantity of water resources.	
Regional	Effect would entail an entire watershed, subbasin, or basin or greater than 50 percent of a major water body.	Effect would entail a surficial aquifer or major aquifer.
Localized	Effect would be limited to the immediate area water body or subwatershed.	Effect would be restricted to the immediate area water table.
Intensity		
Major	Aquatic biology chronic effects such as algae blooms, species mortality, or other comparable consequences or water contamination posing secondary risks would occur.	Effect would prohibit or sharply curtail human potable or nonpotable water uses.

Table 4–13. Evaluation Criteria for Analyzing Water Resource Impacts (*continued*)

Attribute	Evaluation Criteria	
	Surface Waters	**Groundwater**
Water Quality(*continued*)		
Moderate	Noticeable change, aquatic biological response such as species avoidance, or water contamination would occur.	Effect would restrict human potable and nonpotable water uses.
Minor	Effect would be at a low level of detection and have no aquatic biology or contamination risks.	Effect on would be at a low level of detection and have no contamination risks.
Negligible	Effect on aquatic biology and water quality parameters would be imperceptible.	Effect to water quality parameters would be imperceptible.
Duration		
Long-Term	Effect would likely endure for the life of the sounding rocket program or beyond.	
Medium-Term	Effect would likely last for a few months to years.	
Short-Term	Effect would likely last for a few days to weeks.	
Wetlands		
Context		Not Applicable
Global	Effect would have worldwide implications on wetland ecosystems.	
Regional	Effect would entail one or more ecoregions.	
Localized	Effect would be limited to the wetland in the immediate area of the impact source.	
Intensity		
Major	Effect would generate a conflict with Federal and/or state wetland protection programs or violates a Federal or state regulation.	
Moderate	Effect may generate a conflict with Federal and/or state programs but could be mitigated through consultations with regulatory agencies.	
Minor	Effect would be mitigated through consultations with regulatory agencies.	
Negligible	Effect on wetland ecosystem quality and/or quantity would be imperceptible.	
Duration	Wetland impact duration evaluation criteria would be the same as for water quality.	

Table 4–13. Evaluation Criteria for Analyzing Water Resource Impacts (*continued*)

Attribute	Evaluation Criteria	
	Surface Waters	**Groundwater**
Wild and Scenic Rivers		
Context		Not Applicable
Global	Effect would substantially diminish the global protection status of wild and scenic rivers.	
Regional	Effect would entail an entire designated river corridor.	
Localized	Effect would be limited to the portion of the river corridor in immediate vicinity of the impact source.	
Intensity		
Major	Effect would generate a conflict with Federal and/or state wild and scenic river protection programs or violates a Federal or state regulation.	
Moderate	Effect may generate a conflict with federal and/or state programs but could be mitigated through consultations with regulatory agencies.	
Minor	Effect would be mitigated through consultations with regulatory agencies.	
Negligible	Effect on the river corridor would be imperceptible.	
Duration	Wild and scenic river effect duration evaluation criteria would be the same as for water quality.	

4.3.2 No Action Alternative

4.3.2.1 *Surface Water*

Surface water resources of concern include rivers, smaller streams, impoundments (lakes, ponds, sloughs, etc.), lagoons, wetlands, floodplains, coastal zones, and the Beaufort Sea within the PFRR launch corridor. Wild rivers are those federally designated rivers that are managed by the U.S. Department of the Interior (USDOI) to preserve a natural state. Depending on the location, the thickness of frozen surface water within the PFRR flight corridor can range from a few centimeters to several meters during a large portion of the year.

Launch Operations

This analysis focuses on both the potential for exhaust emitted from rocket motors and potential onsite materials handling accidents to affect the quality of stormwater runoff from the PFRR launch site. The primary rocket exhaust byproducts of concern include aluminum oxide particulates and hydrogen chloride gas, which combines with water or water vapor to form hydrochloric acid droplets (see Section 4.2.2.1). These materials would likely settle on the immediate vicinity of the launch pad and snow and/or ice ground cover within tens of meters of the pad. In any one area surrounding the pad, the amounts of exhaust materials would likely be present in small amounts. Since all launches occur in winter, launch residues would likely remain on the pad or snow cover until spring melting; some materials could be transported off site during severe winter storms. It is expected that under normal conditions, rocket exhaust clouds would disperse relatively quickly.

The EPA does not list aluminum oxide as a hazardous material requiring treatment or disposal. At the expected low concentrations, aluminum is a nutrient that could benefit plant growth **(Bohn *et al.* 1979)**. A short-term hydrochloric acid-induced slight decrease in pH (increase in acidity) could occur in small drains or ditches near the launch pad.

Runoff from the PFRR launch site discharges through a series of ditches and drains into the Chatanika River. The launch site does not have or require National Pollutant Discharge Elimination System-permitted stormwater discharge outfalls. The area has limited summer rainfall and relies on natural drainage features to collect and convey runoff to constructed drainage features. Launch site flooding from the Chatanika River spring melt and breakup is rare and normally minor in extent.

The accidental release of hazardous materials such as fuels, oils, lubricants, batteries, alcohols, and acetone during rocket launch preparation could also impact water quality. However, pre-flight preparations would take place within existing facilities and precautions are taken to prevent and control spills. PFRR maintains strict adherence with applicable Hazardous Materials Transportation Act, Toxic Substances Control Act, Resource Conservation and Recovery Act, and Hazardous and Solid Waste Act regulations and requirements to prevent and control accidental spills. The potential for rocket propellant or other materials to be accidentally released during flight is considered remote; however, PFRR emergency response personnel would mitigate the impact of any spill.

In summary, given the small number of annual sounding rocket launches planned for PFRR, the low quantities of aluminum oxide and hydrochloric acid exhaust residues, and low risk of accidental spills, it is anticipated that the potential adverse impacts on surface water quality would be localized in context, negligible in intensity, and short-term in duration.

Flight Hardware

This evaluation focuses on the potential for hardware from both normal and failed flights to impact water quality or affect protected waters. Specific issues to be analyzed include the potential for metals, pollutants, payload batteries and other materials to impair water quality in general, as well as the specific characteristics of federally designated wild river segments.

Normal Flights – It is assumed that in most cases, normal flight hardware landing in layers of snow and ice would likely not penetrate the frozen soil or would enter the soil to a depth of less than 0.6 meters (2 feet). Impacts with rocky materials and thick ice could minimize penetration depth, whereas areas with underlying wetland soils may present reduced resistance, particularly in the early or later months of the launch season (*e.g.*, October or April). The weight, velocity, and orientation of the falling flight hardware would also affect penetration depth. Similarly, intact stages and payloads directly impacting frozen water bodies could come to rest on the surface or could penetrate the ice.

In most cases, flight hardware would not be exposed to fluid aquatic environments until spring melt, except for spring-fed stream segments in the Arctic Coastal Plain, Arctic Foothills, and Brooks Range Ecoregions that may continue to flow during winter (see Chapter 3, Section 3.3.4, "Ecoregions"). The dynamic nature of Beaufort Sea ice breakup and deforming (see Section 3.3.4.1, "Beaufort Sea Ecoregion") and river ice-jams during spring and summer could also affect the physical integrity and distribution of hardware.

Steel, magnesium, and aluminum components that enter freshwater or marine environments have the potential to corrode and introduce metal ions to the water column. During wet corrosion, the metal electrons combine with atoms of oxygen and water to make a new hydroxyl ion that reacts to make a stable compound with the metal ions. These new compounds are either deposited loosely on the metal item's surface or away from it, thus providing little protection from continued corrosion. Once corrosion starts, it continues until the ingredients are exhausted. It is estimated that even under long-term interment within the water column, toxic concentrations of metal ions would not be produced because of the slow rates of corrosion and mixing and dilution characteristics of most freshwater and marine environments.

Expended rocket stages may also contain trace amounts of solid propellant not burned during normal flights. Solid propellant dissolves slowly, and the small amounts that would likely occur would dissipate within hours or days in freshwater and marine ecosystems. Potential effects would likely be most pronounced in close proximity of the propellant and in small (0.05-hectare [0.1-acre] or less), shallow ponds and sloughs. Of the ecoregions within the PFRR launch corridor, Yukon Flats likely has the highest overall density of these water features. However, considering the limited number of stages expended over the PFRR launch corridor, dilution and dispersion effects of freshwater and marine environments, potential biological immobilization and degradation, and the minor amount of materials likely involved, very minor, localized impacts on surface water features are anticipated.

Payloads may contain battery electrolytes, hydraulic fluids, and other materials that could affect water quality. Silver zinc and nickel cadmium are common types of power systems **(NASA 2001)**. The types, quantities, and combinations of these payload materials can vary with each flight experiment and are discussed in detail in Section 4.12, Waste Management. These materials occur in relatively small quantities for most sounding rocket payloads and may be recovered. In the case of flights that terminate accidentally, recovery teams attempt to recover all on- and offsite fragments. Based on the relatively low number of flights, small payload quantities, and established recovery procedures in the event of a failure, negligible impacts on the quality of surface water features, including wetlands and coastal zones, are anticipated.

Failed Flights – The most likely causes leading to a sounding rocket failure would be non-ignition of a motor during ascent followed by burn-through of the rocket motor casing. Should a motor fail to ignite, the vehicle would fall to Earth and explode on ground impact, producing fragmented metal and small amounts of unspent propellant. Should a rocket motor experience burn-through, it would most likely expend its propellant prior to landing. Depending on which stage the failure were to occur, upper stages would not ignite and would detonate upon landing. This type of malfunction, although possible, would be rare and likely have an occurrence probability of approximately two percent based on past NASA experience **(Hickman 2012)**. Should such a failure occur, a PFRR recovery team would, to the degree possible, locate and retrieve all components of the rocket.

It is estimated that a rocket vehicle explosion on non-wetland areas could create a crater estimated to be as large as 6 meters (20 feet) in diameter, up to 3 meters (10 feet) deep, with an area of 28 square meters (304 square feet). The surface snow, ice, and frozen surface soils in the immediate area would partly melt. The greater the depth of the snow or ice or the harder the surface impacted, the lower the amount of land that would be disturbed. During the spring melt process, runoff could result in soil erosion. The extent of soil detachment and transport by runoff could range from minor sheet erosion to the development of a gully system that may contribute amounts of sediment. The mechanics of soil erosion for a site would be highly variable and primarily depend on the volume, velocity, and duration of surface runoff, soil morphology, vegetative cover, and topography. An example of what would be considered a worst-case failed flight scenario is shown below in **Figure 4–4**, which depicts the impact site of a Black Brant V motor (the third stage of a Black Brant XII launch vehicle) that failed to ignite in March 2005. However, other failed flights, such as that of the March 2003 Terrier-Improved Orion depicted below in **Figure 4–5**, would be expected to have little, if any physically induced disturbances to water resources.

Water resource exposure to unspent quantities of rocket propellant may occur following a flight failure. It is assumed that most of the propellant would explode upon impact of the failed payloads or stages and any remaining residual composite-base solid propellant would be fragmented into smaller pieces averaging less than 2 kilograms (5 pounds). The chemical material of particular concern would be aluminum perchlorate, which typically composes 50 to 85 percent by weight of the propellant.

Figure 4–4. Impact Site of Non-Ignited Black Brant V from March 2005

Figure 4–5. Impact Site of Failed Terrier-Improved Orion from March 2003

A laboratory study conducted by **Lang *et al.* (2003)** investigated the rates for perchlorate release from composite-base propellants immersed in water as affected by salinity (deionized water and salt-water solutions) and temperature. Samples were studied at temperatures ranging from 5, 20, and 29 degrees Celsius (°C) (41, 68, and 84 degrees Fahrenheit [°F]). The results showed a direct correlation between increased rates of perchlorate release with increasing temperature, higher release rates in pure water than in salt water, and larger immersed samples. The diffusion[2] coefficients for tested propellants ranged from of 1.1×10^{-13} to 3.6×10^{-12} square meters per second (1.2×10^{-12} to 3.9×10^{-11} square feet per second). The estimated time for a propellant sample to lose 90 percent of its mass to leaching is presented in **Table 4–14**.

Table 4–14. Estimated Time to Reach 90 Percent Mass Loss of Perchlorate from Propellant Sample

Water Type	Water Temperature Celsius (Fahrenheit)	Days	Years
Deionized Water	29 (84)	200	0.5
	20 (68)	330	0.9
	5 (41)	3,800	11.0
Salt Water	29 (84)	270	0.7
	20 (68)	540	1.5
	5 (41)	6,700	18.0

Source: Lang *et al.* 2003.

[2] Diffusion is the process whereby material is transported by the random movements of molecules. There is an average measurable movement of areas of high to low areas of concentration **(Lang *et al.* 2003)**.

Based on the lowest average temperature of 5 °C (41 °F)[3] shown in Table 4–14, it would take approximately 11 to 18 years for 90 percent of perchlorate to leach from propellant immersed in freshwater and marine ecosystems, respectively.

Based on the low probability of a flight terminating and producing unspent propellant, dynamic hydrologic dispersion and dilution effects of wave action and ocean currents, large volume of water available for dilution, and expected slow rate of perchlorate release, no impacts on Beaufort Sea water quality are anticipated. For freshwater ecosystems, potential impacts could occur, particularly in small (less than 0.1-hectare [0.2-acre]), shallow ponds and sloughs. At the expected low concentrations, ammonium is a plant nutrient that could stimulate plant growth for short periods. Perchlorate ions tend to react (oxidize) with organic matter that is common to many wetlands and pond ecosystems within the PFRR launch corridor. Potential adverse water quality impacts would be localized in context, minor in intensity, and short-term in duration.

Wild Rivers – Four federally designated Wild River segments occur partly or wholly with the PFRR launch corridor (see Chapter 3, Section 3.3.2, Table 3–8 "Poker Flat Research Range National Wild and Scenic River Segments"). It is possible for flight hardware from normal flights and flights that malfunction to land within these river segments. From a purely biological or chemical perspective, if flight hardware were to land within a designated river, the effects would be the same as equivalent non-designated water bodies; however, given their special designation, additional socio-cultural effects could occur. These potential effects are discussed in this *PFRR EIS* in Section 4.8, Land Use and Recreation.

The potential for sounding rocket hardware to land within wild river segments was calculated (see Appendix G). Potential impact areas would include the designated Wild river channel and adjacent land areas. For a typical launch from PFRR, the potential for flight hardware impacts on the Beaver Creek, Ivishak River, and Wind River designated wild river segments is estimated to be 6, 4, and up to 5 percent, respectively (see Appendix G, Table G–2). Potential impact ellipses range in size from 2,600 to 28,400 square kilometers (1,000 to 11,000 square miles). Based on these low relative probabilities, it is estimated that the potential for flight hardware from a typical launch to land within the designated Wild River corridors is remote; therefore, impacts are anticipated to be negligible. Additional information on flight hardware impact probabilities is discussed in Section 4.15.9, Cumulative Effects, and Appendix G.

Search and Recovery

Payload recovery operations (*e.g.*, hand-digging buried items) have the potential to disturb surface soils, which in turn could result in sediment-laden runoff entering nearby waterways during storm events. However, those payloads planned for recovery would employ recovery systems (parachutes), which would substantially reduce the potential for burial. Accordingly, the extent of potential disturbance would be minor in intensity, localized in extent, and short-term in duration.

[3] Average water temperatures in the Beaufort Sea are estimated to be approximately 0 °C (32 °F) **(Encyclopedia Britannica 2011)** and average water temperatures in Arctic National Wildlife Refuge (NWR) are also expected to be low due to melting snow and ice.

Should a helicopter or airplane accident occur during search or recovery operations, there is the potential for fuselage metal debris, fuel, and other materials to land in surface water and affect water quality. Impacts would primarily be associated with the release of fuels and hydraulic fluids. The cleanup of reportable quantities of hazardous materials is also required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) **(42 U.S.C. 9601 *et seq.*)**. Since the probability of an accident is remote and it is anticipated that spills would be cleaned up to CERCLA standards, no environmental impacts on surface waters from search and recovery activities were identified.

4.3.2.2 *Groundwater*

Subsurface water features of concern include near-surface groundwater associated with perched and permafrost talik layer (see Chapter 3, Section 3.4.1, "Permafrost"), water tables, and perennial springs. Near-surface water tables a few centimeters to 1 meter (3.3 feet) below the surface are common to the Arctic Coastal Plain and ecoregions south of Brooks Range. These systems interact directly with surface water features. Even during the coldest winters, some groundwater continues to flow beneath much of the PFRR launch corridor.

Launch Operations

Although there is a potential for spills of hazardous materials during flight preparation activities and deposition of low amounts of rocket exhaust residues on the surface to affect water tables, no groundwater impact pathways were identified. No perennial springs were identified in the vicinity of the PFRR launch site. Accordingly, it is anticipated that the impacts on the PFRR launch site water table or perennial spring water quality would be negligible.

Flight Hardware

Normal and failed flights would produce hardware that would reside on the surface or could penetrate the soil during winter. Potential exposure of near-surface groundwater to metal ions, perchlorate propellant residues, battery electrolytes, or hydraulic fluids from the limited number of NASA SRP launches from PFRR would be localized and likely at trace-level concentrations. Failed rocket impacts and surface detonation could cause an immediate disturbance of near-surface groundwater environments, but overall effects would be considered negligible. Impacts on water table or perennial spring water quality or recharge are anticipated to be negligible.

Search and Recovery

Search and recovery activities could occur in areas with near-surface groundwater and perennial springs. Operational impacts on groundwater features would be associated with an unintended fuel or hydraulic fluid spill by a helicopter at the recovery site during debris item extraction. Fluid spills could also occur from fixed-wing aircraft or helicopter accidents during search and recovery operations. These impact scenarios would rarely occur within the PFRR launch corridor, and individual events would be isolated and limited in extent. The limited number of search and recovery operations under the No Action Alternative would also reduce the probability of adverse impacts. Therefore, impacts on groundwater resources are anticipated to be negligible.

4.3.3 Alternative 1 – Environmentally Responsible Search and Recovery

Under Alternative 1, the number of anticipated rocket launches at PFRR would remain the same as the No Action Alternative. Additional efforts would be made to locate and recover historic spent stages and payloads and recover, to the extent practicable, newly expended rocket stages in an environmentally sensitive and safe manner. Accordingly, additional recovery-related surface disturbance would occur, potentially increasing the potential for sediment-laden runoff to enter surface waters. The risk of spills from recovery equipment would also increase; however, the additional impacts on surface water or groundwater resources beyond those discussed for the No Action Alternative in Section 4.3.2 would be minor. NASA would ensure that recovery crews minimize and mitigate any site damage incurred during recovery.

4.3.4 Alternative 2 – Maximum Cleanup Search and Recovery

Under Alternative 2, the number of anticipated rocket launches at PFRR would remain the same as the No Action Alternative. Maximum practical efforts would be made to locate and recover historic spent stages and payloads and recover, to the degree possible, newly expended rocket stages. During search and recovery operations, there would be the potential for impacts that are minor in magnitude and short-term in duration. Actions would be taken to minimize and mitigate any site damage incurred during recovery; however, a more frequent and aggressive recovery program could result in the greatest potential for impacts on surface waters through land disturbance during removal, as well as risk of fuel spills.

4.3.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts on surface water and groundwater quality under Alternative 3 would be similar to those identified under Alternative 1 in Section 4.3.3, with the exception of NASA's restricting trajectories on future launches such that designated wild river segments would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could lessen the already low probabilities that spent stages or payloads would land within designated Wild and Scenic River segments within PFRR.

4.3.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts on surface water and groundwater quality under Alternative 4 would be similar to those identified under Alternative 2 in Section 4.3.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or proposed Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could lessen the already low probabilities that spent stages or payloads would land within designated Wild and Scenic River segments within PFRR.

4.3.7 Summer Launches

There is a possibility that a rocket experiment could be launched from PFRR during the summer. Compared to winter conditions, interaction of flight hardware with surface water or groundwater resources would be more immediate. However, the principles and patterns of possible water resource impacts would follow similar trends and ultimate endpoints, as discussed in the previous subsections related to surface water and groundwater impacts. No further precautions would be required related to potential surface water and groundwater impacts should a summer launch be planned from PFRR.

4.4 GEOLOGY AND SOILS

This section describes potential impacts on geology and soil resources in and around PFRR and under the launch corridor as a result of the alternatives.

4.4.1 Methodology

The project alternatives do not include construction or significant surface alteration activities that would expose or disrupt geologic formations or impact glaciers, cause slope mass wasting and debris avalanches, or induce seismic activity. Further analysis of potential consequences to geologic features is subsequently excluded from this section. However, there is the potential for soil impacts, including soil damage and soil erosion.

The determination of soil impacts is based on an analysis of the potential for PFRR alternative rocket launch and search and recovery activities to alter the physical or chemical properties of soil or increase the potential for soil erosion. Criteria for evaluating potential impacts on soil resources are presented in **Table 4–15**.

Table 4–15. Evaluation Criteria for Analyzing Soils Impacts

Attribute	Evaluation Criteria
Type	
Adverse	The impact would result in some level of impairment, degradation, or disturbance to soil resources.
Beneficial	The impact would result in some level of environmental improvement to soil resources.
Attribute	**Soil Chemistry**
Context	
Global	Effect would have worldwide implications on the quality of soil resources.
Regional	Effect would be transported by runoff or stream flow throughout the watershed, subbasin, or basin.
Localized	Effect would be isolated to the area affected by the disturbance source.
Intensity	
Major	Effect would generate a substantial change in multiple soil chemistry parameters and result in the eradication of one or more naturally occurring soil organisms.
Moderate	Effect would create a noticeable change in one or more soil chemistry parameters and result in discernible declines in naturally occurring soil organisms.
Minor	Effect on soil chemistry and/or soil organisms would be at a low level of detection and present no contamination risks; effect could be mitigated by onsite personnel or consultations with regulatory agencies.
Negligible	Effect on soil chemistry and/or soil organisms would be at the lowest level of detection or imperceptible.

Table 4–15. Evaluation Criteria for Analyzing Soils Impacts (*continued*)

Attribute	Soil Chemistry (*continued*)
Duration	
Long-Term	Effect on soil chemistry beyond natural thresholds and/or declines in soil organisms would persist for the duration of the program or beyond.
Medium-Term	Effect on soil chemistry and/or soil organisms would stabilize within a few months to years.
Short-Term	Effect on soil chemistry and/or soil organisms would stabilize within a few days to months.
Attribute	**Soil Erosion**
Context	
Global	Effect would have worldwide implications on the quality and/or quantity of soil resources.
Regional	Sediment generated by the disturbance source rill and/or gully erosion features is discharged off site onto adjacent land areas, water bodies, and/or watershed streams.
Localized	Sediment generated by sheet and/or rill erosion features remains on site in close proximity to the disturbance source and is not discharged into water resources.
Intensity	
Major	Impact site disturbances are extensive and prominent gully features deliver substantial amounts of sediment off site that may smother terrestrial vegetation or is discharged into water resources; a violation of the Clean Water Act.
Moderate	Impact site exhibits prominent area of bare ground and rill and/or gully features are present; generated sediment primarily remains on site.
Minor	Impact site exhibits physical soil disturbances and soil sheet and/or rill features are present but would quickly stabilize or be mitigated by onsite personnel or consultations with regulatory agencies.
Negligible	Impact site exhibits small areas of ground disturbance and the effects of erosion are imperceptible; no distinguishable erosion features would form.
Duration	
Long-Term	Effect of gully soil erosion features would persist for the duration of the program or beyond.
Medium-Term	Effect of rill and/or gully soil erosion features would stabilize within months to years.
Short-Term	Effect of sheet and/or rill soil erosion features would stabilize within weeks to months.

4.4.2 No Action Alternative

Activity-induced soil erosion and sediment generation and offsite delivery can damage and destabilize soils, impact water quality, and alter localized area biological productivity. The Gelisol soil order, which is dominant within the Arctic Coastal Plain, Arctic Foothills, and Brooks Range Ecoregions, is particularly sensitive to surface disturbance, and impacts are often long-term and irreversible (see Chapter 3, Section 3.4.5 "Ecoregions"). Disruption of surface soils that alters the seasonal patterns and properties of thawing and freezing could adversely affect permafrost integrity. The sandy soil texture that characterizes many soil series in the Entisol soil order that frequently occupies portions of stream and river floodplains and sandy to silty soil texture of soil series in the Incepitosol soil order may be particularly susceptible to runoff-induced soil erosion and sedimentation (Section 3.4.4, "Soil Orders," and Table 3–11, "Poker Flat Research Range Soil Orders"). Entisols and Incepitosols are common to the Interior

Forested Lowlands and Uplands, Interior Highlands, and Yukon Flats Ecoregions (see Chapter 3, Section 3.4.5).

4.4.2.1 *Launch Operations*

This analysis focuses on the potential impacts of rocket launches and accidental spills of chemical materials during launch preparations on PFRR launch pad area soil chemistry and soil erosion. During launches, the rocket composite-base motors would deposit aluminum oxide particulates and hydrogen acid droplets created when hydrogen chloride gas combines with water or water vapor. These materials could come into contact with soils not covered with snow in the immediate launch area.

The ground concentration of aluminum oxide and hydrogen acid per launch event is anticipated to be small, and deposition of measurable levels from moving exhaust clouds would likely be negligible. Hydrogen acid droplets would be dispersed in the exhaust cloud and would likely not reach concentrations that would affect soil pH. However, aluminum oxide has the potential for long-term residence in the soil environment, which could affect soil chemistry. It is estimated that expended aluminum oxide particulates would be confined to the immediate soil area and would remain within a few centimeters of where they first contacted the soil because of the strong retention characteristics of inorganic and organic components, plant uptake and decay, and other mechanisms. Once released, metal molecules become mobile or immobile in the soil, depending on the site characteristics of the soil, vegetation, hydrology, and climate. Aluminum is a plant nutrient that may be sequestered by plants near the launch pads **(Bohn *et al.* 1979; McLean and Bledsoe 1992)**. It is expected that over multiple launches, aluminum oxide and hydrogen chloride in the soil would remain at non-critical levels. Additional soil disturbance could increase the mobility and availability of aluminum, as well as its susceptibility to offsite transport.

Pre-flight preparation could result in accidental spills of hazardous materials such as fuels, oils, lubricants, batteries, alcohols, and acetone during rocket launch preparation, which in turn could affect soil chemistry. However, nearly all pre-launch activities involving such substances are performed within shelters or buildings, further reducing the potential for a release. PFRR maintains strict adherence with applicable Hazardous Materials Transportation Act, Toxic Substances Control Act, Resource Conservation and Recovery Act, and Hazardous and Solid Waste Act regulations and requirements to prevent and control accidental spills.

In summary, it is anticipated that the potential impacts on soils associated with the limited number of annual sounding rocket launches (an average of four per year), low quantities of aluminum oxide and hydrochloric acid residues, and low probability of accidental spills at PFRR would be localized in context, negligible in intensity, and short-term in duration.

4.4.2.2 *Flight Hardware*

This evaluation focuses on the potential for flight hardware from normal flights and failed flights to impact PFRR launch site and launch corridor soil environments. Specific issues to be analyzed include the potential for fallen hardware to affect soil disturbance and erosion and for metals, propellants, payload batteries, and other materials to impact soil chemistry.

Normal Flights – For normal flights, a rocket stage returning to Earth at ballistic velocities could disturb and displace soil materials on impact. However, since all launches would be conducted during winter, when the surface is covered in snow and ice, the potential damage to the surface would be significantly reduced. It is anticipated that most flight hardware would not impact the ground surface but would remain in the ice or snow until the area thaws, and the items that do impact the ground surface would result in minor secondary soil disturbance. Under winter snow and ice cover and frozen soil conditions, no soil erosion impacts or degradation of permafrost from flight hardware is expected.

Rocket steel, magnesium, and aluminum components that reenter and land on the ground could corrode and introduce metal ions to the soil environment. During dry corrosion, metal atoms and oxygen combine to produce a protective surface layer of converted metal (oxide) that does not react with oxygen in the air or the metal. Eventually, the layer of oxide grows so thick that the movement of electrons and ions that fuels the corrosion process stops. Provided the layer of oxide is thick enough and not cracked or perforated, the metal is protected from further corrosion. However, the protective layer may crack and spall due to the differences in the thermal expansion coefficients between the corrosion products and the metal. Dry corrosion is primarily regulated by climate and soil chemistry and ranges from a few years to hundreds of years **(USEPA 2001**, **2002; Rashidi *et al.* 2007)**. In most cases, metal ions introduced to the soil surface tend to be relatively immobile or move slowly through the soil profile **(McLean and Bledsoe 1992)**. The relatively low rainfall and cooler climate of PFRR reduce metal corrosion rates compared to warmer, wetter climates. As such, no measurable impacts on PFRR launch site or launch corridor soil chemistry are anticipated from the corrosion of metal debris.

Expended rocket stages may also contain trace amounts of solid propellant, and vehicle payloads may contain battery electrolytes, hydraulic fluids, and other toxic materials that could affect soil chemistry. Perchlorate in the soil at levels of about 100 to 1,000 milligrams per liter (100 to 1,000 parts per million) could decrease soil respiration, which may adversely affect nutrient cycling and plant growth. However, the levels of perchlorate in the soil associated with normal flights are expected to be well below 100 milligrams per liter (100 parts per million). The buffering capacity of soils with substantial amounts of organic matter would further diminish potential effects on soil chemistry **(Federer and Hornbeck 1985)**. Based on the relatively low number of flights, small payload quantities, relatively small ground area that would be affected, low levels and decomposition rates of perchlorate in the soil, and recovery procedures as outlined in Section 4.3.2.1, adverse impacts on soil chemistry would be short-term, negligible, and localized.

Failed Flights – Failed rockets that fall to the Earth and explode on impact could affect surface soil physical and chemical environments. It is estimated that a rocket vehicle explosion on non-wetland areas could create a crater estimated to be up to 6 meters (20 feet) in diameter, up to 3 meters (10 feet) deep, with an area of 28 square meters (304 square feet). The surface snow, ice, and frozen surface soils in the immediate area would partly melt. During the spring melt process, runoff could result in disturbance area site soil erosion and subsequent offsite sediment delivery. Sediment generation and delivery are discussed in Section 4.3.2.1. Most of the propellant would be consumed at impact or in secondary burn-offs of dispersed material. In summary, potential adverse impacts on soil erosion would be possible, minor in intensity and medium-term in duration. Short-term, localized, negligible adverse impacts on soil chemistry are anticipated.

4.4.2.3 *Search and Recovery*

Under the No Action Alternative, expended payloads would only be recovered if desirable for scientific or programmatic needs. No impacts on soil resources associated with the transfer of materials from helicopter to fixed-wing aircraft for ultimate delivery to the PFRR launch site are anticipated.

Recovery operations have the potential to disturb surface soils; however, the effects are expected to be negligible. Since off-road vehicles (*i.e.*, snow machines) would only be used in response to an off-nominal flight that would have landed immediately downrange from the launch site, soil compaction and rutting damage would not be expected. Snow at depths greater than 25 centimeters (10 inches) has been found to measurably reduce potential subsurface disturbances from much larger off-road vehicles **(Felix and Raynolds 1989)**, and given that a snow-machine-based response would not likely entail many passes over the same trail, any effects would be negligible. It is possible that small quantities of fuels or lubricants could be deposited along regularly used trails **(Ingersoll 1999)**; however, the limited use of these vehicles would not result in measurable impacts on soils. Should a helicopter or airplane accident occur during search or recovery operations, there is the potential for fuselage metal debris, fuel, and other materials to affect soils. However, based on previous analysis, negligible adverse impacts on soil chemistry are anticipated and adverse impacts on soil erosion would be minor in magnitude and medium-term in duration.

4.4.3 Alternative 1 – Environmentally Responsible Search and Recovery

Under Alternative 1, the number of anticipated rocket launches at PFRR would remain the same as the No Action Alternative. Additional efforts would be made to locate and recover historic spent stages and payloads and recover, to the extent practicable, newly expended rocket stages in an environmentally sensitive and safe manner. Therefore, potential impacts beyond those discussed for the No Action Alternative would be minor.

4.4.4 Alternative 2 – Maximum Cleanup Search and Recovery

Under Alternative 2, the number of anticipated rocket launches at PFRR would remain the same as the No Action Alternative. Maximum practical efforts would be made to locate and recover historic spent stages and payloads and recover newly expended rocket stages. During recovery operations, there would be the potential for isolated impacts that are minor in magnitude and short-term in duration. Actions would be taken to minimize and mitigate any site damage incurred during recovery. No additional impacts on soils beyond those discussed for the No Action Alternative in Section 4.4.2 are anticipated.

4.4.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts on soils under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.4.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild River segments or Wilderness Areas would not be permitted to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential impacts on soils within PFRR.

4.4.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts on soils under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.4.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential impacts on soils within PFRR.

4.4.7 Summer Launches

Compared to winter conditions, interaction of rocket stages with soil resources would be more immediate because there would not be as much snow and ice on the surface to cushion the impact of spent stages or payloads. However, the principles and patterns of possible soil-related impacts would follow the same trends and ultimate endpoints, as discussed in the previous subsections, and no substantial direct impacts on soils are expected to result from summer launches. Indirect impacts could result from the increased likelihood of a wildfire starting as a result of a spent stage igniting such a fire. Under such circumstances, before a summer launch was conducted, additional precautions would be taken to minimize the risks associated with igniting such a fire, including notifying appropriate fire patrol personnel.

4.5 NOISE

This section describes potential impacts that would result from noise generated by the alternatives. The primary focus of this section is to characterize the noise levels that would occur. The potential effects of the noise on receptors (*e.g.,* wildlife, recreational users) are discussed within each resource's respective section.

4.5.1 Methodology

Noise impacts could result from routine PFRR activities, employee vehicles, delivery vehicles, rocket launches, and search and recovery activities. Noise from ongoing routine activities at PFRR is evaluated qualitatively. Noise from sounding rockets and search and recovery aircraft is provided in a quantitative format.

Estimation of Rocket Noise

NASA estimated rocket noise levels using a simple methodology that considers several of the primary performance factors of a rocket. The overall sound power of a rocket is taken to be one-half percent of its mechanical power; mechanical power is simply half the product of the rocket thrust and the gas velocity at the rocket nozzle exit plane. The gas exit velocity does not vary too much for different rockets, so it is the *thrust* that mainly determines the sound power. When these parameters are known, a source level calculation can be made.

Noise impacts from the BB XII and T-IO launch vehicles are presented as they are expected to generate the highest noise levels of the launch vehicles planned for future use at PFRR. Although other launch vehicles may be used at PFRR, their associated noise levels are expected to be less than or equal to the BB XII and T-IO. Much of the discussion regarding rocket noise is adapted from the *SRP SEIS* **(NASA 2000a)**, with appropriate modifications to focus on launches from PFRR.

An additional quantitative analysis that was not performed for the *SRP SEIS* **(NASA 2000a)**, but is included in this section, is the characterization of potential sonic booms felt on the ground during flight. For this analysis, NASA employed the PCBoom4 computer model **(Plotkin and Grandi 2002)**.

Estimation of Aircraft Noise

Aircraft noise levels from search and recovery activities were calculated using the Federal Aviation Administration's INM [Integrated Noise Model] **(FAA 2008)**. Each search and recovery operation would warrant specific consideration, and accordingly, a variety of craft could be flown. The specific vehicles that were chosen for this EIS are representative of the class of aircraft that would be employed by PFRR during such efforts. Other aircraft may be used by PFRR; however, noise levels would not be expected to deviate substantially from those evaluated.

An important consideration when assessing sound generated by aircraft is *slant distance*, which is a combination of aircraft height above ground level (AGL) and the horizontal distance from the receptor to an aircraft not directly overhead. A National Park Service study **(Anderson and Horonjeff 1992)** described the relationship between increasing altitude or slant distances and diminution of sound levels. Very large reductions in sound levels (on the order of 15 to 25 decibels [dB]) are experienced as altitude or slant distance increases from 38 to 305 meters (125 to 1,000 feet). Increases from 305 to 610 meters (1,000 to 2,000 feet) in altitude would produce smaller, but still moderate to substantial, reductions (on the order of 4 to 8 dB). Between 610 and 2,133 meters (2,000 and 7,000 feet) AGL, 305-meter (1,000-foot) increases in distance produce considerably smaller reductions in sound levels (on the order of 3 to 5 dB) and above 2,133 meters (7,000 feet) AGL, each 305-meter (1,000-foot) increase in altitude results in only very small reductions in sound level **(Anderson and Horonjeff 1992)**.

Classification of Impacts

For the evaluation of magnitude of noise impacts, major impacts would be any that result in noise levels that interfere with long-term use of nearby properties or displacement of wildlife in wilderness or wildlife refuge areas (see Section 4.7). Moderate impacts would be those that result in temporary interference with intended uses of nearby properties, temporary startle of wildlife, or temporary interference with the natural experience of visitors to a wilderness, wildlife refuge, or recreation area, such as from the low-level overflight of a search plane or helicopter. Minor impacts would be those that result in measurable noise levels but do not normally interfere with activities, result in startle of wildlife, or normally interfere with the natural experience of visitors to a wilderness, wildlife refuge, or recreation area, such as from employee traffic. Negligible impacts would be those that are immeasurable.

For the evaluation of duration of noise impacts, short-term impacts would be any that occur for brief periods that are much less than the total project life, such as from rocket launches, which typically only produce first-stage noise for a few seconds and overall launch noise for a minute or two. Medium-term impacts would be any that occur for relatively brief periods less than the total project life but may occur repeatedly, such as from search and recovery operations. Long-term impacts would be any that occur for periods longer than medium-term and as long as the life of the project or longer, such as routine operations at PFRR and employee traffic.

Although data are not readily available to characterize the naturally occurring sound levels within PFRR's downrange lands, the National Park Service **(NPS 2008)** conducted such a study during summer in nearby Denali National Park. Average sound levels ranged from approximately 23 decibels A-weighted (dBA) to 41 dBA, depending upon site. The highest sound levels were recorded at a location near flowing water and elevated levels of aircraft activity. It is acknowledged that the land areas may experience different seasonal use patterns; however, the information collected may serve as a reasonable proxy of conditions within the PFRR launch corridor.

4.5.2 No Action Alternative

As stated in Chapter 3, Section 3.5, sources of noise from daily activities at the PFRR launch site include ventilation systems, delivery vehicles, and employee vehicles. Continued launch and recovery of NASA sounding rockets would be consistent with existing sources of noises at PFRR and no additional impacts are anticipated under the No Action Alternative.

Launch Operations

Noise generated by the suborbital SRP flights can be grouped into three general categories: launch noise, flight noise, and landing noise. Launch noise is heard primarily in the immediate vicinity of the launch site. Flight noise and landing noise have not been investigated in this detail because they are at heights at which the noise cannot be heard or in areas where humans are not expected to be, such as near impact points for returning spent stages. Far-field sound levels of sounding rocket launches are presented in **Table 4–16**. The four most powerful rocket motors in the NASA SRP that have previously been used at PFRR are Talos (the first stage of the BB XII), Taurus (the second stage of the BB XII), Terrier, and Nike, listed beginning with the most powerful. These sound levels will persist for a fraction of a minute as the launch vehicle gains altitude. Increasing distance and atmospheric attenuation then sharply reduce the sound level at the ground.

Table 4–16. Far-Field Sound Levels Due to Sounding Rockets Program Rocket Launches

Launch Rocket	Overall Sound Power (kNm/s)	Maximum Sound Levels (dBA) at Distances (D) from Launch Pad		
		D = 1 km	D = 3 km	D = 11 km
Talos	2,700	110	97	75
Taurus	2,700	110	97	75
Terrier	1,700	110	96	74
Nike	990	107	91	71

Note: To convert kilometers to miles, multiply by 0.6214.
Key: D=distance; dBA=decibels A-weighted (referenced to 20 micro Pascals), km=kilometers; kNm/s=kilo Newton-meter per second.
Source: NASA 2000.

Sounding rockets reach supersonic speeds very quickly (*i.e.,* after several seconds); however, they generally would not generate a sonic boom noticeable on the ground due to their high angle of ascent **(Downing 2011)**. As long as a rocket's motors are burning, noise would be generated, especially at the lower altitudes when the air density is appreciable. Above a 10-kilometer (6-mile) altitude, where vacuum conditions are approached, no sound would be propagated. In the case of a typical T-IO launched from PFRR, the vehicle reaches this altitude at approximately 15 seconds into flight; a typical BB XII would be expected to reach the same height at just over 25 seconds of flight time.

When the rocket's motors are no longer burning, only aerodynamic noise would prevail. As the spent rocket stages reenter the Earth's atmosphere at supersonic speeds, sonic booms may be heard on the ground; however, they would be very small when compared to commonly encountered sources of sonic booms, including jet aircraft. The sonic boom analysis indicated that a typical reentering BB XII fourth stage would generate a sonic boom of approximately 0.2 pounds per square foot, equating to an instantaneous peak sound level directly under the boom footprint of approximately 114 dB **(Downing 2011)**. The duration of the low-frequency sound would be very brief, at approximately 30 milliseconds. In an unrelated study of sonic booms of similar magnitude, observers on the ground who were operating the sonic boom recording equipment within the predicted footprint of the sounding rocket boom "heard the boom but felt that they would not have noticed it had they been engaged in an unrelated activity" **(Plotkin *et al*. 2006)**. By comparison, sonic booms generated by supersonic aircraft typically have overpressures 5 to 10 times as large (5 to 10 kilograms per square meter [1 to 2 pounds per square foot]) and last for 100 to 500 milliseconds.

Descending sounding rockets would be expected to drop below the speed of sound at approximately 9,000 meters (30,000 feet) altitude. Spent stages or incoming payloads traveling at subsonic speeds would produce a characteristic whistling sound, followed by a momentary impact-type sound as they land on soil, ice, or a water surface. Acoustic waves would propagate below the surface of solid ground or ice pack. The sound produced and spreading of sound waves through the ground would depend on the nature of the ground material; the presence of snow and ice should help cushion the blow. The impact noise of a stage or payload hitting the ice pack over the Arctic Ocean and possibly penetrating the ice pack was estimated to result in a low-frequency impulse noise of less than 190 dB (referenced to 1 micro Pascal). Based on the transmission loss curves presented by **Buck (1966)** and **Roth (2008)**, the low-frequency noise could be attenuated by 80 to 90 dB in 100 kilometers (60 miles). Higher-frequency noise would be attenuated much more rapidly.

In summary, the noise impact from routine PFRR activities, employee vehicles, and delivery vehicles would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent-stage reentry and impact would be regional, adverse, short-term, and minor in intensity.

Search and Recovery

Estimates of noise levels on the ground under search and recovery aircraft typical of those that may be used in support of search and recovery operations at PFRR are presented in **Tables 4–17** and **4–18**. Permit conditions for flights over Arctic NWR and Yukon Flats NWR request a minimum flight altitude of 610 meters (2,000 feet) AGL, except for takeoff and landing

(USFWS 2011a, 2011b). At this altitude noise levels on the ground would be between 60 and 65 dBA from an overflight of a fixed-wing aircraft. Noise levels from a hovering helicopter would be 51 dBA for a Bell 206 and 60 dBA for a Bell 214. Noise generated during search and recovery aircraft operations is of medium duration. Although no recovery operations would expose persons to unsafe noise levels, there is the potential for temporary annoyance if related sounds were heard within the context of the natural quiet of a wilderness, wildlife refuge, or recreation area. The quiet of uninhabited areas may be temporarily interrupted by aircraft activity from search and recovery operations. However, aircraft activity would be very infrequent (less than several flights total per year) and sounds of overflights are familiar to residents of these areas, who rely on aircraft as a primary means of year-round transportation.

Table 4–17. Typical Noise Levels at Ground Level Under Fixed-Wing Aircraft Operations (decibels A-weighted)

Altitude (meters AGL)	Aviant Husky	Short Skyvan
91	82	86
150	76	81
305	68	73
460	65	69
610	60	65

Key: AGL=above ground level.
Note: Aviant Husky or comparable fixed-wing aircraft would be used for search operations and shorter-range recovery operations. The Short Skyvan or comparable aircraft would be used for longer-range recovery operations. To convert meters to feet, multiply by 3.281. Levels indicated are the maximum sound levels in decibels A-weighted (referenced to 20 micro Pascals).

Table 4–18. Typical Noise Levels at Ground Level Under Helicopter Operations (decibels A-weighted)

Altitude (meters AGL)	Bell 206 Jet Ranger		Bell 214 Huey II	
	Constant Speed Departure	Hovering	Constant Speed Departure	Hovering
8	N/A	98	N/A	110
15	N/A	91	N/A	102
91	82	71	88	82
150	77	66	83	76
305	70	59	76	68
460	67	55	72	64
610	63	51	68	60

Note: The Bell 206 Jet Ranger or a comparable helicopter is typically used for search and recovery operations when the payload or spent stage is within the lift capability of this lighter helicopter. The Bell 214 Huey II or comparable helicopter is typically used for recovery operations when the spent stage is heavier than the lift capability of the Bell 206 Jet Ranger. To convert meters to feet, multiply by 3.281. Levels indicated are the maximum sound levels in decibels A-weighted (referenced to 20 micro Pascals).
Key: AGL=above ground level; N/A=not applicable.

In summary, the adverse noise impact from search and recovery operations would be regional in scope, medium-term, and minor.

4.5.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.5.3.1 *Launch Operations*

Under Alternative 1, noise impacts from routine operations and launch activities would be similar to those under the No Action Alternative. The noise impact from routine PFRR activities, employee vehicles, and delivery vehicles would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent-stage reentry and impact would be regional in scope, adverse, short-term in duration, and minor in intensity.

4.5.3.2 *Search and Recovery*

Estimates of noise levels on the ground under search and recovery aircraft would be similar to those under the No Action Alternative, but the number of search and recovery operations would be greater. Accordingly, the noise impact from search and recovery operations would be greater than the No Action Alternative.

A key difference between Alternative 1 and the No Action Alternative is the level of recovery of spent rocket stages. Under the No Action Alternative, the payloads that would be recovered would most likely return to land via parachute, requiring relatively little on-the-ground manipulation that could generate elevated sound levels. In the case of removing spent stages, some of which would land and embed nose-down, it is likely that power tools could be needed to cut the motor into manageable sized pieces or to cut off the stage to below ground level in a case where full removal would cause more damage than partial removal. The most likely power tool employed would be a gasoline-powered "cut-off saw," which has been found to generate sound levels of approximately 95 dBA at 1.5 meters (5 feet) distance (estimated at 108 dBA at the source) when cutting steel rebar **(Eaton 2000)**.

The rate at which the sound from these activities would attenuate would be highly dependent upon where the work is taking place and the weather conditions. For example, conducting a recovery and disassembly operation on a day with little wind within an open, rocky area with little buffer between the activity and a receiver could result in sound levels in excess of 40 dBA at 1.1 kilometers (0.7 miles). However, performing the same work within an area of dense conifers could result in additional attenuation on the order of 5 dB for every 30 meters (100 feet) of distance (per the curves presented in **Aylor [1971]**), resulting in 40 dBA at an approximate distance of 120 meters (400 feet).

The presence of deep powder, which would occur on downrange lands during recovery of an off-nominal flight in winter, can also provide substantial attenuation (and was not considered in either case presented above), further reducing the intensity of the sound. A study conducted for the National Park Service by the U.S. Department of Transportation found deep snow to provide an additional attenuation of nearly 5 dB per doubling of distance from the source **(USDOT 2008)**.

In summary, sound levels generated from disassembly of rocket motors would likely be above background levels within the downrange lands; however, in either scenario, the sound generated would be short-term (*i.e.*, generally less than an hour per motor), infrequent, and depending on specific conditions, would be confined to a limited distance from the source.

Overall, noise generated by Alternative 1 search and recovery would be considered regional in scope, adverse, medium-term in duration, and moderate in intensity.

4.5.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.5.4.1 *Launch Operations*

Under Alternative 2, noise impacts from routine operations and launch activities would be similar to those under the No Action Alternative and Alternative 1. The noise impact from routine PFRR activities, employee vehicles, and delivery vehicles would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent-stage reentry and impact would be regional in scope, adverse, short-term in duration, and minor in intensity.

4.5.4.2 *Search and Recovery*

Estimates of noise levels on the ground under search and recovery aircraft would be similar to those under the No Action Alternative and Alternative 1, but the number of search and recovery operations would be greater. Accordingly, the noise impact from search and recovery operations would be the greatest of the alternatives and considered regional in scope, adverse, medium-term in duration, and moderate in intensity.

4.5.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Noise impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.5.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could result in lower probabilities that future rocket launches from PFRR would impact in these areas.

4.5.5.1 *Launch Operations*

The noise impact from routine PFRR activities, employee vehicles, and delivery vehicles would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent stage reentry and impact would be regional, adverse, short-term, and minor in intensity.

4.5.5.2 *Search and Recovery*

Since the Wild and Scenic River segments or Wilderness Areas may attract a greater number of visitors due to their designations, avoidance of these areas would result in fewer search and recovery actions within the area and less potential noise impacts on visitors.

The noise impact from search and recovery operations would be regional, adverse, medium-term, and moderate in intensity.

4.5.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Noise impacts under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.5, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could result in lower probabilities that future rocket launches from PFRR would impact in these areas.

4.5.6.1 *Launch Operations*

The noise impact from routine PFRR activities, employee vehicles, and delivery vehicles would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent stage reentry and impact would be regional, adverse, short-term, and minor in intensity.

4.5.6.2 *Search and Recovery*

Since Wild and Scenic River segments or Wilderness Areas may attract a greater number of visitors due to their designations, avoidance of these areas would result in fewer search and recovery actions within the area and less potential noise impacts on visitors.

The noise impact from search and recovery operations would be regional, adverse, medium-term, and moderate in intensity.

4.5.7 Summer Launches

The noise generated from rocket launches and spent stage reentry and impact would continue to be regional, adverse, short-term, and moderate. The noise generated from search and recovery operations would not likely change and would continue to be regional, adverse, medium-term, and moderate.

4.6 VISUAL RESOURCES

4.6.1 Methodology

Visual resource assessments in this section are based on a description of the viewshed and the U.S. Bureau of Land Management's (BLM's) visual resource management (VRM) classification **(USDOI 1986a)**. A qualitative visual resource analysis was conducted to determine whether disturbances associated with the launch and recovery of NASA sounding rockets launched from PFRR would alter the visual environment of the PFRR launch site or launch corridor. Both the degree of contrast between the alternatives and the existing visual landscape and the visual impact of a person discovering a payload or spent stage are presented. The ROI for visual resources includes areas within the PFRR launch site and the PFRR launch corridor. The BLM VRM classification is further described in Chapter 3, Section 3.6, of this EIS.

An impact to visual resources would be considered major if a component of an alternative were to change the overall appearance of the ROI and would result in a change in the BLM VRM classification. A moderate impact would result in a change in the visual appearance of an area within the ROI and result in a change in the BLM VRM classification; however, the change would be limited to a 2-kilometer (1-mile) radius surrounding the payload or spent stage. A minor to negligible impact would result when there would be little or no change to the visual appearance of the ROI, there would be no change to the BLM VRM classification, and the visual impact would be limited to the immediate area surrounding the payload or spent stage. Regarding duration, a visual impact would be considered long-term if the effect lasted longer than 5 years, as could be the case if a payload or spent stage were left in an area with high visibility for more than 5 years; medium-term if the payload or spent stage were left unrecovered in an area with high visibility for 1–5 years; and short-term if the payload or spent stage were recovered within 1 year of being launched or located in an area with high visibility.

4.6.2 No Action Alternative

4.6.2.1 *Launch Operations*

Launch Site

The PFRR launch site consists of a developed area with offices, rocket launch facilities, a blockhouse, pad support, and a rocket storage building. Under the No Action Alternative, no measurable changes would be made to the appearance of the PFRR launch site.

Rocket Flight

During the launch of a sounding rocket, the vehicle propels a scientific payload to the upper atmosphere, after which the payload and spent rocket stages fall back to Earth along a parabolic trajectory. Most launches would occur at night. When launched, the sounding rocket can be seen for approximately 20 seconds from the PFRR launch site before disappearing. **Figure 4–6** shows a NASA sounding rocket launch from PFRR in April 2011.

Figure 4–6. Sounding Rocket Launch at Poker Flat Research Range

The impact on visual resources from the launching of sounding rockets would be minor and short-term. No change in BLM VRM classification **(USDOI 1986a)** would be anticipated for the areas within the PFRR launch corridor.

Flight Hardware

When the payloads and spent stages return to the Earth, they land within the PFRR launch corridor. **Figures 4–7** through **4–9** show sounding rocket stages that have landed within the PFRR launch corridor. Payloads and spent stages that would occur under the No Action Alternative would have similar appearances, as presented in Figures 4–7 through 4–9.

Figure 4–7. Spent Stage Within Poker Flat Research Range Launch Corridor

Figure 4–8. Aerial View of a Payload Within Poker Flat Research Range Launch Corridor

Figure 4–9. Payload Within Poker Flat Research Range Launch Corridor

Discovery of spent stages or payloads within the PFRR launch corridor could negatively impact some visitors' experience. Others may find it a positive experience to discover a spent stage or payload. In 2010 and 2011, the University of Alaska Fairbanks (UAF) and NASA received feedback from users of the areas within the launch corridor who have located spent stages and payloads. The comments received expressed both positive and negative reactions of these visitors from locating the spent stages and payloads within the launch corridor. The visual impact would be on a person-by-person basis and would be influenced by the perception of the individual.

The intensity of the impact would be dependent upon where flight hardware is located and how often it is seen by users of the downrange lands. It is likely that given the remote and vast nature of the launch corridor, many stages and payloads would go unnoticed. In that case, there would be little or no impact. In contrast, although the physical extent of the impact site would be small and limited to the area immediately surrounding the payload or spent stage (thereby deemed minor in most circumstances), its long-term presence in a high-value environmental feature such as a Wild River or Wilderness Area would most likely be considered a moderate impact. The duration of impacts on visual resources would vary depending on how long the stages and payloads were left unrecovered. In general, few payloads (and even fewer stages) would be recovered. Accordingly, impacts would most likely be long-term.

4.6.2.2 *Search and Recovery*

Searches for the payloads and spent stages would be conducted by fixed-wing aircraft, as discussed in Appendix F. Due to the vastness of the PFRR launch corridor, payloads are often not visible and difficult to locate. Brightly colored parachutes are deployed with some payloads to assist in the recovery of these payloads. **Figure 4–10** shows an aerial view of a payload recovered from the PFRR launch corridor. **Figure 4–11** shows an aerial view of the same payload with the parachute deployed as presented in Figure 4–10, except from a higher altitude. An arrow is provided in the picture to help with locating the parachute in the figure.

Figure 4–10. Aerial View of a Payload with Parachute Deployed

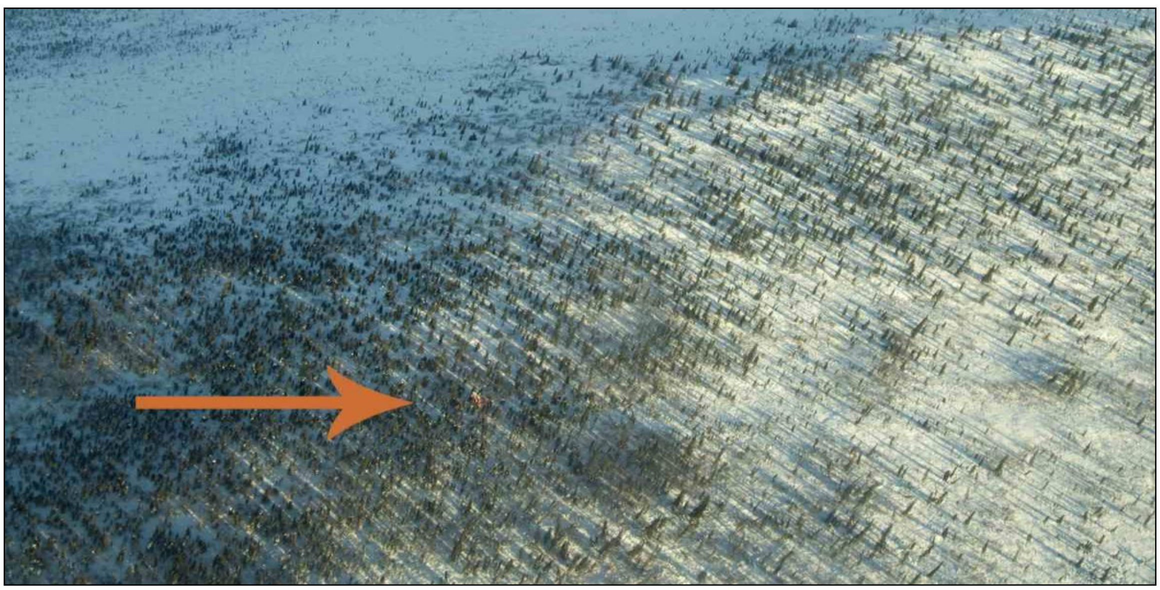


Figure 4–11. Higher Altitude of Aerial View of a Payload with a Parachute Deployed

Once located, the payloads and spent stages would be removed by helicopter, either by transporting to a nearby airstrip or to PFRR. Users of and visitors to subject lands would be able to see the aircraft performing search and recovery activities. Because of the long distances, remoteness, and climate, much of the state of Alaska is accessible only by general aviation aircraft. There are 18 rural airports and a number of unmarked airstrips in or near the PFRR launch corridor. As such, the additional presence of aircraft for search and recovery operations associated with the No Action Alternative would not have a measurable impact on the visual characteristics or BLM VRM Class of the PFRR launch corridor.

4.6.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.6.3.1 *Launch Operations*

Launch Site and Rocket Flight

Visual impacts from launch operations under Alternative 1 would be consistent with the impacts associated with the No Action Alternative and would be short-term and minor.

Flight Hardware

As compared to the No Action Alternative, the same amount of hardware would land within downrange properties. As such, the type and intensity of the impact would be similar. However, recovery of additional payloads and spent stages would reduce the probability of a visitor or user of the lands encountering such materials, thereby reducing the long-term visual impact.

4.6.3.2 *Search and Recovery*

The type of visual impacts from search and recovery activities under Alternative 1 would be consistent with the impacts associated with the No Action Alternative. However, attempted recovery of additional payload and spent stages would require additional aircraft to be flown over the PFRR launch corridor. Accordingly, the potential for a visual resource impact would be greater. However, when considered within the context of the existing aircraft traffic within the PFRR launch corridor, the large areas covered, and the infrequency of these operations, visual impacts from the additional air traffic are anticipated to be negligible. No change in the BLM VRM classification would be expected due to search and recovery activities under Alternative 1.

4.6.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.6.4.1 *Launch Operations*

Launch Site and Rocket Flight

Visual impacts from launch operations under Alternative 2 would be consistent with the impacts of the No Action Alternative and Alternative 1.

Flight Hardware

As compared to the No Action Alternative and Alternative 1, the same amount of hardware would land within downrange properties. As such, the type and intensity of the impact would be similar. However, as this alternative would entail the greatest efforts for recovery of payloads and spent stages, it would likely present the least probability of a visitor or user of the lands encountering such materials, thereby reducing the long-term visual impact.

4.6.4.2 *Search and Recovery*

The type of visual impacts from search and recovery activities under Alternative 2 would be consistent with the impacts associated with the No Action Alternative and Alternative 1. However, attempted recovery of additional payload and spent stages would require the most aircraft to be flown over the PFRR launch corridor. Accordingly, the potential for a visual resource impact would be greater. However, when considered within the context of the existing aircraft traffic within the PFRR launch corridor, the large areas covered, and the infrequency of these operations, visual impacts from the additional air traffic are anticipated to be negligible.

No change in the BLM VRM classification would be expected due to search and recovery activities under Alternative 2.

4.6.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Visual impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.6.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could result in lower probabilities that future rocket launches from PFRR would impact in these areas. Since these areas may attract a greater number of visitors due to their designations, avoidance of these areas would result in fewer search and recovery actions within the area and less potential visual impacts on visitors.

4.6.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Visual impacts under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.6.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could result in lower probabilities that future rocket launches from PFRR would impact in these areas. Since these areas may attract a greater number of visitors due to their designations, avoidance of these areas would result in fewer search and recovery actions within the area and less potential visual impacts on visual resources.

4.6.7 Summer Launches

As more activities would occur within the PFRR launch corridor during non-winter months, the potential for someone to observe a rocket overflight would be greater. However, the visual impact from such activities would continue to be short-term and minor. Regarding flight hardware, the type, magnitude, and duration of impacts would remain generally the same. However, in the absence of frozen ground and ice during the summer in areas of lower elevation, there is the potential that spent stages (particularly those that are fin-stabilized) would bury themselves in shallow bogs and sloughs (particularly in the wetland areas of the Yukon Flats), thereby negating the likelihood of a lands user encountering such materials.

Additionally, there is the potential that a lands user would observe a post-launch fixed-wing search operation within the PFRR launch corridor; however, the impacts would be short-term and negligible when considered within the context of the infrequency of a non-winter launch and the number of aircraft that are typically within the area supporting existing recreational and commercial activities.

4.7 ECOLOGICAL RESOURCES

This section describes potential impacts of each alternative on ecological resources in and around PFRR and the launch corridor. The categories of ecological resources will be analyzed in the same sequence as presented in Chapter 3, Section 3.7.

4.7.1 Methodology

The analysis encompasses direct and indirect effects on biological resources, including threatened and endangered species, associated with the following aspects of the NASA SRP at PFRR:

1. NASA SRP launches from PFRR,
2. descending spent stages and payloads,
3. search and recovery of spent stages and payloads, and
4. unrecovered spent stages and payloads.

Effects on ecological resources would mainly occur as a result of localized land disturbance, in which a spent stage or payload comes to Earth, and as a result of potential disturbances to wildlife caused by low-altitude overflight of aircraft associated with search and recovery operations. An area of 6–15 square meters (65–160 square feet) was used to evaluate the lethal area of impact for both vegetation and wildlife. It was assumed that the potential for disturbance would decrease rapidly as distance from the actual impact point increased. Historical data were used as a guide for analyzing past, as well as future, impacts.

Since launches would take place in the winter months (October through April), it was assumed that snow and ice cover would minimize effects on vegetation and subterranean or underwater wildlife. In addition, seasonal variation was taken into consideration when evaluating impacts on migratory or otherwise highly mobile species. The potential for effects on threatened, endangered, proposed, and candidate species and their habitats was evaluated in greater detail in recognition of their status.

Vegetation

Vegetation impacts evaluated in this section are addressed by ecoregion. The intensity of impact is categorized as negligible, minor, moderate, or major according to the definitions in Table 4–1. Direct impacts on vegetation and habitat are considered short-term if a functional vegetative cover is expected to reestablish within 1–2 years or less; moderate-term, within 3–5 years or less; and long-term, 5 years or longer. Reestablishment of functional vegetation cover is considered to be development of cover of herbaceous or woody plants capable of holding the soil.

Continued successional processes such as establishment of longer-lived plant species or growth of trees would be expected after reestablishment of functional vegetative cover.

Wildlife

To determine potential impacts on wildlife, this section relies heavily on available published literature evaluating the response of wildlife to noise associated with sounding rocket launch; overflight; descent, including sonic booms and impact on the surface; as well as the response to overflight by fixed-wing aircraft and helicopters used in search and recovery activities.

Potential noise levels generated by the alternatives were derived using industry-accepted noise modeling to define noise levels from rocket launch and descent and from aircraft and helicopters engaged in search and recovery activities (see Section 4.5).

Special-Status Species

For endangered and threatened species, additional considerations specific to the Endangered Species Act (ESA) are applied. A major impact would reach the scale at which multiple "takes" of more than one listed species would occur, or if the expected impact on a single species was such that a consulted expert agency (*i.e.,* U.S. Fish and Wildlife Service [USFWS] or National Oceanic and Atmospheric Administration [NOAA] Fisheries Service) would conclude that the species' recovery or continued existence might be in jeopardy. As defined under the ESA, "take" includes death, harm, or harassment of an individual. An impact would be considered moderate if an alternative had the likelihood of "taking" a single individual from more than one listed species or multiple individuals from a single species, but would not result in jeopardy as outlined above. A minor impact would occur if a single take were anticipated for a single species. An impact would be considered negligible if the likelihood of "take" were to be "insignificant and discountable" as defined by the ESA. Per the ESA, an "insignificant and discountable" impact is generally defined as one that would be very small in size and highly unlikely to occur. For species having designated critical habitat, a determination is made as to whether there would be adverse modification of critical habitat.

To best predict the likelihood of potential impact on listed species, calculations were performed to predict the likelihood of a descending payload or spent stage directly impacting or landing within their expected range. The methodology employed is very similar to that relied upon by NASA when assessing flight safety risk for a sounding rocket mission. Best available data on population densities were used.

4.7.2 Applicable Permit Conditions

The following is a summary of the stipulations from the most recent USFWS and BLM permits that are most applicable to the ecological resources analysis (see Appendix C for full permits). Under all permits, PFRR is required to contact the respective landowner prior to attempting a recovery action.

Stipulations of the 2011 Yukon Flats NWR permit include the following restrictions on launch operations and aircraft use:

Seasonal Restrictions on Launch Operations

- Rocket or debris impacts within Yukon Flats NWR are prohibited from May 1 through September 30 to avoid periods of high public use. A provision is made enabling exceptions to the seasonal restriction to be provided for specific time periods and areas, given appropriate justification.

Restrictions on Aircraft Use

- Aircraft are recommended to maintain a minimum of 610 meters (2,000 feet) AGL over refuge lands, except during takeoff, landing, and when safety considerations require a lower altitude.[4]

- The operation of aircraft at altitudes and in flight paths resulting in the herding, harassment, hazing, or driving of wildlife is prohibited.

- Landing of helicopters is authorized only in direct support of the recovery activities or in emergencies.

- Clearing of vegetation for landing/takeoff is prohibited, as well as low-level slinging of gear from site to site.

- Helicopter activity is prohibited within 0.8 kilometers (0.5 miles) of active raptor nest sites on cliffs or bluff faces during the period from May 1 through August 15.

The Special Use Permit for Arctic NWR also includes restrictions associated with the wilderness and wildlife use areas:

Restrictions on Mollie Beattie Wilderness Area

- Conducting launches with a planned impact site within the Mollie Beattie Wilderness Area is prohibited.

- Recovery of rockets or debris that enters the wilderness area inadvertently may be authorized on a case-by-case basis by the Arctic NWR manager in consideration of the appropriate action under the Wilderness Act of 1964.

Restrictions on Wildlife Use Areas

- Activities may not occur in some special use areas and/or during some time periods (*e.g.,* caribou calving, snow goose staging, Sadlerochit Springs). Special area boundaries or the effective dates may be modified by the Arctic NWR manager as needed.

[4] This permit condition was recently discussed with USFWS as the recommended altitude would be too high thereby precluding effective search operations. It was agreed upon that the recommended altitude would be maintained when transiting from the airfield to anticipated rocket hardware location, and that lower altitudes (*e.g.,* approximately several hundred feet AGL) would be necessary (and permissible) when searching.

- Specific authorization to use localities within special areas may sometimes be obtained on a case-by-case basis, depending on the location of animal concentrations, access route, proposed activity, etc.

- Unless specifically exempted, all activities, including helicopter flights, are prohibited within one-half mile of occupied raptor nest sites at the locations and during the time periods that follow: (1) north of the continental divide, March 15–August 15; and (2) south of the continental divide, April 15–August 15.

Stipulations of the BLM-issued permit include:

- All operations are to be conducted in such a manner as not to cause damage or disturbance to any fish or wildlife and subsistence resources.

- Excavation or disturbance during the recovery needs to be filled to avoid water ponding, soil erosion or thermokarsting (localized soil subsidence caused by melting of permafrost).

- Minor clearing of brush (less than 6 meters by 6 meters [20 feet by 20 feet] total area) for extracting rocket parts is allowed, although extensive clearing of trees or brush for helipads is prohibited.

- Appropriate action is required to clean equipment used to recover flight hardware to prevent propagating invasive and noxious weeds and plant species at recovery sites.

- Aircraft are required to fly at a minimum of 457 meters (1,500 feet) AGL within a half-mile radius of priority raptor species' nest sites from April 15 through August 15 (except March 15 through July 20 for gyrfalcons).

4.7.3 Vegetation

4.7.3.1 *No Action Alternative*

Launch Operations

There would be no impacts on vegetation at the launch site because the surrounding area is cleared and maintained free of vegetation. Upon landing of flight hardware, impacts on vegetation would be restricted to the area immediately surrounding the item(s) and would diminish rapidly as distance from the impact point increases. Impacts would generally not be observable more than about 5 meters (approximately 16 feet) from the impact point. Since the majority of launches would be conducted during the winter months (October to April), when substantial snow cover is present, minimal impacts on vegetation are anticipated. Given the small and localized area of disturbance and the small number of launches annually, potential adverse impacts on vegetation and habitat would be negligible.

Due to the large area under the PFRR launch corridor and the dispersion characteristics inherent in sounding rocket flights, it is not possible to provide estimates for each plant species or habitat type that could potentially be disturbed. However, the number of spent stage and payload impacts within each ecoregion has been calculated for the last 15 years of launches from PFRR and is presented in **Table 4–19**. If future impacts follow a similar pattern, the data could be used to estimate the number of impacts affecting each ecoregion.

Table 4–19. Percentage and Number of Spent Stages and Payloads that Have Landed in Each Ecoregion, 1997–2011

Ecoregion (Ecoregion number)	Percent (Number) of Impact Points (n=112)	Total Area Impacted[a] (square meters)	Percent of Ecoregion Impacted by Combined Stages and Payloads
Brooks Range (103)	19 (21)	1,680	4.0×10^{-6}
Interior Highlands (105)	63 (71)	5,680	2.5×10^{-5}
Interior Forested Lowland (104)	5 (6)	480	3.3×10^{-6}
Yukon Flats (107)	4 (4)	320	1.3×10^{-6}
Arctic Coastal Plain (101)	0 (0)	0	0
Arctic Foothills (102)	0 (0)	0	0
Beaufort Sea	9 (10)	800	2.4×10^{-5}

a. An 80-square-meter disturbance area was used to estimate disturbance based on a circular area with a radius of 5 meters; generally, ground disturbance would be confined to a much smaller area.

Note: To convert square meters to square feet, multiply by 10.7639.

Source: NASA 2011a.

The data show the small and insignificant cumulative area of disturbance by ecoregion resulting from the past 15 years of launches from PFRR.

Search and Recovery

Recovery operations with the potential to impact vegetation are limited to the "on-the-ground" activities associated with helicopter landing and rigging the payload to the helicopter. It is anticipated that during this time period, vegetation could be crushed, uprooted, or otherwise disturbed in a localized area. Such disturbances are expected to be very small in area, temporary, and would be naturally mitigated through succession and natural regrowth. Landing by fixed-wing reconnaissance aircraft would have minimal impacts because landings would be limited to existing airstrips or areas lacking obstacles and with naturally occurring low vegetation such as gravel beds. Because of the small and isolated area of vegetation affected by a single payload recovery, and natural vegetative regeneration, adverse impacts on vegetation would be negligible under the No Action Alternative.

In the unusual event of a wintertime (October to April) recovery, adverse impacts on vegetation would occur to an even lesser degree due to the presence of frozen ground and snow cover.

4.7.3.2 *Alternative 1 – Environmentally Responsible Search and Recovery*

Launch Operations

Ground-disturbing activities associated with launch operations at PFRR under this alternative would be similar to those associated with the No Action Alternative and Alternative 1 since the same number of launches per year is anticipated.

Search and Recovery

Under Alternative 1, search and recovery of newly spent stages and payloads would be made to the extent practical and done in an environmentally responsible manner. Although the same types of impacts on vegetation would occur as under the No Action Alternative (localized crushing, uprooting), the number of stages and payloads recovered is anticipated to increase. Thus, the areal extent of the impacts would also increase. Because of the low number of recovery efforts annually, the small and isolated area of vegetation affected by recovery of a spent stage or payload, and the natural regeneration of vegetation after disturbance, adverse impacts on vegetation would be negligible under Alternative 1.

4.7.3.3 *Alternative 2 – Maximum Cleanup Search and Recovery*

Launch Operations

Ground-disturbing activities associated with launch operations at the PFRR launch site under Alternative 2 would be similar to those associated with the No Action Alternative and Alternative 1 since the same number of launches per year is anticipated.

Search and Recovery

Impacts on vegetation as a result of recovery efforts under Alternative 2 would be similar to those under Alternative 1, except increased efforts would be made to recover existing payloads, as well as new and existing stages. The additional recovery efforts under Alternative 2 would add to the areal extent of disturbance to vegetation, although the types of disturbance would be the same as those described under the No Action Alternative. Because of the low number of recovery efforts annually, the small and isolated area of vegetation affected by recovery of a spent stage or payload, and the natural regeneration of vegetation after disturbance, adverse impacts on vegetation would be negligible under Alternative 2.

4.7.3.4 *Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories*

Impacts on vegetation under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.7.4.2, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential impacts on vegetation within PFRR and any adverse impacts of launch and recovery activities on vegetation would be negligible as described above.

4.7.3.5 *Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories*

Impacts on vegetation under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.7.4.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential impacts on vegetation within PFRR and any adverse impacts of launch and recovery activities on vegetation would be negligible as described above.

4.7.4 Wildlife

This section describes potential impacts on wildlife occurring within the ROI as a result of the alternatives. For purposes of impact analysis, wildlife includes terrestrial mammals, marine mammals, birds, and fish. Species protected under Federal or state endangered species legislation is discussed separately in Section 4.7.7.

The composition of species within the ROI would change depending on season. For example, from October to April, species that overwinter within the PFRR launch corridor, such as the musk ox, would be present during winter launches, whereas migratory waterfowl and shorebirds would be absent during winter launches. Additionally, activities of species and their sensitivity to disturbance may vary with the season.

4.7.4.1 *No Action Alternative*

Launch Operations

Wildlife in the immediate vicinity of the PFRR launch site would be exposed briefly to the sound and light from each launch, which is moderate in intensity (up to 110 dBA at 1 kilometer [0.6 mile]; see Section 4.5). After ignition, the sound builds to its maximum volume in seconds as the rocket lifts off and then diminishes rapidly as it climbs. Winter launches would occur during darkness, when migratory species would be absent and most resident species would be inactive. Due to the infrequency of launches and the brief duration of associated noise, species present near the launch site are expected to have negligible to minor short-term behavioral responses, if any, to the sound and sight of a launch and are not expected to experience harm as a result.

The sounding rocket climbs to approximately 805 kilometers (500 miles) above the Earth's surface before beginning its descent. Descending spent stages and payloads would drop below the speed of sound about 9,000 meters (30,000 feet) AGL. A low-intensity sonic boom would be generated above 9,000 meters (30,000 feet). Although hearing response varies from species to species, it is unlikely that momentary (less than 1 half-second) exposure to a very low-intensity sonic boom would cause an adverse response in any wildlife species.

The subsonic sound associated with the incoming spent stage or payload was not commented upon by **Plotkin *et al*. (2006)**, but exposure to the subsonic sound would be brief in duration and would end as the payload or spent stage hits the surface. The sound of the payload hitting the surface would be related to its mass and velocity and to properties of the surface such as snow cover, vegetation, or rock (see Section 4.5). Disturbance of wildlife due to the sound and impact of a descending stage or payload would be infrequent because of the small number of annual launches and minimal due to the localized affected area. Effects would most likely be limited to a momentary interruption of routine behaviors, such as foraging, but could extend to individuals temporarily leaving the area immediately surrounding the point of impact. For example, an incoming item hitting the Earth within or very near a herd of caribou (a very unlikely event) could cause the animals to temporarily take flight in a response similar to one elicited by a potential predator. Adverse impacts would be short term and range from negligible to minor. Due to the low number of descending stages and payloads and their wide spatial dispersion, it is unlikely that any individual animal would be in proximity to more than one descending item during its lifetime.

The likelihood of a direct impact on an animal is extremely low due to the extent of the area under the PFRR launch corridor (113,000 square kilometers [43,600 square miles]), the small area of lethal impact (generally ranging from 6–15 square meters [65–160 square feet], depending on the rocket type and stage number), and the small number of estimated annual launches (an average of 4). The potential for injury or disturbance would decrease rapidly with distance from the impact point. The chances of a direct impact due to a payload or spent stage striking an individual animal are therefore negligible.

In summary, adverse impacts on wildlife from launch, flight, and landing of spent stages or payloads would be short-term and could range in magnitude from negligible to minor.

Search and Recovery

Whenever feasible, a search plane would attempt to find spent stages and payloads after launch and document their locations for later recovery. Recovery activities would typically be conducted during summer months, when weather conditions and day length are more favorable for search and recovery activities.

The literature contains a variety of reports of wildlife exhibiting potentially adverse responses to aircraft overflight (*e.g.,* **NPS 1994**); however, conducting well-controlled studies on unconfined wildlife is difficult and relatively few are available.

Terrestrial Mammals

Ungulates (hooved mammals) occupying landscapes with little cover, such as caribou, have been the subject of focused studies because of a concern that a response such as running in response to an aircraft overflight might be of high energetic cost. An additional, perhaps greater concern, is that disturbance during calving season (generally May through June) could lead to a cow (female) abandoning her young.

The PFRR launch corridor overlaps the range of two important caribou herds, the Central Arctic Herd and the Porcupine Caribou Herd. In addition, range of the relatively smaller White Mountains herd is located north of the launch site within the White Mountains NRA. Accordingly, most of this section will focus on potential effects on these animals. Areas of concentrated calving for the Central Arctic and Porcupine herds occur along the northern coast of Alaska, an area that has very low probability for sounding rocket hardware landings due to protection of nearby towns (*e.g.,* Kaktovik) and infrastructure (offshore oil and gas platforms). Performing a recovery operation in this area, although possible, would be highly unlikely. The most likely areas that caribou would be encountered during recovery would be migratory routes and summer and wintering grounds, particularly in the Brooks Range vicinity. Although there is limited information regarding the distribution of the White Mountains herd, available data suggest that calving occurs mostly east of Beaver Creek. In the event that a recovery operation is planned to occur in an area where the White Mountains herd could potentially exist, coordination with BLM would occur in an effort to minimize impacts on the herd. Specifically, recovery operations would be timed to avoid sensitive periods of the caribou life cycle, including the calving and migration seasons **(Durtsche and Hobgood 1990)**.

A study conducted by **Calef *et al.* (1976)** concluded that barren-ground caribou reacted to small fixed-wing (*e.g.,* Cessna 185) and helicopter (*i.e.,* Bell 206) overflights most strongly during calving (late May to early June), post-calving (early June to late June) and winter. During the calving period and in early winter, and often during the rut, a substantial percentage of strong escape responses occurred when the aircraft were flying at 90–150 meters (300–500 feet) AGL. The authors suggest that if aircraft operate in level flight at heights above 150 meters (500 feet) during the spring or fall migration, most potentially injurious reactions by caribou would be avoided. To avoid the possibility of even mild escape responses, the authors recommended flying at a 305 meters (1,000 feet) altitude. These recommendations correspond well with the findings of two other caribou-focused studies **(Gunn and Miller 1978; McCourt *et al*. 1974)**, which document minimal reactions to aircraft at altitudes of approximately 300–400 meters (1,000–1,300 feet) AGL during both times of calving and post-calving. The study by **McCourt *et al.* (1974)** also evaluated disturbances to both moose and grizzly bear from fixed-wing overflight and found that altitudes over 183 meters (600 feet) AGL had negligible effects on moose, whereas grizzlies were more sensitive. For appropriate consideration of all species, the authors recommended a buffer of at least 305 meters (1,000 feet) AGL.

Gunn *et al.* (1985) documented the effects of helicopter (*i.e.*, Bell 206) overflight and landing on post-calving barren-ground caribou in the Northwest Territory, Canada. The authors observed that a helicopter overpass at 305 meters (1,000 feet) AGL, followed by a landing within 300–2,000 meters (100–6,600 feet) of aggregations of cow-calf pairs caused disruption of ongoing activities and elicited behavioral responses that led to displacements of at least 1–3 kilometers (0.6–1.8 miles).

Regarding difference in reaction between fixed-wing and rotary-wing (helicopter) aircraft, **McCourt *et al.* (1974)** noted that caribou were more responsive to helicopter than to small fixed-wing overflights only at low altitudes (below 100 meters [300 feet] AGL), whereas **Calef *et al.* (1976)** documented stronger responses to fixed-wing aircraft at altitudes below 150 meters (500 feet) AGL.

Lawler *et al*. (2004) reported on a study of the effects of military jet overflights on Dall sheep east of Fairbanks, Alaska. Like caribou, Dall sheep occupy terrain having little cover. The study could find no difference in population trends, productivity, survival rates, behavior, or habitat use between areas mitigated and not mitigated for low-level military aircraft. In a mitigated area, flights are restricted to above 1,500 meters (5,000 feet) AGL during the lambing season, whereas there were no such restrictions in the unmitigated areas.

In the rare case of a failed flight, snow machines could be used to effect an immediate response to the expected point of impact. Such responses would be expected to be limited to the areas adjacent to the launch site and would not span further north than the White Mountains. However, some disturbance to resident wildlife (*e.g.*, moose) could occur. A study conducted by **Colescott and Gillingham (1998)** found that moose within a 300-meter (1,000-foot) distance from snow machines may alter their behavior (*e.g.,* move to adjacent habitat); however, the measured effects were temporary and minor. When considered within the context of the infrequency of failed flights and the limited number of snow machine trips that would occur in such an event, potential effects of off-highway vehicle use on wildlife would be short-term and minor.

Birds

Large areas of the PFRR launch corridor are important breeding and staging areas for a variety of dabbling and diving ducks, geese, and swans. In particular, Yukon Flats NWR hosts some of the highest nesting densities of waterfowl in North America **(USFWS 1987)**. Most nesting occurs in May and June of each year, and therefore could be affected by search and recovery operations. The primary concern would be the potential to startle nesting females, potentially exposing eggs to thermal stress or an increased risk of predation. Studies of waterfowl, including ducks and geese, have shown (1) temporary behavioral responses to low-altitude overflight, ranging from assuming an alert posture to taking flight; (2) responses decreasing in magnitude as overflight elevation increases; and (3) rapid resumption of the behaviors exhibited prior to the overflight (*e.g.,* **Komenda-Zehnder *et al.* 2003**). The authors of the referenced study state that potential effects on waterbirds can be reduced substantially if aircraft maintain minimum altitudes of at least 450 meters (1,500 feet) for helicopters and 305 meters (1,000 feet) for fixed-wing aircraft. However, it is also noted that the birds within the study site were within an area of somewhat regular disturbance, which could have led to some habituation. Avifauna in more remote areas, such as the ROI, which may be less accustomed to such stimuli, could be more sensitive. Maintaining an altitude in excess of that recommended by the above study would be possible when transiting from the airfield to the expected search area and would ensure minimal effects. However, search operations would require a lower altitude, likely several hundred meters AGL, which would be expected to startle nearby waterfowl. When considered within the context of the No Action Alternative, it is reasonable to assume that the infrequency of such flights (approximately 1 per year), coupled with the already present air traffic in the area, would not lead to substantial effects.

Search and recovery activities within the PFRR launch corridor may be conducted during the nesting season of eagles and other raptors. Helicopters generally create a greater response at a given altitude or approach distance than do fixed-wing aircraft. Songbirds and raptors vary in their responses to overflight, but documented responses have been limited to short-term behavioral responses and no effects that would be measurable at a population level have been recorded. For example, **Windsor (1977)** conducted a study in which nine active peregrine nests were exposed to regular aircraft (fixed wing and helicopter) overflights ranging in altitude from 75 to 305 meters (250–1,000 feet). Of the nine nests, only one was abandoned. The other eight, however, showed no effect on hatch rate or fledging rate. Eagles and other raptors on nests or caring for young are less likely to respond to overflights or show response to overflights at greater distances than would non-nesting birds.

It is noteworthy that several studies have found that pedestrians tend to have the most extreme effects on breeding eagles when compared to boats, vehicles, short-duration noises, or aircraft **(Grubb and King 1991; Grubb *et al.* 1992)**. Although specific to bald eagles (which would not be expected to occur in sizeable numbers within the PFRR launch corridor), this information suggests that on-the-ground activities could be a greater disturbance to raptors than overflight. However, every recovery operation in the vicinity of an active nest would not necessarily elicit an adverse response. A clear line of sight is an important factor in a raptor’s response to a particular disturbance **(Suter and Joness 1981)**. In some instances, non-threatening activities in close proximity to nests may have minimal effects if the activity is visually or audibly buffered by vegetation or topography **(Knight and Temple 1995)**. Clearly, actual effects would vary and be highly situation-specific. In either case, potential adverse impacts would be minor as the land use permits summarized in Section 4.7.2 provide protection for raptors through stipulations of both minimum altitudes and lateral avoidance of active nests.

Marine Mammals

Search and recovery activities would not be conducted over marine mammal habitat on or adjacent to the Beaufort Sea, so marine mammal species would not be exposed to overflight associated with search and recovery activities.

Fish

Fish would not be affected at the sound levels associated with overflight at altitudes that would be utilized during search and recovery operations.

Summary

PFRR-sponsored single-engine search aircraft (*e.g.*, Aviat Husky) flying at altitudes greater than 150 meters (500 feet) AGL would generally be expected to cause minimal, if any, response from wildlife (based on data provided in reviews including **NPS 1994; Manci *et al*. 1988; Larkin 1994; Gladwin *et al*. 1987**). Similar aircraft are utilized by resource management agencies to survey waterfowl and game species at altitudes as low as 30.5 meters (100 feet) AGL **(USFWS 2011c)**. Lower-level flight, especially combined with maneuvering such as circling and landing at an identified hardware recovery site, may cause temporary and localized responses such as taking flight by waterfowl or running by ungulates (*e.g.*, caribou). Permit stipulations with USFWS recommend minimum altitudes of 610 meters (2,000 feet) AGL or higher for overflight over Yukon Flats NWR and Arctic NWR lands, which constitute the majority of the area within the PFRR launch corridor. Under these circumstances, no adverse impacts on wildlife from the overflight are expected.

Generally, helicopters approaching wildlife tend to evoke a behavioral response at a greater distance than do fixed-wing aircraft. However, the responses to helicopters range from negligible to minor at distances that would be involved in the search and recovery exercises, with the exception of landings and takeoffs, when, for example, nearby animals would move away from the site or take cover.

Overall, any adverse impacts on wildlife due to search and recovery operations would be localized to the vicinity of search and recovery activities, would be short-term in duration, and would range from negligible to minor.

In the event of an aircraft-based winter recovery, disturbances would be similar to those described under the "Launch Operations" section. Species with larger numbers and wider distributions under the PFRR launch corridor, such as musk ox and moose, would be more likely to be exposed to search and recovery activities than less common or more narrowly distributed species, but any adverse impacts would continue to be negligible due to their short duration and localized nature.

4.7.4.2 *Alternative 1 – Environmentally Responsible Search and Recovery*

Launch Operations

Since the same number of launches is anticipated to occur under Alternative 1 as under the No Action Alternative, any adverse impacts from launch operations on wildlife under this alternative would be similar to those described under the No Action Alternative and would be negligible.

Search and Recovery

The number of stages and payloads recovered under Alternative 1 is anticipated to increase compared to the No Action Alternative. Although the type of impacts on wildlife would be similar to those described under the No Action Alternative, the magnitude of any adverse impacts is anticipated to be higher based on the increased recovery effort. The areal extent of the impacts would also increase. However, any adverse impacts would be minor in intensity and short-term in duration due to the infrequent exposure to search and recovery aircraft over a very large search area and the short duration and localized nature of on-the-ground recovery activities.

4.7.4.3 *Alternative 2 – Maximum Cleanup Search and Recovery*

Launch Operations

Since the same number of launches is anticipated under Alternative 2 as under the No Action Alternative and Alternative 1, any adverse impacts from launch operations on wildlife under Alternative 2 would be similar to those described under the No Action Alternative and Alternative 1.

Search and Recovery

Under Alternative 2, the greatest efforts would be made to recover new and existing payloads and stages. Although the type of impacts on wildlife would be similar to those described under the No Action Alternative and Alternative 1, the magnitude of any adverse impacts is anticipated to be higher based on the increased recovery effort. However, any adverse impacts would remain minor in intensity and short-term in duration due to the infrequent exposure to search and recovery aircraft over a very large search area and the short duration and very localized nature of on-the-ground recovery activities.

4.7.4.4 *Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories*

Impacts on wildlife under Alternative 3 would be nearly identical to those identified under Alternative 1 in Section 4.7.4.2, with the exception of NASA's restricting trajectories on future launches such that designated Wild River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. As such, these restricted trajectories could lessen the potential impacts on wildlife within these areas. However, any adverse impacts on wildlife are already considered to be negligible so any decrease in impacts is not expected to be substantial.

4.7.4.5 *Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories*

Impacts on wildlife under Alternative 4 would be nearly identical to those identified under Alternative 2 in Section 4.7.4.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could lessen the potential impacts on wildlife within these areas. However, any adverse impacts on wildlife are already considered to be negligible so any decrease in impacts is not expected to be substantial.

4.7.5 Fisheries Management Plans, Essential Fish Habitat, and Subsistence Fisheries

Although there is a possibility for a payload or spent stage to descend into essential fish habitat (EFH), as designated under the 2009 Arctic Fisheries Management Plan, or the Salmon Management Plan, or into an area utilized as a subsistence fishery, for all alternatives, the probability of directly impacting a target species, such as the Arctic cod, or a subsistence species, such as pink salmon, would be so small as to be discountable. The salmon management plan EFH covers anadromous fish streams on the Alaska North Slope (north of the Brooks Range) that drain into the Beaufort Sea and are occupied by pink and chum salmon. The Arctic Management Plan EFH encompasses a 509,000-square-kilometer (approximately 200,000-square-mile) area of the Beaufort Sea out to 200 nautical miles that supports the Arctic cod.

Given the seasonal timing of launches, spent stages or payloads would land when the EFH is ice-covered and would enter the aquatic environment after penetrating the ice or during the seasonal breakup. Payloads and spent stages that enter the marine environment are expected to reach the ocean floor and lodge in oxygen-poor sediments or remain on the ocean floor and corrode or become encrusted by marine organisms **(USN 2011)**. Under normal conditions, spent stages are essentially inert aluminum or steel tubes after short periods of exposure to water (see Section 4.3). Unrecovered payloads contain battery constituents and other materials that would gradually leach into the water column, resulting in limited and localized contamination that would be rapidly dispersed by currents. Considering the limited number of launches per year (an average of four) and their likely geographic dispersion, ice coverage during the winter months when launches are proposed to occur, and the relatively small size of spent stages and payloads, negligible adverse impacts that would be localized and short-term in duration, both direct and indirect, are anticipated under all alternatives. Therefore, the project would not adversely affect EFH, target species, or subsistence species.

4.7.6 Endangered, Threatened, and Special Status Species

This section addresses potential impacts on listed, proposed, and candidate endangered or threatened species that USFWS and NOAA have identified as having the potential to occur within the ROI for all alternatives. There are no listed, proposed, or candidate species known to live in the vicinity of the PFRR launch site or under the launch corridor until it approaches the coast of the Beaufort Sea. Of the species shown in Chapter 3, Section 3.7.2.8, Table 3–13, the ringed seal (proposed threatened) and the polar bear (threatened) have the potential to occur year-round within the ROI and could be affected by descending payloads or spent stages. The bowhead whale (endangered), bearded seal (proposed endangered), and yellow-billed loon (candidate) are summer residents and would be absent during the winter season, when launches are proposed to occur and payloads and spent stages are expected to impact sea ice covering the Beaufort Sea (see Section 3.7.2.8, Table 3–13). Spectacled and Steller's eiders (threatened) are accidental in occurrence and uncommon within the ROI. They would also most likely be present during the summer months, if they were present at all.

No search or recovery activities would be conducted for payloads or spent stages that are predicted to land in the Beaufort Sea. In the unexpected event a spent stage or payload were discovered on the coastal plain and reported to UAF or NASA, recovery would be planned in consultation with cognizant resource agencies such that there would be no effect on listed species. No such recovery operations have been attempted to date and should not be considered a typical scenario.

As discussed in Chapter 3, Section 3.7.2.9, the BLM also keeps a list of sensitive species. National policy directs BLM state directors to designate BLM sensitive species in cooperation with the state fish and wildlife agency (BLM Manual 6840). The sensitive species designation is normally used for species that occur on BLM public lands and for which BLM has the capability to significantly affect the conservation status of the species through management **(USDOI 2012c)**. In addition to those species under the jurisdiction of USFWS and the Alaska Department of Fish and Game, a discussion of potential impacts to species listed as sensitive by the BLM is presented below. BLM-listed species with the potential to occur on or near BLM-owned land within the ROI include six bird species and one mammal; the American peregrine falcon, bald eagle, the trumpeter swan, the grey-cheeked thrush, the olive-sided flycatcher, the blackpoll warbler, and the Canada lynx.

Impacts to BLM-listed species are anticipated to be minimal and similar to those discussed in the above sections regarding disturbance to wildlife as a result of winter launch and recovery activities. The majority of the birds discussed in Chapter 3, Section 3.7.2.3, migrate south to warmer climates during the winter months; thus, no impacts to these species are anticipated from winter launch or recovery activities. The trumpeter swan, bald eagle, and lynx have the potential to occur within PFRR during winter launches and recoveries but due to the vast expanse of PFRR and relatively small-localized populations of these animals, no significant direct impact (such as mortality caused by contact with a descending spent stage) is anticipated. Minor indirect impacts could occur but would most likely be restricted to startling or otherwise scaring wildlife and potentially causing them to temporarily leave the affected habitat.

4.7.6.1 *Ringed Seal*

Launch Operations

Only the longest distance of sounding rockets, particularly the BBs X and XII, would have a likelihood of landing along the margin of the coastal plain, potentially affecting seals. Potential impacts on ringed seals from launch operations for all alternatives would be associated with reentering payloads and/or stages landing within seal habitat, and more specifically, seal concentration areas. During the months when the sea ice extends to the coast (October to June), ringed seals tend to concentrate on shorefast ice adjacent to the coastal areas of Alaska **(Marz 2004)**. From July to September, when the sea ice retreats northward and large stretches of open water appear along the coast, the seals tend to expand their range both northward and westward, diminishing their overall density in the project area.

Probability of Impact

To evaluate the probability of a direct impact adversely affecting a ringed seal, a typical 3-sigma impact ellipse was created for a spent stage or payload predicted to land in the Beaufort Sea (1,000 kilometers [620 miles] from PFRR). The large size of this ellipse (over 500,000 square kilometers [190,000 square miles]) is due to the various factors (such as winds) that affect the flight and descent of the unguided rocket. The impact point location is typical of launches from PFRR into the Beaufort Sea. Of the 24,000-square-kilometer (9,400-square-mile) winter habitat concentrated along the coast, only 45 square kilometers (17 square miles) were intersected by the ellipse (see Appendix G). This equates to a probability of approximately 2.0×10^{-5} (one chance in 50,000 per launch) that a spent stage or payload would land within the winter concentration area of the ringed seals (see Appendix G).

It is possible that ringed seals could exist throughout the Beaufort Sea on sea ice during the winter. Expected density values for ringed seal in areas of concentrated occurrence in the Beaufort Sea are 0.35 individuals per square kilometer (average density) and 1.42 individual per square kilometer (maximum density) for nearshore areas, where the seals are most concentrated, and 0.25 individuals per square kilometer (average density) and 1.00 individual per square kilometer (maximum density) for ice margins **(Ireland *et al.* 2009)**. Assuming a conservative density of 1 individual per square kilometer throughout the Beaufort Sea more sounding rockets could possibly impact and allowing for a 10-meter (33-foot) radius buffer zone around each seal, the per-launch chance of an impact near a ringed seal is very low, approximately 3.1×10^{-4}, or 1 chance in 3,200 (see Appendix G). .

Effects of Sound

As discussed in Section 4.5, the ballistic reentry of a representative stage or payload would generate a mild sonic boom at an altitude between 18,000 meters (60,000 feet) and 9,000 meters (30,000 feet) AGL. The peak instantaneous sound pressure received on the ice would be approximately 114 dB and would be of very low frequency (less than 100 hertz) **(Downing 2011)**.

In addition to the sonic boom, the stage or payload would eventually land on the presumably frozen surface of snow-covered ice, generating a momentary impulse sound conservatively estimated to be 130 dB in air and 192 dB in the water below the impact site.

Physiological Effects

A primary concern of sound exposure on pinnipeds is whether the source would result in either temporary or permanent hearing loss **Southall *et al*. (2007)** proposed exposure criteria for assessing the potential injury to pinnipeds in air exposed to a single sound pulse, such as a sonic boom. The authors recommended a 149 dB exposure criterion for injury from a single pulse in air. Likewise, a similar conservative criterion for injury (218 dB) was suggested for pinnipeds in water. Therefore, when considered within the context of these recommended criteria, the expected sonic boom and snow/ice impact of a reentering sounding rocket payload or stage would cause no temporary or permanent hearing damage to ringed seals.

Behavioral Effects

The same study **(Southall *et al.* 2007)** also proposed a 109 dB criterion for single pulse sound behavioral disturbance of pinnipeds in air. The criterion, noted by the authors as likely conservative, was mostly based upon observation of strong responses (*e.g.,* stampeding behavior) of some species, especially harbor seals, to sonic booms from aircraft and missile launches in certain conditions **(Berg *et al.* 2001, 2002; Holst *et al.* 2005a, 2005b)**. A 212 dB criterion for pinnipeds in water was proposed based upon the level at which some temporary hearing effects may be observed in some species.

The most notable sound-related behavioral response would be the potential for trampling and/or separation of young from females, especially following birth. PFRR launch operations could overlap the general birthing and suckling period (*i.e.,* mid-March to April). During much of this time, female seals and their young remain in snow dens, which have been found to be very effective in muffling sound **(Blix and Lentfer 1992)**. In the referenced article, the authors highlight one particular event during which a helicopter noise level of 115 dB was reduced to 77 dB in an artificial polar bear den covered by less than 1 meter (3 feet) of snow just 3 meters (10 feet) away. The snow dens were also found to be effective in absorbing vibration. Even with relatively modest attenuation, it may be concluded that in-den received sound levels from an incoming sounding rocket section would be below the criteria proposed by **Southall *et al.* (2007)** and would have negligible adverse effects. Furthermore, as nearly all of the sound energy of the sonic boom is below 75 hertz (the minimum estimated range of hearing as presented in **Southall *et al.* [2007]**), it is doubtful that boom-induced sounds received outside of dens would be detected by seals. Finally, the sound resulting from the impact on the snow and ice would not be expected to cause adverse effects on in-water individuals. Although this analysis cannot discount the possibility that ringed seals would hear (or have some reaction to) the sounds generated by stage and payload reentry, it is reasonable to conclude that such effects would be temporary and similar to other natural sounds in their marine environment, such as the sounds of ice cracking, popping, and colliding **(Greening and Zakarauskas 1994; Milne 1972; Milne and Ganton 1964; Xie and Farmer 1991)**.

Effects of Remaining Flight Hardware

Given the buildup of heat generated by friction with the atmosphere the reentering payload is expected to break apart and the pieces to sink into the ice to some degree where they would be frozen over and covered by drifting or blown snow. This is the same expected fate of a spent rocket stage, with the exception that it would be less susceptible to breakup. Based on the melting patterns of sea ice in the Beaufort Sea over the last few years **(NSIDC 2011)**, over 80 percent of the payloads and spent fourth stages are expected to land on sea ice that melts annually, at which time they would sink to the bottom of the ocean. Based on the same analysis, less than 20 percent of the payloads and spent fourth stages are expected to land on "permanent" ice (see Appendix G). Assuming an average of four launches per year, the maximum number of items that would enter the Beaufort Sea annually would be four payloads and up to four spent stages (from the final stage). Considering the limited number of launches per year (an average of four), the relatively small size of spent stages and payloads, and the largely inert or non-reactive nature of the items, no adverse impacts on ringed seals and negligible adverse impacts on their habitat are anticipated.

Search and Recovery

Search and recovery operations for spent stages or payloads that land in the Beaufort Sea or on sea ice would not occur and would therefore have no effect on ringed seals or their habitat.

4.7.6.2 *Polar Bear*

Potential impacts on polar bears would be similar to those discussed above for the ringed seal.

Launch Operations

Probability of Impact

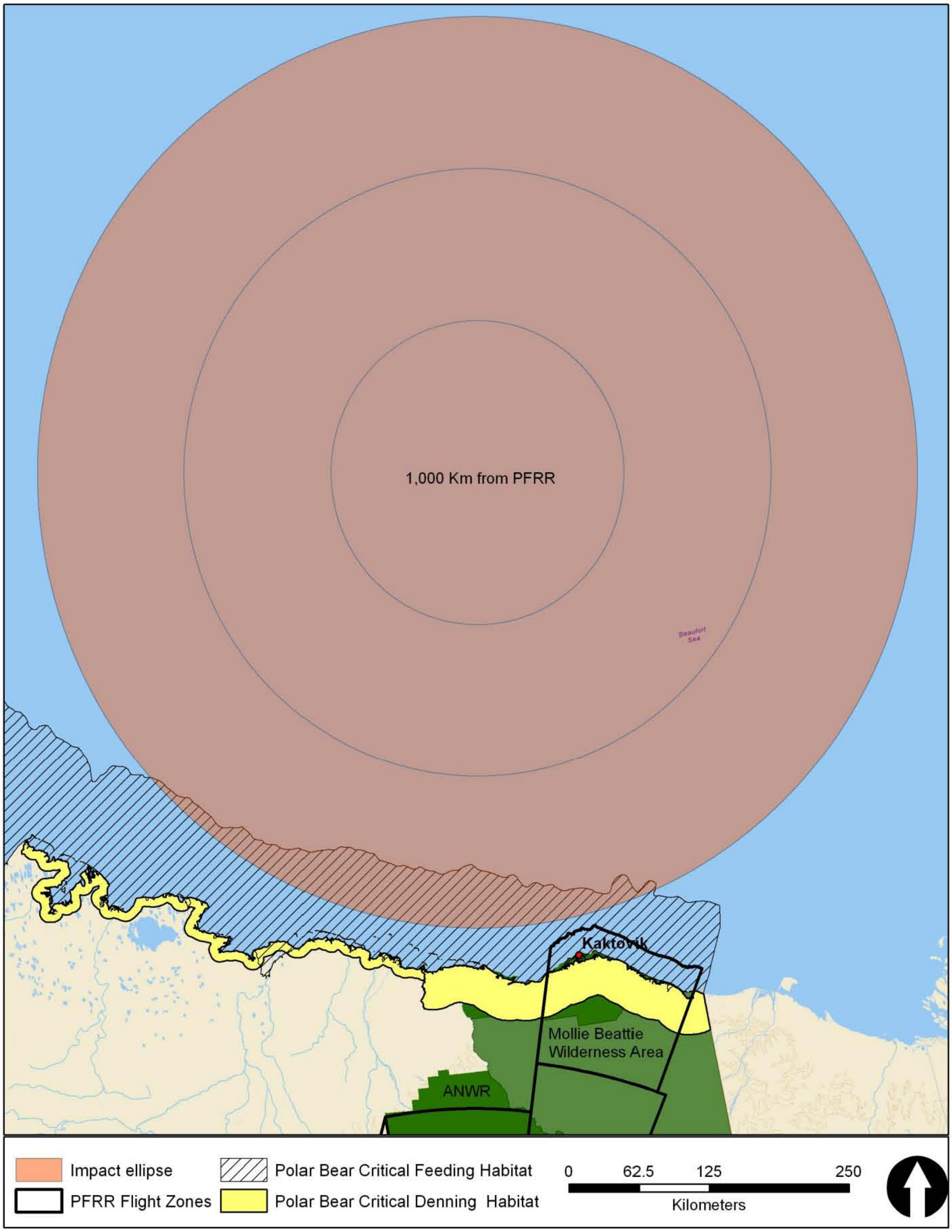
To quantify potential impacts on polar bears from the proposed alternatives, a similar probability calculation to that described for ringed seals was conducted (see Appendix G). The results are provided below in **Table 4–20**, which lists the probability that a payload or spent stage from a typical launch into the Beaufort Sea would land within polar bear critical habitat as designated by USFWS. In addition, **Figure 4–12** provides a graphic representation of the analysis presented in Table 4–20. Sounds associated with an incoming spent stage or payload is discussed in Section 4.5. Polar bears have relatively acute hearing **(Nachtigall, *et al*. 2007; Owen and Bowles 2011)**; however, the possibility that the sound of an incoming item (stage or payload) approaching the ground and hitting the ice close enough to a polar bear to affect its behavior to the scale at which take could occur is somewhat higher than for a direct hit but still very low.

Table 4–20. Likelihood of a Spent Stage or Payload Landing Within Polar Bear Critical Habitat

Distance from Poker Flat Research Range (kilometers)	Polar Bear Critical Habitat	Potential Impact Ellipse (square kilometers)	Amount of Polar Bear Critical Habitat Within Ellipse (square kilometers)	Probability of a Spent Stage or Payload Landing in Polar Bear Critical Habitat
1,000	Feeding habitat	503,000	15,000	6.6×10^{-3}
1,000	Denning habitat	503,000	0	0

Note: To convert kilometers to miles, multiply by 0.6214; square kilometers to square miles, by 0.3861.

This analysis shows that the potential for direct or indirect impact on polar bears or their critical habitat that could reach the scale at which take would occur would be so low as to be discountable, consistent with a “may affect, not likely to adversely affect” finding under the ESA and therefore insignificant.



Source: USFWS 2011j.

Figure 4–12. Likelihood of a Spent Stage or Payload Landing Within Polar Bear Critical Habitat

Payloads and spent stages that land on sea ice would be unlikely to harm a polar bear in the unlikely event that an individual polar bear were to encounter one. The item is expected to partially penetrate the ice and/or rapidly become covered by ice or drifting snow, isolating it from the environment. As the ice melts, the flight hardware would subsequently enter the marine environment, as discussed above. Any accumulation of spent stages or payloads that remained would be on the permanent sea ice approximately 400 kilometers (250 miles) from the coast and over 300 kilometers (185 miles) from the nearest designated Critical Habitat (based on information from **NSIDC [2011]**).

Effects of Sound

As with ringed seals, the primary noise-induced, disturbance-related concern would be the time following the birth of young, which generally occurs in December or early January **(Ramsay and Dunbrack 1986)**. The cubs remain in dens for several months following birth and therefore are potentially vulnerable to disturbances near dens **(Amstrup 1993)**.

As summarized under the discussion of potential effects on Ringed seals, **Blix and Lentfer (1992)** observed that only seismic testing less than 100 meters (330 feet) from a den and a helicopter taking off at a distance of 3 meters (10 feet) produced noises inside artificial dens that were notably above background levels. The authors also concluded that a polar bear in its den is unlikely to feel vibrations unless the source is very close. Supporting their findings is **Amstrup (1993)**, who also reported that polar bears residing within dens are well insulated from outside sound and vibration.

Effects of Remaining Flight Hardware

A potential concern could be injury related to flight hardware as polar bears are curious animals that typically investigate objects or smells that catch their attention **(Stirling 1988)**. Polar bears have been observed to ingest a wide range of indigestible and hazardous materials and to feed at dumps **(Clarkson and Stirling 1994)**. Instances of polar bear injury related to human-made materials (*e.g.,* pieces of a lead battery, ethylene glycol antifreeze) have been documented **(Amstrup *et al.* 1989)**. However, these have been in unnatural settings (including roadsides treated with antifreeze and dye and the Churchill, Manitoba, municipal landfill) that are much different from the habitat within the PFRR launch corridor. The dump example involved individual bears habituated to finding supplemental food in landfills **(Lunn and Stirling 1985)**.

Given the small number, wide dispersion, rapid isolation from the environment, and lack of accumulation of spent stages or payloads the likelihood of polar bears encountering and being harmed by a payload or spent stage is so low as to be discountable. Assuming four launches per year, the maximum number of items that would enter the Beaufort Sea annually would be four payloads and up to four spent stages (from the final stage). As discussed earlier, payloads and spent stages that enter the marine environment would sink to the bottom and be rapidly colonized by benthic encrusting organisms and become part of the substratum. Unrecovered payloads contain materials (*e.g.,* batteries) that would result in limited and localized contamination as the materials gradually enter the aquatic environment. Considering the limited number of launches per year, the relatively small size and spatial dispersion of spent stages and payloads, and the largely inert or non-reactive nature of the items, no impacts on polar bears from these items on the ice or entering the marine environment are anticipated.

Search and Recovery

Search and recovery operations for spent stages or payloads that land in the Beaufort Sea or on sea ice would not occur and therefore would have no effect on polar bears or their critical habitat.

4.7.6.3 *Spectacled Eider*

Spectacled eider breed on the Arctic coastal plain west of the PFRR launch corridor and migrate westward and southward wintering in offshore waters in the Bering Sea. It is now considered accidental in occurrence in the PFRR launch corridor, where it would most likely be present during summer **(USFWS 2011l)**. Given its seasonal absence from the project area, it is concluded that the project would have no effect on the spectacled eider.

4.7.6.4 *Steller's Eider*

Like spectacled eider, Steller's eider breeds on the Arctic coastal plain west of the PFRR launch corridor and migrate westward and southward during the fall and winter **(USFWS 2002, 2011m)**. It is considered accidental in occurrence in the PFRR launch corridor, where it would most likely be present during summer. Given its near absence from the project area, the likelihood of any project effect is so low as to be discountable. Given its seasonal absence from the project area, it is concluded that the project would have no effect on the spectacled eider.

4.7.7 Endangered Species Act Compliance

NASA is consulting with the USFWS and NOAA Fisheries with regard to listed, proposed, and candidate species under their respective jurisdictions. USFWS generally has authority over terrestrial and aquatic plant, fish, and wildlife species onshore. USFWS's jurisdiction includes polar bear and its critical habitat, spectacled eider, and Steller's eider, and would include yellow-billed loon, if the species is proposed for listing. NOAA Fisheries' jurisdiction includes marine and anadromous species, including marine mammals.

NASA has exchanged initial correspondence with both agencies (see Appendix A) and has discussed the project, the proposed analysis, and concerns during several conference calls with agency representatives. Additionally, a Biological Assessment (BA) has been submitted to each agency, documenting the results of the analysis conducted for this *PFRR EIS* with regard to the listed, proposed, and candidate species under their jurisdiction (see Appendix H). **Table 4–21** below summarizes the ESA covered species and NASA's effects determinations. USFWS concurred with NASA's assessment; a response from NOAA Fisheries is pending.

Table 4–21. Summary of Endangered Species Act Determinations for Listed, Proposed, and Candidate Species Potentially Occurring Within PFRR Flight Corridor

Species	ESA Status	Agency with ESA Jurisdiction	NASA ESA Determination	Agency Concurrence
Polar bear	Threatened	USFWS	May affect, not likely to adversely affect	Yes
Polar bear critical habitat	Designated	USFWS	May affect, not likely to adversely affect	Yes
Bowhead whale	Endangered	NOAA Fisheries	No effect (seasonal absence)	Pending
Ringed seal	Proposed threatened	NOAA Fisheries	Not likely to jeopardize continued existence	Pending
Bearded seal	Proposed endangered	NOAA Fisheries	No effect (seasonal absence)	Pending
Spectacled eider	Threatened	USFWS	No effect (seasonal absence)	Yes
Steller's eider	Threatened	USFWS	No effect (seasonal absence)	Yes
Yellow-billed loon	Candidate	USFWS	No effect (seasonal absence)	Yes

Key: ESA=Endangered Species Act; NASA=National Aeronautics and Space Administration; NOAA=National Oceanic and Atmospheric Administration; PFRR=Poker Flat Research Range; *PFRR EIS=Environmental Impact Statement for the Sounding Rockets Program at Poker Flat Research Range*; USFWS=U.S. Fish and Wildlife Service.

4.7.8 Summer Launches

This section briefly considers potential impacts that would need to be considered in the event that summertime launches are proposed. Additional environmental review and regulatory compliance, including ESA consultation, would be conducted by NASA in the event a summer launch is proposed.

4.7.8.1 *Vegetation*

In the event of a summertime launch (May to September), more vegetation would be exposed due to a lack of snow cover, and a higher degree of impact would occur. Within the immediate area of the impact point, it is assumed that individual plants would be crushed, uprooted, or otherwise disturbed in a manner that could potentially result in the temporary loss of vegetation. Retrieval of the payload or spent stage would affect an unknown but localized area of vegetation as discussed in Section 4.7.3 since these activities are proposed to be carried out during the summer under any launch scenario. Regrowth of vegetation would be rapid from resprouting and natural reseeding from nearby plants, given the small area of disturbance and the short-term duration of activities at the site. Given the very small area affected by impact and recovery activities, and the potential recovery of the habitat, adverse impacts from launch and recovery activities would be short-term and negligible.

4.7.8.2 *Wildlife*

During summer months (May through September), migratory avian species that are absent during winter return to the project area and engage courtship, nesting, and young rearing activities. Species that hibernate or are otherwise dormant during winter become active. Grazing and browsing animals are able to take advantage of the abundant new growth stimulated by increasing daylight periods and warmer temperatures and may be moving from winter ranges to summer range. For example, the Central Arctic Caribou Herd moves to summer range outside PFRR from wintering grounds that include the northwestern part of PFRR, whereas the Porcupine Caribou Herd tends to concentrate in the northern part of PFRR and along the coast in Canada during the summer and spends the winter months south of the Brooks Range and in the Richardson and Ogilvie Mountains of the Yukon Territory **(USFWS 2011c)**. Many species are more sensitive during the summer or non-winter months, especially when nesting or bearing young, than during other parts of their life cycle. During summer, spent stages and payloads would have greater potential to land in proximity to wildlife than during winter because of the greater number of species present, potentially causing short-term behavioral response such as flight. Responses to search and recovery activities would be negligible as described in Section 4.7.4, since these activities would normally occur during summer under any launch scenario.

4.7.8.3 *Fisheries Management Plans, Essential Fish Habitat, and Subsistence Fisheries*

Payloads and spent stages are more likely to go directly into freshwater or marine environments during the summer rather than landing on ice during winter and subsequently entering the aquatic environment at breakup. The likelihood of direct impacts on fish of importance for subsistence or commerce fisheries is minimal. Payloads and spent stages would be colonized by encrusting marine organisms and become part of the habitat. Under normal conditions, the spent stages are essentially inert aluminum tubes after short periods of exposure to water (see Section 4.3). Unrecovered payloads would contain materials such as constituents of batteries that would gradually enter the aquatic environment resulting in limited and localized contamination that would be rapidly diluted by currents as described in Section 4.7.5. Considering the limited number of launches per year (an average of four) and the small size and geographic dispersion of spent stages and payloads, any direct and indirect adverse impacts would be minor and short-term in duration for all alternatives. Therefore, the project would not adversely affect EFH, target species, or subsistence species.

4.7.8.4 *Endangered, Threatened, and Special Status Species*

In the event of a summertime launch (May to September), further environmental review would be conducted regarding the potential impacts on federally and state-listed threatened and endangered species, as well as those listed by BLM. The additional review would need to take into account the possibility of status changes of species that are currently proposed or candidates for listing as threatened or endangered, or BLM-listed, as well as an analysis of species' lifecycle activities, which could result in different impacts on listed species such as ringed seals and polar bears. For example, ringed seal populations tend to follow the ice edge northward as it retreats during the summer months, leading to a more widespread and dispersed population distribution. Therefore, since more occupied habitat could fall within the potential impact area, there is a greater chance that a payload or spent stage could land within an area of summertime ringed seal concentration.

Potential for impacts on other ESA species, including the bowhead whale (endangered), bearded seal (proposed endangered), and yellow-billed loon (candidate), which are summer residents and absent from the ROI during the winter, would have to be considered. Additionally, spectacled eiders and Steller's eiders, both threatened species that are accidental in occurrence and uncommon within the ROI, would need to be addressed because they would most likely be present only during the summer, if they were present at all.

4.8 LAND USE AND RECREATION

This section describes potential impacts on land use and recreation within and adjacent to PFRR and its launch corridor.

4.8.1 Methodology

Analysis of land use and recreation includes the land within the PFRR launch corridor (the ROI), pertinent land use plans and regulations, and land ownership and availability. The probability of landing on a particular property of interest, the amount of land disturbed, and conformity with existing land use were considered to evaluate potential impacts. Composite probabilities of impact are summarized from Appendix G. In addition, given the level of public interest in Wilderness Areas (*i.e.,* Mollie Beattie, Yukon Flats recommended area) within the PFRR launch corridor, specific missions from the past 10 years were also analyzed to determine the range of probabilities and demonstrate what is considered typical versus an occasional outlier mission that had a higher probability of landing within the area.

Land use impacts could be adverse if they resulted in some level of degradation, or impairment of the land or beneficial if they resulted in an increased ability to use the land potentially impacted. The context of the impacts would be global if the impact would have worldwide implications; regional if the impact would affect an entire area such as the entire PFRR ROI; and localized if the impact would affect a subset of the PFRR ROI such as the Arctic NWR but not the remainder of the ROI. The intensity of an impact to land use would be considered major if a component of an alternative were inconsistent with an existing land use plan or special use permit or memorandum of agreement. A moderate impact would result in a change in land use; however, the change would be consistent with an existing land use plan or special use permit or memorandum of agreement. A minor to negligible impact would result when there would be little to no change to land use, and all actions would be consistent with existing land use plans, special use permits, or memoranda of agreement. Regarding duration, a land use impact would be considered long-term if the effect lasted longer than 5 years, as could be the case in a right-of-way permit or easement; medium-term if the effect lasted from 1–5 years; and short-term if the change were to persist for 1 year or less, as is the case with annual special-use permits.

Recreation impacts include the potential limitation of those activities due to the launch and recovery of NASA sounding rockets launched from PFRR. Recreation impacts could be adverse if they resulted in some level of degradation or impairment of recreational opportunities or beneficial if they resulted in increased recreational opportunities. The context of the impacts would be global if the impact would have worldwide implications; regional if the impact would affect an entire area such as the entire PFRR ROI; and localized if the impact would affect a subset of the PFRR ROI such as the Arctic NWR but not the remainder of the ROI. The intensity of an impact on recreation would be considered major if a recreational use were permanently displaced due to the implementation of a component of an alternative. A moderate impact would result if a recreational use were to be displaced or halted for up to one season of use; however, the use would be expected to resume the following year. A minor impact would result when a recreational use were to be displaced for up to several weeks. A negligible impact would occur when a recreational use were to be only displaced or required to cease for no more than 1 week. Regarding duration, an impact would be considered long-term if the effect occurred on a regular basis (*i.e.,* annually), medium-term if the effect only occurred occasionally (*i.e.,* semi-annually or less), and short-term if the change were to rarely occur.

4.8.2 No Action Alternative

Table 4–22 shows the typical stage and payload impact locations within the PFRR launch corridor for up to eight launches per year that could occur under the No Action Alternative. It is expected that launches would average four per year over the next 10 years. NASA would continue to avoid launching sounding rockets with predicted impact points in the Mollie Beattie Wilderness Area.

Table 4–22. Typical Payload and Stage Impact Points

Launches Per Year	Predicted Payload Impact Points		Predicted Stage Impact Points	
	Number of Payloads	Location of Impact	Number of Stages	Location of Impact
4 (up to 2 Black Brant XII and 2 Terrier-Improved Orion)	2	Arctic Ocean	2	Arctic Ocean
	2	Yukon Flats NWR or Venetie Indian Corporation and Neets'ai Corporation Lands	2	Wind River Area of Arctic NWR or Venetie Indian Corporation and Neets'ai Corporation Lands
			2	Yukon Flats NWR
			2	White Mountains NRA
			4	Poker Flat North and South Special Use Areas
8 (up to 4 BB XII and 4 T-IO or Terrier-Improved Orion)	4	Arctic Ocean	4	Arctic Ocean
	4	Yukon Flats NWR or Venetie Indian Corporation and Neets'ai Corporation Lands	4	Wind River Area of Arctic NWR or Venetie Indian Corporation and Neets'ai Corporation Lands
			4	Yukon Flats NWR
			4	White Mountains NRA
			8	Poker Flat North and South Special Use Areas

Key: NRA=National Recreation Area; NWR=National Wildlife Refuge.

4.8.2.1 *Land Use*

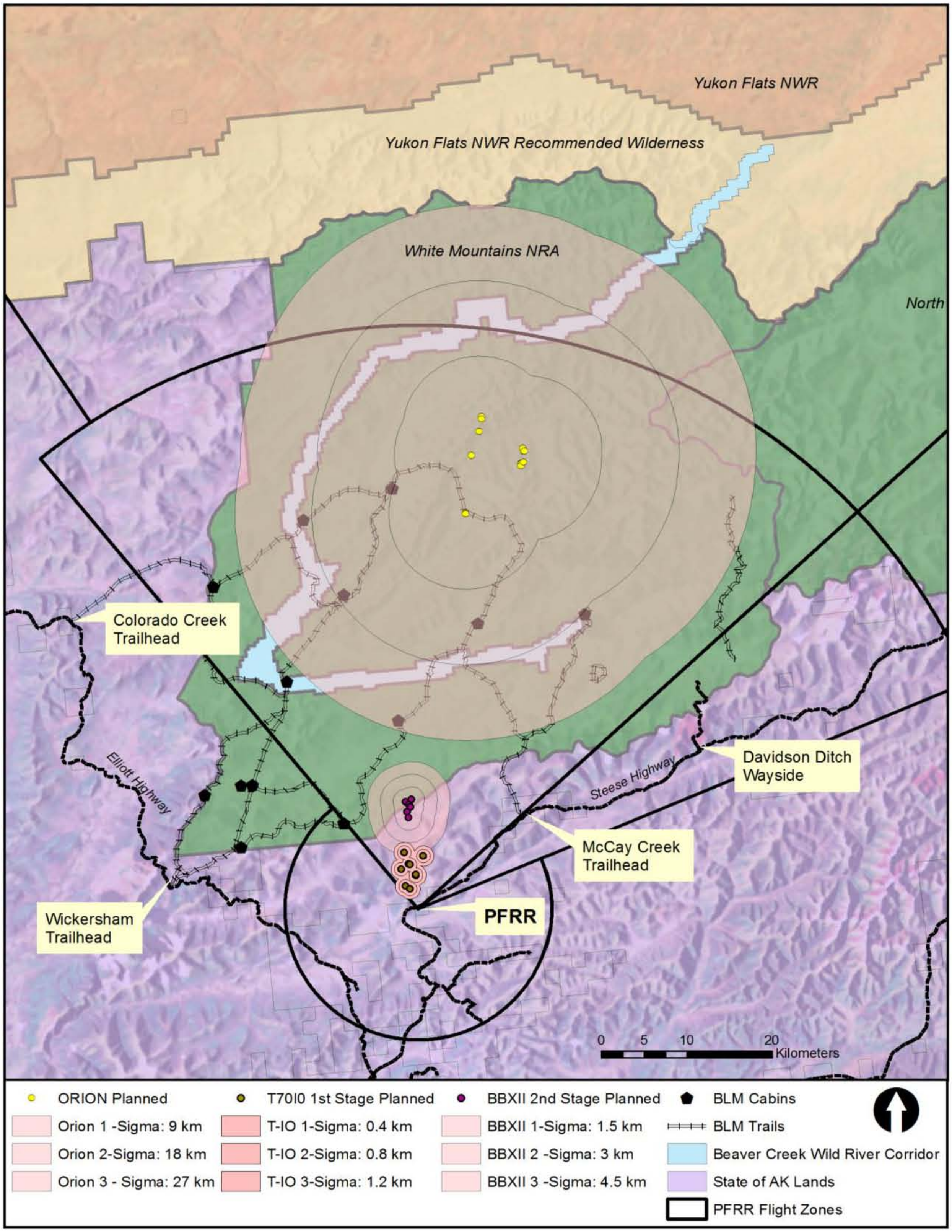
Continued launches by the NASA SRP from PFRR under the No Action Alternative would require authorization from downrange landowners, including USFWS, BLM, the State of Alaska, and the Native Village of Venetie Tribal Government (see Appendix C).

BLM Lands

An evaluation of past flights depicted in **Figure 4–13** indicates that the area most likely impacted would be the southern and central portions of the White Mountains NRA. The initial stages of vehicles most currently flown, the T-IO and BB-class rockets, land well south of most recreational trails and outside of the Wild River corridor. In relative terms, the single-stage Orion vehicle, with its larger dispersion, has the highest probability of landing within the wild river corridor (approximately 1 in 14, or 7 percent chance) or areas frequented by recreational users (*e.g.,* trails and cabins). Of the most commonly used vehicles, the second stage and payload of the T-IO, which would most likely land within Yukon Flats NWR, would have the greatest potential for landing within the Wild River corridor; however, it would be very small. Based upon the southernmost predicted landing point within the past 10 years dataset, the probability is approximately 1 in 1,000, or 0.1 percent. Although possible, it is unlikely that spent stages would land in the north portion of the Steese National Conservation Area (NCA).

In general, the overflight, landing, and recovery of sounding rocket would be in contrast to the natural and recreation-based land uses of the properties. However, in consideration of the infrequency of use, the time of year that operations occur, and the heritage of the program at PFRR (that pre-dates the Alaska National Interest Lands Conservation Act [ANILCA]), the No Action Alternative could continue to be permitted through the BLM 2920 Permit process provided that the lands are not significantly impaired.

To ensure that its operations do not significantly impair the lands, NASA and UAF would continue to follow all terms and conditions of future authorizations issued by BLM. According to the terms and conditions of the most recent land use permit **(USDOI 2011a)**; UAF is required to conduct all recovery activities in a manner that ensures little impact on the physical and biological characteristics of the BLM lands. Details of these conditions are contained within Appendix F.



Key: km=kilometers; NRA=National Recreation Area; NWR=National Wildlife Refuge; PFRR=Poker Flat Research Range.

Figure 4–13. Typical Landing Locations Within U.S. Bureau of Land Management Lands

USFWS Lands

An evaluation of the past 10 years' flights depicted in Figure 4–13 indicates that the area most likely impacted would be the central and western portions (west of Venetie lands) of the Yukon Flats and Arctic NWRs. Moderate-range rockets, including the T-IO and single-stage BB (BB V), could either land on Yukon Flats or Arctic NWR, depending on mission requirements. The longest-range rockets (BBs IX–XII) would typically land in Arctic NWR.

No missions would have planned impacts within Mollie Beattie Wilderness Area. However, the probability cannot be totally discounted. In general, the T-IO, the single-stage Brant, and BBs IX and XII could present the possibility of landing within the Wilderness Area. An analysis of the past 10 years' missions indicates that the second stage of a single T-IO flight had a probability of about 1 in 5, or 20 percent chance, of landing within the Mollie Beattie Wilderness Area. All other flights of this vehicle had 3-sigma dispersions that did not overlap the Wilderness Area; the next highest probability for a flight in the past 10 years was substantially lower, at about 1 in 8,100. The greatest probability for a BB V was calculated to be approximately 2.5 percent, or 1 in 40. All other flights of this vehicle had planned impact locations well away from the Mollie Beattie Wilderness Area, resulting in landing probabilities of approximately 1 in 3 million. The highest probability of impact from a single BB IX second stage was about 44 percent, or 1 in 2.5. All other flights were substantially lower, with the highest of them being about 1 chance in 212,000. The greatest estimated probability for the third stage of the BB XII, which typically lands west of Arctic Village, was approximately 1 in 40, or a 2.5 percent chance. In general, the probability of BB XII flights landing within Mollie Beattie Wilderness may vary between approximately 1 in 200 (0.5 percent chance) and 1 in 500 (0.2 percent chance); however, planned landing locations cannot fluctuate as greatly as the other sounding rockets due to mandatory standoff distances between Arctic Village to the east and the range boundaries to the west.

For all recently flown rocket configurations, only the single-stage Orion and the T-IO have had 3-sigma dispersions that overlap the recommended Wilderness Area within Yukon Flats NWR. The probability of the single T-IO flight landing within the recommended area was 1 in 18, or 5.5 percent; the greatest Orion probability was 1 in 250, or 0.4 percent. All other stages and payloads were well outside (greater than 3-sigma distance) of this area.

Regarding designated Wild Rivers within the USFWS lands, probabilities of longer-range motors or stages landing within the Wind River vary dramatically depending on launch vehicle (see Table 4–38 in Section 4.15.8 for complete data). In general, the vehicle with the most consistent probability of landing within the Wind River corridor is the BB XII, with its probability ranging from between 1 in 14 (7 percent) and 1 in 28 (3.5 percent). The general range of probabilities of landing within the Ivishak River corridor also vary greatly among vehicles, with the BB XII the most consistent between approximately 1 in 10 (10 percent) and 1 in 45 (2.5 percent) While some missions of BB IX and T-IO would have probabilities of approximately 1 in 50 (2 percent) of landing within the Sheenjek, the vast majority of missions would be substantially lower.

In general, the overflight, landing, and recovery of sounding rockets would be compatible with the natural and wildlife-dependent uses of the lands, because USFWS has the ability to authorize the conduct of scientific research, such as that enabled by launches from PFRR, in its refuges. The most recent USFWS-issued permits for rocket landing and recovery within the Yukon Flats and Arctic NWRs require the recovery of flight hardware. Therefore, the No Action Alternative, which would direct recovery of payloads solely for scientific need, would not be consistent with the terms and conditions of the use permits.

State of Alaska Lands

With the exception of the longer-flying single-stage rockets (*e.g.,* Orion, BB V), all first stages and a limited number of second stages would land within the state property (identified as Poker Flat North and South Special Use Areas) just north of the PFRR launch site. The ADNR Poker Flat North and South Special Use Areas are designated as lands where rocket and rocket booster impacts are allowed without further authorization **(ADNR 1990a, 1990b)**. It is noteworthy that the 10,400-hectare (25,700-acre) Caribou-Poker Creeks Research Watershed (CPCRW) is within the state-owned property just north of Steese Highway. Jointly owned by the State of Alaska and UAF, the watershed is reserved for ecological, hydrological, and climatic research. As a result, several miles of gravel roads, bridges, and various hydrologic measurement devices are located within the property, including flumes, water level recorders, and large-capacity rain gauges. In consideration of minimizing potential interruption of the research efforts within this site, PFRR historically has not undertaken land-disturbing recovery efforts, a practice which would continue under the No Action Alternative. Prior to entry into the area (*e.g.,* in the case of a failed flight recovery), PFRR staff would coordinate with CPCRW site managers. Therefore, operations under the No Action Alternative would be consistent with the existing land use.

The use permit between UAF and the ADNR for other state-owned lands within the flight corridor **(ADNR 2009)** allows UAF to continue researching and collecting flight hardware and provides a payload safety area near the PFRR launch site. The permit requires that the ADNR-managed lands within the ROI included in the permit be maintained in a neat, clean, and safe condition, free of any solid waste, debris, or litter. All holes created as a result of the activities authorized under the permit are required to be backfilled. Limited recovery of spent payloads and rocket stages under the No Action Alternative would not be fully consistent with this designation.

Tribal Lands

Based upon the composite analysis of historic impact locations, the probability of a stage or payload landing within Venetie lands can vary greatly, ranging from approximately 1 in 2,700 to 87 percent (see Appendix G). The memorandum of agreement between UAF and the Native Village of Venetie Tribal Government **(Venetie 1989)** includes the requirement for UAF to remove, within a reasonable time, any portions of rocket vehicles or payloads found within the Venetie lands. Additionally, UAF provides compensation for the use of these lands when the probability of landing within the Venetie property is greater than 1 in 100. Under the No Action Alternative, NASA and UAF would continue these practices, and would therefore be consistent with the designated land uses for the area.

Future missions could require the use of lands owned and/or managed by other tribal entities, including villages or regional corporations. The composite analysis of landing within Doyon, Limited, lands shows that probabilities are relatively low for typical missions, ranging from approximately 1 in 250 up to approximately 1 in 125. Although there are no active agreements with such entities, NASA and UAF would ensure that future sounding rocket launches with planned impacts on other landowners' properties are consistent with their designated land uses and that all conditions of use were satisfactory to the owner prior to the launch and/or recovery effort.

Summary of Impacts

Land use impacts from launches would be considered adverse, localized, negligible, and short-term in duration. The continued launch of NASA sounding rockets from PFRR would be consistent with existing permits and agreements between UAF and the land managers within the ROI (see Appendix C). However, land use impacts as a result of remaining flight hardware and limited recovery efforts under the No Action Alternative have the potential to be major. The removal of all new and existing flight hardware with known locations from USFWS- and BLM-managed lands is required as part of the permit requirements. The removal of only a small number of payloads or spent stages, as requested by scientists, as is expected to occur under the No Action Alternative, would not be consistent with existing land use permits. The impacts associated with leaving these payloads and spent stages where they landed have the potential to be regional, affecting multiple areas within the PFRR ROI; major to minor in intensity, depending on where the item is located; and long-term in duration, depending on how long the unrecovered payloads or spent stages remain on downrange lands.

Because limited recovery activities under the No Action Alternative are anticipated within designated Wild River corridors or Wilderness Areas, no direct land use impacts (*e.g.,* aircraft overflight) are anticipated from recovery operations in these areas. However, it is possible for payloads or spent stages to land within the Mollie Beattie Wilderness Area and within designated Wild River corridors. If NASA or UAF were apprised of the location a piece of flight hardware, they would consult with the respective landowner (*i.e.,* BLM or USFWS) to determine the appropriate course of action for conducting a removal operation. Given the sensitivities of these areas, a case-specific analysis would be conducted to determine the least intrusive practicable option for removing the hardware. It is highly likely that any temporary effects of the removal activity would be far less than leaving the visible piece of flight hardware within the special use area.

4.8.2.2 *Recreation*

The launches would occur during the winter months, *i.e.,* October through April, with the possibility of an occasional launch during the summer or non-winter months, *i.e.,* May through September. A wide variety of recreational activities occur during both seasons. Impacts on recreational activities within the ROI would be considered adverse, regional, negligible in intensity, and short-term in duration.

BLM Lands

Areas and Times of Greatest Use – Winter recreational use (*e.g.,* skiing, snowmobiling, dog sledding) of the subject BLM lands is generally expected to be greatest around the cabin and trail system within the White Mountains NRA (see Figure 4–13). Summer use (*e.g.,* hiking, rafting, and camping) in the White Mountains NRA tends to focus on three areas, including Wickersham Dome, Nome Creek (including Cripple Creek Campground and Quartz Creek Trail), and Beaver Creek. Most of the recreational opportunities (*e.g.,* hiking, fishing, and hunting) in the Steese

NCA occur during non-winter months, with fall big game hunting attracting the greatest number of visitors **(USDOI 2012a)**.

Impacts – Activities under the No Action Alternative would not limit the ability of users to visit or take part in recreational activities within White Mountains NRA or Steese NCA. According to the terms and conditions of the land use permit with the Eastern Interior Field Office of BLM **(USDOI 2011a)**, UAF is required to post notices of planned launches to alert visitors of the launches at the following trailheads within BLM lands:

- Wickersham Dome Trailhead
- Colorado Creek Trailhead
- McKay Creek Trailhead
- Davidson Ditch Wayside

It is possible that winter visitors would voluntarily suspend or relocate their planned activities upon reading the posted notices; the potential duration of this could vary from several days up to several weeks if optimum science conditions are not met until the end of the launch window. These impacts would be negligible and short-term. Visitors that opted to enter the area could witness or hear the impact of a spent stage landing in the area. However, since most of the launches are expected to take place in the winter and largely at night, it is unlikely that this would occur. For launches that would cross over White Mountains NRA or Steese NCA, NASA considers the potential of impacting public cabins, and due to safety considerations could be required to delay launch operations until the cabins have been vacated.

As shown on Figure 4–13, the most commonly used rockets would not be expected to have hardware land within areas of highest recreation use, including those that contain public trails and cabins. In the past 10 years, only the single-stage Orion has had a 3-sigma dispersion that overlaps these areas. The higher-performing vehicles, including the T-IO and BB-class vehicles, have stages that land either south or well north of these recreational features.

In the case that a piece of flight hardware were encountered by a recreational user, it is expected that impacts would be greatest on those persons visiting the area for solitude and primitive types of recreation, including hiking, camping, and non-motorized boating. Potential effects would be visitor-specific; however, it is possible that encountering a human-made object could negatively affect a person or group's wilderness experience. Those recreational users of the BLM lands for the purposes of off-highway vehicle use and hunting would be expected to be the most tolerant of encountering these items.

Because no payloads or spent stages are expected to be recovered from the White Mountains NRA or Steese NCA under the No Action Alternative, no impacts associated with search and recovery operations on recreational opportunities are expected in these areas under this alternative.

USFWS Lands

Areas and Times of Greatest Use – Most people visit Arctic NWR and Yukon Flats NWR during the summer in June, July, August, and September **(USFWS 2008b, 2011c)**. Winter recreational uses within Yukon Flats NWR typically are primarily skiing, trapping, and snowmobiling, and expected to be very limited and dispersed. Activities are likely greatest near permitted cabins (used primarily for trapping) and toward the south, adjacent to the White Mountains NRA. Most non-winter recreation is associated with river float trips coupled with hunting; the majority of these activities are expected to occur on Beaver Creek and the Yukon River **(USFWS 2010a)**.

Within Arctic NWR, winter recreational uses may include camping and snowmobiling, with these activities likely to be most prevalent along the western portion of the Arctic NWR due to the presence of several villages and the Dalton Highway **(USFWS 2011c)**. During non-winter months, the most frequent recreational uses are river floating, hiking and backpacking, and hunting **(USFWS 2011c)**. Recreational users who are not commercially guided are thought to concentrate in the Atigun Gorge area **(Reed and St. Martin 2009)**. Commercially supported recreational use is greatest north of the Brooks Range, with this area hosting more than 75 percent of the Arctic NWR's visitors. The most popular areas visited (in order of most visited) are the Kongakut River drainage, Hulahula River, Marsh Fork-Canning River, Jago River, and the main stem of the Canning River. South of the Brooks Range, the Sheenjek and Coleen Rivers are most commonly visited **(USFWS 2011c)**.

Impacts – Launches under the No Action Alternative would not limit the ability of users to visit or take part in recreational activities within Arctic NWR or Yukon Flats NWR. It is possible that visitors to either NWR could witness or hear a launch or the impact of a spent stage landing in the area. However, since most of the launches are expected to take place in the winter, when the numbers of visitors to these areas are very low, it is unlikely that this would occur.

Discovery of spent stages or payloads from past launches within either Yukon Flats or Arctic NWR is also possible while people are participating in recreational activities. Within Yukon Flats NWR, of the two areas of greatest use, recreational users of the Yukon River would have a higher likelihood of encountering a piece of flight hardware. Of the vehicles currently flown, the T-IO and BB V would have the greatest likelihood of landing near the Yukon River; however, given the small subset of these flights in the past 10 years with dispersions overlapping the river corridor, the chance of this occurring in the future (and someone then encountering the item) would be very low.

Within Arctic NWR, users of the areas of highest commercially assisted recreational use north of the Brooks Range (*i.e.*, Kongakut and Hulahula Rivers) would not likely encounter any flight hardware. The most likely vehicles to fly a trajectory that could possibly result in flight hardware landing within these areas would be the BBs IX and XII. However, based upon the past 10 years of flight data, neither mission had a 3-sigma dispersion that overlapped these areas. The Jago River would be even more unlikely to be affected by flight hardware given its easterly location. In relative terms, flight hardware would be most likely to land within the Canning River and its Marsh Fork and would most likely include third stages of BB XIIs and to a lesser extent, second stages and payloads of BB IXs and T-IOs. To provide perspective, the approximate probability of landing the single closest BB XII flight in the past 10 years within the Marsh Fork was approximately 1 in 190 (assuming a corridor width of 1.6 kilometers [1 mile]). The chance of landing within the main stem of the Canning River would be even less.

South of the Brooks Range, trajectories of the T-IO, BB V, and BB IX with planned impact locations east of the East Fork of the Chandalar River could affect the Sheenjek and to a lesser extent, the Coleen River corridors. The highest probability mission for landing within the Sheenjek over the past 10 years for each of these three vehicles was similar, approximately 1 in 50 (assuming a corridor width of 1.6 kilometers [1 mile]) for a single mission. All other missions were approximately 1 in 500 (0.2 percent chance) or greater; therefore, the potential for future impacts is assumed equally remote. The Coleen River is outside of the range boundaries; therefore, landing within it would be highly unlikely.

In the case that recreational users of the NWRs were to discover a piece of flight hardware, it could negatively affect their experience, particularly those persons intending to have a wilderness experience. Others may find it a positive experience to discover a spent stage or payload. It is expected that those persons engaged in hiking and rafting would be the most sensitive to finding sounding rocket hardware, with hunters, trappers, and snow machines the most tolerant. The impact would be on a person-by-person basis and would be influenced by the perception of the individual.

UAF and NASA would only recover payloads and spent stages if desired for scientific reasons; therefore, these search and recovery activities would most likely take place immediately following a launch (*i.e.*, winter). During recovery operations, persons taking part in recreational activities within sight or earshot of the recovery operation may hear or see a helicopter working in the area or a fixed-wing plane flying to a nearby landing area to pick up a recovered payload that has been dropped there by a helicopter. The impacts associated with these activities would be similar to those associated with planes dropping visitors off at various landing spots throughout Arctic NWR and Yukon Flats NWR. Impacts from recovery activities would be considered adverse and localized. However, because they would be limited to a very small area where the recovery activities were taking place, they would be considered negligible in intensity and short-term in duration.

4.8.3 Alternative 1 – Environmentally Responsible Search and Recovery

Under Alternative 1, UAF and NASA would attempt to recover new payloads and new spent and existing spent stages, if practicable. **Table 4–23** below lists the number of payloads and new and existing spent stages that would be recovered if found and the potential recovery locations under Alternative 1. Under Alternative 1, it is estimated that 1 additional payload and 10 additional stage recoveries would be attempted annually compared to the No Action Alternative.

Table 4–23. Alternative 1 Projected Recovery Operations

Payloads	New Spent Stages	Existing Spent Stages	Total Recoveries	Potential Location of Recovery
0	2	1	2–3	Wind River Area of Arctic NWR or Venetie Indian Corporation and Neets'ai Corporation Lands
2	2	0	2–4	Yukon Flats NWR or Venetie Indian Corporation and Neets'ai Corporation Lands
0	2	1	2–3	White Mountains NRA
0	0	2	2	ADNR Land

Key: ADNR=Alaska Department of Natural Resources; NRA=National Recreation Area; NWR=National Wildlife Refuge.

Recovery activities under Alternative 1 are expected to include removal of spent stages that have been identified near the federally designated Wild River corridor of the Wind River.

4.8.3.1 *Land Use*

Land use impacts from launches under Alternative 1 would be consistent with the impacts listed for the No Action Alternative in Section 4.8.1 and would be continue to be considered adverse, localized, negligible in intensity, and short-term in duration. Recovery of payloads and new and existing spent stages under Alternative 1 would further assist UAF in complying with the requirements of the special use permits and memoranda of agreement with BLM, and USFWS, and landowners within the ROI. The attempted recovery of all new payloads and on-land spent stages would be consistent with the Federal special land use permits, which require these efforts. Known components from previous launches would be recovered as they are identified. The adverse impacts associated with search and recovery operations would be localized, minor in intensity, and short-term in duration. It is expected that in most cases, the long-term impacts of leaving a piece of flight hardware within the downrange lands would be greater than the short-term disturbances (*e.g.,* noise, aircraft overflight) associated with recovery. However, NASA and UAF would consult with the respective landowner in making this case-by-case determination. Therefore, it is possible that while some stages could be left in downrange lands, it would only be done so if determined to be in the best interest of the lands and how they are used (*e.g.,* preservation of fish and wildlife habitat, recreational values).

Alternative 1 would also be consistent with the ADNR special use designation of the Poker Flat North and South Special Use Areas. As recovery of items would most likely apply to historic stages, it is expected that impacts on the CPCRW data collection efforts would be minimal, as only those identified or requested by site staff would be removed. Any recoveries deemed to be more damaging than beneficial to the site would be left in place.

No predicted impact points would be targeted within Mollie Beattie Wilderness Area; however, it is possible for payloads or spent stages to land within the wilderness area. In the unlikely event this was to occur, NASA and UAF would work with USFWS to determine if and how the rocket components should be recovered. It is expected that a case-specific assessment would be performed to determine the least intrusive practicable option for removing the flight hardware. Recovery of spent stages within designated Wild River corridors would be conducted in a manner to limit disturbance to the wide variety of vegetation, scenery, and wildlife characteristics of the corridors, should they land there.

4.8.3.2 *Recreation*

Impacts on recreation would be consistent with the impacts listed for the No Action Alternative in Section 4.8.2.2. Activities under Alternative 1 would not limit the ability of users to visit or take part in recreational activities within White Mountains NRA, Steese NCA, Arctic NWR, Yukon Flats NWR, or other areas within the ROI. As described under the No Action Alternative, UAF and NASA would post notices of planned launches to alert visitors at required trailheads, as well as in local newspapers. It is possible that visitors would voluntarily suspend or relocate their planned activities upon reading the posted notices; the potential duration of this could vary from days up to several weeks if optimum science conditions are not met until the end of the launch window. These impacts would be negligible and short-term.

Recovery activities under Alternative 1 would remove payloads and new and existing spent stages in an environmentally friendly manner where practicable. The removal of these additional components, beyond those that would be removed under the No Action Alternative, would reduce the likelihood that future visitors would discover payloads or spent stages during their visits to these areas.

Increased impacts associated with search and recovery operations on recreational opportunities are expected under Alternative 1 compared to the No Action Alternative. Initial search activities would have negligible, short-term impacts on persons participating in recreational activities in areas within the PFRR launch corridors because most of these activities would take place in the winter months, when there are few visitors. Recovery operations would be limited to a small number of days during the summer, when helicopters would be recovering payloads or spent stages under Alternative 1. These activities are estimated to last up to 10 days annually and spread across downrange lands.

As discussed in Section 4.8.2.2, during recovery operations, persons participating in recreational activities within sight or earshot of the recovery operation may hear or see a helicopter working in the area or a fixed-wing plane flying to pick up a recovered payload. This would be especially true within the northern parts of the Arctic NWR, which often have open and treeless riparian areas, allowing recreational visitors to observe the presence of other activities over long distances **(USFWS 2011c)**.

In general, the impacts associated with these activities would be similar to those associated with aircraft dropping visitors off at various landing spots throughout the downrange lands. However, for some visitors, especially for those seeking a wilderness experience, these impacts could be more acute. This could be especially true within Arctic NWR, where helicopters are a generally prohibited activity with the exception of several special use permit holders, one of those being UAF. Therefore, the perceived disturbance of helicopter use on recreational users could again be amplified. However, given the relative infrequency of flights and the very low probability that a low-flying/landing recovery action would be necessary within the most highly used river corridors within the downrange lands, adverse effects are anticipated to be localized, minor in intensity, and short-term in duration.

4.8.4 Alternative 2 – Maximum Cleanup Search and Recovery

Under Alternative 2, UAF and NASA would attempt to recover payloads and new and existing spent stages, as presented in **Table 4–24**, to the maximum extent practicable. Under Alternative 2, two additional payloads and 6 additional stages are projected for attempted recovered annually compared to Alternative 1, and three additional payloads and 16 additional stages are projected for attempted recovery compared to the No Action Alternative.

Table 4–24. Alternative 2 Projected Recovery Operations

Payloads	New Spent Stages	Existing Spent Stages	Total Recoveries	Potential Location of Recovery
0	2	2	3–4	Wind River Area of Arctic NWR
4	2	2	5–8	Yukon Flats NWR or Venetie Indian Corporation and Neets'ai Corporation Lands
0	2	2	2–4	White Mountains NRA
0	2	2	4	ADNR Land

Key: ADNR=Alaska Department of Natural Resources; NRA=National Recreation Area; NWR=National Wildlife Refuge.

4.8.4.1 *Land Use*

Land use impacts from launches under Alternative 2 would be consistent with the impacts listed for the No Action Alternative in Section 4.8.1.3. Recovery of the additional payloads and new and existing spent stages listed in Table 4–24 would further assist UAF in complying with the requirements of the special use permits and memoranda of agreement with the landowners within the ROI. The impact on these areas would be adverse, localized, minor in intensity, and short-term to long-term in duration, depending on how long the known payloads and spent stages remain within the launch corridor. However, it is possible that additional efforts would be made to remove any visible signs of flight hardware. Accordingly, larger clearing of areas or greater excavations could be required. This could result in longer-term impacts and could be inconsistent with existing land use permits, all of which currently stipulate that clearing and digging must be kept to a minimum.

Similar to the No Action Alternative and Alternative 1, Alternative 2 would be consistent with the ADNR special use designation of the Poker Flat North and South Special Use Areas. However, it should be noted that under this alternative some removal of new stages would occur. Therefore, it would be necessary to coordinate with the CPCRW staff to minimize the potential effects on the long-term hydrologic data collection efforts at the site. It is possible that recovery efforts could introduce additional disturbances (*e.g.,* ruts) to the area, which could adversely affect the quality of the data collected, which is intended to be done within an otherwise undisturbed context.

No predicted impact points would be targeted within Mollie Beattie Wilderness Area; however, it is possible for payloads or spent stages to land within the wilderness area. In the unlikely event this was to occur, NASA and UAF would work with USFWS to determine the minimum requirements for how the rocket components should be recovered. Recovery of spent stages within any of the designated Wild River corridors within the PFRR would be conducted in a manner to limit disturbance to the wide variety of vegetation, scenery, and wildlife characteristics of the corridors, should this occur.

4.8.4.2 *Recreation*

Impacts on recreation would be consistent with the impacts listed for the No Action Alternative in Section 4.8.2.2. Activities under Alternative 2 would not limit the ability for users to visit or take part in recreational activities within White Mountains NRA, Steese NCA, Arctic NWR, Yukon Flats NWR, or other areas within the ROI. UAF would continue to meet the requirements of the special land use permits for the federally managed lands within the ROI. UAF would post notices of planned launches to alert visitors at required trailheads, as well as in local newspapers. It is possible that visitors would voluntarily suspend or relocate their planned activities upon reading the posted notices; the potential duration of this could vary from days up to several weeks if optimum science conditions are not met until the end of the launch window. These impacts would be negligible and short-term.

Recovery activities under Alternative 2 would remove payloads and new and existing spent stages to the maximum extent practicable. The removal of these additional components, beyond those that would be removed under the No Action Alternative or Alternative 1, could reduce the likelihood that visitors would discover payloads or spent stages during their visits to these areas, and would further assist NASA and UAF in meeting the requirements of the special use permits for Arctic and Yukon Flats NWRs. However, it is possible that other signs of human activity, including ground scars, ruts, and areas of cleared vegetation, could be present following a more intrusive recovery, which could be discovered by recreational users.

Increased impacts associated with search and recovery operations on recreational opportunities are expected under Alternative 2 compared to Alternative 1 or the No Action Alternative. Impacts on persons participating in recreational activities in areas within the PFRR launch corridor initial search activities would be adverse, localized, negligible in intensity, and short-term in duration because most of these activities would take place in the winter months, when there are few visitors to these areas. Recovery operations would be limited to a small number of days, when helicopters would be recovering payloads or spent stages under Alternative 2. Under Alternative 2, these activities are estimated to last up to 16 days annually and would be spread across downrange lands.

As discussed in Section 4.8.2.2, during recovery operations, persons participating in recreational activities within sight or earshot of the recovery operation may hear or see a helicopter working in the area or a fixed-wing plane flying to pick up a recovered payload. The impacts associated with these activities would be similar to those associated with planes dropping visitors off at various landing spots throughout downrange lands; however, impacts could be greatest in Arctic NWR due to low baseline levels of helicopter use. In the case that recreational users were to discover a piece of flight hardware, it could negatively affect their experience, particularly those persons intending to have a wilderness experience. Others may find it a positive experience to discover a spent stage or payload. It is expected that those persons engaged in hiking and rafting would be the most sensitive to finding flight hardware, with hunters, trappers, and snow machines the most tolerant. The impact would be on a person-by-person basis and would be influenced by the perception of the individual. In summary, anticipated impacts on recreational activities would be adverse, localized, negligible in intensity, and short-term in duration.

4.8.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts on land use and recreation under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.8.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could reduce the probability that spent stages or payloads would land within these areas and therefore reduce the need to recover spent stages or payloads from these areas.

4.8.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts on land use and recreation under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.8.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could reduce the probability that spent stages or payloads would land within these areas and therefore reduce the need to recover spent stages or payloads from these areas.

4.8.7 Summer Launches

Summer launches could result in additional safety concerns because areas within the PFRR launch corridor are used more heavily during the summer months for camping, hunting, and recreation (see Section 4.13, Health and Safety). It is possible that visitors would voluntarily suspend or relocate their planned activities upon reading the posted notices; the potential duration of this could vary from days up to several weeks if optimum science conditions are not met until the end of the launch window. It is also possible that downrange "clear" zones would need to be established to ensure public safety, thereby restricting public access to these areas. These impacts would be greater due to the increased public use of downrange lands within the summer months and potential duration of restricted access and user displacement in planned impact areas, and would likely be considered moderate and short-term. However, in the event that such an operation would be proposed, substantial coordination with downrange landowners would be required to reduce potential impacts to the greatest extent practicable.

4.9 Cultural Resources

4.9.1 Methodology

Analysis of potential impacts on cultural resources considers both direct and indirect impacts. Direct impacts may occur by physically altering, damaging, or destroying all or part of a resource; altering characteristics of the surrounding environment that contribute to the resource's significance; introducing visual or audible elements that are out of character with the property or that alter its setting; or neglecting the resource to the extent that it deteriorates or is destroyed. For archaeological resources, there is no distinction between permanent and temporary disturbance or short-term and long-term effects; because of the unique nature of archaeological deposits, effects on cultural resources from ground disturbance are permanent and cannot be reversed.

Direct impacts can be assessed by identifying the types and locations of proposed activities and determining the exact location of cultural resources that could be affected. Direct impacts that could occur during the launch phase would be limited to the possible effect of a rocket component landing on a historic property. No alterations to buildings or the launch facility are included in this project. Direct impacts from the alternatives could also occur during recovery efforts. Ground-disturbing activities that could occur during recovery efforts have the potential to adversely impact historic properties either through destruction of the resource or through damaging the resource's integrity, a key criterion for determining a historic resource's eligibility for nomination to the National Register of Historic Places (NRHP) **(16 U.S.C. 470 *et seq.*)**. These activities could include travel to and from the recovery location, removal of rocket components, and human trampling. If a rocket component were to land on or in a historic property, removal of the rocket pieces could further damage the cultural resource.

Indirect impacts may result from project-related actions that eventually lead to effects. Indirect impacts may also result from effects on property value or changes in use of historic architectural resources. It is unlikely that the launch phase or recovery efforts would result in indirect impacts on historic properties.

Site types that could be affected by payload or spent stage impacts include Alaska Native archaeological sites, which may also include aboveground structures (*e.g.,* remains of habitations, stone tent rings, driftwood or whalebone house frames, cemeteries, caribou drive lines or fences and corrals, camps, lithic scatters, housepits), or historic era sites, which may be associated with Alaska Natives or Euroamericans (*e.g.,* U.S. military from World War II and Cold War eras, gold mining, mineral and oil exploration, homesteading, transportation, aviation, cemeteries, and other architecture).

Section 106 of the National Historic Preservation Act (NHPA) **(16 U.S.C. 470 *et seq.*)** requires agencies to seek ways to avoid, minimize, or mitigate adverse impacts on cultural resources. Because the size of the area of potential effect (APE) is extremely large and the information about cultural resources is both scarce and uneven over the area, it is not possible to identify all cultural resources in the APE. Furthermore, due to the nature of the flight path of each rocket, it is not possible to precisely predict the impact point for each rocket stage. However, because the frequency of rocket launches is low and the distribution of sites scattered, it is unlikely that impact points will affect cultural resources. In the rare event of an impact, although it could be adverse to the specific resource, it would be limited to that resource, and the overall impact on the full complement of cultural resources within the launch corridor would be negligible.

Historic properties within the APE were identified through examination of NRHP records and records at the Alaska Office of History and Archaeology, also known as the State Historic Preservation Office (SHPO). Cultural resources that have not been formally evaluated for NRHP eligibility are treated as historic properties (*i.e.,* resources that are eligible for listing in the NRHP) until a formal evaluation is made. NASA is currently consulting with the Alaska SHPO, appropriate Alaska Native tribes, and interested parties regarding the effects of the alternatives on cultural resources.

4.9.2 No Action Alternative

Under the No Action Alternative, NASA and UAF would continue to operate the SRP at PFRR in a manner consistent with current operations. Under the anticipated launch schedule of an average of four launches annually, there is an extremely low probability of hitting any specific location. Launches during the winter would likely reduce the potential impact if a landing was to occur on a cultural resource, as snow and ice and frozen ground would reduce surface and subsurface damage. To date, no impacts on cultural resources have been documented through the existing SRP launch and limited recovery program.

NASA would continue to coordinate with agencies and Alaska Natives according to Section 106 of NHPA, NASA regulations, and other pertinent laws and regulations, as appropriate.

4.9.3 Alternative 1 – Environmentally Responsible Search and Recovery

Under Alternative 1, launches would remain at the same level as anticipated under the No Action Alternative, with the same extremely low probability of landing on any specific location, including a historic property.

The airborne search for rocket stages and payloads would have no impact on archaeological or architectural cultural resources. There is a minor potential for impact on properties of traditional religious and cultural importance from search and recovery flights if the noise from aircraft were to intrude on a ceremony. However, because of the infrequency of launches, and thus of search missions, it is unlikely that the search flights would add significantly to existing air traffic. No properties of traditional religious and cultural importance have been identified by Alaska Natives or other groups within the APE, so impacts are anticipated to be negligible. If any such properties were to be identified through the NHPA Section 106 and government-to-government processes, then sensitivity to scheduling requirements would be likely to mitigate any potential impact.

Recovery efforts would occur during the thaw. Activities could include helicopter landing and takeoff; actual recovery of the rocket stage could entail crewmembers walking around the impact location and digging to excavate a rocket component, potentially followed by hauling and/or trampling of the vicinity. These actions have the potential to impact historic properties if a rocket stage were to land on or in the vicinity of such a resource. There would be an associated potential indirect impact on a resource if recovery led to identification of a site that was later purposefully disturbed (*e.g.,* through the illegal collection of artifacts). However, the low probability of hitting such a resource or of one being near a recovery location means that impacts are anticipated to be negligible. Additionally, where land-disturbing removal activities would most likely be conducted with hand tools, it would further reduce the potential for effects.

4.9.4 Alternative 2 – Maximum Cleanup Search and Recovery

Impacts and the potential for adverse impacts under Alternative 2 are essentially the same as for Alternative 1. Because there would be a greater number of recovery activities under this alternative compared to Alternative 1, there would be a greater possibility of disturbing a historic property. However, the low probability of landing on such a resource or of one being near a recovery location would continue to mean that impacts are anticipated to be negligible.

4.9.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts and the potential for adverse impacts on cultural resources under Alternative 3 are basically the same as for Alternative 1. Impacts are anticipated to be negligible.

4.9.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts and the potential for adverse impacts on cultural resources under Alternative 4 are basically the same as for Alternative 2. Impacts are anticipated to be negligible.

4.9.7 Summer Launches

The launch phase of the mission would have no effect on historic properties. The impact point could experience greater effect if the ground were thawed than during the winter, when the ground is frozen. If the impact point were to be on or very near a cultural resource, and if that resource were a historic property, this could have a greater effect than if the rocket fell during the winter. However, the likelihood of a rocket impacting a historic property is extremely low; thus, it is unlikely that summer launches would adversely impact historic properties.

In the event that a summer launch were proposed in the future, additional consultation with Alaska Natives and landowners would help determine if the seasonality of launches would make a difference in the already remote possibility of having any effect on properties of traditional religious and cultural importance.

4.10 Subsistence Use Resources

This section describes potential impacts on subsistence use resources in and around PFRR and under the launch corridor.

4.10.1 Methodology

Many small communities in Alaska are wholly or largely dependent on subsistence use of renewable resources. Subsistence use can be the principal means of support for communities and families that do not participate in a wage-oriented economy. Subsistence activities provide a means for economic self-sufficiency, particularly for rural communities, which may not have regular access to year-round employment or year-round access to make household food purchases.

Section 810(a) of ANILCA states, "In determining whether to withdraw, reserve, lease, or otherwise permit the use, occupancy, or disposition of public lands under any provision of law authorizing such actions, the head of the Federal agency having primary jurisdiction over such lands or his designee shall evaluate the effect of such use, occupancy, or disposition on subsistence uses and needs…" (ANILCA Title VIII, §810[a])." In this *Draft PFRR EIS*, BLM and USFWS are the Federal agencies that have primary jurisdiction over the majority of lands within the PFRR flight zones. Therefore, this section and the evaluation provided in Appendix D have been prepared to satisfy the ANILCA evaluation requirements for BLM and USFWS. ANILCA requires that this evaluation include findings on three specific issues: (1) the effect of use, occupancy, or disposition on subsistence uses and needs; (2) the availability of other lands for the purposes sought to be achieved; and (3) other alternatives that would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes **(16 U.S.C. 3120)**.

To determine if a significant restriction of subsistence uses and needs may result from any of the alternatives under consideration in this EIS, including their cumulative effects, the following three factors are considered: (1) the reduction in the availability of subsistence resources caused by a decline in the population or amount of harvestable resources; (2) reductions in the availability of resources used for subsistence purposes caused by alteration of their normal location and distribution patterns; and (3) limitations on access to subsistence resources, including from increased competition for the resources. A significant restriction to subsistence may occur in at least two instances: (1) when an action substantially reduces populations of harvestable resources or their availability to subsistence users and (2) when an action substantially limits access by subsistence users to these resources. This section evaluates whether the alternatives being considered regarding future operations at PFRR would cause a significant restriction to subsistence. If a significant restriction to subsistence is projected, it would constitute a major adverse impact on those communities dependent on subsistence resources. For these remote communities, even short-term restrictions could have an adverse impact on their ability to harvest subsistence resources.

The ANILCA Section 810(a) Summary of Evaluations and Findings is presented in Appendix D.

4.10.2 No Action Alternative

4.10.2.1 *Launch Operations*

Under the No Action Alternative, launches from PFRR and subsequent search and recovery operations would continue as they are currently conducted. An average of four launches per year, up to a maximum of eight launches, would be conducted. Payloads and spent stages would be recovered if required for scientific purposes or requested by the landowner.

NASA and UAF have been launching suborbital rockets from PFRR since the late 1960s. During that time, subsistence activities continued within the launch corridor without known interruption due to these activities. The launches are typically performed during the night or under darkness, when subsistence activities generally do not take place except during the winter months, when darkness lasts longer than daytime. Landowners and administrators (BLM and USFWS) downrange of PFRR are notified prior to any launches consistent with existing procedures and safety requirements. Launches occur within the Fairbanks North Star Borough, which is considered a nonrural area under Federal subsistence regulations and a non-subsistence area under state regulations. Therefore, it is not likely that subsistence activities would be conducted in the immediate vicinity of the PFRR launch site. Subsistence activities are; however, conducted downrange within the PFRR flight zones.

Since launches are conducted in winter, typically during darkness, the subsistence activities would vary depending on the availability of light and the open seasons for various activities. The primary subsistence activities would include gathering vegetation such as wood for fuel or other plants for ceremonial purposes, hunting, trapping, and fishing. Of these activities, hunting is considered to be the most noise sensitive activity. Many of the large land mammals hunted for subsistence, such as bear, caribou, and moose have multiple open seasons throughout the year or the open season extends through the entire year depending on the Game Management Unit. Previous reports have identified subsistence use areas within PFRR in which subsistence activities are carried out on a regular basis. Appendix D provides maps of the subsistence use areas for various subsistence resources identified in the *Proposed Land Exchange Yukon Flats National Wildlife Refuge Final Environmental Impact Statement* **(USFWS 2010a)** and the *Arctic National Wildlife Refuge Draft Revised Comprehensive Conservation Plan* **(USFWS 2011c)** for the villages of Arctic Village, Beaver, Birch Creek, Chalkyitsik, Fort Yukon, Kaktovik, Stevens Village, and Venetie. These areas are defined by a number of factors including habitat and migration patterns of the wildlife and accessibility of the areas to individuals participating in subsistence. Appendix D also provides maps of these subsistence use areas in relation to the predicted impact areas for spent stages and payloads. Of these subsistence use areas, the areas for Arctic Village, Beaver, Fort Yukon, Stevens Village, and Venetie are included or in close proximity to predicted impact points for spent stages or payloads. As a result, subsistence activities conducted by residents in these villages are more likely to experience potential impacts.

Of these potential impacts, disturbance to wildlife and the harvest of wildlife from a launch would be temporary and related primarily to the noise from impact of the spent stages or payloads as they come back to Earth. As described in Section 4.5, "Noise," and Section 4.7, "Ecological Resources," wildlife in the immediate vicinity of an impact area would be exposed to the sound from impact of spent stages. Launches would occur during the winter and in darkness, when migratory species would be absent and most resident species would be inactive. Due to the infrequency of launches and the brief duration of associated noise, species present near the impact site are expected to have negligible to minor short-term behavioral responses, if any, to the sound and are not expected to experience harm as a result (see Section 4.7.5).

Additionally, the amount of land that would be disturbed as a result of such impacts is very small compared with the amount of land being used for subsistence activities. Impact areas for spent stages are estimated to be between 6 and 15 square meters (65 and 160 square feet), and the impact area for payloads is typically even smaller when a payload is equipped with a parachute. As described in Section 4.7.5, effects would most likely be limited to a momentary interruption of routine behaviors, such as foraging, but could extend to individuals temporarily leaving the area immediately surrounding the point of impact. For example, an incoming item hitting the Earth within or very near a herd of caribou (a very unlikely event, see Appendix G) could cause the animals to temporarily take flight in a response similar to the response to a predator. Adverse impacts would be short-term and range from negligible to minor. The chances of a direct impact due to a payload or spent stage striking an individual animal are negligible. Therefore, adverse effects on subsistence activities would also be negligible to minor and short-term. Continued launch activities at PFRR would not result in adverse impacts as described in ANILCA Section 810(a).

4.10.2.2 *Search and Recovery*

Under the No Action Alternative, search and recovery operations would only be undertaken for scientific requirements or at the request of landowners. It is estimated that, on average, recovery would be attempted on one payload annually under this alternative. Therefore, the use of helicopters and fixed-wing aircraft would be minimal and infrequent. Any disturbance to wildlife or the harvest of wildlife for subsistence purposes is likely to be negligible. Overflight by low-flying search and recovery aircraft could have temporary and localized effects on wildlife (see Section 4.7.5). Fixed-wing aircraft flying at altitudes greater than 150 meters (500 feet) AGL would cause minimal, if any, response from wildlife. Lower-level flight, especially combined with maneuvering such as circling during searches, may cause temporary and localized responses such as taking flight by waterfowl or running by ungulates (for example, caribou). Permit stipulations with USFWS recommend minimum altitudes for overflight over Arctic NWR and Yukon Flats NWR lands, which constitute the majority of the area within the PFRR launch corridor, to be 610 meters (2,000 feet) AGL or higher, except under specific conditions, and prohibit the operation of aircraft at altitudes and in flight paths resulting in the herding, harassment, hazing, or driving of wildlife. Search and recovery activities would not be conducted over marine mammal habitat on or adjacent to the Beaufort Sea, so marine mammal species would not be exposed to overflight associated with search and recovery activities. Fish would not be affected at the sound levels associated with overflight at altitudes that would be utilized during search and recovery operations. As a result, no restriction of subsistence activities or adverse impact on subsistence resources is anticipated.

4.10.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.10.3.1 *Launch Operations*

Potential impacts on subsistence activities as a result of launch operations would be the same as those described under the No Action Alternative.

4.10.3.2 *Search and Recovery*

Following launches under Alternative 1, NASA and UAF would attempt to recover payloads and spent stages in an environmentally responsible manner to the extent practicable. In coordination with the landowners and administrators, PFRR would determine if the recovery of the spent stages and payloads is feasible and would not result in any significant additional environmental impacts.

The villages of Arctic Village, Beaver, Fort Yukon, Stevens Village, and Venetie have subsistence use areas within or in close proximity to the predicted impact areas for spent stages and payloads as shown in the maps provided in Appendix D. The search and recovery process would involve fixed-wing and helicopter overflights of the predicted impact sites, as described in Appendix F. Noise from low-flying aircraft would have the potential to startle wildlife and could cause the wildlife to leave the area in which search and recovery operations are taking place. However, these startle effects and departures from the area are expected to be temporary, limited to the relatively short periods that these aircraft would be within earshot of wildlife. Once any disturbance from the low-flying aircraft has ceased, it is expected that wildlife would return to their normal habits and locations.

Initial search operations are planned to be conducted in the winter soon after launch, depending on conditions, to locate and record the impact points and, as such, would have very little effect on most wildlife, as discussed in Section 4.7.4. Recovery operations would primarily take place during the summer, when the spent stages and payloads could be recovered more easily. Therefore, the level of disturbance to wildlife by the search and recovery operations would be spread throughout the year and would most likely last for up to 2 days for each operation, with a majority of operations expected to take a day or less. These operations would also be spread over great distances since the areas where payloads or spent stages may land within PFRR cover thousands of square kilometers; thus, the impacts on wildlife in any given area would be infrequent.

Therefore, any adverse impacts on subsistence resources or the harvest of subsistence resources are expected to be localized, minor, and short-term in duration under Alternative 1. As a result, no restriction of subsistence activities or adverse impact on subsistence resources is anticipated.

4.10.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.10.4.1 *Launch Operations*

Launch operations would be the same under Alternative 2 as described for Alternative 1 and the No Action Alternative.

4.10.4.2 *Search and Recovery*

For search and recovery operations, it is expected that greater efforts would be taken to recover stages and payloads from the areas shown in Table 4–24. Thus, additional time would be spent using fixed-wing aircraft and helicopters throughout PFRR to search and recover spent stages and payloads compared to Alternative 1 and the No Action Alternative.

Under Alternative 2, startle effects and potential disturbance to wildlife and subsistence harvesting activities (such as hunting) would be more extensive than under Alternative 1. However, these activities would continue to be relatively minor and infrequent across the affected areas since they would be spread over great distances. Therefore, any adverse impacts on subsistence resources and harvest of subsistence resources are expected to be localized minor, and short-term in duration. As a result, no restriction of subsistence activities or adverse impact on subsistence resources is anticipated.

4.10.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts on subsistence use and subsistence users under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.10.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not have any additional adverse effect on subsistence activities within PFRR.

4.10.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts on subsistence use and subsistence users under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.10.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not have any additional adverse effect on subsistence activities within PFRR.

4.10.7 Summer Launches

With regard to potential subsistence use, summer launches could result in additional safety concerns because areas within the PFRR launch corridor are used more heavily during the summer months for subsistence uses, leading to more people being present in the launch corridor as opposed to being concentrated within the towns and villages. Additionally, a non-winter launch would present an elevated fire risk. Should a wildfire occur, it could adversely affect both subsistence resources (through either loss and/or displacement) and the ability of rural residents to conduct subsistence activities. The types of resources and residents potentially affected would be highly mission-specific. As such, NASA would need to take these factors into consideration in the event of a summer launch (see Section 4.13, Health and Safety).

4.11 TRANSPORTATION

4.11.1 Methodology

The transportation analysis evaluates impacts associated with transport of materials to PFRR from Wallops Flight Facility (WFF) and search and recovery operations associated with recovery of spent stages and payloads. Rocket motors would be transported by truck from WFF to PFRR with the assumption that there would be two truck trips per launch. The payload associated with each launch would be transported from WFF to PFRR by air cargo, assuming one air transport per launch. Search operations for the payload and spent stages would be performed by fixed-wing aircraft, and recovery operations would be conducted by helicopter. The analysis includes transport of recovered items from the Fairbanks area to the PFRR launch site by truck.

Adverse impacts are presented in terms of the annual number of additional fatalities related to truck accidents and the annual number of additional fatal accidents for air transport/search and recovery missions. These impacts are determined by using truck-specific fatality rates per vehicle-mile and the distance traveled and air cargo/fixed-wing aircraft/helicopter-specific fatal accident rates per flight hour and the number of hours of flight.

For trucks, the U.S. large truck crash fatality rate would be 1.2×10^{-8} fatalities per vehicle-kilometer traveled (1.86×10^{-8} fatalities per vehicle-mile traveled) **(FMCSA 2010)**. This fatality rate is also equal to the 5-year average fatality rate of all vehicles on Alaska rural roads **(USDOT 2011a)**. The large truck crash fatality rate in Canada would be 2.2×10^{-8} fatalities per vehicle-kilometer traveled (3.5×10^{-8} fatalities per vehicle-mile traveled) **(Transport Canada 2010:7)**. The one-way distance traveled by truck from WFF to PFRR in the United States (including within Alaska) would be about 2,800 kilometers (1,800 miles), while the one-way distance traveled in Canada would be about 4,200 kilometers (2,600 miles) **(Mapquest 2011a)**. The total fatality rate would be 1.3×10^{-4} fatalities per trip (one-way). The one-way distance traveled by a large truck to return recovered items to the PFRR launch site from the Fairbanks area would be about 54 kilometers (33 miles) **(Mapquest 2011b)**, for a total fatality rate of 6.2×10^{-7} fatalities per trip (one-way). When calculating the total number of fatalities for each alternative, the two-way distance is used to account for the return trip of a truck.

The worldwide fatal accident rate is 3.4×10^{-7} fatal accidents per flight hour for all jet aircraft. However, using factors to account for the region in which the flight takes place (North America) and the type of operation (scheduled cargo), this rate was adjusted to 2.5×10^{-7} fatal accidents per flight hour **(OGP 2010)**. For purposes of analysis, it is assumed that one cargo flight would occur per launch, with an average of four launches per year occurring under all alternatives. A flight from the Washington, D.C., area to Fairbanks International Airport is assumed to take about 9.5 hours, which is equivalent to a flight from New York City to Anchorage **(Anchorage Daily News 2011)**.

Alaska is known to be a state that has a high number of aircraft accidents in comparison to the rest of the United States; therefore, it is important to use Alaska-specific fatal accident rates for aircraft. The fatal accident rate for fixed-wing, single-engine aircraft has been determined to be 1.22×10^{-5} fatal accidents per flight hour **(Conway *et al.* 2006)**. The fatal accident rate for helicopters has been determined to be 1.48×10^{-5} fatal accidents per flight hour **(Conway *et al.* 2006)**.

Potential adverse impacts can be categorized as being negligible, minor, moderate, or major. For purposes of analysis, negligible impacts are assumed to be impacts much less than 1 fatality or fatal accident per year, taken to be less than or equal to 0.002 fatalities or fatal accidents per year. Minor impacts are assumed to be greater than 0.002 and less than 0.01 fatalities or fatal accidents per year. Moderate impacts are assumed to be greater than 0.01 and less than 0.1 fatalities or fatal accidents per year. Major impacts are assumed to be greater than or equal to 0.1 fatalities or fatal accidents per year. The risk can also be expressed in terms of the following: a negligible impact of 0.002 fatalities per year would be the same as less than 1 chance in 500 years that a fatality would occur. A minor impact is defined as a fatality or fatal accident occurring every 100 to 500 years. A moderate impact is defined as a fatality or fatal accident occurring every 10 to 100 years. A major impact is defined as a fatality or fatal accident occurring in a 10-year period.

Transportation risks should also be kept in perspective related to national data. The average number of traffic fatalities in the United States is about 34,000 per year **(USDOT 2011b)**. While major impacts are assumed to be equivalent to one or more traffic fatalities, in view of the overall ground transportation system, the additional risk would be small. For air transports, there were 68 accidents in the United States involving both scheduled (primarily passenger service) carriers flying aircraft with fewer than 10 passenger seats and on-demand passenger or cargo services using either fixed-wing airplanes or helicopters, with 2 of these accidents involving fatalities **(NTSB 2011)**. An additional fatal aircraft accident occurring due to implementation of one of the analyzed alternatives would therefore be considered more significant compared to the national data than a traffic fatality due to a truck crash.

4.11.2 No Action Alternative

4.11.2.1 *Launch Operations*

Using the total fatality rate per trip for large truck transport provided in Section 4.11 and assuming four launches per year with two truck shipments per launch, the number of traffic fatalities due to shipment of equipment from WFF to the PFRR launch site would be 2.0×10^{-3} fatalities per year. The number of traffic fatalities related to ground transport of new payloads from Fairbanks International Airport to the PFRR launch site would be 5.0×10^{-6} fatalities per year. This impact would be minor, with a risk of about 1 chance in 500 years that a traffic fatality would occur.

Air transport of new payloads from WFF would have a risk of a fatal accident of 9.3×10^{-6} fatal accidents per year, assuming a flight time of 9.5 hours. This impact would be negligible, with a risk of about 1 chance in 110,000 years that a fatal accident would occur.

4.11.2.2 *Search and Recovery*

The number of traffic fatalities related to ground transport of one recovered payload from the Fairbanks area to the PFRR launch site would be 1.2×10^{-6} fatalities per year. This impact would be negligible, with a risk of about 1 chance in 830,000 years that a fatality would occur.

For search and recovery operations, the annual number of flight hours associated with each alternative and mode of transport (*i.e.,* fixed-wing aircraft or helicopter) is provided in Appendix F. Under the No Action Alternative, there would be a total of 12 flight hours for a fixed-wing aircraft and 4 flight hours for a helicopter each year. The risk of a fatal accident associated with a fixed-wing aircraft would be 1.5×10^{-4} fatal accidents per year, while the risk of a fatal accident associated with helicopter operations would be 5.9×10^{-5} fatal accidents per year. The additional risk associated with search and recovery operations under this alternative would be 2.1×10^{-4} fatal accidents per year. This impact would be negligible, with a risk of about 1 chance in 4,800 years that a fatal accident would occur.

4.11.2.3 *Total Impacts*

The total number of traffic fatalities associated with truck transports during launch and search and recovery operations would be 2.0×10^{-3} fatalities per year. This impact would be minor, with a risk of about 1 chance in 500 years that a traffic fatality would occur. The impact on traffic volume of truck transports related to launch and search and recovery operations would be negligible, based on traffic information in Chapter 3, Section 3.11. The annual average daily traffic count on Steese Highway ranges from 1,500 to 1,800 vehicles, which represents a free-flowing condition; the impact of truck transports due to implementation of this alternative would be much less than 1 percent on the traffic count, with no impact on road conditions.

The total additional risk associated with air transport supporting launch activities and search and recovery operations under this alternative would be 2.1×10^{-4} fatal accidents per year. This impact would be negligible, with a risk of about 1 chance in 4,800 years that a fatal accident would occur.

4.11.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.11.3.1 *Launch Operations*

Impacts related to ground transportation would be minor, to the same as the impacts presented in Section 4.11.2.1 for the No Action Alternative because there would be no changes to the shipment of equipment from WFF to the PFRR launch site. Impacts related to air transport of new payloads from WFF to Fairbanks also would be the same (negligible) as the No Action Alternative.

4.11.3.2 *Search and Recovery*

The number of traffic fatalities related to ground transport of 12 recovered items from the Fairbanks area to the PFRR launch site would be 1.5×10^{-5} fatalities per year. This impact would be negligible, with a risk of about 1 chance in 67,000 years that a fatality would occur.

Under Alternative 1, there would be an estimated total of 67 flight hours for fixed-wing aircraft and 35 hours of flight time for helicopters each year. The risk of a fatal accident associated with fixed-wing aircraft would be 8.2×10^{-4} fatal accidents per year, while the risk of a fatal accident associated with helicopter operations would be 5.2×10^{-4} fatal accidents per year. The additional risk associated with air transport activities that support search and recovery operations under this alternative would be 1.3×10^{-3} fatal accidents per year. This impact would be negligible, with a risk of about 1 chance in 770 years that a fatal accident would occur.

4.11.3.3 *Total Impacts*

For truck transports, the overall fatality rate would continue to be 2.0×10^{-3} fatalities per year, taking into account 11 additional truck trips from the Fairbanks area to transport recovered spent stages and payloads to the PFRR launch site as compared to the No Action Alternative. This result equates to a risk of 1 chance in 500 years that a fatality would occur. The impact on traffic volume on Steese Highway would also be negligible.

The total additional risk associated with air transport supporting launch activities and search and recovery operations under this alternative would be 1.3×10^{-3} fatal accidents per year. This impact would be negligible, with a risk of about 1 chance in 770 years that a fatal accident would occur.

4.11.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.11.4.1 *Launch Operations*

Impacts related to ground transportation would be minor, the same as the impacts presented in Section 4.11.2 for the No Action Alternative because there would be no changes to the shipment of equipment from WFF to the PFRR launch site. Impacts related to air transport of new payloads from WFF to Fairbanks also would be the same (negligible) as the No Action Alternative.

4.11.4.2 *Search and Recovery*

The number of traffic fatalities related to ground transport of 20 recovered items from the Fairbanks area to the PFRR launch site would be 2.5×10^{-5} fatalities per year. This impact would be negligible, with a risk of about 1 chance in 40,000 years that a fatality would occur.

Under Alternative 2, there would be an estimated total of 112 flight hours for fixed-wing aircraft and 56 hours of flight time for helicopters each year. The risk of a fatal accident associated with fixed-wing aircraft would be 1.4×10^{-3} fatal accidents per year, while the risk of a fatal accident associated with helicopter operations would be 8.3×10^{-4} fatal accidents per year. The additional risk associated with air transport activities that support search and recovery operations under this alternative would be 2.2×10^{-3} fatal accidents per year. This impact would be minor, with a risk of about 1 chance in 450 years that a fatal accident would occur.

4.11.4.3 *Total Impacts*

Impacts related to truck transportation would be minor, similar to the impacts presented in Section 4.11.3 for Alternative 1, with the total number of traffic fatalities slightly increasing from 2.0×10^{-3} fatalities per year to 2.1×10^{-3} fatalities per year. This increase is a result of eight more truck trips from Fairbanks International Airport for transportation of recovered spent stages and payloads. This result equates to a risk of 1 chance in 480 years that a fatality would occur. The impact on traffic volume on Steese Highway would also be negligible.

The total additional risk associated with air transport activities under this alternative would be 2.2×10^{-3} fatal accidents per year. This impact would be minor, with a risk of about 1 chance in 450 years that a fatal accident would occur.

4.11.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Transportation impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.11.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential transportation impacts for this alternative as compared to Alternative 1 since the same amount of transportation would be required.

4.11.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Transportation impacts under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.11.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential transportation impacts for this alternative as compared to Alternative 2 since the same amount of transportation would be required.

4.11.7 Summer Launches

The transportation impacts should remain the same as those projected for launch operations in the winter even if launches were conducted during the summer because the truck transports and aircraft operations associated with search and recovery activities would occur during the summer under either launch scenario.

4.12 WASTE MANAGEMENT

This section discusses potential impacts of hazardous waste and solid waste generated during NASA SRP launch, recovery, waste treatment, and disposal activities. In addition to discussing potential impacts from hazardous materials, supplemental information is provided to aid the reader in understanding the specific use of each.

4.12.1 Methodology

The analysis is of potential impacts is divided into three activity areas:

- **Launch Operations** – PFRR rocket launch and spill cleanup activities
- **Recovery Activities** – Retrieval of newly spent and existing stages and payloads from various areas of PFRR
- **Waste Treatment and Disposal Activities** – Cleaning of spent rocket stages and disposal of waste materials

Determination of hazardous materials and solid waste impacts is based on analysis of the potential for the launch, recovery, and disposal activities associated with each alternative to use hazardous materials and generate waste. Material and waste quantities were estimated using rocket component manufacturer's information and records of previous launches, which included data on vehicle type and payload and stage impact location and weight. Where necessary, data were estimated for payloads and stages for which historical data were unavailable. For analysis purposes, the quantity of material recovered annually per alternative was calculated based on the alternatives' recovery scenarios.

Assumptions

The actual quantity of material recovered is dependent on whether the items can be located and recovered. Therefore, the estimated weight of material recovered is presented in this section as a range reflecting both a 50 percent location success rate (consistent with recent experience for "new" launches) up to a 100 percent location success rate, which would be NASA's ultimate goal. For the recovery of items from past launches, estimated weights are not presented as a range, as it is expected that if reported and confirmed to be a sounding rocket item, it would most likely be removed.

Classification of Impacts

Classifying impacts from the deposition of sounding rocket materials in downrange lands presents a unique case. PFRR is the only rocket range of its type in the United States, and it is especially unique when one considers the context of downrange lands. Other U.S. ranges typically deposit launch related items almost exclusively in oceanic or desert environments, where recovery is either not feasible or much easier due to the terrain. In conducting this analysis, NASA evaluated potentially applicable waste management regulations and multiple environmental impact assessment documents; however, was unable to locate appropriate standards against which impact levels could then be derived. Therefore, in the absence of such standards, NASA applied best professional judgment in assigning impact levels.

It is important to note that while quantities of waste are presented for all downrange areas, the focus of this section is those areas beyond the Poker Flat North and South Special Use Areas. As these areas are legally designated by the State of Alaska for the impact of rocket items for an indefinite term, quantities of materials deposited within them are subtracted in the final calculation before concluding a particular level of impact.

Potential impacts would be considered negligible if there was no change in quantity of material deposited or recovered. For purposes of analysis potential impacts would be considered minor if deposition of material is 1,000 kilograms (2,200 pounds) or less; moderate if deposition of material ranges from 1,000 to 2,000 kilograms (2,200 to 4,400 pounds); and major if deposition of material is greater than 2,000 kilograms (4,400 pounds). Potential impacts would be considered adverse under alternatives for which the deposition of material exceeds the quantity of material recovered; potential impacts would be considered beneficial under alternatives for which the recovery of material exceeds the quantity of newly deposited material. Regarding duration, a waste management impact would be considered long-term if the effects lasted longer than 5 years, as could be the case for payloads and stages that remain unrecovered from the launch corridor; medium-term if the effect lasted from 1–5 years; and short-term if the change were to persist for less than 1 year, as is the case with temporary storage of hazardous materials and waste.

Disposal activities would be considered significant if the quantity of hazardous waste exceeds PFRR's conditionally exempt small quantity generator status, which restricts UAF and PFRR from generating more than 100 kilograms (220 pounds) of hazardous waste and accumulating more than 1,000 kilograms (2,205 pounds) of hazardous waste per month **(USA 2001)**.

4.12.2 No Action Alternative

4.12.2.1 *Launch Operations*

Future launch activity would remain at a level similar to the level that has occurred at PFRR in the past. The continuation of launch operations would require the use of hazardous materials, some of which would unavoidably land within downrange properties. The following presentation of information not only assesses the potential environmental consequences of these materials, but also provides the reader an understanding of what role they serve in a sounding rocket mission.

Motors – All rockets launched from PFRR are solid-fueled and comprise either a double base (nitrocellulose-nitroglycerin) or composite (ammonium perchlorate/aluminum) propellant formulation cast within a hardened steel tube. Chapter 2, Section 2.2 of the *SRP SEIS* defines these propellants in full detail **(NASA 2000a)**. On the forward end of each rocket motor is a steel plate; on the aft end is a composite (*e.g.*, graphite) nozzle. By definition, rocket motors are hazardous due to their ignitable or explosive properties. However, once ignited at the launch site, the rocket motors burn until all propellant is exhausted, rendering the motor casing inert when it lands. Any trace amounts of unburned propellant would not be expected to present explosion or a fire risk. It should be noted that initially following land impact, the rocket motors would be extremely hot; however, following a period of cooling, the motors would not present any acute hazards. Fire risks from launches would be negligible due to the time of year when operations typically occur. A more detailed discussion regarding the quantities of motors expected to land within the ROI is provided below under "Nonhazardous Waste."

Pyrotechnics – In addition to the rocket propellant, each rocket motor contains a series of small explosive charges. To provide perspective regarding size, the largest charge currently employed is just less than 0.3 grams (0.01 ounces). These charges serve two primary functions: rocket motor ignition and separation of the stage after it has finished burning.

In addition to the pyrotechnic systems that would be on all rocket motors, the first stage specifically would also contain several spin motors, the purpose of which is to spin the entire rocket immediately following first stage ignition to improve the stability of the rocket during flight. Payloads also contain a number of the above-described pyrotechnic charges for purposes such as removing doors and nosecones to expose the scientific experiment. The size and number of these charges would be mission-specific and would vary; however, even in the case that all charges were of the largest variety, the total charge mass would be less than 28 grams (1 ounce). Once activated, under normal flight conditions, these pyrotechnic systems would pose no hazard to persons on the ground.

Batteries **–** Small electrical systems are required on each rocket motor such that the ignition and separation functions described above may occur. As only the first stage can be ignited from a ground-based circuit, rechargeable batteries are employed (see **Figure 4–14**). On the forward end of each motor, approximately 1.8 kilograms (4 pounds) of nickel-cadmium cells are housed within rigid plastic containers bolted to the head cap of the motor. To assist in providing perspective, this quantity of batteries is comparable to approximately 48 “AA” cells typically used in consumer electronic devices. Of the total battery mass, approximately 15 percent is the cadmium metal, totaling approximately 270 grams (0.6 pounds) per stage. In addition to the nickel-cadmium cells, small quantities of silver oxide cells are used in the motor ignition systems. Weighing less than a gram each, this equates to an approximate mass of 50 grams (0.1 pounds) onboard each motor. These types of batteries are most commonly used in small personal electronic devices, including wristwatches.

Figure 4–14. Typical Rocket Motor Ignition Battery Pack

In addition to the batteries onboard the rocket motor, the payload would contain batteries for the ACS, telemetry, and scientific experiments (see **Figure 4–15**). The total mass of batteries onboard would vary based upon mission requirements; however, a typical mission would be expected to employ approximately 9 kilograms (20 pounds) of nickel-cadmium batteries. This would equate to approximately three packs of 24 “C” cells and single packs of 24 and 16 “A” cells. Assuming that the payload’s batteries contain 15 percent cadmium by mass, the total cadmium returning to land would be approximately 1.4 kilograms (3 pounds) per flight.

Figure 4–15. Typical Payload Battery Configuration

The primary concern regarding the onboard batteries would be the potential for cadmium to enter the environment after the rocket motor returned to Earth. Although it is a trace metal found naturally in the Earth's crust and in oceanic waters, cadmium can be harmful to people and wildlife if elevated concentrations enter the body. Cadmium is efficiently taken up by plants and can therefore enter the food chain for humans and animals. In aquatic systems, it has been shown to accumulate in fish, shellfish, and algae. Although it does not break down in the environment, it may be affected by physical and chemical processes that influence its mobility, bioavailability, and residence time in different settings **(ASTDR 2008)**.

For cadmium to present an environmental or health risk, it must first become exposed such that it comes in contact with an environmental medium such as soil or water. It would be very unlikely that the force of impact would rupture the individual battery cells. Although the batteries are located on the forward end of the rocket motor (which would be the end that would most likely impact the ground first), they are constructed of a steel casing and are packaged in a rigid plastic container that is bolted to an aluminum plate within the rocket motor head cap. In the case of a payload, which would likely land on its side, the batteries are similarly mounted to an aluminum frame that is then encased by an aluminum "skin." Essentially, for the batteries to be punctured, the motor or payload would need to land directly on a rigid, sharp object (analogous to a thick section of steel rebar) for this to happen. Two impact scenarios for fin-stabilized motors are most likely. If the stage were to penetrate the ground or water surface, the batteries would remain intact; however, likely dislodging from the mounting plate several feet below the surface. In the second scenario, if the motor landed on a surface that it could not penetrate, the first several feet of the motor would "peel" back and land on its side, likely dislodging the battery packs to an area adjacent to the impact site, but again it would be very unlikely that the batteries themselves would rupture. In the case of a finless stage or payload, the outside structure would most likely sustain the most damage, with the potential for dislodging the batteries, but it is unlikely that individual cells would expose their internal cadmium-containing contents **(Wilcox 2012)**.

Over time, exposure to air and water would likely cause the ends of the batteries to corrode first. At that point, once soil and water come in contact with the cadmium metal, it would slowly dissolve, releasing small concentrations of cadmium in the local area. The eventual fate of the cadmium would be highly dependent upon its location. For example, if located in an upland area, the released cadmium would likely bind to the soil particles and be taken up by nearby plants. Cadmium in soil may leach into water; however, this would be most pronounced under acidic conditions (*e.g.,* in the presence of acid rain or industrial activities), which would not be common within the ROI.

In wetland areas, such as Yukon Flats NWR, the mobility and plant availability of cadmium in wetland soils would be substantially different from upland soils. Cadmium tends to be retained more strongly in wetland soils and is more available to plants under upland conditions **(Gambrell 1994)**. **Debusk *et al.* (1996)** studied the retention of cadmium in wetland systems. Differences between measured concentrations in inflow and outflow samples indicated that approximately half of the added cadmium was retained. Experiments showed that nearly all trace metals were present in the sediments in a form that is of limited bioavailability and toxicity.

Cadmium is more mobile in aquatic environments than most other heavy metals (*e.g.,* lead). In some riverine settings within the ROI, cadmium would likely remain it its dissolved (bioavailable) form due to the surface water's low organic content; however, surface waters that drain areas with higher organic soil content would lend to the formation of insoluble, less bioavailable complexes that would end up in the sediment bed.

In addition to the cadmium found in the batteries themselves, very small quantities of lead containing solder are used on sounding rocket electrical systems. Lead is a heavy metal that is harmful to people and wildlife in elevated concentrations. Although the majority of electrical systems are connected with crimps, some soldered connections are still employed, including those in the battery packs. It is estimated that approximately 100 grams (3.5 ounces) of solder would be used on a rocket's entire electrical system, with 40 percent (40 grams [1.4 ounces]) of this solder consisting of lead. To assist in providing perspective, this quantity of lead is slightly more than what is contained within a single 12-gauge shotgun shell used for small-game hunting.

Insulation Materials – For some older rocket motor stages, the remaining insulation within the steel tube may contain asbestos materials embedded in resins that could present specific hazards **(Hesh 2011; Wilkie 1981)**. Per the definition in Section 112 of the CAA, an asbestos-containing material is one that contains more than 1 percent asbestos; a recent insulation sample collected and analyzed per EPA protocol indicated that the insulation contained about 15 percent asbestos. A key consideration in assessing asbestos-related hazards to humans is whether the asbestos-containing material would readily release asbestos fibers when damaged or disturbed. The term "friable" is used to define those asbestos-containing substances that, when dry, can be crumbled or reduced to powder by normal hand pressure. Even if an asbestos-containing material is non-friable, it could still present a hazard if it is grinded or cut. In the instance of the motor that was recently sampled, it was found to be non-friable; however, the state of weathering and deterioration would make the friability determination case-specific.

If a person were to handle or cut up the insulation without employing appropriate protective measures, there would be the potential for an uptake of asbestos-containing materials. Airborne dust concentrations of 7.5 fibers per milliliter (48 fibers per cubic inch) were measured while cleaning one type of asbestos insulation (Durestos) used in rocket motors with a wire brush **(Wilkie 1981)**. This concentration level is typical of what asbestos workers were once exposed to on a routine, continuous 40-hour-per-week basis **(ATSDR 2001)**. These short-term concentrations are higher than concentrations now permitted for U.S. workers by the Occupational Safety and Health Administration (OSHA) for an 8-hour day (0.1 fibers per milliliter [0.64 fibers per cubic inch]) or a 30-minute excursion limit of 1.0 fiber per milliliter (6.4 fibers per cubic inch) for construction or shipyard workers **(ATSDR 2001)**. If a person lacking proper personal protective equipment were exposed to 7.5 fibers per milliliter (48 fibers per cubic inch) for 15 minutes, the exposure would be approximately equivalent to that permitted of a worker over about 20 hours at the time-weighted working limit of 0.1 fibers per milliliter (0.64 fibers per cubic inch). The total uptake of respirable materials; however, even if they were cut up without respiratory protection, would be limited compared to long-term uptake by persons working daily with asbestos materials. Asbestos-related lung diseases (malignant and nonmalignant) or signs of these diseases have been reported in groups of occupationally exposed humans with cumulative exposures ranging from about 5 to 1,200 fibers per year per milliliter (0.64 to 7,700 fibers per year per cubic inch) **(ATSDR 2001)**. Therefore, continuous 40-hour-per-week, 50-week-per-year exposure to asbestos at the levels associated with handling rocket motor insulation would be necessary to result in long-term health impacts. Thus, no health impacts are expected from attempting to cut up a rocket motor or from short-term exposure to potential asbestos-containing materials other than the risk of injury from cuts or strains from handling heavy parts. As there would be limited recovery or disassembly of rocket motors under the No Action Alternative, potential risks to PFRR recovery staff would be minimal; however, as there would be a continuing presence of the motors downrange, users of downrange lands could be more likely to encounter the motors and could thus be exposed to asbestos-containing materials. However, as summarized above, expected hazards would be very low.

Pressure Systems – Onboard the payload section of the rocket are small cylinders of high pressure (generally 5,000 pounds per square inch) compressed gas, typically argon or nitrogen (see **Figure 4–16**). These gases are vented during normal flight to align the payload in optimum position for taking its respective measurement. The typical quantity onboard a sounding rocket is small, estimated to be approximately 0.009 cubic meters (0.05 cubic feet). Both gases are nonhazardous; improper handling or damage to the cylinder could cause the cylinder to rupture or act as a projectile. However, the likelihood of such an incident occurring would be very low as this system is designed to vent its contents during reentry.

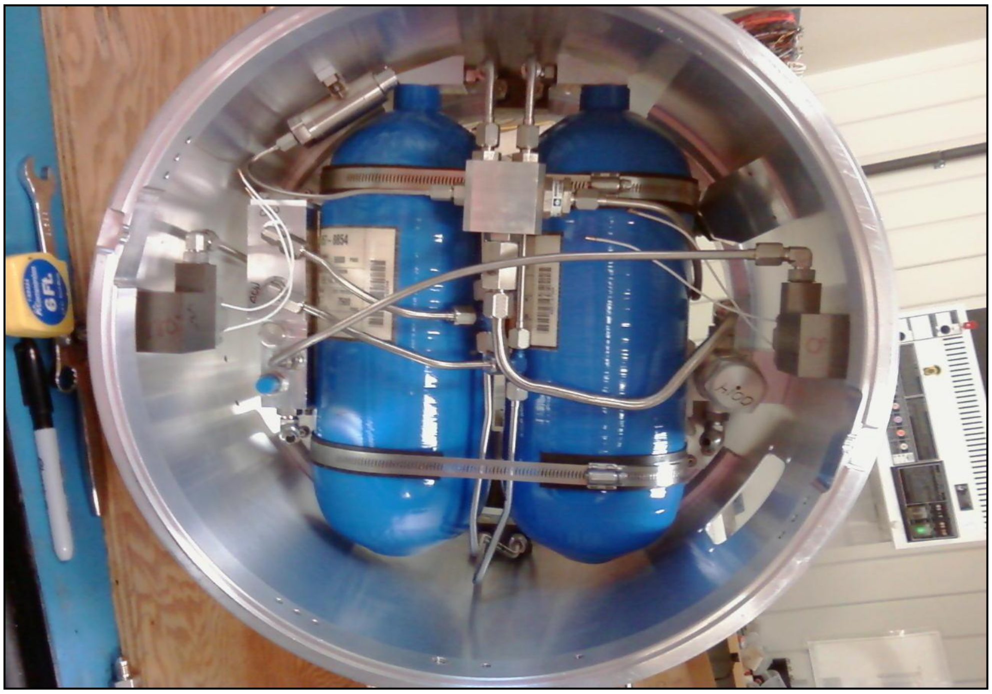


Figure 4–16. Typical 43-Centimeter-Diameter (17-Inch-Diameter) Payload High Pressure Tank Configuration

Chemical Tracers **–** The use of small quantities of metal vapors or TMA for the study of upper-atmospheric processes is discussed in detail in Chapter 2, Section 2.1.2.2 of this EIS. To help provide perspective regarding size, for some TMA payloads (the most commonly employed tracer), modules are released during flight with each containing approximately 380 milliliters (12.9 ounces) of the liquid—slightly more than the contents of a typical soda can. Larger canisters are most commonly used as they release the material along a longer duration of the trajectory and typically hold approximately 6 liters (1.6 gallons). In general, the primary on-the-ground hazard associated with these materials is the potential for fire or burns. However, during launch preparations, specialized procedures are employed to ensure the safety of personnel. During normal flight, these materials are released high in the atmosphere, with only trace amounts (estimated to be less than 100 grams [3.5 ounces]) present in hardware that returns to Earth. The small soda-can-sized modules would not contain any residual as they rupture during flight; the most likely location of the trace quantities would be within the piping of the canister-type systems.

Calibration Sources **–** The potential exists that future payloads could use small amounts of radioactive materials as scientific instrument components. For the purposes of this EIS, the amount of radioactive material that could be carried, and thus launched, is strictly limited by the approval authority level delegated to the NASA Nuclear Flight Safety Assurance Manager (NFSAM) by the most current revision of NASA Procedural Requirement 8715.3, *NASA General Safety Program Requirements*. Per NASA policy, the NFSAM may approve launch for small quantities of radioactive material that have been shown to present no substantial public hazard. As part of the approval process, the payload manager must prepare a Radioactive Materials Report (RMR) that describes all of the radioactive materials to be used. The RMR would be submitted to the NFSAM for safety review and approval. A key decision point during this review is the calculation of what is known as the A2 Mission Multiple.[5] If a radioactive material is approved for use, the land management agencies and landowners within the PFRR launch corridor would be notified immediately of NASA's plans.

To provide perspective regarding the size of typical calibration sources flown on sounding rockets, a recent mission at White Sands Missile Range (36.264) that contained two sources had a mission multiple of approximately 5×10^{-5}. Assuming that the average activity in a single smoke detector containing americium-241 is about one microcurie (one millionth of a curie), it would have a mission multiple of 2×10^{-4}, which would be four times greater than that of the referenced mission.

All of such payloads would be equipped with location and recovery systems, and would be immediately removed from downrange lands following launch. Therefore, the use of small quantities radioactive materials in payloads would not present any measurable risk to the public or to the environment.

Balance Weights – To ensure that the spinning rocket components do not "wobble," between 2.3 and 4.5 kilograms (5 and 10 pounds) of lead balance weights are employed on most sounding rocket payloads. These weights would typically be in the form of 0.6- or 1.3-centimeter-thick (0.25- or 0.5-inch-thick) curved plates that are bolted to the inside of the payload skin sections. It would be highly unlikely that these weights would be dislodged such that they would separate from the payload upon impact **(Wilcox 2012)**.

Launch Site Generated Wastes – Materials typically used during launch preparation activities and in rocket stages and payloads include paints, oils, solvents, photographic and cleaning solutions, and bottled gases. Continued operations at PFRR would result in the generation of small quantities of hazardous waste at the PFRR launch site. Hazardous waste would continue to be managed and disposed of by the UAF Risk Management Office. All NASA SRP missions include an inventory of all hazardous materials and disposal methods used for that particular launch.

PFRR does not have a Hazardous Waste Contingency Plan or a Spill Prevention, Control, and Countermeasures Plan because of the small quantity of materials kept on site, so procedures set forth in the UAF Health, Safety and Risk Management Policies are followed in the event of a spill **(UAF 2003a)**. Future launch activity would remain the same as the previous level of activity; therefore, no change in likelihood of a spill is anticipated.

Nonhazardous Waste – As a component of the launch day flight safety assessment, three sizes of helium-filled latex balloons (shown in Chapter 2, Figure 2–24) containing small meteorological sensors (also referred to as "radiosondes," shown below in **Figure 4–17**) or aluminum foil (as a radar target) are released from PFRR. For a typical 6-hour countdown, approximately one each

[5] The A2 mission multiple is a calculated value based on the total amount of radioactive material being launched. It is used in defining the level of review and approval required for launch.

of the mid- and upper-altitude radiosondes and 12 of the lower-flying aluminum foil "chaff" balloons are flown. The balloons would rarely return to the Earth's surface intact as they would be expected to rise to an altitude between 12 and 30 kilometers (7.5 and 19 miles), where freezing temperatures and expansion (due to lower air pressure) would cause "brittle fracture," creating spaghetti-like pieces that scatter with prevailing winds. The direction in which the balloons fly would be highly dependent upon atmospheric conditions; however, historic experience shows that these balloons generally take a northerly or easterly track.

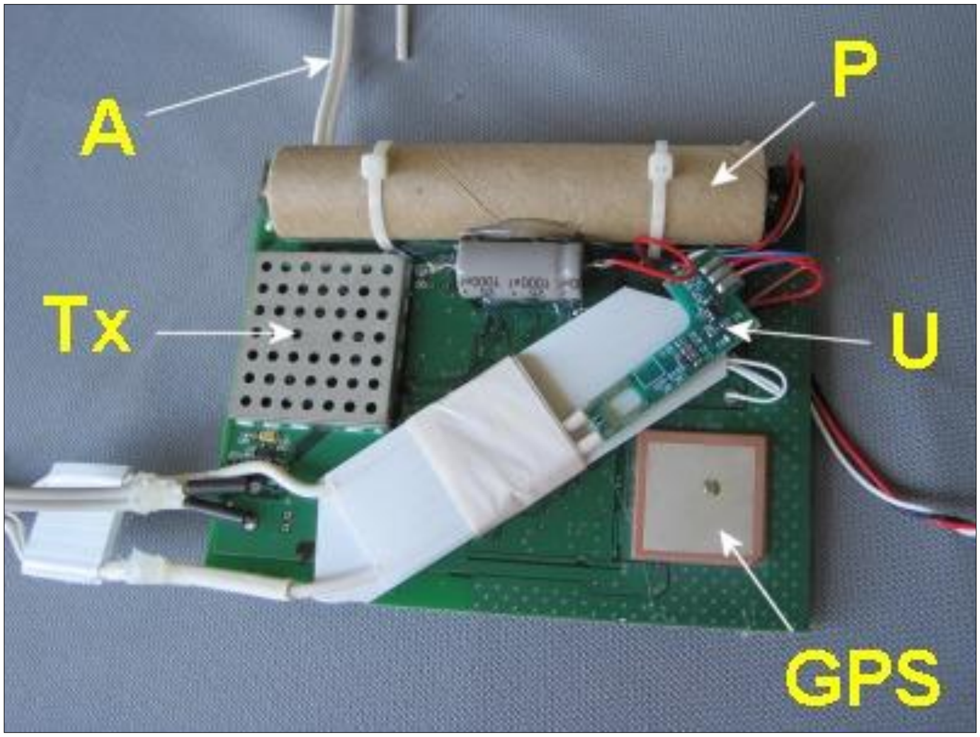


Figure 4–17. GPS Weathersonde Internal Parts; A: Antenna; P: Lithium Battery; Tx: Transmitter; U: Humidity Sensor; GPS: GPS Antenna (photo courtesy Lockheed Martin/Sippican)

Assuming a 320-meter-per-minute (19.2-kilometer-per-hour) ascent rate, the highest altitude balloon would not reach its approximate bursting altitude until about 90 minutes into flight. Over this time, the balloon could travel between approximately 80 and 160 kilometers (50 and 100 miles) from the launch site. Given the lightweight of the multiple pieces to which the balloon would be reduced, they would be spread over a very large area. Once these pieces land, it would be expected that they would break down over time as latex is a biodegradable material. However, given the cold temperatures and limited sunlight experienced within the ROI for approximately half of the year, degradation would likely take longer (in relative terms) than would be expected in warmer climates. In addition, the radiosonde payloads are housed within a 15- by 13- by 8-cenemiter (6- by 5- by 3-inch) polystyrene ("Styrofoam") box (see **Figure 4–18**) that would return to the ground at the end of flight. Polystyrene does not biodegrade for hundreds of years and is resistant to photolysis (degradation from sunlight); therefore, it would be expected that the boxes would remain within the ROI for years to come. Table 4–28 presents a summary of estimated quantities of "launch support items" that would be flown from PFRR during a typical launch season.

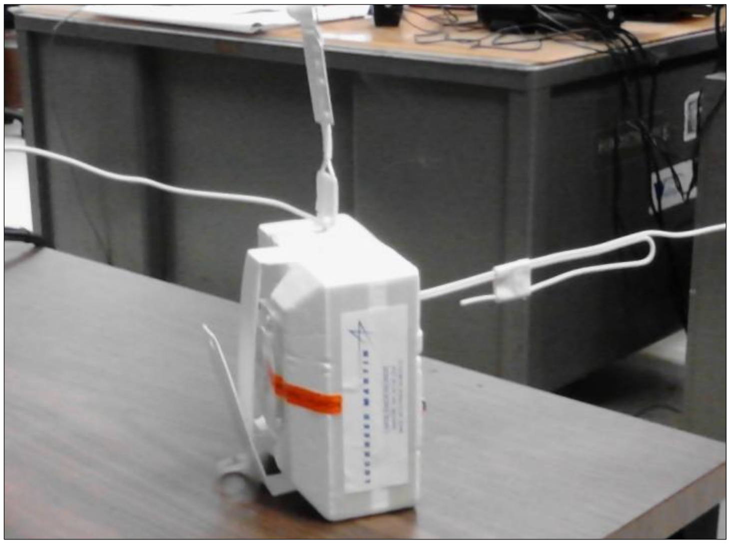


Figure 4–18. GPS Weathersonde Box

4.12.2.2 *Search and Recovery*

The No Action Alternative includes an average of four new launches per year, with a minimum of two launches and a maximum of eight launches. An average of 5,400 kilograms (12,000 pounds) of spent stages and payloads would be deposited in the launch corridor, annually. Of this quantity, 5,000 kilograms (11,000 pounds) would be recoverable. The fourth stage (Nikha) and payload of the BB XII are assumed to land in the Arctic Ocean or Beaufort Sea and would be unrecoverable.

As shown in Table 4–29, recovery of one payload per year from a T-IO class vehicle is anticipated under the No Action Alternative, resulting in the retrieval of a 360-kilogram (800-pound) payload. Payloads from BB XII class vehicles are assumed to land in the Beaufort Sea/Arctic Ocean and would be unrecoverable. As shown in Table 4–31**,** a quantity of approximately 4,600 kilograms (10,000 pounds) of material would be deposited in downrange lands under the No Action Alternative. Of this material, between approximately 2,200 kilograms (4,850 pounds) and 3,40 kilograms (7,500 pounds) would be expected to land within the ADNR Poker Flat North and South special use lands, thus resulting in a net deposition of between 1,200 kilograms (2,650 pounds) and 2,400 kilograms (5,300 pounds) elsewhere, a moderate to major long-term adverse impact.

4.12.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.12.3.1 *Launch Operations*

Under Alternative 1, the launch operations would be the same as described under the No Action Alternative.

4.12.3.2 *Recovery of Newly Launched Payloads and Stages*

Under Alternative 1, assuming an average of four launches per year, one to two payloads and one to two stages would be attempted to be recovered from Yukon Flats NWR, one to two stages from the Venetie/Wind River Area, one to two stages from the White Mountains NRA, for a total of approximately 1,400–2,800 kilograms (3,100–6,200 pounds). Table 4–26 shows the recovery scenario for the recovery of newly launched stages for each of the alternatives evaluated in this EIS.

4.12.3.3 *Recovery of Existing Payloads and Stages*

Approximately 20 different types of rockets have been launched by NASA in the past from PFRR, with impact weights ranging from 5-kilogram (11-pound) payloads to 800-kilogram (1,800-pound) first-stage motors (see **Table 4–25**). Launch operations have resulted in the deposition of approximately 163,000 kilograms (360,000 pounds) of material from the various stages and payloads that have been launched (estimated based on launch information in **(UAF 2011a)**. Fifty payloads have been recovered, resulting in the removal of approximately 12,000 kilograms (26,000 pounds) of debris from the launch corridor. In addition, an estimated 25,000 kilograms (55,000 pounds) of spent stages have been recovered from the launch corridor and returned to the PFRR launch site for disposal. Therefore, approximately 126,000 kilograms (278,000 pounds) of spent stages and payloads are estimated to remain in the launch corridor. As discussed in Chapter 3, Section 3.12, the majority of this material (estimated to be up to 82,000 kilograms [181,000 pounds]) is located in ADNR Poker Flat North and South Special Use Areas that have been set aside by the state for rocket launches.

To calculate the weight of hardware that would be recovered from previously launched items, the vehicles were broken down by the location each would likely impact. The average stage and payload weight per recovery area was calculated based on the impact weight and number of launches of that vehicle type in each recovery area (see **Table 4–26**).

Table 4–25. Historical Launch Vehicles and Impact Weights

Launch Vehicle	First-Stage Impact Weight (kilograms)	Second-Stage Impact Weight (kilograms)	Third-Stage Impact Weight (kilograms)	Fourth-Stage Impact Weight (kilograms)	Payload Impact Weight (kilograms)	Impact Weight per Launch (kilograms)	Number of Vehicles Launched	Total Weight Launched (kilograms)
Black Brant V	270	–	–	–	270	540	9	4,900
Black Brant IX	300	270	–	–	440	1,000	14	14,000
Black Brant X	300	270	94	–	300	960	15	14,500
Black Brant XI	800	610	270	–	360	2,000	2	4,100
Black Brant XII[a]	800	610	270	93	300	2,100	19	39,900
Nike-Apache[b, c]	280	140	–	–	100	520	3	1,500
Nike-Black Brant	280	270	–	–	240	780	7	5,460
Nike-Orion	280	140	–	–	360	770	12	9,300
Nike-Tomahawk	280	68	–	–	65	410	63	26,020
Orion (improved)[d]	140		–	–	68	210	14	2,940
Super Arcas	13		–	–	5	18	10	180
Strypi[e]	540	200	–	–	–	740	1	740
Taurus-Nike-Tomahawk	600	290	68	–	95	1,100	1	1,100
Taurus-Orion	610	140	–	–	140	890	16	14,240
Taurus-Tomahawk	610	68	–	–	38	710	10	7,100
Terrier-Malemute	300	130	–	–	200	630	10	6,300
Terrier-Improved Orion	300	140	–	–	360	810	13	10,500
Total							**219**	**163,000**

a. **Source: Parsch 2005**.
b. **Source: NASA 1972.**
c. Data for the Orion stage were used as a proxy for the Apache stage.
d. **Source: NASA 2005.**
e. **Source: Encyclopedia Astronautica 2011.**

Note: Stage and payload weights and impact distances were obtained from the *Final Supplemental Environmental Impact Statement for Sounding Rocket Program* **(NASA 2000a)** unless otherwise noted. To convert kilograms to pounds, multiply by 2.2046.

Table 4–26. Average Existing Stage and Payload Weight per Recovery Area

Location	Average Stage Weight (kilograms)	Average Payload Weight (kilograms)
ADNR Poker Flat North and South Special Use Areas	400	N/A
White Mountains NRA	290	60
Yukon Flats NWR	140	130
Venetie/Wind River Area	150	85

Note: Numbers rounded to two significant figures. To convert kilograms to pounds, multiply by 2.2046.
Key: ADNR=Alaska Department of Natural Resources; N/A=not applicable; NRA=National Recreation Area; NWR=National Wildlife Refuge.
Source: for impact weight: NASA 2000, 2011a.

Under Alternative 1, it is estimated that one existing stage each would be reported and recovered from the Venetie/Wind River Area, White Mountains NRA, and Yukon Flats NWR, and two existing stages would be recovered from the ADNR Poker Flat North and South Special Use Areas (see Table 4–30). No existing payloads would be expected to be recovered under Alternative 1.

As shown in Table 4–31, approximately 900 to 2,300 kilograms (2,000 to 5,100 pounds) of material would be deposited in downrange lands annually under this alternative. Excluding the materials within the designated ADNR Poker Flat North and South lands, other downrange lands could realize a net reduction of 500 kilograms (1,100 pounds) up to a 900 kilogram (1,980 pounds) increase in materials, which would correspond to either a minor beneficial to minor adverse long-term impact of regional scope.

4.12.3.4 *Waste Treatment and Disposal Practices*

Payloads would not be cleaned before being returned to the principal investigator because they do not contain fuel or motors. The stages would be cleaned once they have been retrieved from the range per the SRP's established procedure, which includes the inspection, removal, and steam cleaning of residue/materials remaining within the rocket motors **(Cornwell 2005)**. Hazardous materials that could be encountered during cleaning include minor quantities of spent fuel residue, asbestos-containing insulation, paint, and batteries. Stages launched in the past likely contain asbestos insulation; workers would take appropriate protective steps to ensure that asbestos residue is contained, stored, and disposed of per the University of Alaska Fairbanks Safety System Policy and Procedure **(UAF 2003a)**. However, it should be noted that wetting an asbestos-containing material is a generally accepted practice for reducing the potential for fibers to be inhaled.

Pressure washing of the spent stages would generate approximately one 208-liter (55-gallon) drum per activity. This waste would be considered hazardous and would be disposed of through the Environmental Health and Safety Risk Management Department at PFRR **(UAF 2011a)**. Under Alternative 1, 2,100 liters (550 gallons) of hazardous rinsate would be generated (see **Table 4-27**). The cleaned stages and other nonhazardous waste would be disposed of or recycled at the Fairbanks North Star Borough's landfill. PFRR is not expected to exceed its Conditionally Exempt Small Quantity Generator status, resulting in a negligible adverse impact.

Table 4–27. Rinsate Volume Generated During Stage Cleaning Activities

	No Action Alternative		Alternatives 1 and 3		Alternatives 2 and 4	
	Number Recovered	**Volume of Hazardous Rinsate (liters)**	**Number Recovered**	**Volume of Hazardous Rinsate (liters)**	**Number Recovered**	**Volume of Hazardous Rinsate (liters)**
Newly Spent Stages	0	0	5	1,000	8	1,700
Existing Stages	0	0	5	1,000	8	1,700
Total Volume of Hazardous Rinsate	**0**	**0**	**10**	**2,100**	**16**	**3,300**

Note: To convert liters to gallons, multiply by 0.264.

4.12.4 Alternative 2 – Maximum Cleanup Search and Recovery

Under Alternative 2, the attempted recovery of one to two newly launched payloads would be the same as under Alternative 1. In addition, two newly launched stages would be attempted to be recovered from the Venetie/Wind River Area, along with one to two stages from Yukon Flats NWR, one to two stages from White Mountains NRA, and one to two stages from ADNR Poker Flat North and South Special Use Areas (see Table 4–29). Two payloads from previously launched vehicles would also be recovered annually from the Venetie/Wind River area (see Table 4–30). In addition, two existing stages each would be recovered annually from the Venetie/Wind River Area, White Mountains NRA, Yukon Flats NWR, and the ADNR Poker Flat North and South Special Use Areas.

As shown in Table 4–31, up to a 900-kilogram (2,000-pound) overall reduction could occur, however up to 400 kilograms (880 pounds) of material could be deposited in downrange lands annually under this alternative. Excluding the items within the designated ADNR Poker Flat North and South Special Use Areas, other downrange lands could realize a net reduction of 1,200 kilograms (2,650 pounds) up to a 100-kilogram (220-pound) increase in materials, which would correspond to either a moderate beneficial to minor adverse long-term impact of regional scope.

4.12.4.1 *Waste Treatment and Disposal Practices*

Under Alternative 2 and assuming an average of four launches per year, 3,300 liters (880 gallons) of hazardous rinsate would be generated (see Table 4–27). PFRR is not expected to exceed its Conditionally Exempt Small Quantity Generator status under Alternative 2 even if up to eight launches occurred annually, resulting in a negligible adverse impact.

4.12.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Hazardous materials and hazardous waste impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.12.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential hazardous materials and hazardous waste impacts associated with this alternative compared to those described for Alternative 1. It could however, reduce the potential for such materials to land within the avoided areas.

4.12.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Hazardous materials and hazardous waste impacts under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.12.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential hazardous materials and hazardous waste impacts associated with this alternative compared to those described for Alternative 2. It could; however, reduce the potential for such materials to land within the avoided areas.

4.12.7 Summary of the Alternatives

This section includes several tables to provide the reader a comparison of the estimated disposition of flight hardware (rocket motors and payloads) on a per-year basis. **Table 4–28** provides an estimate of launch support hardware flown from PFRR during a typical launch season; **Table 4–29** presents a comparison of newly flown stages; **Table 4–30** presents a comparison of previously flown stages and payloads; and **Table 4–31** shows the total weight recovered (both new and old), assuming four launches per year.

Table 4–28. Estimate of Launch Support Items Flown from PFRR During a Typical Launch Season

Item	Weight Each (kg)	Items Per Launch[a]	Weight Per Year[b] (kg)		Downrange Distance (km)	Landowner
			4 Launches	8 Launches		
"Chaff" Latex Balloon	0.1	120	48	96	50–80	ADNR Land or BLM
Mid-Altitude Latex Balloon	0.3	10	12	24	80–100	ADNR Land, BLM, or USFWS Yukon Flats NWR
High-Altitude Latex Balloon	1.2	10	48	96	80–160	ADNR Land, BLM, or USFWS Yukon Flats NWR

Table 4–28. Estimate of Launch Support Items Flown from PFRR During a Typical Launch Season (*continued*)

Item	Weight Each (kg)	Items Per Launch[a]	Weight Per Year[b] (kg)		Downrange Distance (km)	Landowner
			4 Launches	8 Launches		
Polystyrene Radiosonde Package	0.25	20	20	40	80–160	ADNR Land, BLM, or USFWS Yukon Flats NWR
Test Rocket	6.8	15	408	816	4–5	ADNR Land

a. Each launch requires 10 days of countdown with a 6-hour launch window.

b. Estimates in this table do not include instances when several launches would occur on the same day, which would reduce the presented weights as launch support items would be "shared" among all those launches.

Note: To convert kilograms to pounds, multiply by 2.2046; kilometers to miles, by 0.6214.

Key: ADNR=Alaska Department of Natural Resources; BLM=Bureau of Land Management; kg=kilogram; km=kilometer; USFWS=U. S. Fish and Wildlife Service.

Table 4–29. Possible Recovery Scenarios for Newly Launched Payloads and Stages (four launches per year)

Vehicle	Payload/ Stage	Impact Location	No Action Alternative		Alternatives 1 and 3		Alternatives 2 and 4	
			Number Recovered	Weight Recovered (kg)	Number Recovered	Weight Recovered (kg)	Number Recovered	Weight Recovered (kg)
Black Brant XII	Payload	Beaufort Sea	0	0	0	0	0	0
	Talos	ADNR Land	0	0	0	0	1	800
	Taurus	White Mountains NRA	0	0	1–2	600–1,200	1–2	600–1,200
	Black Brant V	Venetie/ Wind River Area	0	0	1–2	270–540	1–2	270–540
	Nihka	Beaufort Sea	0	0	0	0	0	0
Terrier-Improved Orion	Payload	Yukon Flats NWR	1	360	1–2	360–720	1–2	360–720
	Terrier	ADNR Land	0	0	0	0	1	300
	Orion	Yukon Flats NWR	0	0	1–2	140–280	1–2	140–280
TOTAL			**1**	**360**	**4–8**	**1,400–2,800**	**6–10**	**2,500–3,800**
Excluding ADNR Special Use Lands			**1**	**360**	**4–8**	**1,400–2,800**	**4–8**	**1,400–2,700**

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: ADNR=Alaska Department of Natural Resources; kg=kilograms; NRA=National Recreation Area; NWR=National Wildlife Refuge.

Source: for impact weight: NASA 2000a, 2011a.

Table 4–30. Possible Existing Payload and Stage Weight Recovered per Alternative

Recovery Area	No Action Alternative		Alternatives 1 and 3		Alternatives 2 and 4	
	Number Recovered	Weight Recovered (km)	Number Recovered	Weight Recovered (km)	Number Recovered	Weight Recovered (km)
Payloads						
Yukon Flats NWR/Venetie	0	0	0	0	2	170
Stages						
Venetie/Wind River Area	0	0	1	150	2	290
White Mountains NRA	0	0	1	280	2	590
Yukon Flats NWR	0	0	1	140	2	280
ADNR Poker Flat North and South Special Use Areas	0	0	2	780	2	780
TOTAL	**0**	**0**	**5**	**1,300**	**10**	**2,100**
Excluding ADNR Special Use Lands	**0**	**0**	**3**	**500**	**8**	**1,300**

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: ADNR=Alaska Department of Natural Resources; NRA=National Recreation Area; NWR=National Wildlife Refuge.

Source: for impact weight: NASA 2000a, 2011a.

Table 4–31. Possible Annual Recovery of Stages and Payloads per Alternative (four launches per year)

	No Action Alternative		Alternatives 1 and 3		Alternatives 2 and 4	
	Number Recovered	Weight Recovered (kilograms)	Number Recovered	Weight Recovered (kilograms)	Number Recovered	Weight Recovered (kilograms)
Newly Launched Payloads	1	360	1–2	360–720	1–2	360–720
Newly Spent Stages	0	0	3–6	1,000–2,000	4–8	2,100–3,100
Existing Payloads	0	0	0	0	2	170
Existing Stages	0	0	5	1,300	8	1,900
Total	**1**	**360**	**9–13**	**2,700–4,100**	**15–20**	**4,600–5,900**
Excluding ADNR Special Use Lands	**1**	**360**	**7-11**	**1,900–3,300**	**12–16**	**2,700–4,000**
Annual Recoverable Weight Launched	**5,000**		**5,000**		**5,000**	
Recoverable Weight Excluding ADNR Special Use Lands	**2,800**		**2,800**		**2,800**	
Net Weight Deposited Annually in Launch Corridor	**4,600**		**900–2,300**		**(900) –400**	
Net Weight Excluding ADNR Special Use Lands	**2,400**		**(500) –900**		**(1,200) –100**	

Note: To convert kilograms to pounds, multiply by 2.2046.
Source: for impact weight NASA 2000a, 2011a.

4.12.8 Summer Launches

No change in hazardous material and waste use or generation or its impact on the environment is anticipated in the event of a summer launch.

4.13 HEALTH AND SAFETY

4.13.1 Methodology

Human health impacts were addressed by evaluating the potential impacts on workers and the public of each alternative's launch operations and recovery activities.

4.13.1.1 Launch Operations – Worker Health and Safety

The health and safety of workers before, during, and after launches at PFRR was addressed by reviewing past activities and practices, including health and safety records, at PFRR, as well as at other NASA SRP launch locations. Past launch-related activities were found to be well controlled, especially recently, by NASA safety requirements, practices, procedures, and standards **(NPR 8715.3C)**. These practices would be continued or improved for future launch operations due to the implementation of a new *University of Alaska Health and Safety Plan* for PFRR **(UAF 2011b)**.

4.13.1.2 *Launch Operations – Public Health and Safety*

The health and safety of the public before, during, and after launches at PFRR was addressed by first reviewing past activities and practices at PFRR, as well as at other NASA SRP launch locations. All public risks due to launch-related activities were found to be well controlled by NASA Range Safety requirements, practices, procedures, and standards **(NASA 2008; NPR 8715.5A)**. These practices would be continued for future launch operations.

NASA Range Safety requires that the risks to the public be evaluated during the planning stages and updated prior to a launch and demonstrated to meet NASA Range Safety criteria. UAF and PFRR imposed additional range safety criteria. Below are the risk criteria that are applied to sounding rocket launches at PFRR:

- PFRR/UAF: The mission casualty expectancy criterion is 11.4×10^{-6} (1 in 87,700). (This includes the assessment of Alaskan and Canadian areas).
- NASA: Probability of casualty for individuals, applied separately for each hazard, shall be less than 1×10^{-6} (1 in 1,000,000).
- PFRR: Town impact probability criterion is 5×10^{-4} (1 in 2,000).
- PFRR: The probability of impacting outside the range criterion is 1×10^{-2} (1 in 100).
- PFRR: The pipeline impact probability criterion is 1×10^{-5} (1 in 10,000).
- PFRR: Predicted impact must be outside the 1-sigma uncertainty area from a populated U.S. town and outside the 3-sigma uncertainty area from a populated Canadian town or area (see Appendix G).
- PFRR: The Aircraft Hazard Areas must be contained within areas for which clearance has been obtained from the Federal Aviation Administration.

To estimate the risks to the public from future launches for the proposed alternatives, future launches were assumed to be a 50-50 split of the four-stage BB XII, one of the largest launch vehicles available, and the two-stage T-IO. Both of these launch vehicles are relatively new and are expected to be representative of future launches and to collectively represent the risk of future launches. The payloads are also typical in terms of mass so the flight trajectories and impact points of the stages and payloads are also expected to be representative of future launches. Therefore, the Flight Safety Plans for recent BB XII missions, the Lynch Mission **(Skees 2009)** and the Conde Mission **(Skees 2010)**, are expected to be typical of future missions and to well characterize the risks of future missions. The information from these flight safety risk assessments from these recent BB XII and T-IO missions was used to project annual future risks with two, four, and eight launches per year, with a 50-50 split of the two launch vehicles.

Other potential health and safety impacts on the public, such as the potential for fires ignited by spent stages and the hazards associated with encounters with stages in the field, were also addressed.

4.13.1.3 *Search and Recovery – Worker Health and Safety*

The potential health and safety impacts on workers performing the search and recovery operations were based on past experience with recovery operations, which consisted primarily of payloads designed to be recovered and preliminary plans for future spent stage and payload recovery operations. Projected annual worker impacts were estimated for each stage of the search and recovery process, including flight time during the initial search for the payload and flight and helicopter times during the recovery process. Projected impacts were estimated based on the assumed times and workers required for each recovery task, together with established injury and fatality rates for similar types of activities. Specific risks of injury or death associated with time on the ground associated with digging up, disassembling, rigging, and other recovery activities were also estimated. Associated time at PFRR disassembling each payload or spent stage was also included.

4.13.1.4 *Search and Recovery – Public Health and Safety*

Based on past experience with search and recovery operations, which consisted primarily of recovering payloads that were designed to be recovered, and preliminary plans for future spent stage and payload recovery operations, the health and safety risks to the public were found to be negligible. Search and recovery activities would all be conducted with personnel associated with or hired by PFRR for the specific recovery operation. The potential health and safety of any contact or encounters with spent stages or payloads by members of the public is addressed in Section 4.13.2.2. **Table 4–32** describes the intensity of impacts used in the health and safety analysis.

Table 4–32. Description of Intensity and Duration of Potential Health and Safety Impacts

Intensity of Impact	
No effect	Public risks < 0.1 NASA range safety criteria
Negligible	Public risks at or below NASA range safety criteria
Minor	Public property damage to structures, small fires ignited by failed stage, risks to public increased Public safety risks 10 × NASA range safety criteria
Moderate	Injuries and property damage expected Public risks 100 × NASA range safety criteria Workers likely to receive days-off injuries
Major	Worker or public fatalities likely
Duration of Impact	
Short-term	Health impacts or risks occur only during the launch
Medium-term	Health impacts continue for weeks
Long-term	Health impacts continue for years

4.13.2 No Action Alternative

4.13.2.1 *Rocket Launch Worker Health and Safety*

PFRR operates under the health and safety policies and procedures of the University of Alaska **(UAF 2011a, 2011b)**. OSHA's industrial and occupational safety rules and regulations and the State of Alaska's occupational safety and health standards apply as well **(UAF 2011b)**. PFRR complies with these regulations in the areas of industrial and occupational safety and health.

PFRR's operation of the sounding rocket launch range is unique within the university system. Many aspects of its operations are not specifically addressed within university, OSHA, or State of Alaska safety rules. Therefore, a PFRR internal safety policy and *Health and Safety Plan* **(UAF 2011b)** augments those sources to address specific challenges associated with working with equipment and procedures specific to rocket launches.

The worker safety risks inherent in rocket operations in extremely cold weather are expected to continue and not change substantially with any of the anticipated operations. For launch-related operations, the worker safety and accident rates are driven primarily by the number of hours worked, which should be primarily proportional to the number of launches. Thus, the launch-related accident risk would approximately double, with eight launches per year instead of four, and halve, with two launches per year instead of four.

The principal unusual worker hazard at PFRR is working with solid propellant rocket motors and associated hardware. These motors present an explosion and fire hazard in addition to more routine hazards associated with handling large, heavy objects and supporting equipment. NASA requires each SRP mission to prepare a Ground Safety Plan to minimize risk to human life, property, and natural resources. The Ground Safety Plan identifies the hazardous systems that exist on the vehicle and payload and the NASA safety category for each hazardous system. Depending on the safety category during various launch operations, restrictions may be imposed on NASA personnel, NASA contractors, and experimenters.

Typical restrictions include establishment of prelaunch and launch danger areas. For a recent BB XII launch, the prelaunch danger area for the assembled vehicle and payload was within a 152.5-meter (500-foot) radius centered on the vehicle, and the launch danger area was within a 432-meter (1,420-foot) radius centered on the launcher **(Ellis 2009)**. Within the PFRR launch site (which is only accessible by authorized personnel), roadblocks are established to enforce these mandatory safety zones.

In spite of the excellent safety record for workers at PFRR and for NASA's SRP in general, the inherent hazards associated with working with high-energy rockets remain, and the possibility of a serious accident involving a rocket motor exists. Continued adherence to the NASA safety rules should ensure that the risk to the PFRR workers and visitors would remain very low with future missions.

4.13.2.2 *Rocket Launch Public Risks*

As discussed in Chapter 3, Section 3.13.2, the public is protected from the impacts of sounding rockets and their components through the safety policies and practices of the NASA SRP. All

NASA SRP missions are required to prepare both Ground and Flight Safety Plans to minimize risk to human life, property, and natural resources. A Flight Safety Risk Assessment is also prepared for each mission. Both impact and overflight criteria are considered in the Flight Safety Plans and, while risk cannot be entirely eliminated, it is reduced to an acceptable margin.

During the planning process for each mission, the various safety analyses are performed to ensure that the mission can be conducted in accordance with the NASA and PFRR safety requirements identified in Chapter 2, Section 2.1.6. The flight safety risks are calculated by comparing the population within potential impact areas for the stages and payloads for both normal launches and launches where something fails, such as failure of a motor to ignite, and results in the motor impacting an area outside of the planned impact area. Calculations that are performed include evaluation of the probability that anyone within the general population would be harmed (*i.e.*, a "casualty"), the probability that a rocket impact might occur within a town, and the probability that a rocket might impact the Trans-Alaska Pipeline. In addition, the probability that any individual might be directly impacted is also evaluated. Aircraft hazard areas and clear zones are developed and coordinated with the FAA.

The criteria that are imposed are a combination of NASA criteria from NASA's *Range Safety Manual* **(NASA 2008)**, which is common across the U.S. Government rocket launch ranges, and additional criteria or guidelines adopted by UAF and PFRR. In most cases, these criteria are acceptance criteria, and nominally less restrictive risk estimates may be approved on a case-by-case basis with recognition of the conservatism built into the risk calculations.

For each Flight Safety Plan, the potential impact locations for each stage under normal and off-normal conditions are calculated. There is a high level of uncertainty associated with these estimates because of the large number of variables associated with each launch, including wind, temperature, and variations in the performance of the solid rocket fuel. These variations become even more pronounced the higher the payload or spent stage is launched from the launch site. The biggest variants are thrust misalignment, which is a measure of how straight the rocket really is, and uncompensated winds. This is the change in wind from the time it was last measured prior to launch until the instant the rocket is launched (*e.g.*, a wind gust).

There are often some tradeoffs in flight trajectory in terms of azimuth and elevation of the initial trajectory to balance the competing range safety criteria. Often, the goals of minimizing the potential risks to people have to be balanced against other criteria, such as keeping the flight path with impact dispersion areas within the range corridors.

As a result, the predicted impact points have bands of uncertainty associated with them that can vary north and south (downrange) and east and west (cross-range) by relatively small amounts on a percentage basis (for example, 5 to 10 percent), but that end up being relatively large distances for spent stages or payloads that are predicted to land further from the launch site. For example, a typical BB XII launch has a third stage that would be predicted to land approximately 350 kilometers (220 miles) from the launch site with a 1-sigma[6] downrange dispersion of approximately 38 kilometers (24 miles) and a 1-sigma cross-range dispersion of

[6] Sigma or standard deviation is a measure of how much variation or "dispersion" there is from the average (the mean, or, in this case, predicted impact point).

27 square kilometers (10 square miles).[7] Using these dispersion estimates, it is possible to estimate a predicted impact area within the ellipse formed by these dispersion factors. The 1-sigma impact area for this example would be an ellipse with an area of approximately 3,200 square kilometers (1,235 square miles) **(Bowker 2011)**. Using a bivariate circular probability distribution, approximately 39 percent of its launches are expected to land within 1 sigma of the predicted impact point, 86 percent within 2 sigma, and 99 percent within 3 sigma (see Appendix G).

Typical Flight Risks

To estimate the risks to the public from future launches for the proposed alternatives, future launches were assumed to be a 50-50 split of the four-stage BB XII, one of the largest launch vehicles available, and the two-stage T-IO. Both of these launch vehicles are relatively new and are expected to be representative of future launches and to collectively represent the risk of future launches. The payloads are also typical in terms of mass so the flight trajectories and impact points of the stages and payloads are also expected to be representative of future launches. Therefore, the Flight Safety Plans for recent BB XII missions, the Lynch Mission **(Skees 2009)** and the Conde Mission **(Skees 2010)**, are expected to be typical of future missions and to well characterize the risks of future missions.

To confirm that these results would be representative of future launches, the risk analysis for the recent two-stage BB IX Mission, the Bailey Mission **(Skees 2011)**, was also reviewed. This vehicle and mission were selected because a number of these have been flown over the last decade and, while the risks are similar to or smaller than the T-IO, the mission selected did have a higher probability of impacting a town.

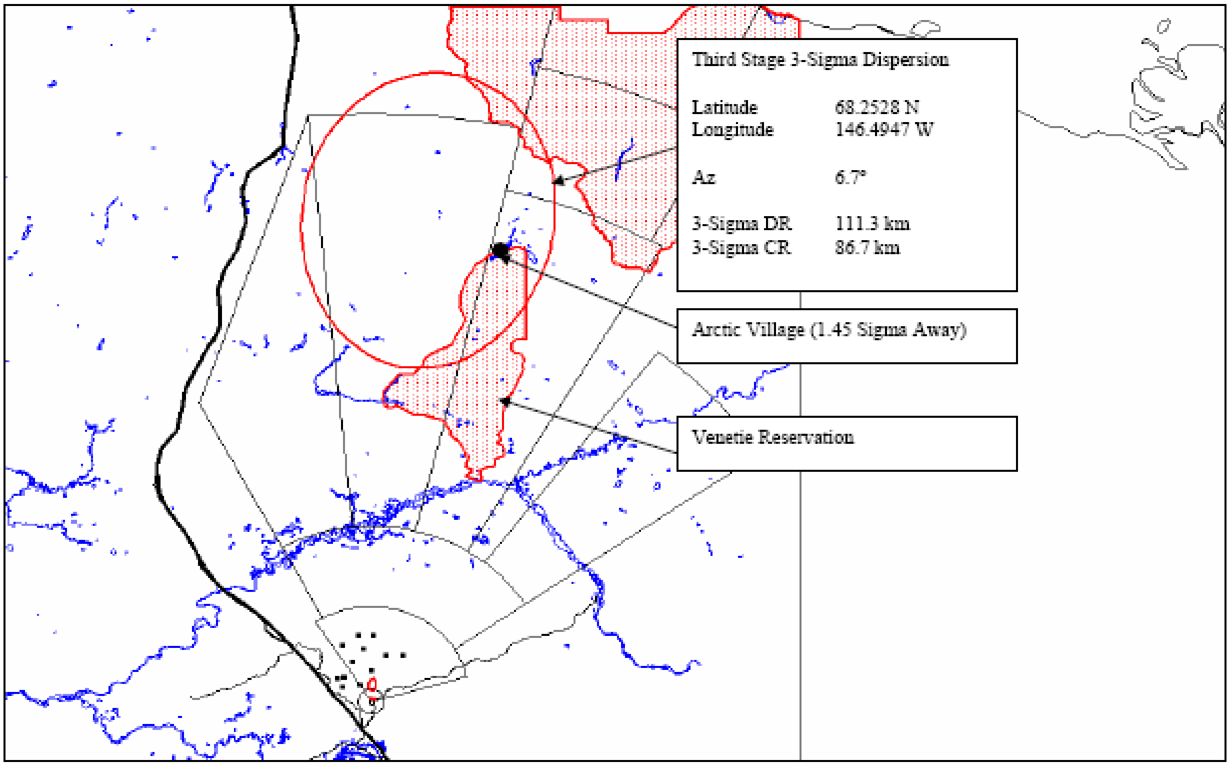
With either launch vehicle, called the "Nominal Case," the "Casualty Expectation," or probability of a casualty among the general public, would be 3.5×10^{-7}, or less or 1 in 3 million. This means that the likelihood of a casualty among the population within the range is negligible. This estimate is far below the NASA acceptance criteria of 30 in a million and the PFRR acceptance criteria of 11.4 in a million.

Even though the probability of a casualty is extremely low, with some missions, villages such as Arctic Village or Beaver have fallen within the impact uncertainty areas and had a nominal probability of 1 in 2,200 (BB XII) and 1 in 630 (T-IO) of a stage landing within the area of the village **(Skees 2009, 2010)**. To ensure that village population data and boundaries of seasonal use areas are considered in mission planning, on an annual basis, PFRR contacts local residents to verify existing information or suggest appropriate changes.

With the BB XII mission, the first stage Talos motor would land about 2 kilometers (1.25 miles) +/- 0.2 kilometers (0.12 miles) downrange within the state land designated for use by PFRR. The second stage Taurus motor would land about 13 kilometers (8 miles) +/- 2 kilometers (1.25 miles) downrange. The third stage Black Brant motor would land about 350 kilometers (220 miles) downrange with 1-sigma uncertainties of 37 kilometers (23 miles) downrange and

[7] Since the launches from PFRR are generally from south to north, downrange dispersion refers to differences in the actual impact point along the south-to-north axis and cross-range dispersion refers to possible differences in the actual impact point along the west-to-east axis (see Appendix G).

29 kilometers (18 miles) cross range, in the Brooks Range area. The fourth stage Nihka motor would land in the Beaufort Sea **(Skees 2009)**. **Figure 4–19** illustrates the BB XII dispersion ellipse for the third-stage motor. For that mission, Arctic Village was approximately 1.45 sigma away from the nominal center of the ellipse. The probability of landing within Arctic Village for that mission was about 1 in 3,000 **(Skees 2009)**.



Source: Skees 2009.

Figure 4–19. Typical Black Brant XII Third-Stage Three-Sigma Dispersion Ellipse

With a T-IO mission, the first-stage Terrier motor would land about 5 kilometers (3 miles) +/- 0.5 kilometers (0.31 miles) within the state land designated for use by PFRR, and the second-stage Orion motor would land about 120 kilometers (75 miles) +/- 15 kilometers (9 miles) (1 sigma) downrange, in the Yukon Flats NWR near Beaver **(Skees 2010)**.

With a BB IX mission, the first-stage Terrier motor would land about 2 kilometers (1.25 miles) +/- 0.2 kilometers (0.12 miles) within the state land designated for use by PFRR, and the second-stage BB Mk1 motor would land about 260 kilometers (160 miles) +/- 24 kilometers (15 miles) (1 sigma) further downrange, with a 30 percent chance of landing in the Venetie lands and a 1 in 4,400 nominal probability of town impact **(Skees 2011)**.

For any launch, the probability of impacting the pipeline would be very small for long-range rockets like the BB XII and is not possible for smaller rockets like the T-IO.

Noise

OSHA limits for employees are 115 dBA for 15 minutes, 97 dBA for 3 hours, and no limit for 75 dBA. The launch noise persists for less than a minute. For the loudest of launch vehicles, the public at the nearest noise-sensitive receptor—Chatanika Lodge, 1.6 kilometers (1 mile) from PFRR—would be exposed, for a few seconds, to a noise level lower than the acceptable 15-minute OSHA exposure level. The public at 11 kilometers (7 miles) would be exposed to a noise level lower than a diesel truck at 15 meters (50 feet), which generates a noise level of about 85 dBA.

Off-Normal Flights and Accidents

On any rocket flight, there is a potential for a failure that results in one or more stages landing outside of the predicted nominal impact areas. While operations at PFRR have been quite safe, there have been launches with malfunctions in which the rockets did not perform as expected. Of 219 NASA SRP launches at PFRR since 1971, 14, or 6.4 percent, of the total launched had some sort of vehicle failure that resulted in failure of the mission and the experiment **(UAF 2011a)**. However, in recent years, the success rate at PFRR has been better, with only 2 vehicle failures since 1997, a success rate of over 96 percent **(UAF 2011a)**.

For both launch vehicles, the failures of most concern are failure of a motor to ignite, which would result in an intact motor impacting the ground at a high velocity, and in-flight failures of an upper-stage motor. If a motor fails to ignite, it is expected to explode on impact with a TNT-equivalent energy of about 100 percent of the propellant mass. In the case of a Black Brant motor, the motor would impact at 344 meters (1,128 feet) per second, with 1,000 kilograms (2,200 pounds) of propellant. The hazard radius would be 72 meters (240 feet), resulting in a lethal area of 16,000 square meters (180,000 square feet) **(Skees 2009)**.

The impact of smaller, un-ignited motors would have smaller lethal areas, but these motors are still expected to explode on impact and potentially spread burning propellant into the immediate vicinity of the impact point. There would also be the potential for an incompletely burned motor to impact the ground, continue burning, and start secondary fires. For typical winter season launches, the cold temperatures and snow cover would limit the potential for secondary fires.

It is notable that for the BB XII and T-IO missions discussed in this EIS, the public accident risks were predominantly driven by the consideration of a motor failing to ignite, which could result in an unfired motor impacting near the BLM Crowberry cabin north of the launch site. If the cabin were unoccupied, the public risk would drop substantially. However, to maximize public safety, it is standing NASA policy to assume that there are two persons in the cabin at all times. PFRR also coordinates directly with BLM to ensure that it is aware of the most current status of the cabin during launch windows.

4.13.2.3 *Annual Impacts*

Table 4–33 also presents the projected annual future risks with two, four, and eight launches per year, assuming a 50-50 split of launches with the BB XII and T-IO launch vehicles. With a nominal launch rate of four per year (two BB IX and two T-IO), the mission casualty expectation is 1.1×10^{-5}. The overall probability of a motor landing within the town limits is about 1 in 260. The overall probability of a motor landing near the pipeline is 1 in 240,000. The probability of a motor landing outside PFRR is 1 in 28. With a launch rate of two per year, the casualty expectation and probabilities are reduced by half. With eight launches per year, the numbers would double.

Table 4–33. Projected Probabilities and Public Risks from Future Sounding Rockets Program Launches from Poker Flat Research Range

	PFRR Mission Risk Criteria[a]	Black Brant XII 40.023 Mission[b]	Terrier-Improved Orion Mission 41.084[c]	Terrier-Black Brant 36.256 Mission[d]	Projected Cumulative Annual Risk and Probabilities: With 2 launches per year	With 4 launches per year	With 8 launches per year
Total Risk: Nominal + Accident							
Risk of a casualty among members of the public[e]	1.1×10^{-5}	2.1×10^{-6}	3.5×10^{-6}	1.4×10^{-7}	5.5×10^{-6}	1.1×10^{-5}	2.2×10^{-5}
Probability of landing in a town	5×10^{-4}	4.6×10^{-4}	1.6×10^{-3}	6.6×10^{-4}	2.0×10^{-3}	4.0×10^{-3}	8.1×10^{-3}
Probability of landing in the vicinity of the pipeline	1×10^{-5}	2.1×10^{-6}	Negligible	Negligible	2.1×10^{-6}	4.2×10^{-6}	8.4×10^{-6}
Total Risk: Nominal + Accident							
Probability of landing outside PFRR	1×10^{-2}	1.8×10^{-2} [f]	Negligible	Negligible	1.8×10^{-2}	3.5×10^{-2}	7.0×10^{-2}
Risk to individual members of the public	1×10^{-6}		1.57×10^{-6}		1.6×10^{-6}	3.1×10^{-6}	6.3×10^{-6}

a. PFRR risk criteria except individual criterion is specified in NASA Procedural Requirement **(NPR) 8715.5A**. The PFRR collective public risk criterion of 11.4×10^{-6} is more restrictive than the NASA Range Safety Manual **(NASA 2008)** criterion of 30×10^{-6} and the NPR 8715.5A criterion of 100×10^{-6}. See Chapter 3, Section 3.13, for more details.
b. Skees 2009, Lynch 40.023 Risk Assessment Rev. A 6/27/2011.
c. Skees 2010, 41.084 Risk Assessment 1/7/2010.
d. Skees 2011, Black Brant IX 35.256 Risk Assessment.
e. Mission casualty expectation is expected number of fatalities given a launch. It is estimated by evaluating the danger or lethal area represented by a rocket motor or payload impacting the ground and the density of people in the general impact area. The estimate includes the probability that a rocket fails in the case of accidents. This number is very small because the danger area would typically have a danger radius of only a few tens of meters.
f. The principal off-range area at risk of impact with the third stage of the Black Brant XII is Arctic National Wildlife Refuge and a small portion of Mollie Beattie Wilderness Area.

Comparison of PFRR Risks to the Public with Other Common Risks

The principal criterion imposed by NASA Procedural Requirements Range Safety Program **(NPR 8715.5A)** and NASA's *Range Safety Manual* **(NASA 2008)** is that the probability of a casualty among the potentially affected population must be less than or equal to 30×10^{-6} **(NASA 2008)** or 1 in 33,000, and 100×10^{-6} (**NPR 8715.5A)** or 1 in 10,000, over the course of the mission. This includes both normal launches and accidents, such as stages that do not ignite and motors with misdirected thrust and impact in unintended locations. The second basic criterion imposed by NASA is that the risk of casualty to any member of the public must be less than one in a million. These two types of criteria—one for the general population and one for individuals—are common across all U.S. rocket ranges, including those operated by NASA and the U.S. Department of Defense and those regulated by the Federal Aviation Administration. The criteria have their roots in public law. In 1949, Congress enacted Public Law 81-60 for establishment of a guided missile proving ground. The legislative history indicated, "From a safety standpoint [test flights of missiles] will be no more dangerous than conventional airplanes flying overhead" **(RCC 2002)**. The Range Safety Group compared individual and collective fatality risks to people on the ground from commercial aircraft and general aviation near commercial airports and casualty risks to the general public from military aircraft near several Air Force Bases. The Range Safety Group established common range safety criteria that met the intent of Congress **(RCC 2002, 2010)**. These criteria were then applied to current rocket test ranges, including those operated by and for NASA, including PFRR **(NPR 8715.5A)**.

The risks from PFRR operations on the public within the range are very small compared to the other risks that they face. Residents and visitors within the PFRR launch corridor face a number of other risks of accidents that could result in serious injuries or death. The remote nature of the area and the severe winter weather both contribute to injury and accidental death rates higher than many areas. Snow machine injuries and death rates in northern Alaska are among the highest in the country, with a death rate of 11 and hospitalization rate of 97 per 100,000 people in the 1993–1994 period **(Landen 1999)**. The death rate was comparable to automobiles and the hospitalization rate was twice that of on-road vehicles.

The serious injury and death rate among youth, ages 0–19 for rural, interior Alaska is also high. In the period from 1994–1998, the annual injury rate per 100,000 was 993, with 7 percent of the risk due to suicide, 15 percent due to falls, 4 percent due to motor vehicles, 7 percent due to snow machines, 6 percent due to sports, and 41 percent due to other activities **(Alaska 2001)**.

Among the approximately 1,500 residents within the PFRR area, this means that the annual individual risk of serious injury from snow machines alone is about 1 in 8,900 and the risk of accidental death is about 1 in 1,000. Among the youth in the region, the serious injury risk is even higher, about 1 in 1,000.

Other Potential Public Hazards with Normal Missions and Accidents

***Fires* –** Spent stages are hot when they impact the ground and have the potential to start fires. However, launches primarily occur in the winter months and fires are not expected.

The propellant in motors that fail to ignite and return to Earth at high speed is likely to explosively detonate on ground impact, and again has the potential to start fires, but this is not expected as a result of the launches primarily occurring during the winter months.

Public Encounters with Payloads and Spent Stages – Members of the public have and are expected to continue to encounter spent payloads and spent stages in the field. The health and safety risks of these encounters should be very small unless an attempt is made to move, disassemble, or cut up the payloads or stages. Typical hazards associated with handling or disassembling payloads and spent stages include sharp or fractured metal associated with a damaged stage or payload; heavy objects; compressed springs; spent pyrotechnic devices;

charred materials, such as insulation, that might be an inhalation hazard in certain circumstances; and unique hazards that might be associated with a particular payload, such as pressurized containers. To avoid duplication, the potential hazards, and resulting risks, are presented in Section 4.12, Waste Management.

Sounding rocket motors, by their very nature, have explosive hazards, fire hazards, and stored energy hazards (such as compressed springs). If members of the public encountered an unspent stage before the NASA recovery team, they could face substantial risks if they attempted to handle, disassemble, or cut up the motor. A rocket motor that failed to fire or a payload containing explosive pyrotechnic devices or hazardous substances that did not function properly could be a substantial hazard. NASA would not leave any object on the ground that would pose a risk to anyone who might encounter it and would make all reasonable efforts to ensure that such motors are not a hazard to the public or the environment. It is for these reasons that NASA procedures call for quick actions following a mishap that might leave a failed rocket motor stage or payload in a hazardous condition. With this process in place, the likelihood of a member of the public encountering an unspent stage or a payload that could pose a substantial risk to a member of the public is low.

4.13.2.4 *Search and Recovery – Worker Health and Safety*

Initial search activities generally occur within a few days of the launch and would therefore most often occur during northern Alaska winter conditions. These extreme cold weather conditions present unique challenges and threats to the pilot and observers in the search plane during the initial, post-launch search activities. These personnel are required by NASA and UAF **(UAF 2011b)** to be adequately trained to perform their functions during these conditions. They would search for spent stages or payloads and mark their position, if found, as discussed in Appendix F.

Recovery teams would generally not be deployed until after the winter launch season and are expected to have a recovery plan for each recovery activity that would detail, among other things, the safety concerns and protocols associated with the specific recovery. Each payload or spent stage should have well-defined hazards, and the recovery team is expected to be fully aware of these hazards and to have appropriate equipment to deal with these hazards. Typical hazards include sharp or fractured metal associated with a damaged stage or payload; heavy objects; compressed springs; spent pyrotechnic devices; charred materials, such as insulation, that might be an inhalation hazard; and unique hazards that might be associated with a particular payload, such as pressurized containers. For some older rocket motor stages, the remaining insulation may contain asbestos materials embedded in resins that could present specific hazards **(Hesh 2011; Wilkie 1981)**. In all cases, the recovery plan is expected to identify all these hazards and present procedures for safe recovery by the team.

Once intact or damaged payloads or rocket motor stages or components are returned to PFRR, additional handling and disassembly and cleanup may be performed. As with the initial contact with these motors and stages in the field by the recovery team, worker hazards at the PFRR launch site would include sharp or fractured metal; heavy objects; charred materials that might be a inhalation hazard; and unique hazards that might be associated with a particular payload, such as pressurized containers. Some of the items recovered may be quite old, and detailed records of them may not be available. These operations would be conducted in accordance with

NASA and UAF environment, safety, and health procedures, including NASA WFF Occupational Safety & Health Manual requirements **(NASA 2006)**. Because these items can be unique and may not be well-characterized because of their age, it is expected that a job hazard analysis to identify the specific hazards and procedures to minimize risk to the workers and the environment would be performed prior to commencing work on a payload or stage. These types of analyses are required by the UAF PFRR Health and Safety Plan **(UAF 2011b)**.

4.13.2.5 *Search and Recovery – Failed Payloads and Stages*

Some payloads or stages may be recovered for safety reasons. An example might be a rocket motor that failed to fire or a payload containing explosive devices or hazardous substances that did not function properly. NASA would not want to leave any object on the ground that would pose a risk to anyone who might happen to come across it. Sounding rocket motors, by their very nature, have explosive hazards, fire hazards, and stored energy hazards (such as compressed springs). NASA would make all reasonable efforts to ensure that such motors are not a hazard to the public or the environment.

For rocket motor stages that do not ignite, it is likely that the impact forces would be sufficient that they ignite or detonate on impact with hard surfaces. For impacts on softer surfaces or water, it is possible that they may not detonate and would present a risk to the public. The recovery plan is expected to identify these possibilities and have detailed plans and procedures for their safe recovery as quickly as possible after a launch failure is confirmed.

A stage or payload that did not perform as expected could present other hazards. A failed rocket could result in the return to Earth of the payload containing the planned experiment. In some cases, the experimental materials may survive impact and present hazards to personnel encountering the payload or attempting to recover the payload. One type of common experiment at PFRR has a payload designed to release TMA (described in Chapter 2, Section 2.1.2.2, Chapter 3, Section 3.1.1, and Chapter 4, Section 4.2.2.2) in the upper atmosphere. This payload consists of two sections, one containing liquid TMA with a movable piston separating it from an area with high-pressure nitrogen. At altitude, an explosive valve is opened and the piston pushes the TMA into the atmosphere such that a long chemical trail is left behind.

On March 27, 2003, a T-IO rocket (41.028) was launched as part of a four-rocket experiment to study winds in the upper atmosphere, but the Orion motor failed. One of the four rocket motors did not thrust properly during its flight, causing it to fall short of its predicted altitude and land in a different part of the designated impact area than expected. It was found 9 kilometers (5.8 miles) north of the range in the ADNR Poker Flat North and South Special Use Areas. NASA wanted to study the rocket's remains to better understand the cause of the thrust failure. For safety purposes, NASA handled retrieval of the rocket as though it could be hazardous even though analysis indicated that the payload would not be dangerous. This safety precaution included having experts from the Air Force's Explosive Ordinance Disposal team puncture the payload's TMA canister before PFRR crews returned the second-stage motor and payload debris back to the range via helicopter for analysis. When the canister was punctured, there did not appear to be any TMA present **(GI 2003; Larsen 2001)**.

4.13.2.6 *Annual Worker Health and Safety Impacts*

Projected annual worker impacts were estimated for each stage of the search and recovery process, including flight time during the initial search for the payload and flight and helicopter times during the recovery process. Projected impacts were estimated based on the assumed times and workers required for each recovery task, together with established injury and fatality rates for similar types of activities. Specific risks of injury or death associated with time on the ground associated with digging up, disassembling, rigging, and other recovery activities were also estimated. Associated time at the PFRR launch site disassembling each payload or spent stage was also included. Table 4–33 summarizes the potential impacts of each of the proposed alternatives. Impacts were estimated for each of the options assuming four launches per year. With fewer or more launches, the impacts should scale proportionally. Similarly, the impacts would scale proportionally with more or fewer payloads or stages recovered. Under the No Action Alternative, it was assumed that only a single payload would be recovered annually and that the worker risks are small. Payloads are designed to be recovered with parachutes to reduce impact damage and facilitate recovery. An assumed 5-person recovery team is estimated to require 3 hours on the ground to recover the payload.

4.13.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.13.3.1 *Rocket Launch Health and Safety*

Under Alternative 1, public and worker health and safety impacts associated with the launch of NASA SRP sounding rockets from PFRR would be the same as described under the No Action Alternative.

4.13.3.2 *Search and Recovery – Health and Safety*

Under Alternative 1, it was assumed that an average of two payloads and 10 stages would be attempted to be recovered annually. Accordingly, with less flight hardware within downrange lands, potential risks to the public would be smaller.

Although this alternative would result in a large number of fixed-wing and helicopter flight hours in the launch corridor, the worker risks should still be small (see Table 4–33). The estimated time on the ground for a 5-person recovery team under Alternative 1 is assumed to average 5 hours per stage. Projected impacts under Alternative 1 are about a factor of 6.4 to 9 times higher than the No Action recovery option, but are still small, with no lost work day injuries or fatalities expected during a year's recovery operations. Physically handling payloads and stages in remote areas with limited equipment is likely the most dangerous portion of the recovery team's activities. Rigging the payloads and stages and subsequent helicopter lifting is also a dangerous activity, but one in which the risks can be minimized with training and procedures.

4.13.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.13.4.1 *Rocket Launch Health and Safety*

Under Alternative 2, launch-related public and worker health and safety impacts would be the same as described under the No Action Alternative.

4.13.4.2 *Search and Recovery –Health and Safety*

Under Alternative 2, it was assumed that an average of four payloads and 16 stages would be attempted to be recovered annually. Accordingly, with the least flight hardware within downrange lands, potential risks to the public would be the smallest of the alternatives. With proper recovery procedures and practices, the worker risks should still be small. Under Alternative 2, some of the stages are expected to be difficult to recover and require more time on the ground for the recovery team. The estimated time on the ground for a 5-person recovery team under Alternative 2 is assumed to average 10 hours for stages. Projected impacts of Alternative 2 are about a factor of 11 to 19 times higher than the No Action Alternative. Even so, the likelihood of a lost-work-day injury over a year among the recovery team is low, as shown in Table 4–33.

4.13.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Worker and public health and safety impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.13.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not greatly change the potential health and safety risks associated with this alternative compared to those described for Alternative 1.

4.13.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Worker and public health and safety impacts under Alternative 3 would be identical to those identified under Alternative 2 in Section 4.13.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not greatly change the potential health and safety risks associated with this alternative compared to those described for Alternative 2.

4.13.7 Summary of the Alternatives

This section includes several tables to provide the reader a concise comparison of the estimated safety risks resulting from launch and recovery of SRP rockets and payloads on a per-year basis.

Table 4–33 presents the risk estimates and probabilities from the flight safety risk assessments from recent BB XII and T-IO missions, along with projected annual future risks with two, four, and eight launches per year with a 50-50 split of the two launch vehicles. As the proposed number of future launches is the same for all alternatives, this table is applicable to them all.

Table 4–34 summarizes the potential impacts on worker safety resulting from each of the alternatives under consideration.

Table 4–34. Projected Annual Worker Safety Impacts of Recovery Operations

Annual Impact Area	No Action Alternative	Alternatives 1 and 3	Alternatives 2 and 4
Recoveries per year, assuming 4 launches per year	1 payload, 0 stages	2 payloads, 10 stages	4 payloads, 16 stages
Projected number of fatal and serious injury flight accidents[a]	3.5×10^{-4}	2.2×10^{-3}	3.7×10^{-3}
Total annual occupational injuries during ground recovery activities[b]	3.6×10^{-3}	3.1×10^{-2}	6.2×10^{-2}
Total annual occupational fatalities during ground recovery activities[c]	4.1×10^{-5}	3.7×10^{-4}	7.9×10^{-4}

a. Based on Federal Aviation Administration accident rates for general aviation in Alaska in 2010 **(FAA 2011)**.
b. Based on U.S. Bureau of Labor statistics estimates of injuries that require days away from work **(BLS 2011b)**.
c. Based on U.S. Bureau of Labor statistics estimates of fatal work injuries **(BLS 2011a)**.

Table 4–35 summarizes the projected health and safety impacts on the public and PFRR workers for each of the alternatives considered. Projected launch impacts are based on an annual average of four launches per year, which, for analysis purposes, was assumed to be an equal mix of BB XII and T-IO launch vehicles.

Table 4–35. Projected Annual Impacts on the Public and Workers

	PFRR Mission Risk Criteria[a]	Normal Launch			Restricted Flight Trajectories		
		No Action Recovery	Alternative 1	Alternative 2	No Action Recovery	Alternative 3	Alternative 4
Annual Public Risk from Four PFRR launches per year:							
Risk of a casualty among members of the public[b]	1.1×10^{-5}	5.5×10^{-6}	1.1×10^{-5}	2.2×10^{-5}	Similar to Normal Launch–No Action	Similar to Normal Launch–Alternative 1	Similar to Normal Launch–Alternative 2
Probability of landing in a town	5×10^{-4}	2.0×10^{-3}	4.0×10^{-3}	8.1×10^{-3}	Similar to Normal Launch–No Action	Similar to Normal Launch–Alternative 1	Similar to Normal Launch–Alternative 2
Probability of landing in the vicinity of the pipeline	1×10^{-5}	2.1×10^{-6}	4.2×10^{-6}	8.4×10^{-6}	Similar to Normal Launch–No Action	Similar to Normal Launch–Alternative 1	Similar to Normal Launch–Alternative 2
Probability of landing outside PFRR[c]	1×10^{-2}	1.8×10^{-2}	3.5×10^{-2}	7.0×10^{-2}	Similar to Normal Launch–No Action	Similar to Normal Launch–Alternative 1	Similar to Normal Launch–Alternative 2
Risk to individual members of the public							
	1×10^{-6}	1.6×10^{-6}	3.1×10^{-6}	6.3×10^{-6}	Similar to Normal Launch–No Action	Similar to Normal Launch–Alternative 1	Similar to Normal Launch–Alternative 2

Table 4–35. Projected Annual Impacts on the Public and Workers (*continued*)

	PFRR Mission Risk Criteria[a]	Normal Launch			Restricted Flight Trajectories		
		No Action Recovery	Alternative 1	Alternative 2	No Action Recovery	Alternative 3	Alternative 4
Annual risk to PFRR workers and recovery personnel with annual recoveries of:							
Projected number of fatal and serious injury flight accidents	N/A	3.5×10^{-4}	2.2×10^{-3}	3.7×10^{-3}	3.5×10^{-4}	2.2×10^{-3}	3.7×10^{-3}
Total annual occupational injuries	N/A	3.6×10^{-3}	3.1×10^{-2}	6.2×10^{-2}	3.6×10^{-3}	3.1×10^{-2}	6.2×10^{-2}
Total annual occupational fatalities[d]	N/A	4.1×10^{-5}	3.7×10^{-4}	7.9×10^{-4}	4.1×10^{-5}	3.7×10^{-4}	7.9×10^{-4}

a. PFRR risk criteria except individual criterion is specified in NASA Procedural Requirement **(NPR) 8715.5A**. The PFRR collective public risk criterion of 11.4×10^{-6} is more restrictive than the NASA *Range Safety Manual* **(NASA 2008)** criterion of 30×10^{-6} and the **NPR 8715.5A** criterion of 100×10^{-6}. See Chapter 3, Section 3.13, for more details.

b. Mission casualty expectation is expected number of fatalities given a launch. It is estimated by evaluating the danger or lethal area represented by a rocket motor or payload impacting the ground and the density of people in the general impact area. The estimate includes the probability that a rocket fails in the case of accidents. This number is very small because the danger area would typically have a danger radius of only a few tens of meters.

c. The principal off-range area at risk of impact with the third stage of the Black Brant XII includes a portion of Arctic National Wildlife Refuge and a small portion of Mollie Beattie Wilderness Area.

d. The major contributor to public risk from accidents is a failed motor impacting near the U.S. Bureau of Land Management Crowberry cabin, which is assumed to be occupied **(Skees 2009, 2010)**.

4.13.8 Summer Launches

The potential population risks would be higher for summer launches due to higher population densities and greater potential for unintended impacts due to accidents, including fires started by incompletely burned stages. The NASA SRP would likely have to establish mandatory clear zones or accept a higher risk with a summer launch. Areas that are not normally populated during winter launches might see substantially higher risks if they are in the predicted impact areas.

Burning solid propellant and hot rocket motors could produce fires in areas of impact. This would be especially true where impacts occurred in dry areas during the summer months. As part of the PFRR safety efforts, an emergency response plan would be developed for launches in non-winter periods, which will address the requirements for responding to fires caused by PFRR operations. Since the probability of impact at any given location is remote, it would be unfeasible to pre-position fire-fighting equipment. As such, agencies landowners of the potentially impacted areas would be notified of upcoming PFRR flights and appropriate plans would be developed.

PFRR would assume primary responsibility for investigation of the impact site and recovery of flight hardware. The Alaska Fire Service would likely provide the primary firefighting force depending on the land ownership. The hazards to these firefighting crews would only be those normally associated with wilderness fire fighting since burning solid fuels and other potentially dangerous materials would be consumed before a response force could arrive on the scene.

Since PFRR and coordinating agencies would act to fight any fires resulting from rocket mishaps it is assumed that and would undertake debris recovery operations, safety impacts of secondary effects of debris impact are considered to be small.

The potential worker risks would be unchanged or slightly less for summer launches because workers would not be subject to the below freezing temperatures present at PFRR during the winter months. The potential public risks would be greater for summer launches because more people would likely be recreating in areas of the PFRR where payloads and spent stages could impact. Before scheduling a summer launch, additional safety analyses would need to be performed to ensure that such launches could be conducted safely in accordance with NASA and UAF guidelines.

4.14 SOCIOECONOMICS AND ENVIRONMENTAL JUSTICE

4.14.1 Socioeconomics

This section presents the potential socioeconomic impacts from PFRR operations and search and recovery activities under the proposed alternatives. Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics of a region. The ROI for the socioeconomic environment includes the geographic area that supplies the majority of inputs for an activity. As discussed in Chapter 3, the majority of PFRR employees reside in Fairbanks North Star Borough. Therefore, the Fairbanks North Star Borough is the ROI for this socioeconomic analysis. Economic impacts are estimated using the Regional Input-Output Modeling System (RIMS II) developed by the Bureau of Economic Analysis (BEA) **(BEA 2011)**. BEA RIMS II multipliers use a combination of national and regional data to estimate the potential economic impacts of an industry's activity on other industries within the ROI that supplies resources to that industry. Multipliers are provided to estimate impacts on economic output, earnings, employment and value added. Impacts from normal operations at PFRR were estimated using multipliers for the "scientific research and development services" industry, impacts from annual maintenance activity were estimated using multipliers from the "commercial and industrial machinery and equipment repair and maintenance" industry, impacts from search and recovery operations were estimated using multipliers for the "air transportation" industry, and impacts related to the accommodative services needed for temporary personnel visiting for launch activities are estimated using multipliers for the "hotels and motels" and "food services and drinking places" industries. The direct requirements of labor and resources under each alternative were used to estimate the potential impacts in terms of employment, economic output, earnings, and value added from PFRR activities, as well as the resulting indirect impacts within the ROI. Employment impacts are evaluated in terms of the potential impact to the regional work force from the alternatives. Impacts from economic output are evaluated using the value added to the regional economy in terms of final goods and services directly comparable to gross domestic product (GDP). GDP is a widely used indicator of economic activity that represents the final value of all goods and services.

Impacts are considered minor if they are determined to account for less than 1 percent of the evaluation criteria for that resource. Similarly, impacts between 1 and 5 percent are considered to be moderate and impacts greater than 5 percent are considered major. Impacts determined to be immeasurable are considered negligible. The duration of the impacts would be considered short-term if they were to last for less than 1 year. Impacts would be considered medium-term if they would persist throughout the period where NASA SRP would continue to launch from PFRR and come to an end if the NASA SRP discontinued launching from PFRR. Impacts would be considered long-term if the impact persists after the NASA SRP discontinued launching from PFRR.

4.14.1.1 *No Action Alternative*

Launch Operations

Minor, beneficial socioeconomic impacts estimated under the No Action Alternative as a result of continued PFRR operations are expected to be medium-term. **Table 4–36** displays the estimated economic impacts attributable to PFRR activities under the No Action Alternative.

Table 4–36. Estimated Economic Impacts from PFRR Operations by Activity

Annual Impacts (2010 Dollars)	Direct Economic Output	Value Added	Direct Earnings	Indirect Earnings
Normal Operations	$1,900,000	$1,900,000	$1,400,000	$640,000
Launch Activities	$310,000	$300,000	$210,000	$100,000
Maintenance Activities	$160,000	$150,000	$52,000	$24,000
Total	$2,400,000	$2,300,000	$1,600,000	$800,000

Normal operations at PFRR are estimated to result in direct employment of approximately 17 full-time equivalents annually. Direct employment at PFRR is expected to generate indirect employment of approximately 11 jobs, for a total impact of 28 jobs within the ROI attributable to PFRR activities. Normal operations at PFRR are estimated to generate approximately $1.9 million of direct economic activity annually. It is estimated that approximately 97 percent of the direct economic activity is value added to the local economy in terms directly comparable to GDP. The value added from PFRR operations accounts for less than one-tenth of 1 percent of the total GDP, and approximately 1.3 percent of the professional, scientific, and technical services industry GDP for the Fairbanks area of Alaska. Approximately $1.4 million of the value added would be in the form of earnings to PFRR employees, which in turn would generate an estimated $640,000 of indirect earnings within the ROI.

Several times a year, the number of people engaged in PFRR operations increases to support launch and maintenance activities. It is estimated that launches would occur, on average, four times per year under the No Action Alternative. During launch periods, visiting personnel are estimated to reach up to 35 people at any given time. Maintenance activities occur for a 3-week period annually during the summer and require approximately 15 additional workers. Due to their temporary nature, these launch and maintenance activities are expected to generate up to two additional full-time jobs within the ROI. Per diem spending on lodging, meals, and incidentals for visiting and payload personnel would create additional beneficial impacts. It is estimated that an additional 5 full-time jobs can be attributed to per diem spending. Additional direct economic output attributable to launch and maintenance activities is estimated to be approximately $0.5 million annually.

Search and Recovery

Under the No Action Alternative, the level of search and recovery activity at PFRR would continue as it has in the past. It is assumed that one payload would be attempted to be recovered annually. Search and recovery activities under the No Action Alternative would result in negligible, though beneficial, impacts over the medium-term. Approximately $20,500 of direct economic output would be generated during recovery. The value added to the local economy in terms of final goods and services directly comparable to GDP is estimated to be approximately $18,000. Search and recovery activities under the No Action Alternative are not expected to create any additional indirect employment opportunities in the ROI.

4.14.1.2 *Alternative 1 – Environmentally Responsible Search and Recovery*

Launch Operations

NASA launches and PFRR operations under Alternative 1 would be the same as those described above under the No Action Alternative. Therefore, impacts on employment, earnings, output, and value added under Alternative 1 would be identical to those described under the No Action Alternative.

Search and Recovery

Under Alternative 1, it is assumed that two payloads and 10 spent stages would be recovered annually. Search and recovery activities under this alternative are expected to result in minor, though beneficial, economic impacts over the medium-term. Approximately $190,000 of direct economic output would be generated during search and recovery operations. The value added to the local economy in terms of final goods and services directly comparable to GDP is estimated to be approximately $166,000. Search and recovery activities under Alternative 1 are estimated to generate up to three additional full-time jobs in the ROI.

4.14.1.3 *Alternative 2 – Maximum Cleanup Search and Recovery*

Launch Operations

NASA launches and PFRR operations under Alternative 2 would be the same as those described above under the No Action Alternative and Alternative 1. Therefore, impacts on employment, earnings, output, and value added under Alternative 2 would be identical to those described under the No Action Alternative.

Search and Recovery

Under Alternative 2, it is assumed that four payloads and 16 spent stages would be attempted to be recovered annually. Search and recovery activities under this alternative are expected to result in minor, though beneficial economic impacts over the medium-term. Approximately $321,000 of direct economic output would be generated during search and recovery operations. The value added to the local economy in terms of final goods and services directly comparable to GDP is estimated to be approximately $282,000. Search and recovery activities under Alternative 2 are estimated to generate up to four additional full-time jobs in the ROI.

4.14.1.4 *Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories*

Socioeconomic impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.14.1.2, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential socioeconomic impacts associated with this alternative compared to those described for Alternative 1.

4.14.1.5 *Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories*

Socioeconomic impacts under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.14.1.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential socioeconomic impacts associated with this alternative compared to those described for Alternative 2.

4.14.2 Summer Launches

Summer launches would not change the socioeconomic impacts projected for the different alternatives under consideration. The same number of people would be needed to support the launches and search and recovery activities regardless of whether they occurred during the winter or summer.

4.14.3 Environmental Justice

This section addresses the potential for the proposed alternatives to result in disproportionately high and adverse impacts on minority and low-income populations. The criteria for evaluation of environmental justice impacts are based on the impacts identified for the various resource areas analyzed throughout this EIS. The intensity and duration of the impacts presented in this section are consistent with those defined under each resource area. Wherever adverse impacts on offsite populations are identified, further evaluations are considered to determine whether those impacts would disproportionately affect minority and low-income populations. Due to the nature of operations at PFRR, impacts from launch and search and recovery operations would result in little to no adverse impacts on offsite populations for the majority of resource areas. Potential human health impacts from PFRR operations and transportation and impacts on subsistence users within PFRR as a result of normal operations and accidents are the primary concerns likely to have the potential to adversely impact offsite populations.

Potential human health impacts on offsite populations from normal launch operations are discussed in Section 4.13. This analysis determined that the risk of a casualty to offsite populations would be negligible and medium-term. Safety policies and practices at PFRR are designed to protect populations and minimize the risk of impacts on human life, property, and natural resources within the PFRR launch corridor. UAF has agreements in place with two villages (Venetie, Arctic Village) regarding the use of tribal lands for research purposes. These agreements secure permission for potential impact areas on tribal lands. Additionally, NASA and UAF have designed programs that use monetary incentives to help locate and retrieve spent stages and payloads, providing opportunities for native populations to benefit economically (see Appendix E).

Potential impacts on offsite populations from off-normal flights and accidents are discussed in Section 4.13.2.2. This analysis determined that the risk of a casualty to offsite populations would be negligible to minor, and medium-term for all accident scenarios.

Sections 4.13.5 and 4.13.6 discuss the potential impacts on human health due to utilizing alternate flight zones. Alternate flight zones are designed to avoid impacting environmentally sensitive areas. Current practice is to minimize impacts on human health by avoiding populated places. Avoidance of environmentally sensitive areas could result in the potential impact areas being in closer proximity to populations. Under such a scenario, the probability of spent stages impacting offsite populations would increase when compared to the flight zones currently in use; however, the analysis determined that the overall risk to offsite populations remains negligible to minor, and medium-term.

As described in Section 4.10, any adverse impacts on subsistence resources or the harvest of subsistence resources are expected to be minor and short-term in duration under any of the alternatives. Similarly, transportation impacts are projected to be negligible under any of the alternatives, as discussed in Section 4.11.

Section 4.3 discusses the potential impacts on water resources. Any adverse impacts on surface water and groundwater under any alternatives are expected to be short-term and negligible.

Section 4.5 discusses the potential noise impacts from launch and recovery operations. Adverse impacts from launch operations under any of the alternatives would be short-term and moderate. Adverse impacts from search and recovery operations under any of the alternatives would be medium-term and moderate.

Section 4.6 discusses potential impacts on visual resources. Minor impacts to visual resources within the PFRR launch corridor are expected from launch and recovery operations under any of the alternatives. Impacts to visual resources may be short-term or long-term depending on how long the payload or spent stage is left unrecovered and how often the flight hardware is viewed by users of the areas within the launch corridor.

Section 4.12 discusses the potential impacts from hazardous materials and hazardous waste. Any potentially adverse impacts under any of the alternatives would be temporary and minor. Alternatives 2 and 4 that involve increased recovery scenarios would have a temporary minor beneficial impact.

As described in Chapter 3, Section 3.14, the downrange population primarily consists of minority and low-income communities. However, the analysis presented throughout Chapter 4 has shown the intensity of the risks to public health and safety from NASA SRP normal operations, off-normal flights, postulated accidents, and transportation are estimated to be negligible to minor. In addition, continued SRP operations at PFRR, including search and recovery activities, are not expected to adversely affect subsistence resources or users within the PFRR launch corridor.

Therefore, continued NASA SRP operations at PFRR are not expected to result in disproportionately high and adverse impacts on minority or low-income populations under any of the alternatives under consideration in this *Draft PFRR EIS*.

4.15 CUMULATIVE EFFECTS

CEQ regulations define cumulative effects as effects on the environment that result from implementing one of the alternatives when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions **(40 CFR 1508.7)**. Cumulative effects can result from individually minor but collectively significant actions taken over a period of time. Cumulative effects can also result from spatial (geographic) and/or temporal (time) crowding of environmental disturbances (*i.e.*, concurrent human activities and the resulting effects on the environment are additive if there is insufficient time for the environment to recover).

4.15.1 Geographic Extent of Cumulative Effects Analysis

The geographic extent of the cumulative effects analysis includes the area within the PFRR launch corridor and the area surrounding the Alaska Pipeline Project (see Section 4.15.2) located directly west of the PFRR launch corridor. The location of the areas included in the cumulative effects analysis is shown in **Figure 4–20**. Located within the PFRR launch corridor are landmasses owned by the U.S. government, Alaska Native organizations and villages, the State of Alaska, and private landowners.

4.15.2 Temporal Extent of Cumulative Effects Analysis

The temporal extent begins with the initiation of the PFRR (circa 1968) up through 10 years into the future (*i.e.*, 2023).

4.15.3 Specific Actions Within the Poker Flat Research Range Launch Corridor

The sections below describe the past, present, and reasonably foreseeable future actions within the PFRR launch corridor that NASA considered in its cumulative effects analysis. The sequence in which the actions are discussed is related to geographic location, starting at the PFRR launch site and moving north up to the Beaufort Sea/Arctic Ocean.

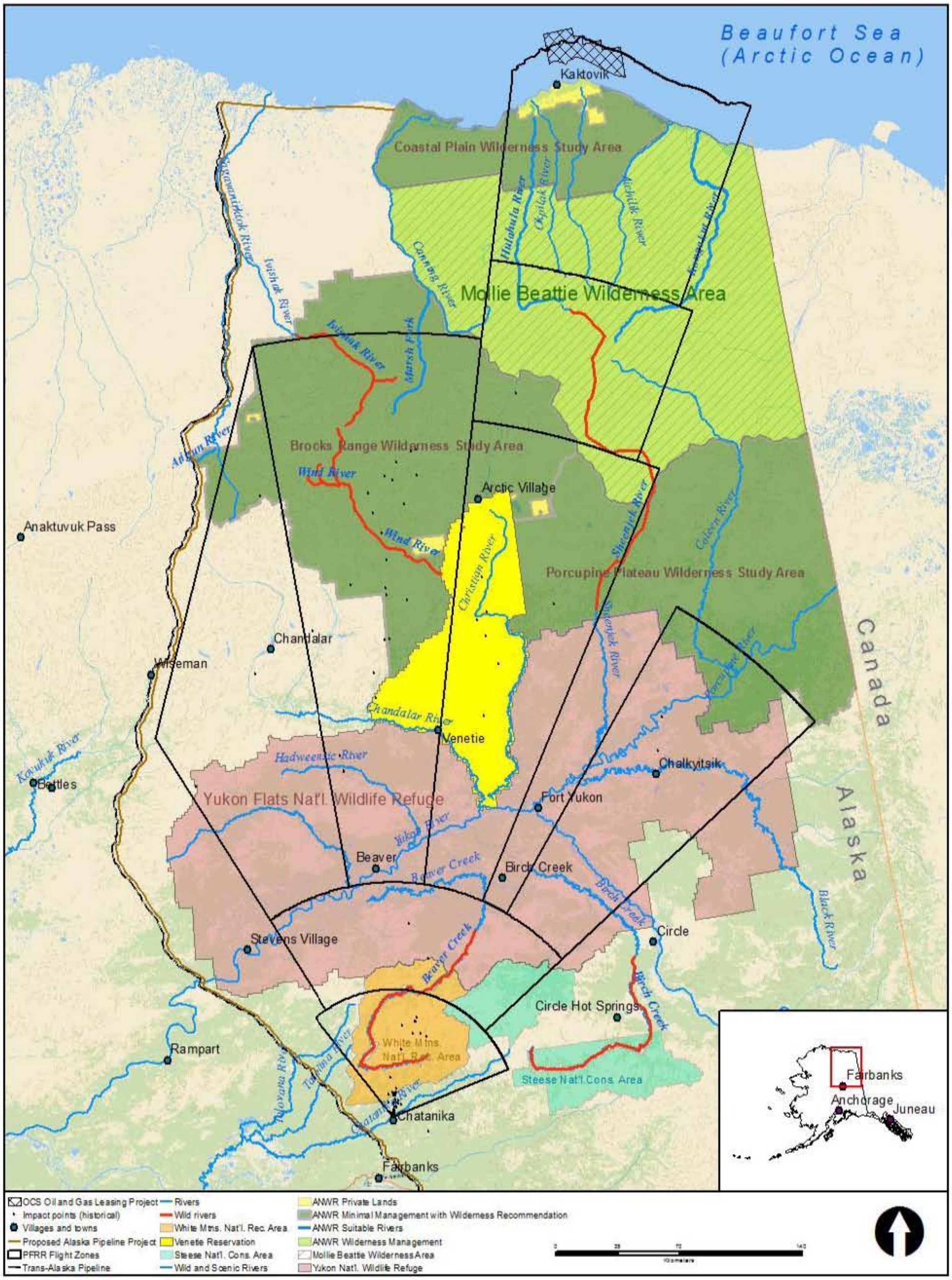


Figure 4–20. Activities Included Within Cumulative Effects Analysis

4.15.3.1 *Poker Flat Research Range Past Launches 1968–Present*

As discussed in Chapter 2, NASA has been launching sounding rockets from PFRR for over 40 years. During that time, 219 NASA launches have been conducted. In addition to the NASA launches, PFRR has enabled 116 launches in support of other agencies, primarily the U.S. Department of Defense and National Science Foundation. No non-NASA-sponsored launches have flown from PFRR since 1995. In support of these launches, latex balloons and small test rockets have been launched routinely during countdowns to obtain upper atmospheric weather data and calibrate radar systems, respectively. In addition to the relatively larger sounding rocket launches summarized above, the U.S. Army launched a standard meteorological balloon and rocket (Loki/Super Loki-Dart) from PFRR three times per week between approximately 1971 and 1979.

4.15.3.2 *Eastern Interior Resource Management Plan*

BLM is developing a Resource Management Plan (RMP) for its Eastern Interior Planning Area. The RMP will provide future direction for 2.7 million hectares (6.7 million acres) of public land including the White Mountains NRA, the Steese NCA, and the Forty-mile area near Chicken and Eagle, Alaska. Resource management plans provide BLM with long-term direction regarding the use and management of resources on its managed public lands. The RMP will establish goals and objectives for managing resources, and it will outline the measures needed to achieve those goals and objectives. It will identify lands available for certain uses, along with any restrictions on those uses, and will identify lands closed to certain uses. The draft RMP was released in February 2012 for public review.

4.15.3.3 *Interior Oil and Gas Exploration*

Oil and gas exploration has been conducted in the Yukon Flats area since 1954 and has consisted of airborne magnetometer surveys, seismic surveys, well drilling, and borings. Past surveys resulted in the clearing of an estimated 174 hectares (430 acres) of vegetation; these areas are generally located between the Villages of Beaver and Chalkyitsik. The other surveys were conducted in the water, along roads, or via helicopter. Some of the survey lines are currently used as transportation and/or trapping routes. No development or production of oil and gas has occurred to date in Yukon Flats NWR **(USFWS 2010a)**.

Winter seismic exploration was conducted on the coastal plain of the Arctic NWR in 1984 and 1985. Approximately 2,000 kilometer (1,240 miles) of seismic lines, arranged in a grid pattern, were completed between January and May of both years. Collection of data along each seismic line required multiple passes by tracked vehicles. Ski-mounted camps pulled by tractors created a second series of trails **(Raynolds and Felix 1989)**. Some of the trails created by this effort are still visible today **(USFWS 2012)**.

Oil exploration and development could be expected to occur in the future on private lands within the ROI as there are approximately 405,000 hectares (1 million acres) of land under private ownership within the Yukon Flats NWR identified as having the potential for such resources. Gas development is not expected to occur on these lands in the reasonably foreseeable future due to the lack of infrastructure to transport gas to market, along which a gas line might be constructed. In its 2010 *Land Exchange EIS*, USFWS estimated that land disturbance from establishing rights-of-way associated with selected future activities could range in size from 162 to 688 hectares (400 to 1,700 acres) per right-of-way **(USFWS 2010a)**.

Doyon, Limited is actively sponsoring new oil and gas exploration near Stevens Village in the Yukon Flats Basin. Two-dimensional seismic, land and airborne gravity, and geochemical surveys have been ongoing and will likely continue into the reasonably foreseeable future. Exploration wells may be constructed within the next several years. Access to these areas for data collection efforts would be via helicopter and snow machine.

4.15.3.4 *Chandalar Mining District*

Located approximately 310 kilometers (190 miles) north of Fairbanks, the Chandalar Gold District (District) consists of four hard-rock and 7 historic mines on approximately 9,300 hectares (23,000 acres). In addition, the company that has mining rights within the District has identified 28 prospects in the area that could be mined in the future. There is presently no all-weather road access; however, four airstrips within the claim boundaries accommodate air access to the 25-person camp. Seasonal overland access is from Coldfoot via a 90-kilometer-long (55-mile-long) winter trail to the state airport at Chandalar Lake. All major prospects within the district are connected via a 45-kilometer-long (28-mile-long) network of access roads.

4.15.3.5 *Burnt Mountain Seismic Observatory*

The U.S. Air Force operates an unattended seismic observatory station on an approximately 40-hectare (100-acre) parcel in the Burnt Mountain area to help verify compliance with nuclear test ban treaties. The principal equipment at Burnt Mountain consists of borehole seismometers to collect the seismic data and a radio to communicate the data off site for analysis. There are five seismometers clustered within a 2-kilometer (1.5-mile) radius and linked to a central communications station via surface-laid data cable.

The station is located along the boundary of Arctic and Yukon Flats NWRs in a remote area about 80 kilometers (50 miles) from the closest villages (Venetie, Arctic Village, and Chalkyitsik). All personnel and materials are flown in from Fort Yukon via helicopter. On average, there are approximately six personnel visits a year for the purposes of maintenance and inspection.

4.15.3.6 *Arctic National Wildlife Refuge Revised Comprehensive Conservation Plan*

In August 2011, USFWS published the *Arctic Refuge Draft Revised Comprehensive Conservation Plan (Draft Revised Arctic CCP)* **(USFWS 2011c)**. Once complete, the Arctic CCP will provide management direction for Arctic NWR for the next 15 years. USFWS is evaluating six alternatives in the *Draft Revised Arctic CCP*, including designation of additional areas within Arctic NWR to be managed as Wilderness, Wild River, and minimal management areas **(USFWS 2011c)**. Many of these potentially designated areas are within the PFRR launch corridor.

4.15.3.7 *State of Alaska Sale of North Slope Leases*

On December 7, 2011, ADNR issued a Notice of Sale for 3,145 tracts of State land ranging in size from 260 to 2,330 hectares (640 to 5,760 acres) in the Beaufort Sea, the North Slope, and the North Slope Foothills areas. These leases allow for the possibility of oil and gas exploration and development in the areas adjacent to Arctic NWR. The sale resulted in a preliminary sale of 178 tracts (135,600 total hectares [334,969 total acres]). Of those tracts sold, 34, or 44,300 hectares (109,440 acres), were between the Arctic NWR boundary and the existing Trans-Alaska Pipeline. Three tracts (734, 740, and 743) are adjacent to the Arctic NWR boundary, and the Canning River constitutes the easternmost boundary of tract (743).

4.15.3.8 *Long-Range Transportation Plan*

In 2009, the Alaska Department of Transportation and Public Facilities undertook an effort to develop a multi-agency transportation plan. Still in its early stages of development, the plan's objective is to identify and prioritize transportation improvements on Federal lands in the State of Alaska. Along with the Alaska Department of Transportation and Public Facilities, the following Federal agencies are involved: National Park Service, USFWS, BLM U.S. Forest Service, and the Federal Highway Administration's Western Federal Lands Highway Division. The plan will not seek to identify specific projects or suggest changes to Federal lands management. Instead, its intent is to serve as a tool to collectively engage agencies on how to work together and leverage funding. The Long-Range Transportation Plan consists of two parts: (1) an overarching plan addressing common objectives among the agencies, and (2) "dropdown" plans specific to each agency to address individual transportation needs.

4.15.3.9 *Polar Bear Conservation Plan*

USFWS is in the early planning stage of developing the Polar Bear Conservation Plan (Plan). Polar bears were listed under the ESA on May 15, 2008. The ESA and the Marine Mammal Protection Act require USFWS to develop a recovery plan and a conservation plan, respectively, to identify and implement future conservation, management, and research activities. USFWS has determined that the Plan will identify threats to polar bears, identify action items to address those threats and involve partners in the process of development and implementation. The intent of the Plan is to guide management and research activities now and into the future; it is scheduled to be completed in the fall/winter of 2013 **(USFWS 2012)**.

4.15.3.10 *Barter Island Airport Improvement Project*

The existing Barter Island Airport is in Arctic NWR and is located on a gravel spit extending from the northeast corner of Barter Island. The airport provides the only year-round access to the community of Kaktovik, Alaska. The FAA and North Slope Borough plan to relocate the airport to the south side of Barter Island, about 1 mile southwest of Kaktovik, onto lands owned by the Kaktovik Iñupiat Corporation.

4.15.3.11 *Barter Island Distant Early Warning-Line Cleanup*

The Barter Island Distant Early Warning-Line (DEW-Line) is an integrated chain of radar and communications sites stretching across Alaska, northern Canada and Greenland. Its purpose was to detect any incoming, over-the-pole, aircraft invasions emanating from the Soviet Union.

The program was discontinued in 1963 and most sites were closed at that time. Cleanup of the stations occurred in the late 1990s and continues today. Many of the sites had contaminated soils or expected contamination consisting of petroleum, lubricants, polychlorinated biphenyls, and insecticides, along with considerable volumes of debris and general refuse.

The Barter Island DEW-Line station consists of 14 determined Installation Restoration Program sites, many of which have undergone building/structure demolition and disposal and environmental background sampling.

4.15.3.12 *Beaufort Sea Planning Area*

In November 2011, the USDOI released the *Outer Continental Shelf Oil and Gas Leasing Program: 2012–2017 Draft Programmatic Environmental Impact Statement (OCS Oil and Gas Draft PEIS)* **(USDOI 2011e)** for public review. In the *OCS Oil and Gas Draft PEIS*, USDOI is evaluating the impacts of holding lease sales in six of the Outer Continental Shelf (OCS) Planning Areas in the Gulf of Mexico and offshore Alaska from 2012–2017. USDOI analyzed the impacts associated with eight alternatives that would occur associated with lease sales located in the Central, Western, and Eastern Gulf of Mexico, the Beaufort Sea, the Chukchi Sea, and the Cook Inlet Planning Areas. Under seven of the eight alternatives, the Beaufort Sea Planning Area would be included in the lease sales. Under Alternative 5, the Beaufort Sea Planning Area would be excluded from the lease sales.

4.15.4 Specific Actions Outside of the Poker Flat Research Range Launch Corridor

4.15.4.1 *Gold Mining at Livengood*

A Canadian mining company is currently pursuing the establishment of a large gold mine on a 20,000-hectare (50,000-acre) site known as “Money Knob” in the Livengood Mining District. Depending on the season, between approximately 50 and 125 personnel are currently involved in exploratory activities, with the staging area for those operations at an old Elliott Highway pipeline construction camp near the prospect. Since 2006, more than 700 exploration-related boreholes have been drilled as part of the project.

Located approximately 110 kilometers (70 miles) north of Fairbanks, the open pit mine is not expected to begin work any sooner than 2018 and would have an expected 23-year life once operational. To extract the recoverable portion of the gold, the material would be hauled away, crushed in a mill and ground to a consistency that allows the gold to be removed.

If the mine proceeds, it is estimated that up to 1,100 people would be employed during a several-year-long construction phase. Once operational, an estimated 500 people would work at the mine.

4.15.4.2 *Dalton Highway Scenic Partnership Plan*

The Dalton Highway Scenic Byway Corridor Partnership Plan was completed in March 2010. It is a comprehensive evaluation of the byway's intrinsic qualities; it also serves as a guide for management, protection, and enhancement of present and future intrinsic qualities. The plan was developed by ADNR to designate the highway as a National Scenic Byway. The overall mission of the plan is "to act as a collective voice for all byway stakeholders in order to address concerns relating to current and future uses, management actions, and developments in the Dalton Highway corridor and to preserve, protect, and enhance the byway's intrinsic qualities...for the benefit of current and future travelers" **(USFWS 2012)**.

4.15.4.3 *Foothills West Transportation Access Project*

The Foothills West Transportation Access Project (commonly referred to as the "Foothills Project" or "Umiat Road Project") includes construction of an all-season gravel road from Dalton Highway to Umiat, Alaska. The purpose of the Foothills Project is to provide access to oil and gas resources both along the northwestern foothills of the Brooks Range and in the National Petroleum Reserve-Alaska. The U.S. Army Corps of Engineers is currently preparing an EIS for the proposed project. The U.S. Army Corps of Engineers expects to release the draft EIS in the fall 2013; the Record of Decision is expected to be published by winter 2014.

4.15.4.4 *Alaska Pipeline Project*

The Alaska Pipeline Project involves construction of two additional oil pipelines and one additional gas pipeline from Point Thompson, Alaska, to Prudhoe Bay, Alaska. The two additional oil pipelines would be constructed from Prudhoe Bay, Alaska, to Valdez, Alaska, and from Prudhoe Bay, Alaska, to Caroline, Alberta. These pipelines would follow the existing Trans-Alaska Pipeline from Prudhoe Bay to Fairbanks, where one would continue following the Trans-Alaska Pipeline to Valdez and the other would continue on to Caroline in Alberta, Canada. The additional gas pipeline would be constructed from Prudhoe Bay east to Point Thompson. A new gas treatment plant would also be constructed near Prudhoe Bay to prepare the gas for pipeline transport. Once completed, the pipelines would have a total length of 4,200 kilometers (2,600 miles) and capacity to handle 250 million cubic meters (8.9 billion cubic feet) of oil per day and 31 million cubic meters (1.1 billion cubic feet) of natural gas per day **(TransCanada 2011)**.

4.15.5 General Actions Considered for Cumulative Effects

The sections below present several general categories of recurring actions occurring within and adjacent to the PFRR launch corridor that NASA considered in its cumulative effects analysis.

4.15.5.1 *Land Management, Research, and Monitoring*

It is expected that activities inherent in land management, including law enforcement, biological survey, and wildland fire monitoring, will continue on Federal, state, and Native lands as they have in the recent past. Remote areas will continue to be accessed by fixed-wing aircraft, helicopters, boats, and snowmobiles, depending on season and the type of activity undertaken.

4.15.5.2 *Recreational Use*

Recreational uses of downrange lands include riding OHVs, hiking, river floating, fishing, hunting, and camping during non-winter months. Winter uses primarily include trapping, cross-country skiing, and snowmobiling. Based upon recent trends, the two primary Federal land management agencies within the PFRR launch corridor expect demands for recreation to increase in the next 10 years **(USDOI 2012a; USFWS 2012)**.

4.15.5.3 *Placer Mining*

Placer mining refers to removing precious metal deposits found in alluvial deposits, which are deposits of sand and gravel in modern or ancient stream beds. Since its first discovery within the southern portion of the launch corridor in the late 1800s, gold mining has occurred ever since **(USDOI 2012a)**.

4.15.6 Methodology

4.15.6.1 *Overview*

The cumulative effects analysis for this *Draft PFRR EIS* involved combining the impacts of the proposed alternatives on each resource area with the impacts of other past, present and reasonably foreseeable activities within the ROI. The general approach to the analysis involved the following process:

- Identify baseline impacts from past and present actions (*i.e.,* the baseline conditions described in Chapter 3).
- Identify potential impacts produced by the continued launch and search and recovery of NASA sounding rockets from PFRR (as described in Sections 4.1 through 4.14).
- Identify potential impacts associated with the actions described in Sections 4.15.1 and 4.15.2.

For each resource area, the impact descriptors (*e.g.,* type, intensity, duration) presented correspond directly to those established for the assessment of direct and indirect impacts in earlier sections of this EIS. Rather than repeating the impact descriptor definitions in this section, should the reader desire to learn what would constitute a particular impact on a resource area, he/she is directed to the respective methodology presented for that resource.

4.15.6.2 *Unavailable Information*

CEQ regulations **(40 CFR 1502.22)** require that Federal agencies clearly identify when information having a bearing on either significant environmental impacts or choice among alternatives is either incomplete or unavailable. During the scoping period for this EIS, the most substantial cumulative effect-related concern raised by members of the public focused on the quantity and location of previously launched flight hardware. As such, during the preparation of this *Draft PFRR EIS*, NASA and UAF researched known sources of information, including post-mission summary reports and flight safety plans, and held discussions with former PFRR employees; however, it has been concluded that impact location data for all past sounding rockets launched from PFRR are not available. Due primarily to personnel changes and a historically lower emphasis on the downrange location of items, such information has not been maintained at either the PFRR launch site or within the NASA SRP. Of particular note is a large records disposal that occurred at PFRR sometime in the 1990s **(Brown 2012)**. Pre-1990 NASA and all non-NASA launch data are particularly scarce.

Therefore, in the absence of complete information for many past launches, NASA has employed best professional judgment in making assumptions regarding "expected" landing distances and azimuths to estimate the quantity and location of historic flight hardware in downrange lands. Regarding whether the absence of this information would be essential to making a reasoned choice among alternatives, it is not expected that it would be essential because it would be a historical baseline applicable to all alternatives considered in this EIS. While having complete information regarding the location of flight hardware would provide the best assessment of the cumulative effects of the program at PFRR, it is not expected to have a major bearing on NASA and or its cooperating agencies' abilities to select the most appropriate alternative for ultimate implementation.

4.15.6.3 *Actions Considered but not Evaluated in Detail*

Of the actions discussed in Sections 4.5.1 and 4.5.2, NASA eliminated a number of those not expected to measurably contribute to cumulative effects on key resource areas. **Table 4–37** below presents those actions eliminated from detailed evaluation of cumulative effects and NASA's reason for doing so.

Table 4–37. Projects Not Evaluated in Detail for Cumulative Effects

Action	Rationale for Not Evaluating in Detail
Long-Range Transportation Plan	No PFRR launches or recoveries expected within ROI of action
Polar Bear Conservation Plan	Negligible interaction between PFRR and action
Barter Island Airport Improvement	No PFRR launches or recoveries expected within ROI of action
Barter Island DEW-Line Cleanup	No PFRR launches or recoveries expected within ROI of action
Gold Mining at Livengood	No PFRR launches or recoveries expected within ROI of action
Dalton Highway Scenic Partnership Plan	No PFRR launches or recoveries expected within ROI of action
Foothills West Transportation	No PFRR launches or recoveries expected within ROI of action

Key: DEW=Distant Early Warning; PFRR=Poker Flat Research Range; ROI=region of influence.

4.15.6.4 *Resources Considered but not Evaluated in Detail*

In keeping with CEQ regulations **(40 CFR 1500–1508)**, those resource areas that were predicted to be impacted in at least a minor way were evaluated for their potential to contribute to cumulative effects within the cumulative effects ROI. Where impacts were predicted not to occur or were negligible, cumulative effects were generally not analyzed since there would be either no, or only a very small incremental increase in effects on the resource within the ROI.

No cumulative effects are anticipated for the following resource areas with respect to additional actions taking place within the PFRR launch site and launch corridor: geology and soils, subsistence resources, cultural resources, health and safety, and socioeconomics and environmental justice; thus, these resource areas are not discussed in the following sections.

4.15.7 Air Quality and Global Atmosphere

4.15.7.1 *Resource Context*

None of the areas within the PFRR launch corridor are designated as nonattainment areas with respect to the National Ambient Air Quality Standards for criteria air pollutants. Elevated concentrations of particulate matter occur near occupied areas during the winter partially as a result of wood-fired devices and throughout the launch corridor during summer as a result of wildfires.

The Earth's radiation balance is affected largely by water vapor; carbon dioxide; and other trace gases, including nitrous oxide, halocarbons, and methane. Increases in atmospheric concentrations of these pollutants are believed to influence the Earth's global climate **(IPCC 2007)**. The Arctic is especially vulnerable to global climate change and increased ultraviolet radiation. The primary impacts are expected physical and biological changes.

4.15.7.2 *Past and Present Impacts*

PFRR Actions

Past and current launches from PFRR have resulted in temporary air quality impacts from criteria pollutant and other air pollutant emissions from both sounding rocket flight and occasional recovery actions. These activities also produce greenhouse gases, which have global, negligible, and long-term adverse impacts.

Actions by Others

General Land Management **–** Landowner and resource agency aviation contributes to temporary impacts from production of criteria and other air pollutants throughout downrange lands. Long-term impacts from production of greenhouse gases also occur.

Recreational Use **–** The recreational use of all-terrain vehicles (ATVs) and outboard motors on downrange lands contributes to temporary impacts from production of criteria and other air pollutants throughout downrange lands during non-winter months, particularly on BLM lands where maintained trails are readily available for users. The use of snow machines during winter months also produces air pollutants. Long-term impacts from production of greenhouse gases also occur.

Interior Oil and Gas Exploration **–** Interior Oil and Gas exploration activities produce criteria and other air pollutants and greenhouse gases. The airborne transportation of equipment and personnel, mulching, borehole drilling, and the detonation of small explosive charges are sources of air pollutants.

4.15.7.3 *Future Impacts*

PFRR Actions

PFRR routine activities and rocket launches would result in minor, adverse, long- and short-term air quality impacts on a global level, as discussed in Section 4.2. Adverse impacts from search and recovery operations would be regional, minor, and medium-term. The adverse impact on the global atmosphere from emissions of greenhouse gases would be global, negligible, and long-term, as discussed in Section 4.2. When combined with the existing air quality impacts in the area near PFRR, little change in air pollutant concentrations is expected, and the air pollutant concentrations are expected to continue to be below ambient standards.

Actions by Others

Interior Oil and Gas Exploration – Similar in nature to the impacts of past operations, future oil and gas exploration could result in air pollutant emissions from construction and exploration activities.

Arctic Refuge Revised CCP – It is expected that all alternatives under consideration in the Draft Revised Arctic CCP would preserve minimal management of lands within Arctic NWR and air pollutant-producing activities would be kept to a minimum, thereby minimizing impacts on air quality.

OCS Oil and Gas Leasing – Of the projects within the PFRR launch corridor, alternatives under the OCS Oil and Gas Leasing Program in the Beaufort Sea Planning Area could lead to air pollutant emissions from construction, exploration, and processing activities **(USDOI 2011b)**. These activities could result in fugitive dust emissions and other air pollutant emissions from drilling equipment, compressor stations, and other equipment. The impacts are not expected to result in significant adverse impacts on the communities within PFRR or the global atmosphere.

4.15.7.4 *Differences Among Alternatives Under Consideration*

Under Alternatives 1, 2, 3, and 4, there would be a minor change in air pollutant emissions from additional search and recovery operations in areas within the PFRR launch corridor.

Although annual emissions of greenhouse gases from launches at PFRR are negligible, when combined with those from other projects in the PFRR launch corridor, the effects would be additive and therefore would result in some contribution to climate change. However, scientific uncertainty limits the ability to assess directly attributable effects that directly contribute to climate change from selected individual actions. Therefore, NASA provides only a qualitative statement concerning these impacts. Cumulative effects from all alternatives under consideration would likely create impacts that increase climate change.

In general, climate change induced effects in the Arctic have led to earlier spring snowmelt, reduced sea ice, glacier retreat, and permafrost warming. Other effects of climate change in Alaska could include increased coastal erosion, flooding, shifts in marine species, drier conditions, increased wildfires, longer growing season, drought stress, and insect infestation of forests **(GCRP 2009)**.

4.15.8 Land Use and Recreation

4.15.8.1 *Resource Context*

Current land use patterns were largely set by ANILCA in 1980, which expanded Arctic NWR and established Yukon Flats NWR and the BLM-managed White Mountains NRA and Steese NCA. ANILCA also added Beaver Creek and the Ivishak, Sheenjek, and Wind Rivers to the National Wild and Scenic River System and the Mollie Beattie Wilderness Area of Arctic NWR to the National Wilderness Preservation System. With the exception of the area immediately surrounding villages, nearly all Federal lands within the PFRR launch corridor meet most Wilderness suitability criteria.

4.15.8.2 *Past and Present Impacts*

PFRR Actions

From the onset of operations at PFRR in the late 1960s, the Federal Government, the state of Alaska, and various tribal organizations have largely controlled downrange lands. As such, PFRR has historically maintained a series of agreements with downrange landowners to ensure that its operations do not conflict with land uses. The most notable of these agreements is likely that with the USDOI that was signed in 1969 to allow for the landing and recovery of flight hardware on DOI-managed lands, including what was at the time known as the Arctic Range (now Arctic NWR) **(Davis 2006)**.

Table 4–38 below presents a summary of probabilities of sounding rocket impact within designated and recommended Wilderness areas for the past 10 years; this timeframe was selected as it contains the most accurate dataset of planned impact locations for which probabilities of impact could be calculated. The probabilities indicate that the likelihood of impact from launches from the recent past was generally unlikely with the exception of several cases. Earlier launches, particularly those prior to ANILCA, could have had planned impact locations within these lands. The presence of historic impacts within a Wilderness area would detract from the wilderness characteristics of the area; however, the extent of the effect would be localized.

Table 4–38. Probability of Impact Within Wilderness over the Past 10 Years

Vehicle	Mission	Mollie Beattie Wilderness Area		Yukon NWR Recommended Wilderness	
		Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)
Black Brant V	21128				
	21131			0.0	6,117
	21138	0.0	3,363,719		
	21139	2.5	40		
Orion	30044			0.1	1,569
	30047			0.1	1,010
	30049			0.1	778
	30050			0.1	768
	30051			0.0	12,786
	30052			0.4	252
	30058			0.2	405
	30059			0.2	401
	30073			0.2	545
Black Brant X	35034 & 037				
Black Brant IX	36200 & 206				
	36234	0.0	2,697,308		
	36242	44.2	2		
	36256 & 278				
	36257	0.0	6,649,820		
Black Brant XII	40014	0.3	350		
	40016	0.1	758		
	40017	2.4	42		
	40019	0.2	528		
	40020	0.3	399		
	40023	0.6	173		
	40025	0.4	245		

Table 4–38. Probability of Impact Within Wilderness over the Past 10 Years (*continued*)

Vehicle	Mission	Mollie Beattie Wilderness		Yukon NWR Recommended Wilderness	
		Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)
Terrier-Improved Orion	41028	0.0	25,099		
	41029			0.0	28,986
	41034	0.0	8,986		
	41061				
	41062	0.0	168,350		
	41063	19.6	5		
	41064	0.0	29,103		
	41065	0.0	8,128		
	41076			0.0	8,333,333
	41077			0.0	1,559,673
	41078			0.0	17,403,108
	41079				
	41084			5.5	18

a. Blank cells indicate that calculated value was below reporting threshold of software.

Given the special designations that ANILCA established for the lands downrange from PFRR, over time the sensitivity to evidence of human presence within the lands, including PFRR-launched flight hardware, has increased, particularly for those recreational users hoping to have a wilderness experience. Based upon recent response to items located by downrange users visiting the downrange lands, reactions to locating PFRR-launched hardware have ranged from positive to negative and were highly dependent upon the individual. Those persons who reacted adversely to finding an item were concerned that its presence detracted from their ability to enjoy a wilderness experience.

According to data from USFWS, during the past 10 years, the number of permitted air operators in Arctic NWR has grown approximately 40 percent with the number of permitted recreational guiding businesses nearly doubling **(USFWS 2012)**. On BLM-managed lands, use has increased by approximately 5 percent each year and is expected to continue doing so **(USDOI 2012a)**. Given that visible evidence of past launches remains in downrange lands, and would likely be the case for years to come, the potential for a recreational user to encounter an item from a past launch is likely increasing. Coupled with a higher likelihood of encountering other users of downrange lands, effects of finding a piece of flight hardware on recreationalists desiring a wilderness experience could be exacerbated.

Actions by Others

Interior Oil and Gas Exploration **–** Past effects on wilderness values of Federal lands are largely limited to the seismic survey lines that are still visible on the ground and from the air, and some limited placer mining on the BLM-managed White Mountains NRA. There is no evidence that the survey lines from past oil and gas exploration within Yukon Flats NWR are negatively affecting land use or recreation, though they may be facilitating access for trapping through the use of the cleared seismic survey lines **(USFWS 2010a)**.

4.15.8.3 *Future Impacts*

PFRR Actions

Future launches from PFRR would be expected to consist mostly of the longer-range class of rockets, requiring impact locations primarily in the ADNR North and South Special Use Areas, the southernmost portion of White Mountains NRA, and lands north of Yukon Flats NWR. In all cases, UAF would be required to obtain authorizations from the respective landowner(s) to ensure that impacts and recoveries are consistent with land uses. Based upon an assessment of the past 10 years of flight records, it would not be likely for items to land within the areas of greatest recreational uses, which in general terms are along Beaver Creek within White Mountains NRA and Yukon Flats NWR and several rivers north of the Brooks Range within Arctic NWR. Given that future recovery efforts would occur during non-winter months, it is possible that users of downrange lands could observe recovery aircraft as it transits between its home airport and the search or recovery site. Within the context of land use, NASA and PFRR would maintain an active search and recovery program and recovery aircraft would adhere to minimum flight elevation requirements as stipulated in landowner-issued authorizations. Regarding recreation, to some users, observing an aircraft could adversely affect his/her wilderness experience; however, to others it may have limited effect given that air transportation is very common in Interior Alaska. In either case, the impact would be short-term.

Given the success rate of locating newly launched stages and payloads from downrange lands, it is expected that some flight hardware would remain in downrange lands following each successive launch season. Therefore, similar to the discussion regarding the effects of past launches, localized long-term adverse cumulative effects on recreation, and in particular, wilderness-based recreation, would be anticipated should a sounding rocket-related item be encountered on downrange lands.

Actions by Others

BLM Eastern Interior RMP – Of the land areas under consideration in BLM's revised RMP/EIS, the White Mountains subunit would have the greatest potential for overlap with PFRR's activities. Under BLM's preferred management alternative, identified as Alternative C in the Draft RMP/EIS, recreation management would be the focus in White Mountains NRA and surrounding lands, which would be identified as a Special Recreation Management Area. Under Alternative C, less land would be managed for Primitive and Semi-Primitive settings than other alternatives under consideration. A slight increase in site and facility development would occur. As such, it is expected that BLM's future management of White Mountains NRA would result in beneficial impacts on recreation, particularly those activities that involve OHV use. Some displacement of non-motorized users could be expected **(USDOI 2012a)**. Based upon NASA's discussions with BLM, it is not expected that land management changes under BLM's preferred alternative would have a measurable effect on future launches of sounding rockets from PFRR.

Arctic Refuge Revised CCP – Once complete, the *Draft Revised Arctic CCP* will provide management direction for Arctic NWR for the next 15 years **(USFWS 2011c)**. USFWS is evaluating six alternatives in the *Draft Revised Arctic CCP*. These alternatives and their potential impact on land management within Arctic NWR and, by extension, portions of PFRR, are listed in **Table 4–39.**

Table 4–39. Alternatives Considered in the Arctic Refuge Draft Revised Comprehensive Conservation Plan

Alternative	Description	Wilderness
A	The original land management categories, as described in the 1988 Comprehensive Conservation Plan, would continue to apply to lands in Arctic NWR. Lands administered by Arctic NWR would fall into three management categories as follows: Minimal (4.3 million hectares), Wilderness (3.2 million hectares), and Wild River (202,000 hectares).	No new areas would be recommended for Wilderness designation.
B	Lands in Arctic NWR would be managed under the Minimal, Wilderness, and Wild River management categories described in the *Draft Revised Arctic CCP*. This alternative would maintain the same area in each of the management categories as Alternative A. If Congress were to designate the Brooks Range WSA as Wilderness, there would be a reduction of 2.2 million hectares from the Minimal management category and a corresponding increase in the Wilderness management category. Similarly, if the recommended rivers were designated by Congress for inclusion in the NWSRS, there would be a further reduction of approximately 21,200 hectares of Minimal management and an increase of 21,100 hectares of Wild River management.	The Brooks Range WSA would be recommended for Wilderness designation.
C	Lands in Arctic NWR would be managed under the Minimal, Wilderness, and Wild River management categories described in the *Draft Revised Arctic CCP*. This alternative would maintain the same area in each of the management categories as Alternative A. If Congress were to designate the Coastal Plain WSA as Wilderness, there would be a reduction of 570,000 hectares from the Minimal management category and a corresponding increase in the Wilderness management category. Similarly, if Congress were to designate the rivers recommended for inclusion in the NWSRS, there would be a further reduction of approximately 2,800 hectares from the Minimal management category and an increase of 2,800 acres in the Wild River management category.	The Coastal Plain WSA would be recommended for Wilderness designation.

Table 4–39. Alternatives Considered in the Arctic Refuge Draft Revised Comprehensive Conservation Plan (*continued*)

Alternative	Description	Wilderness
D	Lands in Arctic NWR would be managed under the Minimal, Wilderness, and Wild River management categories described in the *Draft Revised Arctic CCP*. This alternative would maintain the same area in each of the management categories as Alternative A. If Congress were to designate the Brooks Range and Porcupine Plateau WSAs as wilderness, there would be a reduction of 4 million hectares from the Minimal management category and a corresponding increase under the Wilderness management category. Similarly, if recommended rivers were designated by Congress for inclusion in the NWSRS, there would be a further reduction of approximately 22,000 hectares of Minimal management and an increase of 22,000 hectares of Wild River management.	The Brooks Range and Porcupine Plateau WSAs would be recommended for Wilderness designation.
E	Lands in Arctic NWR would be managed under the Minimal, Wilderness, and Wild River management categories described in the *Draft Revised Arctic CCP*. This alternative would maintain the same area in each of the management categories as Alternative A. If Congress were to designate the Brooks Range, Porcupine Plateau, and Coastal Plain WSAs as Wilderness, there would be a reduction of 4.5 million hectares from the Minimal management category and a corresponding increase in the Wilderness management category. If rivers recommended under this alternative were designated as Wild Rivers by Congress, there would be a further reduction of 24,000 hectares from the Minimal management category and a corresponding increase in the Wild River management category.	The Brooks Range, Porcupine Plateau, and Coastal Plain WSAs would be recommended for Wilderness designation.
F	Lands in Arctic NWR would be managed under the Minimal, Wilderness, and Wild River management categories described in the *Draft Revised Arctic CCP*. This alternative would maintain the same area in each of the management categories as Alternative A.	No new areas would be recommended for Wilderness designation.

Note: To convert hectares to acres, multiply by 2.471.
Key: *Draft Revised Arctic CCP=Arctic Refuge Draft Revised Comprehensive Conservation Plan*; NWR=National Wildlife Refuge; NWSRS=National Wild and Scenic River System; WSA=Wilderness Study Area.
Source: USFWS 2011c.

The alternatives considering managing areas as Wilderness areas and Wild River segments, as shown in Table 4–39, could limit activities that could occur within Arctic NWR, decrease the area within Arctic NWR in which UAF and NASA would be able to launch and recover sounding rockets, and limit the potential impacts of such launches on land use and recreation within Arctic NWR. Given this potential conflict, NASA has joined the USFWS project team as a formal cooperating agency and has provided information for the *Final CCP/EIS* regarding the potential effects of each alternative on its sounding rockets operations at PFRR.

It is not anticipated that implementation of Alternative A would have an effect on the continued launch of sounding rockets from PFRR. NASA would continue to conduct its missions such that there are no planned impacts within Mollie Beattie Wilderness Area, and through the UAF, would secure permission for landing and recovery of rocket hardware within the remaining areas of Arctic NWR on an as-needed basis.

Implementation of Alternative B would have a major adverse effect on NASA's ability to launch sounding rockets from PFRR. As shown below in **Figure 4–21**, the most commonly flown sounding rocket configurations within the past 10 years have been the BB-class and T-IOs, the trajectories of which would likely have a planned impact within the Brooks Range Wilderness Study Area (WSA). Therefore, assuming a launch rate of four rockets per year, the designation of the Brooks Range WSA as Wilderness could eliminate NASA's ability to fly an expected 28 of the 30 Arctic NWR landing missions within the 15-year planning horizon of the CCP.

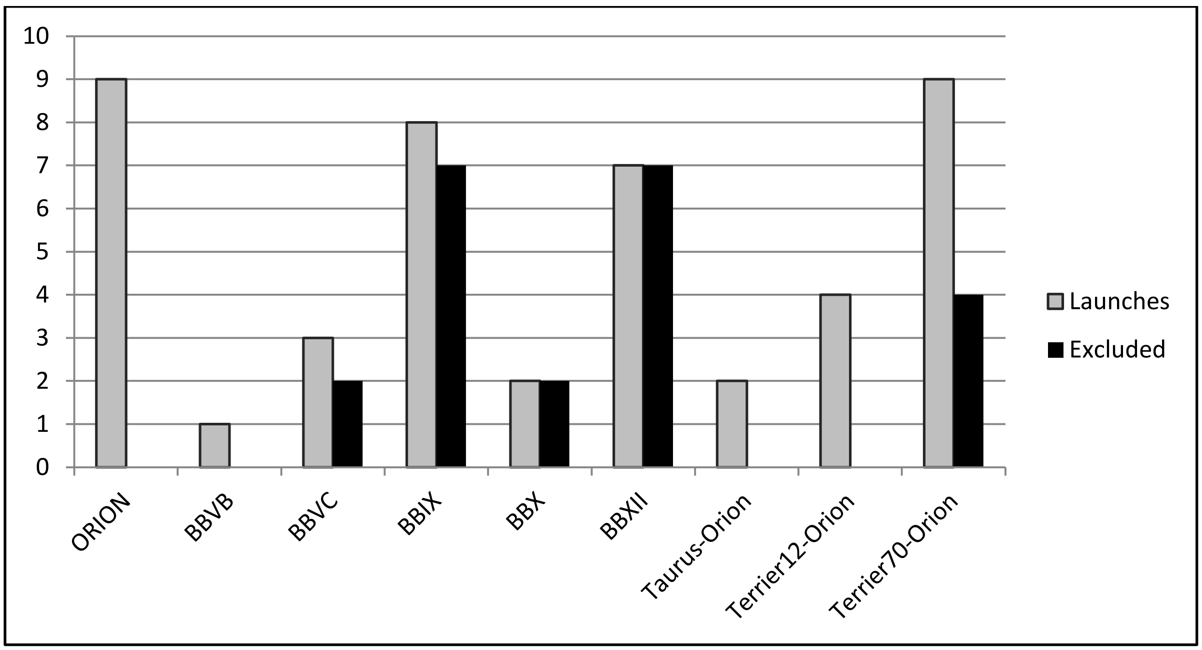


Figure 4–21. Sounding Rockets Launched from PFRR Within Last 10 Years and Those That Would Have Been Excluded by Designation of Brooks Range WSA

Considering that at least half of its future missions at PFRR would be excluded by implementation of this alternative, it is likely that NASA would discontinue funding PFRR's operations and maintenance altogether.

It is not expected that implementation of Alternative C would have an adverse impact on the continued launch of sounding rockets from PFRR. In general, planned impact locations within Arctic NWR are not further north of the Ivishak River; water landings in the Beaufort Sea/Arctic Ocean are generally not closer than 350 kilometers (220 miles) north of Barter Island.

As designation of the Coastal Plain WSA would likely restrict the future installation of certain infrastructure and the onset of commercial activities within the area, it could benefit SRP. The future year-round presence of high-value infrastructure and additional people within the PFRR launch corridor could place further restrictions on allowable missions due to mandatory flight safety considerations. Implementation of Alternative C could alleviate this possibility.

Alternative D's impacts on the NASA SRP would be similar in type but likely greater in magnitude to those discussed under Alternative B. Although there have been no planned impacts within the Porcupine Plateau WSA within the past 10 years of PFRR launches, the potential cannot be discounted. Therefore, it is possible that a currently unquantified number of moderate-range launches could be eliminated in addition to those affected by designation of the Brooks Range WSA. Accordingly, of all the alternatives under consideration, this alternative would likely have the greatest adverse effects on SRP.

Impacts on the NASA SRP from Alternative E would be the same as under Alternative D. It is not expected that the additional designation of the Coastal Plain WSA provided under this alternative would have a measurable positive effect on the program given that all rocket configurations having the capability to either overfly or land within the vicinity of the Coastal Plain (*e.g.*, BB X and XII) would also require authorization for spent rocket motors to impact within one of the lower-latitude WSAs, thereby precluding their flight.

OCS Oil and Gas Leasing – According to the *OCS Oil and Gas Draft PEIS* **(USDOI 2011b)** impacts on land use within the Beaufort Sea Planning Area would be minor to moderate from the development of new oil and gas leases within Beaufort Sea. Existing land use and infrastructure likely would be able to accommodate new leases. In general, land use changes would be needed only in locations where new onshore pipeline routes would be constructed, and in areas requiring new transportation networks. No cumulative effects from implementation of the *PFRR EIS* alternatives and the alternatives evaluated in the *OCS Oil and Gas Draft PEIS* are anticipated. No additional cumulative effects on land use are anticipated when combined with the potential impacts of the other actions in the cumulative effects ROI beyond those associated with the *Draft Revised Arctic CCP*.

4.15.8.4 *Differences Among Alternatives Under Consideration*

The No Action Alternative would contribute the most to long-term adverse cumulative effects on land use and recreation because it would not involve search and recovery for either historic or future PFRR-launched flight hardware unless dictated by scientific need. Given the sensitivity of downrange lands, and current requirements of downrange landowners to recover items, it is expected that continuation of the program under the No Action Alternative could lead to moderate to major cumulative effects on these resource areas. Alternative 1 would have lesser effects as it would entail a formal Recovery Program for all reported items, old and new. Alternatives 2 and 4, which would require recovery with consideration only to safety, could result in more frequent low-altitude aircraft flights, more short-term noise, and the potential for recovery-related impacts, such as ground scars or ruts. However, it is expected that more materials would be removed in the long term. Alternatives 3 and 5, which would extend the restriction on planned impacts on designated Wild Rivers within the PFRR launch corridor, and permit an environmentally conscious decisionmaking process to govern recovery decisions, would likely result in the least potential for adverse cumulative effects.

4.15.9 Visual Resources

4.15.9.1 *Resource Context*

The lands within the PFRR launch corridor are largely undeveloped and pristine, showing little sign of human activity except in villages.

4.15.9.2 *Past and Present Impacts*

PFRR Actions

The launching of sounding rockets from PFRR since 1969 has led to the impacting of rocket motors, payloads, and ancillary items within the PFRR launch corridor. Given the limited focus on search and recovery of these items in the past, much remains in downrange lands (see Section 4.12, Waste Management). For some users of the downrange lands, particularly those desiring a wilderness experience, encountering an item launched from PFRR could be considered an adverse impact on visual resources. However, to others, it could be viewed as a positive experience. In either case, the extent of the effect would be localized and confined to a small area immediately at and adjacent to the impact site.

Actions by Others

Past activities related to resource exploration, public use, and military operations have resulted in visible signs of human activity in areas that are otherwise in a natural condition. For example, scattered across downrange lands is an unquantified amount of debris (*e.g.,* drums, aircraft remains) from past activities. Additionally, a 1950s bulldozer trail parallels a section of the Coleen River within Arctic NWR. It is recovering and becoming less apparent from the ground; however, two abandoned tractor-trailers and other heavy debris are found along the trail. Along the coast, structures at the former Camden Bay, Beaufort Lagoon, and Demarcation Point DEW-Line sites have been removed, but gravel pads and some concrete foundations remain **(USFWS 2012)**.

General Land Management – The construction of support infrastructure in downrange lands has modified the landscape, however at a negligible scale when considered within the geographic extent of the cumulative effects analysis area. Yukon Flats NWR maintains three small radio repeater sites and one cabin at Canvasback Lake. Additionally, approximately 12 seasonal weather stations are deployed by the Alaska Fire Service on Yukon Flats NWR lands during the summer months. Several cabins have been constructed within Arctic NWR in the Old John Lake area and several other Native allotments. USFWS maintains two cabins on Big Ram Lake.

Recreational Use – In White Mountains NRA, summer ATV travel has historically occurred within White Mountains NRA with many trails visible for long distances from elevated locations **(USDOI 2012a)**.

Historic Placer Mining – Although some placer mining has been conducted in the past, particularly in the Nome Creek area, White Mountains NRA remains largely pristine, with no noticeable cumulative effects due to past or present activities.

Interior Oil and Gas Exploration – Other evidence of past effects on visual resources within the Yukon Flats Basin is associated with the cleared survey lines from past (1970 to 2001) seismic surveys. Approximately 175 hectares (430 acres) have been cleared along 286 kilometers (178 miles) of survey lines. The lines are still visible from the ground and air and portions of two of these seismic lines are within the recommended-Wilderness area in Yukon Flats NWR **(USFWS 2010a)**. Scattered sections of seismic trails from the 1984–1985 oil and gas exploration in Arctic NWR are visible, mostly from the air **(USFWS 2012)**.

Summary

The presence of visible signs of human activity within downrange lands would result in an adverse impact on the lands' otherwise natural visual resources; however, the extent of the impacts is localized when considered within the vast geographic area that composes the PFRR launch corridor. The duration of most past impacts are generally long-term, either in the form of a disturbance (such as the trail) which would require years of successional growth for the site to regain its natural character, or in the form of a semi-permanent facility such as a structure.

4.15.9.3 *Future Impacts*

PFRR Actions

With the recent focus on recovery of flight hardware from the lands within the PFRR flight corridor, it is possible that users of downrange lands could see a search or recovery aircraft, which to some would be considered an adverse impact. The sensitivity to witnessing a recovery-related helicopter flight would likely be greatest in Arctic NWR, where helicopter landings are infrequent. However, the duration of the sighting would be short-term. The geographic extent from which the aircraft or ground crew could be seen would be highly variable and a function of the elevation and ground cover at both the recovery site and the vantage point of the observer. Based upon an assessment of the past 10 years of flight records, it would not be likely for items to land within the areas of greatest recreational uses (see Section 4.8), which would limit the potential for interaction.

Given the approximately 50 percent success rate of locating newly launched stages and payloads from downrange lands, it is expected that some flight hardware would remain in downrange lands following each successive launch season. Therefore, similar to the discussion regarding the effects of past launches, long-term adverse cumulative effects on visual resources would be anticipated; however, the geographic extent of the impact would be local.

Actions by Others

BLM Eastern Interior RMP – Under BLM's preferred alternative, approximately 33 percent of White Mountains NRA would be managed as VRM Classes I and II, which would be expected to provide continuing long-term benefits to visual resources.

Interior Oil and Gas Exploration – Visual resources would be affected by the clearing of vegetation for seismic survey lines and access trails, or for ice pads for exploratory drilling. These clearings would be visible from the air and from the ground and would contrast markedly from the surrounding lands in forested areas, thereby adversely affecting visual resources. The effects would be additive due to the length of time required for regrowth of the vegetation, which can be multiple decades in forested areas. The clearings would be spread over several hundred thousand acres in the Arctic NWR and would be visible for several miles from the air. These effects would be masked in areas burned by wildland fires before or after the surveys.

4.15.9.4 *Differences Among Alternatives Under Consideration*

The No Action Alternative would contribute the most to long-term adverse cumulative effects on visual resources because it would not involve search and recovery for either historic or future PFRR-launched flight hardware unless dictated by scientific need. Given the sensitivity of downrange lands, it is expected that continuation of the program under the No Action Alternative could lead to moderate to major effects on these resource areas. Alternative 1 would have lesser effects as it would entail a formal Recovery Program for all reported items, old and new. Alternatives 2 and 4, which would require recovery with consideration only to safety, could result in more frequent low-altitude aircraft flights, more short-term noise, and the potential for recovery-related impacts, such as ground scars or ruts. However, it is expected that more materials would be removed in the long term. Alternatives 3 and 5, which would extend the restriction on planned impacts on designated Wild and Scenic Rivers within the PFRR launch corridor, and permit an environmentally conscious decisionmaking process to govern recovery decisions, would likely result in the least potential for adverse cumulative effects.

4.15.10 Water Resources

4.15.10.1 *Resource Context*

Though water quality data are generally limited for the vast number of wetlands, lakes, rivers, and streams within the PFRR launch corridor, it is generally accepted that water quality is good **(USDOI 2012a; USFWS 2012)**. Designated Wild Rivers within the PFRR launch corridor (from south to north) are Beaver Creek within White Mountains NRA and Yukon Flats NWR, and the Sheenjek, Wind, and Ivishak Rivers within Arctic NWR.

4.15.10.2 *Past and Present Impacts*

PFRR Actions

Historic launches from PFRR have likely landed within downrange water resources, likely resulting in localized degradation of water quality immediately adjacent to the impact site. Stages or payloads that have landed within designated Wild River corridors could also detract from the natural, undisturbed setting of the area; however, the extent of the impact would be localized. Recent reports from recreational users of downrange lands, notably Arctic NWR, have reported spent rocket stages within the Wind River corridor; however, those items were removed by PFRR during summer 2011. **Table 4–40** presents the calculated probabilities of impact within each respective Wild River for the past 10 years of launches; this timeframe was selected as it contains the most accurate dataset of planned impact locations for which probabilities of impact could be calculated.

Table 4–40. Probability of Impact Within Wild River Corridors over the Past 10 Years

Vehicle	Mission	Ivishak River		Wind River		Sheenjek River		Beaver Creek	
		Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)
Black Brant V	21128			0.3	301	0.0	11,272		
	21131			0.0	953,380			0.0	1,990,565
	21138	0.0	8,151	6.4	16	0.0	382,146		
	21139			0.0	27,997	0.2	446		
Orion	30044							7.9	13
	30047							10.2	10
	30049							6.5	15
	30050							6.5	15
	30051							3.7	27
	30052							7.9	13
	30058							7.9	13
	30059							7.9	13
	30073							12.0	8
Black Brant X	35034			0.7	141				
	35037			1.0	105				
Black Brant IX	36200	0.0	1,907,378	1.1	92	0.0	357,654		
	36206			0.4	236	0.0	31,319		
	36234			7.5	13				
	36242	0.3	335	0.1	672	2.5	41		
	36256	0.0	40,304,704	0.7	139	0.0	3,399,279		
	36257	0.0	81,064	2.0	50	0.0	142,584		
	36278	0.0	32,634,945	0.7	152	0.0	3,440,328		

Table 4–40. Probability of Impact Within Wild River Corridors over the Past 10 Years (*continued*)

Vehicle	Mission	Ivishak River		Wind River		Sheenjek River		Beaver Creek	
		Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)
Black Brant XII	40014	9.2	11	7.1	14	0.0	560,884		
	40016	2.8	36	6.8	15	0.0	457,917		
	40017	5.3	19	3.6	28	0.0	29,526		
	40019	3.1	33	6.5	15	0.0	254,634		
	40020	4.0	25	5.9	17	0.0	479,823		
	40023	3.2	32	4.8	21	0.0	40,414		
	40025	2.3	43	5.0	20	0.0	46,098		
Terrier-Improved Orion	41028	0.0	4,528,370	1.3	75	0.2	565		
	41029			0.0	3,394,548				
	41034	0.0	1,588,487	1.6	62	0.2	466		
	41061	0.0	7,122,000	0.2	502				
	41062	16.3	6	29.8	3				
	41063	0.0	222,010	0.0	6,350	1.7	58		
	41064	0.4	249	10.6	9	0.0	91,676		
	41065	0.6	167	10.2	10	0.0	31,589		
	41076-41084								

a. Blank cells indicate that calculated value was below reporting threshold of software.

Actions by Others

Minor cumulative effects on water resources have occurred over time from activities within the PFRR launch corridor. These include effects on water movement and quality from the construction of roads, airstrips, building pads, and other infrastructure associated with villages, and from untreated sewage **(USFWS 2010a)**.

Recreational Use **–** Cross-country summer use of OHVs can occur on up to 61 percent of the White Mountains NRA and has the potential to contribute to adverse impacts on water quality **(USDOI 2012a)**. ATVs can disturb sediments, leading to sediment-laden runoff during storm events. During non-winter months, the use of snowmobiles on downrange lands can result in the deposition of petroleum products, particularly within and immediately adjacent to well-used trails.

Historic Placer Mining – Historical placer mining in Nome Creek, a tributary to Beaver Creek Wild River, resulted in the destruction of approximately 11 kilometers (7 miles) of the stream channel, floodplain, and riparian areas. Additionally, the exposed mine tailings cause excessive sediment transport and are the principal source of sediment carried to Beaver Creek. In 1991, BLM initiated a program to reclaim the headwaters of Nome Creek and restore its associated riparian habitat. To date, a total of over 6 miles of Nome Creek have been reconstructed and stabilized and over 120 hectares (300 acres) of floodplain have been created during the project.

4.15.10.3 *Future Impacts*

PFRR Actions

The future probabilities of sounding rocket flight hardware landing within Wild and Scenic River corridors would likely be similar to those shown for the past 10 years in **Table 4–41**. The vehicle with the greatest likelihood of landing within Beaver Creek would be the single-stage Orion, the launch of which is possible; however, it is expected to be infrequent due to the consistent specification of longer-range rockets by PFRR-supported researchers. Impacts on the Sheenjek River from most launches would be negligible; however, it is possible that several missions could have a minor probability of impact if the scientific objectives dictated a flight along a more northeasterly trajectory. Potential impacts within the Wind and Ivishak Rivers would be highly variable with the moderate range two-stage rockets (*e.g.*, T-IO, BB IX), as evidenced by the probabilities from the past 10 years. Given the mandatory safety buffers from the Trans-Alaska Pipeline on the west and Arctic Village to the east, launching the BB XII would be expected to present similar probabilities of impact on both rivers, generally ranging from 2 to 10 percent.

Table 4–41. Wild Rivers Being Considered by the Arctic National Wildlife Refuge

Alternative	Wild Rivers
A	No new rivers would be recommended for Wild River designation. Arctic NWR would use existing management tools to maintain values on the Atigun, Hulahula, Kongakut, and Marsh Fork Canning Rivers.
B	The Hulahula, Kongakut, and Marsh Fork Canning Rivers would be recommended for inclusion in NWSRS as Wild Rivers. Arctic NWR would use existing management tools to maintain values for the Atigun River.
C	The Atigun River would be recommended for inclusion in NWSRS as a Wild River. Arctic NWR would use existing management tools to maintain values for the Hulahula, Kongakut, and Marsh Fork Canning Rivers.
D	The Atigun, Hulahula, Kongakut, and Marsh Fork Canning Rivers would be recommended for inclusion in NWSRS as Wild Rivers. Only those portions of the Hulahula River managed by Arctic NWR would be included in the recommendation.
E	The Atigun, Hulahula, Kongakut, and Marsh Fork Canning Rivers would be recommended for inclusion in NWSRS as Wild Rivers.
F	No new rivers would be recommended for Wild River designation. Arctic NWR would use existing management tools to maintain values on the Atigun, Hulahula, Kongakut, and Marsh Fork Canning Rivers.

Key: NWR=National Wildlife Refuge; NWSRS=National Wild and Scenic River System.
Source: USFWS 2011c.

Actions by Others

BLM Eastern Interior RMP – Although Alternative B in the *Draft RMP/EIS* would recommend Fossil Creek as "scenic," it is not BLM's preferred alternative, and will not be further considered in this section.

As BLM's preferred alternative would entail an increased development of visitor facilities within White Mountains NRA, minor adverse impacts on water quality could result during land-disturbing construction activities. However, it is expected that seasonal travel restrictions on OHVs would reduce the level of impact on water resources that is currently occurring. It is also expected that the effects of user-made trails would be substantially reduced **(USDOI 2012a)**.

Interior Oil and Gas Exploration – Cumulative effects on water resources from oil and gas exploration could include disturbances to soil, water, and vegetation from seismic surveys, which could lead to increased erosion and sedimentation in rivers and lakes; removal of water from lakes for ice pads and drilling; and small leaks or spills of fuels or lubricants during the use of petroleum-powered equipment. Such effects would be minimized by requirements to conduct such work during winter months when the ground and surface waters are frozen. Although there are no such requirements for work conducted on private lands, many of the downrange lands within the PFRR launch corridor are owned by either the Federal or state government, both of which have established protocols to minimized environmental impacts. For example, on state lands on Alaska's North Slope, ADNR requires that there be 15 centimeters (6 inches) of frost and 15 centimeters (6 inches) of snow before overland tundra travel can occur. On other State of Alaska lands in the interior, permits issued by ADNR for exploration stipulate that there must sufficient depth of snow and ice to protect the ground surface.

Arctic Refuge Revised CCP **–** Alternatives evaluated in the *Draft Revised Arctic CCP* **(USFWS 2011c)** could affect Wild River segments within the PFRR launch corridor (see Chapter 3, Section 3.3.2). Proposed changes being considered by Arctic NWR are presented in Table 4–44. Should these rivers be managed as Wild Rivers, it could limit some launch trajectories (as proposed for Alternatives 3 and 4 of this *PFRR EIS*) for future launches from PFRR. In particular, the designation of river segments outside of Mollie Beattie Wilderness Area (*e.g.,* Atigun and Marsh Fork) could result in potential use conflicts similar to those discussed in Section 4.15.5. However, given the proximity of the Atigun River to the Trans-Alaska Pipeline and in consideration of mandatory range safety requirements, it is not expected that a planned impact point would be located in its vicinity. In relative terms, the Marsh Fork of the Canning River would have a higher likelihood of a sounding rocket stage or payload landing within it; however, given its smaller size and the dispersion of rockets that would be expected to land within that area, the probabilities would be lower than those calculated for the nearby Wind and Ivishak Rivers. Designation of the other proposed rivers (*i.e.,* Hulahula, Kongakut) would not have a measurable impact on the NASA SRP as they are within an area that is already avoided during mission planning (*i.e.,* Mollie Beattie Wilderness Area).

OCS Oil and Gas Leasing **–** The proposed OCS Oil and Gas Leasing Program provides a schedule for offshore oil and gas exploration and development lease sales spanning from 2012 to 2017. For the program period, one sale is scheduled for 2015 in the Beaufort Sea **(USDOI 2011c)**. The OCS *Oil and Gas Draft PEIS* **(USDOI 2011b)** found that routine lease exploration and development activities near construction sites within the Beaufort Sea would result in minor to moderate, short-term, localized water quality impacts (sedimentation and increased turbidity) primarily from operational discharges. Should offshore oil and gas exploration begin in areas of the Beaufort Sea within the PFRR launch corridor, it could possibly limit future launch trajectories from PFRR.

4.15.10.4 *Differences Among Alternatives Under Consideration*

It is expected that all five alternatives would contribute similarly to cumulative effects on water resources. In relative terms, it is likely that the No Action Alternative would have the greatest potential effects due to the infrequent recovery actions that it would entail; therefore, the greatest quantities of wastes would remain in downrange lands, which could result in a localized reduction in water quality at aqueous impact sites. Alternative 1 would have fewer adverse effects as stages and payloads would be removed when deemed environmentally responsible. Alternative 2 would have fewer long-term cumulative effects, as more items would be removed from downrange lands. Short-term impacts (*e.g.,* turbidity from recovery) could be greater than Alternative 1 due to more intense recovery efforts; however, in either case impacts would be expected to be negligible due to the limited extent of an impact site. Alternatives 3 and 4 would likely have the least additive effects on water resources, as they would require restricted trajectories such that no planned impacts would occur within designated Wild and Scenic River corridors.

4.15.11 Ecological Resources

4.15.11.1 *Resource Context*

The PFRR launch corridor is home to a diverse array of plants, fish, and resident and migratory wildlife species. Wildlife abundance is highest during non-winter months.

4.15.11.2 *Past and Present Impacts*

PFRR Actions

Ground-disturbing activities (and resulting effects on vegetation) associated with past operations have been minimal due to the limited focus on recovery of stages and payloads. Likewise, noise and visual disturbances to wildlife from aircraft overflights have been minimal.

Actions by Others

Interior Oil and Gas Exploration – In the Yukon Flats Basin, past seismic surveys have resulted in clearing of vegetation on about 175 hectares (430 acres) along 286 kilometers (178 miles) of survey lines. These lines are still visible, and may be having some effect on the habitat value to wildlife. Researchers have reported that boreal birds appear resistant to the edge/habitat fragmentation effects associated with forest clearing, and studies in boreal forests have found no effects on bird populations or bird densities from seismic lines **(USFWS 2010a)**. Moreover, the small size of the disturbance in relation to the amount of available habitat for all species leads to the conclusion that adverse cumulative effects, while long term, would be minor.

4.15.11.3 *Future Impacts*

PFRR Actions

Continuation of sounding rocket launches at PFRR would result in negligible adverse impacts on vegetation from either crushing or clearing during recovery activities; the extent of the impact would be limited to the area immediately adjacent to the impact site. It is expected that successional processes would result in the re-establishment of ground cover shortly thereafter.

Short-term noise and visual disturbances on wildlife would be expected primarily from search and recovery activities; however, impacts would be limited in extent.

Actions by Others

BLM Eastern Interior RMP – BLM's preferred alternative in its *Draft RMP/EIS* would permit a slight increase in the area in which summer OHVs would be allowed within White Mountains NRA; however, all would be required to operate on designated trails, which would considerably reduce adverse effects on both vegetation and wildlife. Primitive camping would be allowed within designated Research Natural Areas (RNAs), which could result in greater disturbance of wildlife species in those areas; however, effects would be minor. During winter months, a provision to monitor snowmobile use within non-forested caribou habitat and adjust management as needed would benefit the species **(USDOI 2012a)**.

Interior Oil and Gas Exploration – Adverse cumulative effects on vegetation would be expected due to the clearing necessary to perform seismic surveys or establish exploratory wells. The time required to re-establish pre-existing cover would depend upon the vegetative community, and could take multiple decades in the case of forested areas. A complicating factor in estimating the required timeframe for recovery is the frequency of wildfires in the Yukon Flats, which could possibly interrupt or reset the process of succession **(USFWS 2010a)**. Direct impacts on migratory birds would also be minimized because most activities would be expected to occur during late winter outside of the prime migration window of most species. However, raptors migrate to the Yukon Flats in mid- to late-April and waterfowl species, such as mallard and northern pintail, arrive in late April **(USFWS 2010a)**. Short-term, localized disturbance may occur to wildlife (*e.g.,* wolf, moose) in the area of the activities. For example, wildlife may scatter and be displaced during detonation of explosives or when helicopters are low to the ground. However, any displacement would likely be short-term and on a localized scale.

Arctic Refuge Revised CCP – The alternatives presented in the *Draft Revised Arctic CCP* consider the designation of additional areas within Arctic NWR to be managed as Wilderness, Wild and Scenic Rivers, and minimal management areas **(USFWS 2011c)**. These changes in land use designation and management are expected to have beneficial or neutral effects on biological resources.

OCS Oil and Gas Leasing – The potential leasing of the waters offshore of Kaktovik for oil and gas exploration would occur in the same general area where BB XII payloads and final spent stages could land. The effects of the PFRR activities would be negligible in comparison to the considerable human, boat, aircraft, seismic exploration, and exploratory drilling activities, as well as the potential spills or other environmental contamination that could be associated with the OCS oil and gas exploration in the region and would not contribute appreciably to cumulative effects.

4.15.11.4 *Differences Among Alternatives Under Consideration*

In relative terms, Alternative 2 and 4 would likely contribute the most to potential cumulative effects on ecological resources where they would entail the greatest recovery effort. Their implementation could result in more frequent low-altitude aircraft flights, more short-term noise, and the potential for recovery-related impacts, such as ground scars or ruts. Alternative 1 would contribute fewer effects as it would enable certain items to be left in place if an attempted recovery would be more intrusive than leaving the item in place. Alternative 3, which would extend the restriction on planned impacts to designated Wild Rivers within the PFRR launch corridor, and permit an environmentally conscious decisionmaking process to govern recovery decisions, would likely result in the least potential for adverse cumulative effects. The No Action Alternative would contribute the least to adverse cumulative short-term disturbance due to its very limited search and recovery effort.

In summary, potential adverse impacts on ecological resources from either alternative would be infrequent and negligible in extent when compared to other actions considered in the cumulative effects analysis. Therefore, the project would not contribute appreciably to cumulative effects of other projects in the region.

4.15.12 Waste

4.15.12.1 *Past and Present Impacts*

PFRR Actions

Spent Stages and Payloads **–** Currently, there are no non-NASA launches occurring at PFRR, nor are any planned for the future. However, 116 non-NASA launches occurred from 1969 to 1995 **(UAF 2011c)**. These launches deposited approximately 64,000 kilograms (141,000 pounds) of material into the launch corridor. Thirty-four payloads were retrieved, resulting in the removal of approximately 9,900 kilograms (22,000 pounds) of material. Therefore, approximately 55,000 kilograms (121,000 pounds) remain in the launch corridor.

As discussed in Section 4.12, approximately 126,000 kilograms (278,000 pounds) of spent stages and payloads are estimated to remain in the launch corridor from past NASA launches with the majority of this material located within the special use areas designated by ADNR. Therefore, a combined total of approximately 181,000 kilograms (399,000 pounds) of payloads and spent stages remain in the launch corridor from past NASA and non-NASA launches. **Table 4–42** presents a summary of the PFRR-launched items estimated to remain in downrange lands.

Table 4–42. Summary of Flight Hardware Estimated to Remain in Downrange Lands

Distance (km)	Location[a]	NASA		Non-NASA		Total		Percent of Total	
		Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]
0–12	State of Alaska - PFRR Special Use	202	0	93	1	295	1	44%	<1%
12–80	BLM - White Mountains NRA	50	23	31	23	81	46	12%	18%
80–250	USFWS - Yukon Flats NWR	46	33	34	18	80	51	12%	20%
250–550	USFWS - Arctic NWR[d]	76–89	46–54	4	2	80–93	48–56	12–14%	19–22%
250–350	Native Village of Venetie[d]	19–25	12–15	1	1	20–26	13–16	3–4%	5–6%
250–350	State of Alaska[d]	19–25	12–15	1	1	20–26	13–16	3–4%	5–6%

Table 4–42. Summary of Flight Hardware Estimated to Remain in Downrange Lands (*continued*)

Distance (km)	Location[a]	NASA		Non-NASA		Total		Percent of Total	
		Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]
Over 550	Beaufort Sea/Arctic Ocean	34	34	0	0	34	34	5%	14%
Unknown[e]		2	1	43	35	45	36	7%	14%
Total		**461**	**168**	**207**	**81**	**589[b]**	**249**		

a. While possible that flight hardware may be located on other private or Village lands, it is expected that the majority of items are within the lands shown in this table.

b. Only the final Total figure reflects those spent stages recovered in the past (n=77) as specific detail regarding land parcel or sponsoring agency (*i.e.*, NASA versus Non-NASA) is not available; the figures presented for each land parcel should therefore be considered a maximum case.

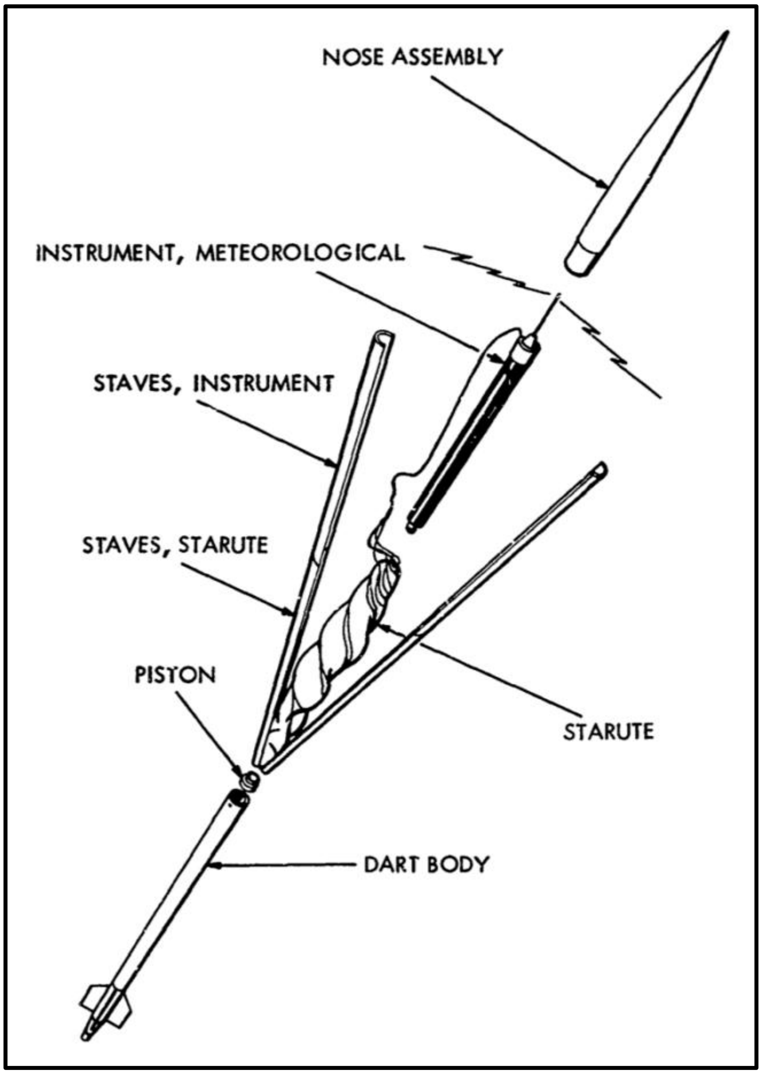
c. Figures presented account for payloads known to have been recovered (NASA 50; non-NASA 35).

d. Assumes between 60 and 70 percent of stages at this distance are within Arctic NWR, with remaining items split equally.

e. Indicates that neither mission-specific nor general vehicle performance data were available.

Key: km=kilometers; PFRR=Poker Flat Research Range; BLM=U.S. Bureau of Land Management; NWR=National Wildlife Refuge; NRA=National Recreation Area; USFWS=U.S. Fish and Wildlife Service.

Meteorological Rockets **–** The U.S. Army's meteorological rocket program at PFRR launched an estimated 1,400 Super Loki Darts during its 9-year tenure (see **Figure 4–22**). The rocket motor for these vehicles consisted of a 2-meter-long (6.5-feet-long), 10-centimeter-diamter (4-inch-diameter) aluminum casing filed with solid propellant. The 1.3-meter-long (4.3-feet-long), 5 centimeter-diameter (2 inch-diameter) steel non-propulsive second stage contained a small (about 1 pound) parachuted transponder payload which upon release provided data to a ground station. Power for the instrument was provided by an 8-ounce nickel cadmium battery pack. Nearly all launches were along an easterly trajectory. **Table 4–43** provides a summary of the material that is estimated to remain in downrange lands.



Source: Bollerman *et al.* 1972.

Figure 4–22. Meteorological Rocket Flown from PFRR in the 1970s (does not show booster)

Table 4–43. Meteorological Rocket Hardware Estimated to Remain in Downrange Lands

Item	Weight Each (kilograms)	Items Launched	Cumulative Weight (kilograms)	Downrange Distance (kilometers)	Landowner
Expended Booster	6	1,400	8,400	0.5	State of Alaska
Instrumented Dart	8	1,400	11,200	45–55	State of Alaska

Launch Support Items – In the early years of PFRR's operations, and specifically regarding non-NASA launches, mid- and upper-level meteorological balloons carrying a small piece of aluminum foil "chaff" were used (see **Figure 4–23**). For the NASA launches, it was assumed that the bulk of balloons were carrying "chaff" with the exception of a middle and upper-level balloon that carried a foil-covered polystyrene foil target (see **Figure 4–24**) during each night of countdown. It has only been within approximately the last five launch seasons that the GPS radiosonde instruments have been flown on the mid- and upper-level balloons. The small folding fin test rockets, which are used to calibrate radar systems prior to launch, have historically been flown at a frequency of 1–2 per night counting.

Figure 4–23. Typical Aluminum Foil "Chaff" Historically and Currently Flown During Countdown

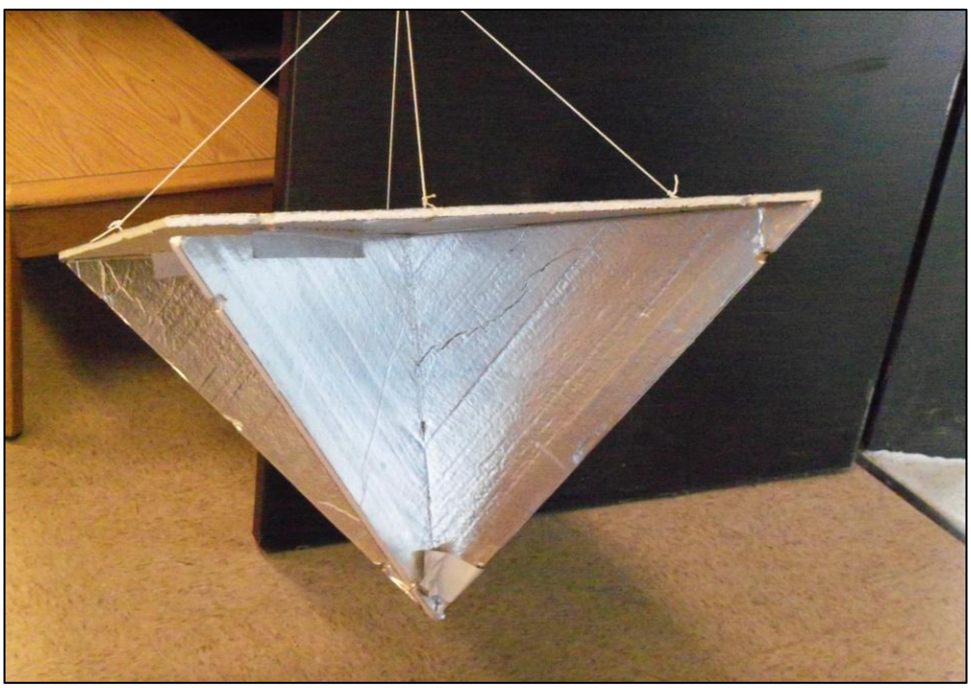


Figure 4–24. Radar Target Historically Flown During Countdown

As latex is a biodegradable material, it is assumed that all latex items older than 2 years have already degraded. The polystyrene items and test rockets, which would not be expected to undergo any measurable form of degradation, are assumed to remain in downrange lands. **Table 4–44** below provides a summary estimate of launch support items flown from PFRR since its inception and the weight of those items expected to remain in downrange lands.

Table 4–44. Past Launch Support Items and Estimated Weights in Downrange Lands

Item	Weight Each (kg)	Items Per Launch[a]	Launches Supported[b]	Cumulative Weight (kg)	Downrange Distance (km)	Landowner
NASA Launches						
"Chaff" Latex Balloon	0.1	120	172	2,064	50–80	State of AK or BLM
Mid-Altitude Latex Balloon	0.3	10	172	516	80–100	State of AK, BLM, or USFWS YFNWR
High-Altitude Latex Balloon	1.2	10	172	2,064	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Polystyrene Items	0.25	20	14	70	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Foil-Covered Polystyrene Radar Target	0.225	20	158	711	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Test Rocket	6.8	15	172	17,544	4–5	State of AK
Mid-Altitude Latex Balloon with Foil	0.3	180	116	6,264	80–100	State of AK, BLM, or USFWS Yukon Flats NWR
High-Altitude Latex Balloon with Foil	1.2	20	116	2,784	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Test Rocket	6.8	15	116	11,832	4–5	State of AK

Table 4–44. Past Launch Support Items and Estimated Weights in Downrange Lands (*continued*)

Item	Weight Each (kg)	Items Per Launch[a]	Launches Supported[b]	Cumulative Weight (kg)	Downrange Distance (km)	Landowner
Summary (kg)						
Latex Balloons Launched	–	–	–	13,692		
Less Latex Degradation	–	–	–	(13,557)		
Remaining Latex	–	–	–	135	50–160	State of AK, BLM, or USFWS Yukon Flats NWR
Polystyrene Items	–	–	–	781	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Test Rockets	–	–	–	29,376	4–5	State of AK

a. Each launch requires 10 days of countdown with a 6-hour launch window.

b. When multiple launches occurred on the same day (n=44), data collected by launch support items are “shared” among all launches.

Notes: To convert kilograms to pounds, multiply by 2.2046; kilometers to miles, by 0.6214.

Key: AK=Alaska; BLM=U.S. Bureau of Land Management; kg=kilograms; km=kilometers; NWR=National Wildlife Refuge; USFWS=U.S. Fish and Wildlife Service.

Actions by Others

Past activities related to public use, military operations, and other agencies and institutions have resulted in the deposition of an unquantified amount of miscellaneous debris on downrange lands. Items could include steel drums and refuse from abandoned camps, and mining operations. Much of this debris is expected to have originated prior to 1980 when ANILCA provided additional protections to much of the PFRR launch corridor.

4.15.12.2 *Future Impacts*

PFRR Actions

Spent Stages and Payloads **–** Under the No Action Alternative, taking into account the materials associated with an average of four launches per year and the removal of one payload per year, a net quantity of approximately 2,400 kilograms (5,300 pounds) of material would be deposited annually in downrange lands outside of the Poker Flat North and South Special Use Areas (see Section 4.12 for details on the number of payloads and spent stages recovered under each alternative). Under Alternatives 1 and 3, a net quantity ranging from a 500 kilogram (1,100 pounds) reduction up to a 900 kilogram (2,000 pounds) increase could occur within the these same lands. Under Alternatives 2 and 4, the estimated net change could range from a net reduction of up to 1,200 kilograms (2,650 pounds) or an increase of 100 kilograms (220 pounds); the actual quantity within these ranges would depend upon how successful PFRR would be in locating newly launched items.

Launch Support Items **–** It is expected that meteorological support requirements for future launches would remain the same as in the recent past. As such, low-altitude "chaff," medium- and high-altitude latex balloons would be flown, with the medium- and high-altitude configurations carrying the polystyrene-encased GPS radiosonde sensors. A summary of these items expected to remain in downrange lands is presented below in **Table 4–45**.

Table 4–45. Estimated Weights of Future Launch Support Items in Downrange Lands

Item	Weight Each (kg)	Items Per Launch[a]	Weight Per Year[b] (kg)		Downrange Distance (km)	Landowner
			4 Launches	8 Launches		
"Chaff" Latex Balloon	0.1	120	48	96	50–80	State of AK or BLM
Mid-Altitude Latex Balloon	0.3	10	12	24	80–100	State of AK, BLM, or USFWS Yukon Flats NWR
High-Altitude Latex Balloon	1.2	10	48	96	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Polystyrene Items	0.25	20	20	40	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Test Rocket	6.8	15	408	816	4–5	ADNR Poker Flat North and South Special Use Areas
10-year Summary[b] (kg)						
Latex Balloons			1,080	2,160	50–160	State of AK, BLM, or USFWS Yukon Flats NWR
Latex Degradation			(972)	(1,944)		
Net Latex Remaining			108	216	50–160	State of AK, BLM, or USFWS Yukon Flats NWR
Polystyrene Items			200	400	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Test Rocket			4,080	8,160	4–5	ADNR Poker Flat North and South Special Use Areas

a. Each launch requires 10 days of countdown with a 6-hour launch window.

b. Estimates in this table do not include instances when several launches would occur on the same day, which would reduce the presented weights as launch support items would be "shared" among all those launches.

Note: To convert kilograms to pounds, multiply by 2.2046; kilometers to miles, by 0.6214.

Key: ADNR=Alaska Department of Natural Resources; AK=Alaska; BLM=U.S. Bureau of Land Management; kg=kilograms; km=kilometers; NWR=National Wildlife Refuge; USFWS=U.S. Fish and Wildlife Service.

Actions by Others

Recreational Use – Given the growing recreational user base in downrange lands, it is possible that miscellaneous debris could be deposited in the future; however, it cannot be estimated quantitatively.

Arctic Refuge Revised CCP – An objective of the *Draft Revised Arctic CCP* is to expand the Arctic NWR's efforts to restore sites that have historically been impaired or degraded. Actions include removing trash, barrels and contaminants, rehabilitating extensively impaired camp sites, cleaning up abandoned cabin sites and hunting guide camps; and removing downed civilian aircraft, military aircraft and debris, and items left by NASA SRP **(USFWS 2012)**.

Given the commitment of the Arctic NWR to removing debris from its lands, and the ongoing relationship that NASA, UAF, and USFWS staff have developed in identifying and removing flight hardware from downrange lands, it is expected that the effort would have a long-term beneficial impact on the quantities of waste remaining in downrange lands.

4.15.12.3 *Differences Among Alternatives Under Consideration*

Among the five alternatives, the amount of launch-related waste (*e.g.*, stages, payloads, launch support items) initially deposited in downrange lands would be the same; the key difference is the level of search and recovery planned following a launch. The No Action Alternative would contribute the most to long-term adverse cumulative effects on the deposition of waste on downrange lands because it would not involve search and recovery for either historic or future PFRR-launched flight hardware unless dictated by scientific need. Given the sensitivity of downrange lands, it is expected that continuation of the program under the No Action Alternative could lead to moderate to major effects on these resource areas. Alternative 1 would have lesser effects, as it would entail a formal Recovery Program for all reported items, old and new. Alternative 3, which would extend the restriction on planned impacts to designated Wild and Scenic Rivers within the PFRR launch corridor, would have similar effects to Alternative 1. Alternatives 2 and 4, which would require recovery with consideration only to safety, would likely result in the most waste removed from downrange lands over time, and would likely contribute the least to long-term adverse cumulative effects. **Table 4–46** provides a comparative summary of the estimated weights of sounding rocket-related items in downrange lands at year 10 of the cumulative effects analysis period.

Table 4–46. Estimated Weights of Sounding Rocket-Related Items in Downrange Lands at Year 10 of Cumulative Effects Analysis Period

Spent Rocket Motors and Payloads[a]						
			Alternatives 1 and 3		Alternatives 2 and 4	
Land Parcel	Past and Present	No Action	50% Location Success	100% Location Success	50% Location Success	100% Location Success
ADNR Poker Flat North and South Special Use Areas	116,180	138,180	130,011	130,011	119,011	119,011
White Mountains NRA	15,043	27,243	19,303	13,203	17,463	11,363
Yukon Flats NWR	20,763	27,163	24,492	19,492	21,520	16,520
Arctic NWR	22,025	27,425	23,081	20,381	21,437	18,737
Native Village of Venetie	4,720	4,720	4,720	4,720	3,020	3,020
State of Alaska	4,720	4,720	4,720	4,720	4,720	4,720
Beaufort Sea	13,396	22,276	22,276	22,276	22,276	22,276
Unknown	8,519	8,519	8,519	8,519	8,519	8,519
Total All Areas	**180,365**	**235,245**	**212,121**	**198,321**	**192,966**	**179,166**
Total Interior Lands Only	166,969	212,969	189,845	176,045	170,690	156,890
Total Lands Excluding ADNR Poker Flat North and South Special Use Areas	**50,789**	**74,789**	**59,834**	**46,034**	**51,679**	**37,879**

Launch Support Items Applicable to all Alternatives			
Land Parcel	Latex from Balloons	Polystyrene Items	Test Rocket
ADNR Poker Flat North and South Special Use Areas	0	0	33,456–37,536
State of Alaska East of PFRR, White Mountains NRA, or USFWS Yukon Flats NWR	108–216	981–1,381	0

a. Totals reflect approximately 25,000 kg of stages removed in the past whereas individual land parcels do not; therefore, weights calculated for individual parcels should be considered a maximum case.

Key: ADNR=Alaska Department of Natural Resources; NRA=National Recreation Area; NWR=National Wildlife Refuge; PFRR=Poker Flat Research Range; USFWS= U.S. Fish and Wildlife Service.

4.15.13 Noise

4.15.13.1 *Resource Context*

With the exception of the lands immediately adjacent to Villages, the sounds within the PFRR launch corridor are generally dominated by those produced by natural forces, including wind, flowing water, insects, and wildlife. Transient human-caused noise from aircraft would be highest along well-used river corridors and in areas used as flight paths to common landing areas.

4.15.13.2 *Past and Present Impacts*

PFRR Actions

Past and current launches from PFRR have resulted in temporary noise impacts from both sounding rocket flight and occasional recovery actions. However, as most launches have historically occurred during the winter months, when both recreational and subsistence use, as well as wildlife presence is lowest, adverse impacts have most likely been negligible and short term.

Actions by Others

General Land Management **–** Landowner and resource agency aviation contributes to occasional disruption of the natural soundscape of downrange lands; however, the effects are temporary.

Recreational Use **–** The recreational use of ATVs and outboard motors on downrange lands contributes to cumulative noise on downrange lands during non-winter months, particularly on BLM lands where maintained trails are readily available for users. The use of snowmobiles during winter months also produces noticeable anthropogenic noise.

Interior Oil and Gas Exploration **–** Likely the greatest noise-producing action in the past and present would be associated with Interior Oil and Gas exploration. The airborne transportation of equipment and personnel, as well as the sounds generated from mulching, borehole drilling, and the detonation of small explosive charges, could result in additive impacts when such operations are taking place before, during, or immediately after a launch campaign. However, due to the relatively low extent of the exploration, and that most activities would take place during winter months when ground conditions are most favorable for exploration, additive impacts would be minor and short-term.

4.15.13.3 *Future Impacts*

PFRR Actions

Future sounding rocket launches from PFRR would generate short-term noise during the boost and reentry stages of flight; however, as discussed in Section 4.5, these sounds would be audible to receptors on the ground for less than 1 minute per flight. Also, as launches would be expected to occur during winter months, effects would be negligible. The most notable potential change in future operations would be the greater focus on search and recovery of previously launched stages and payloads and those to be launched in the future, which would occur during non-winter months.

Actions by Others

Interior Oil and Gas Exploration **–** Similar in nature to the impacts of past operations, future oil and gas exploration could result in additive impacts on noise when such operations were taking place before, during, or immediately after a launch campaign. However, due to the relatively low extent of the exploration, and that most activities would likely take place during winter months when ground conditions were most favorable for exploration (and number of receivers the lowest), impacts would be minor and short-term.

Arctic Refuge Revised CCP **–** It is expected that where all alternatives under consideration in the *Draft Revised Arctic CCP* would preserve minimal management of lands within Arctic NWR, noise-producing activities would be kept to a minimum, thereby resulting in beneficial long-term effects on the lands' natural soundscape.

OCS Oil and Gas Leasing **–** Of the projects within the PFRR launch corridor, alternatives under the OCS Oil and Gas Leasing Program in the Beaufort Sea Planning Area could lead to increased noise levels at the northern extent of the PFRR launch corridor from construction, exploration, and processing activities. These activities could result in increased noise levels from construction equipment, compressor stations, other equipment, and increased aircraft activity in that area. However, these noise impacts would not add significantly to the noise impacts associated with continued SRP operations at PFRR because of the great distances between the Beaufort Sea (hundreds of kilometers) and the areas where PFRR launches and search and recovery activities would take place.

4.15.13.4 *Differences Among Alternatives Under Consideration*

Differences in noise impacts from the different alternatives would result primarily from varying levels of search and recovery operations as discussed in Section 4.5. Contributions to cumulative noise impacts from search and recovery operations are expected to be minimal due to the limited frequency and duration of these activities.

In relative terms, Alternative 2 would likely contribute the most to potential cumulative effects on noise because it would entail the greatest recovery effort. Alternative 1 would have lesser effects as it would entail a formal Recovery Program for all reported items, old and new. Alternatives 2 and 4, which would require recovery with consideration only to safety, could result in more frequent low-altitude aircraft flights, more short-term noise, and the potential for recovery-related impacts, such as ground scars or ruts. However, it is expected that more materials would be removed in the long term. Alternative 3, which would extend the restriction on planned impacts to designated Wild and Scenic Rivers within the PFRR launch corridor, and permit an environmentally conscious decisionmaking process to govern recovery decisions, would likely result in the least potential for adverse cumulative effects. The No Action Alternative would contribute the least to adverse cumulative noise impacts due to its very limited search and recovery effort.

4.15.14 Transportation

4.15.14.1 *Resource Context*

Recreational and commercial flights occur in the vicinity of PFRR, including from Fairbanks International Airport. Nearby highways, include Route 2, Airport Way, Robert Mitchell Expressway, and Steese Highway.

4.15.14.2 *Past and Present Impacts*

PFRR Actions

Transportation activities associated with past activities have been minimal due to the limited focus on recovery of stages and payloads and the infrequency of launch material shipments.

Actions by Others

***General Land Management* –** Landowner and resource agency aviation contributes to temporary transportation impacts throughout downrange lands.

***Recreational Use* –** In the vicinity of the PFRR launch corridor, recreational fixed-wing aircraft and helicopter use has occurred and is ongoing. Summer ATV travel has occurred and is ongoing within White Mountains NRA.

***Interior Oil and Gas Exploration* –** The use of fixed-wing aircraft and helicopters to transport equipment and personnel related to oil and gas exploration occurs in the vicinity of the PFRR launch corridor.

4.15.14.3 *Future Impacts*

PFRR Actions

Continuation of sounding rocket launches at PFRR would result in negligible transportation impacts. The possible increase in stage/payload shipments and recovery operations would not result in any additional impacts.

Actions by Others

***Interior Oil and Gas Exploration* –** Similar to the past and present operations, future oil and gas exploration would not result in any additional impacts.

***Arctic Refuge Revised CCP* –** The alternatives evaluated in the *Draft Revised Arctic CCP* would allow commercial transportation companies that provide visitor access to Arctic NWR to continue doing so **(USFWS 2011c)**. Flights of fixed-wing aircraft and helicopters in support of activities associated with PFRR would not impact other transportation activities being conducted in Arctic NWR.

***OCS Oil and Gas Leasing* –** The alternatives evaluated in the *OCS Oil and Gas Draft PEIS* **(USDOI 2011e)** would include the construction of additional roads and port facilities. However, these transportation infrastructure improvements would not impact transportation activities associated with PFRR operations and launches. PFRR would remain inaccessible similar to current conditions, and aircraft would still be used for search and recovery activities. PFRR transportation activities would have negligible impacts, as determined in Section 4.11.

4.15.14.4 *Differences Among Alternatives Under Consideration*

The No Action Alternative would provide the smallest transportation impacts because there would be no change to PFRR operations. Alternatives 1 and 3 would result in a negligible increase in fatal accidents due to the increased amount of search and recovery operations. Alternatives 2 and 4 would increase the number of search and recovery operations; however, they would also result in a negligible increase in fatal accidents.

4.16 THE RELATIONSHIP BETWEEN THE SHORT-TERM USES AND LONG-TERM MAINTENANCE AND ENHANCEMENT OF THE ENVIRONMENT

The past, current, and future conduct of the NASA SRP activities at PFRR is a scientific endeavor designed to increase the depth of knowledge of near-space, the Earth's atmosphere, and outer space. This activity enhances the ability to protect the environment through technological means.

The short- and long-term outputs resulting from the NASA SRP activities at PFRR have a positive impact on the understanding of the physical environment in the near-space and the atmosphere. In general, the launch and recovery processes represent relatively minor transient effects. The results of the scientific experiments in the near-space and atmosphere, on the other hand, are making contributions to the protection of the environment.

It is impractical to itemize all known and potential benefits generated by past or planned sounding rocket activities, but the general value can be expressed simply as follows. It is clear that practical and cost-effective means for protecting the environment can be developed only on the basis of knowledge and understanding of the physical, chemical, and biological processes affecting such an environment. Scientifically, more has been learned about the immediate environment and that of the solar system in the last two decades than in all the previous decades combined. Specifically, the NASA SRP makes unique contributions to the total effort to provide an operational capability to measure, monitor, and manage environmental conditions and natural resources from a local to global scale. Launches from PFRR play a significant role in these contributions, including:

1. Serving as a test bed for development of instruments and measurement techniques in a hostile environment (*e.g.,* vacuum, rocket launch vibrations, and temperature extremes). In fact, instruments developed in whole or in part on sounding rockets have later been used on satellites, space shuttles, and space probes.

2. Providing a short lead time capability in flight preparation for observing short-term and sudden events.

3. Providing opportunities for university research groups to perform space science research, for graduate student training, and for beneficial international scientific cooperation in the space area.

In fulfilling its responsibility, the NASA SRP has followed a philosophy that has emphasized safety and economy in conducting these experiments, both in near-space and in the near and far reaches of the atmosphere. At the same time, the NASA SRP has provided a relatively inexpensive approach to partial satisfaction of the fundamental need to better understand, utilize, predict, and control the life-sustaining, and sometimes hostile, environment.

In summary, NASA acknowledges the sensitive environmental context within which it must conduct its operations at PFRR. While doing so, NASA also acknowledges that due to the number of challenges it faces in locating the relatively small items within a large area, it is probable that not all items launched from PFRR (either from the past or future) can be recovered. Therefore, there could be a long-term deposition of flight hardware within these lands for years to come. However, by implementing programmatic commitments to improving location technologies, establishing a recovery budget, and expeditiously removing items that are reported, NASA expects that in the future such impacts would be measurably reduced. Additionally, as supported by the analyses in this EIS, the potential impacts of the SRP on the physical and biological resources of downrange lands are generally negligible to minor. As such, NASA is confident that although there are unavoidable short- and long-term impacts on environmental resources, conducting the science enabled at PFRR would contribute a net benefit to the overall maintenance and enhancement of the environment.

4.17 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The continuation of the NASA SRP at PFRR would result in an irreversible and irretrievable commitment of small quantities of structural materials and propellants. Materials such as aluminum, nickel, stainless steel, carbon, copper, titanium, and other metallic and plastic components are used in the fabrication of rocket propulsion systems and payloads. The propellants used in these rockets are synthetic organic and inorganic compounds.

The total SRP rocket launch activity at PFRR over the last 10 years resulted in the consumption of 35,000 kilograms (77,000 pounds) of structural materials and 51,000 kilograms (110,000 pounds) of propellants. This level of consumption corresponds roughly to materials used in the manufacturing of 22 standard size automobiles and a 10-year fuel equivalent (as mass) for maintaining 15 automobiles. It is not considered to be substantial in terms of use of natural resources.

Search and recovery activities by airplanes, helicopters, and trucks under each of the alternatives evaluated in this *PFRR EIS* would require the consumption of fossil fuels. Fossil fuel that would be consumed annually ranges from 3,070 liters (810 gallons) under the No Action Alternative to 35,000 liters (9,300 gallons) under Alternatives 2 and 4.

Use of military surplus solid propellant rockets, such as Orion, Talos, Taurus, Terrier, and Aries, in the NASA SRP activities further reduces the commitment of new raw materials and provides for the beneficial use of already expended resources that might otherwise become hazardous waste. Consequently, the continuation of the NASA SRP will not commit expenditures of natural resources in substantial quantities.

4.18 SUMMARY OF MITIGATION MEASURES

This section summarizes the mitigation measures and operating procedures that would be used to avoid or reduce potential environmental impacts that may result from implementation of the alternatives analyzed in this EIS. As specified in the CEQ's NEPA regulations **(40 CFR 1508.20)**, mitigation includes:

- Avoiding the impact altogether by not taking a certain action or parts of an action
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action
- Compensating for the impact by replacing or providing substitute resources or environments

All of the alternatives evaluated in detail in this EIS have the potential to cause adverse impacts on one or more resource areas. However, based upon the analyses in this chapter, only the No Action Alternative could potentially result in significant impacts on land use and waste management. The key factor contributing to the magnitude of these impacts is that recovery of flight hardware would only be conducted if dictated by scientific need.

Therefore, in response to concerns raised by agencies and members of the public during scoping, and to the findings of this EIS regarding the No Action Alternative, NASA has included mitigation measures as integral components of Alternatives 1–4. These measures, described in detail in Chapter 2, Section 2.3, and Appendix G, provide consideration of all resource areas while focusing primarily on the location and removal of past and future flight hardware from downrange lands. **Table 4–47** provides a summary of mitigation measures that would be undertaken under the alternatives.

In addition to the mitigation measures NASA would implement to reduce the potential for flight hardware to remain in downrange lands, NASA would continue to follow the requirements levied on its operations by downrange landowners. Summarized in **Table 4–48** are those notable requirements from the most recent permits and authorizations. The full details of landowner-imposed requirements are available in Chapter 2, Section 2.1, and Appendix C. It is possible that landowners could modify permit conditions in the future, and thereby levy additional requirements. In that instance, NASA would continue to work with downrange landowners to ensure that its operations are consistent with the requirements of future authorizations.

Table 4–47. Mitigation Measures Summarized by Alternative

Alternatives 1 through 4
Development of a formal Recovery Program that includes: • Programmatically committing to continually improving recovery aides • Establishing a minimum $250,000 annual recovery budget • Searching for all newly launched, land-impacting stages and payloads • Recovering those items that can be done so in a safe (Alternative 2) and environmentally responsible manner (Alternative 1) • Employing the least tools necessary for the recovery • Engaging outside parties in recovery efforts through an improved, ongoing outreach campaign • Establishing a Rewards Program for persons reporting items in downrange lands • Prioritizing recovery efforts and funding such that items within the most sensitive areas (e.g., Wilderness, Wild and Scenic Rivers) are recovered first • Establishing and maintaining a database to track impact location information for future and past (as available) launches
Alternatives 3 and 4
• Limiting trajectories of future missions such that no planned impact points can be within designated Wild or Scenic River corridors

Table 4–48. Landowner Requirements

All Alternatives

• Notifying landowners and users of planned launch and recovery activity
• Avoiding launches and recovery operations during the most sensitive times of year and/or locations
    o Avoiding launches between May 1 and September 30 unless special authorization is granted
    o Avoiding known raptor nest locations during recovery
    o Avoiding planned impacts within Mollie Beattie Wilderness Area
    o Conducting off-highway moves within existing trails or during winter months
• Protecting natural, cultural, and subsistence resources
    o Maintaining a flight elevation of greater than 2,000 feet above ground level unless actively searching for an item
    o Operating aircraft in a manner that does not harass wildlife
    o Limiting clearing of vegetation to hand-clearing incidental to recovery
    o Filling in excavated areas with native soil or rock materials
    o Avoiding disturbance to subsistence activities and cultural and historic resources
    o Cleaning equipment regularly to minimize the potential spread of noxious or invasive species