6.0 DESCRIPTION OF ENVIRONMENTAL IMPACTS

6.1 Introduction

This portion of the Comprehensive Environmental Evaluation (CEE) identifies potential impacts that may occur as a result of, or in association with, the proposed action to develop and implement surface traverse capabilities in Antarctica. Section 6.2 discusses the methods and sources of data used to identify, quantify, and evaluate the potential impacts. Section 6.3 describes the nature and extent of activities that have the potential to yield impacts to the Antarctic environment resulting from the proposed performance of surface re-supply traverses. Similarly, Section 6.4 identifies potential environmental impacts associated with the performance of science-related traverse activities.

Potential impacts to the environment that are described in Sections 6.3 and 6.4 include operational impacts that may be realized at McMurdo Station, other USAP facilities, including the Amundsen-Scott Station, and potential impacts to scientific research in the USAP and to the social conditions in the Antarctic, including historical, cultural heritage, and wilderness values. Additional impacts that may result from the use of surface traverses include indirect or second-order impacts, cumulative impacts, and unavoidable impacts; they are described accordingly. Section 6.5 presents a summary of all foreseeable potential impacts caused by the development and use of surface traverse capabilities in the USAP.

6.2 Methodology and Data Sources

The proposed action in this CEE involves the development and implementation of surface traverse capabilities by the USAP. A specific purpose or route for future traverse activities cannot be definitively stated at this time. In order to identify and assess potential environmental and operational impacts associated with the use of surface traverse capabilities, two representative traverse examples were selected for analysis. The first involves the re-supply of the Amundsen-Scott Station at the South Pole by surface traverse from McMurdo Station. The second involves the performance of a science-related traverse such as the 2002-03 International Trans Antarctic Scientific Expedition (ITASE). Data available from these two examples serves to characterize typical traverse operations, including equipment and personnel resources, operating factors, field logistics, and other support needs that may have environmental and operational impacts. The methods used to evaluate potential environmental and operational impacts associated with re-supply traverse activities are similar to those described in the Environmental Document and Finding of No Significant and Not More Than Minor or Transitory Environmental Impact entitled *Develop Proof of Concept Traverse from McMurdo Station, Antarctic to the South Pole* (reference 6).

The initial environmental state presented in chapter 5 described the conditions currently existing at the Ross Ice Shelf, Transantarctic Mountains, and Polar Plateau, and selected USAP facilities, in the absence of the proposed action. Potential environmental impacts resulting from operation of USAP facilities and logistical support systems, including aircraft, have already been evaluated in the *U.S. Antarctic Program Final Supplemental Environmental Impact Statement* (reference 7). The USAP provides further continuous monitoring and assessment of potential environmental impacts using data compiled for the *USAP Master Permit* (reference 3). These assessments noted that there are more than minor or transitory impacts associated with land use, air quality, waste management, wastewater discharge, fuel spills, or ecological resources, that these impacts are localized and do not result in a major adverse impact to the environment, and that there are no significant long-term and widespread impacts to human health or the environment resulting from operation of USAP facilities.

Potential impacts of the proposed action were identified and evaluated for the following environmental and operational aspects using data characterizing the examples of re-supply and science-related traverses:

- Physical Disturbance to the Snow/Ice Environment
- Air Quality
- Releases to the Snow/Ice Environment
- Impacts to McMurdo Station Operations
- Impacts to Other USAP Facilities
- Impacts to Scientific Research in the USAP
- Impacts to Social Conditions
- Second Order and Cumulative Impacts

6.2.1 Physical Disturbance to Snow/Ice Environment

The extent of physical disturbances that will result from traverse activities was estimated based on traverse route development activities documented for the Proof of Concept study (reference 6) and traverse operations documented in the US ITASE 2002-2003 Field Report (Appendix B). Additional data characterizing disturbances caused by surface traverse activities performed by other Antarctic Treaty Nations were derived from Comprehensive Environmental Evaluations (CEEs) and preliminary environmental assessment documents (references 18-21).

6.2.2 Air Emissions

Air emissions resulting from the operation of equipment (tractors, electrical power generation, heating, ancillary equipment) were calculated using factors compiled by U.S. EPA (references 8 and 9). These calculations, including emissions factors, are presented in Appendices C and D. Data characterizing the fuel consumption rates for traverse equipment operating under Antarctic conditions were derived from the traverse examples (Appendices A and B). Emission rates from the use of explosives were based on factors compiled by U.S. EPA (reference 8). Logistical support aircraft air emissions were derived from U.S. EPA emissions factors (reference 8), the number of hours flown, and the number of takeoff/landing cycles.

6.2.3 Releases to the Snow/Ice Environment

Releases to the snow/ice environment such as the discharge of wastewater were quantified using various models. The volume of wastewater that would be released by a traverse activity was assumed to be equivalent to the volume of water produced and consumed and was estimated using the average per capita water consumption rate for remote field operations (reference 3) and the projected population. Wastewater pollutant loadings (e.g., BOD, total suspended solids) were calculated based on per capita loading factors (reference 3) and the projected population. Minor releases of irretrievable operational materials expected during route development and maintenance activities (e.g., flags, poles) occur on a random basis and could not be quantified.

Accidental releases may include spills or leaks from containers primarily involving liquids, the unrecoverable loss of equipment, or the dispersal and loss of materials and wastes due to high winds. Since accidental releases are not planned, their frequency, magnitude, and composition cannot be projected in advance. Records of previous USAP spills will be compiled and reviewed to identify the types of equipment and operations that pose the greatest risk for accidental releases. Using this failure analysis information, the USAP will design and specify equipment and procedures for use on surface traverses which minimize the potential for accidental spills. In the event of an accidental release, specific procedures and resources will be available to facilitate cleanup and removal of contaminated media (e.g., snow, ice) to the maximum extent practical (see Chapter 7, Mitigating Measures).

6.2.4 Impacts to McMurdo Station Operations

The projected impacts to McMurdo Station operations were evaluated based on a qualitative review of the proposed traverse activities and potential inter-relationships or conflicts with ongoing station operations such as vehicle maintenance, cargo handling and storage.

6.2.5 Impacts to Other USAP Facility Operations

Projected impacts to other USAP facility operations, including Williams Field and the Amundsen-Scott Station, were evaluated based on a qualitative review of the proposed traverse activities and potential inter-relationships or conflicts with station and facility operations.

6.2.6 Impacts to Scientific Research in the USAP

The impact to other science projects in the USAP was evaluated on a qualitative basis by identifying the potential benefits of traverse capabilities to conducting science in the field and by reviewing the needs of current science projects and identifying potential conflicts with the proposed traverse operations.

6.2.7 Impacts to Social Conditions

The impacts to the social conditions in Antarctica were evaluated by examining the historical development and use of surface traverses in Antarctica, the cultural heritage of Antarctic exploration using surface traverse mechanisms, and the wilderness values of the Antarctic environment that may be affected by such actions. Although comprehensive lists of documented re-supply and science –related traverses have been compiled, see Tables 2-1 and 2-2 respectively, the assessment of potential impacts to social conditions in Antarctica is primarily qualitative.

If the USAP proceeds with the development and implementation of surface traverse capabilities, it is possible that other international entities or nongovernmental organizations (NGOs) may choose to use the traverse routes established by the USAP. There are no sources of information available to definitively suggest the extent to which non-USAP entities may use surface traverse mechanisms or USAP routes. Nonetheless, the recent rise in Antarctic tourism suggests that if tour operators have access to the diverse variety of resources needed to transit the surface in Antarctica, they may use USAP traverse routes as well as those developed by other signatory nations.

6.2.8 Second Order and Cumulative Impacts

Quantitative and qualitative indicators were used to evaluate potential second-order impacts. Quantitative characteristics included the estimated number of logistical support flights that would be deferred as a result of traverse activities. Qualitative indicators were used to identify potential conflicts associated with the addition of more equipment, fuel, and other supplies needed to support the development of traverse capabilities into existing USAP systems. Cumulative impact analysis was performed on a qualitative basis, and took into consideration activities expected to occur at the South Pole and other field sites.

6.3 Environmental Impacts Associated with a Re-supply Traverse

The evaluation of potential environmental impacts associated with surface traverses used for re-supply missions are based on the example of modeled traverse activities between McMurdo Station and the South Pole. The analysis of environmental impacts focuses on physical disturbance, air quality, releases to the environment, and impacts to McMurdo Station operations, other USAP facilities, scientific research, and social conditions (i.e. the human environment). Additional impacts that are addressed include indirect or second-order impacts, cumulative impacts, and unavoidable impacts.

The existing environmental conditions in the areas that could potentially be impacted by the proposed action include the Ross Ice Shelf, Transantarctic Mountains, and Polar Plateau. Impacts to flora and fauna in these areas are not expected since the extremely dry, cold, snow-covered terrain in any of these areas does not support local biota. In addition, these inland areas of the continent are not located near any Antarctic Specially Protected Areas (ASPAs) including marine areas, lakes, or ice-free areas where localized impacts could affect nearby receptors. However, if the traverse capabilities developed as a result of the proposed action are used for re-supply missions in other environmental settings, supplemental environmental reviews would be required to identify potential impacts.

The assessment of the potential environmental and operational impacts described below assumes that selected mitigating measures detailed in Chapter 7 would be implemented as part of re-supply traverse activities. If feasible, additional mitigating measures may be developed that would further reduce potential environmental impacts. Certainly, mitigation techniques and protocols will be validated and perhaps modified as a result of monitoring results.

6.3.1 Physical Disturbance to Snow/Ice Environment

Traverse activities will only occur on snow and ice covered areas. Physical disturbance (i.e., terrain alteration) of the snow and ice environment will be a certain outcome resulting from the use of traverse capabilities along any route. An existing traverse route that may be of practical benefit to the USAP includes the 1,600-km route between McMurdo Station and the South Pole that will be a consequence of the recent Proof of Concept evaluation. All traverse activities involving the development and use of routes in areas different than the environmental conditions characterized in this CEE (i.e., Ross Ice Shelf, Transantarctic Mountains, Polar Plateau) would require subsequent supplemental environmental review.

The specific routes that may be used for re-supply purposes are dependent upon the specific needs of the mission and cannot be defined at this time. Nonetheless, it is assumed that any route will require minimal terrain alteration by grooming the surface to create a drivable path which would be approximately five meters wide. In addition, crevasses would either be avoided where practical, or exposed and filled to mitigate potential human and equipment hazards. The terrain would therefore be altered either through the filling of crevasses or the creation of level surfaces or ramps over low areas. Additional physical disturbances along improved routes may occur during required periodic maintenance (e.g., surface grooming) to ensure continued safe and efficient traverse operations.

If needed, crevasses would be mitigated using snow moved from the surrounding area to fill the opening and provide a stable path across the crevasse at an elevation matching the surrounding surface contour. The area of the crevasse to be filled will be tapered upward to yield a path at the surface sufficiently wide enough to accommodate the traverse equipment. Since many of the crevasses would be covered on the surface by snow bridges, it is anticipated that explosives would be used to collapse the bridges and thoroughly expose the underlying crevasses for subsequent mitigation. In general, it is anticipated that snow bridges would be removed for up to 20 m along the length of each crevasse to ensure that the limit of the crevasse is visible and can be safely mitigated. The area and volume of snow that would be moved from the surrounding area to fill the crevasse and create the path would depend on the depth and width of each crevasse.

While the number and size of crevasses to be mitigated will depend on the specific route, based on the USAP's experience with a route between McMurdo and Amundsen-Scott Stations, the largest crevasses encountered were approximately six meters wide and 55 m deep. This size of crevasse would require approximately 9,500 cubic meters of snow to fill, and would typically utilize fill taken from an adjacent 5,250 m^2 area to a depth of 1.8 meters.

Because an established re-supply traverse route may be used multiple times during a year, it is expected that the snow's surface would be regularly disturbed. However, snow will continue to accumulate in these areas either as new snow or blowing and drifting snow, thereby minimizing the duration of the time the route visually appears to be disturbed. As a result, physical disturbance would represent a transitory impact.

During the development of a traverse route intended to be used for re-supply purposes, markers consisting of bamboo poles with cloth flags would be installed to identify the borders of the route, crevasses, obstacles, or other significant features. The markers are expected to remain in the field and would eventually either disintegrate or become covered with snow and ice. The markers would result in a minor, temporary alteration of the terrain.

Incorporating the use of the mitigating measures identified in Chapter 7 and realizing that the material used to fill a crevasse would be snow and ice native to the surrounding area, the effects of altering the terrain to develop and implement a traverse capability are expected to be localized along the route and virtually negligible. The nature and extent of any additional physical disturbances that may result from the use of established traverse routes by others (e.g., nongovernmental organizations) may include the use of temporary camps, development of spurs to the route, and the risk of additional hazardous materials releases.

Other types of environmental disturbances that would be expected to occur as a result of the proposed action include the generation of noise and vibrations from the traverse vehicles, generators, and ancillary equipment. Individually or combined, these disturbances are not expected to result in a significant impact because they would occur in extremely remote inland areas, with no receptors, and no ecologically sensitive wildlife habitats and be extremely transitory.

6.3.2 Air Emissions

During the use of the proposed USAP traverse capabilities, emissions from the combustion of petroleum hydrocarbon fuels will be released to the atmosphere. These emissions will originate from the internal combustion engines on tractors used to haul trailers, generators and heaters operated for personnel support, and ancillary equipment such as snowmobiles. Table 6-1 presents the estimated annual operating time and fuel usage for equipment used to transport re-supply cargo to the South Pole from McMurdo Station.

Table 6-1. Projected Annual Operating Time and Fuel Usage for Re-supply Traverse Activities

Equipment	Total Operating Time (hours) [1]	Fuel Combustion Rate (L/hr) [2]	Annual Fuel Consumption (liters)		Possible Number of Equipment Refuelings [3]
			Diesel	Gasoline	
Alternatives A (Optimal Configuration), D (Minimal Field Support), & E (Existing Routes Only)					
6 - Tractors (Challenger 95)	12,000	58	700,000		1,000
2 - Snowmobiles	1,000	1		1,200	110
1 - Generator (30 kW)	2,050	12	25,000		60
2 - Heaters	4,100	1.5	6,600		120

Table 6-1. Projected Annual Operating Time and Fuel Usage for Re-supply Traverse Activities

Equipment	Total Operating Time (hours) [1]	Fuel Combustion Rate (L/hr) [2]	Annual Fuel Consumption (liters)		Possible Number of Equipment Refuelings [3]
			Diesel	Gasoline	
Alternative B (Minimal Frequency)					
6 - Tractors (Challenger 95)	6,000	58	350,000		500
2 - Snowmobiles	500	1		600	55
1 - Generator (30 kW)	1,050	12	13,000		30
2 - Heaters	2,050	1.5	3,400		30
Alternative C (Reduced Intensity, Six Swings per Year)					
3 - Tractors (Challenger 95)	6,000	58	350,000		500
2 - Snowmobiles	1,000	1		1,200	110
1 - Generator (30 kW)	2,050	12	25,000		60
2 - Heaters	4,100	1.5	6,600		60

Notes:
[1] Includes time for weather delays and equipment maintenance.
[2] Fuel consumption rate for tractors based on *Analysis of McMurdo to South Pole Traverse as a Means to Increase LC-130 Availability in the USAP* (Appendix A); fuel consumption rates for other equipment based on manufacturer specifications.
[3] Assumes tractors are refueled daily and all other equipment is refueled every third day.

Table 6-2 provides practical comparison of the quantity of cargo that may be transported to the Amundsen-Scott Station if transported by traverse and airlift mechanisms.

Table 6-2. Projected Cargo Transport Amounts for Re-supply Traverses

Alternative	Projected Cargo Transported by Traverse (kg per year)	Traverse Fuel Consumed (liters)	Equivalent LC-130 Resources		Potential Fuel Savings (liters)
			No. of Flights	Fuel (liters)	
A (optimal configuration) or E (existing routes only)	800,000	750,000	69	1,200,000	450,000
B (minimal frequency)	400,000	375,000	35	600,000	225,000
C (reduced intensity)	400,000	375,000	35	600,000	225,000
D (minimal field support)	768,000	750,000	67	1,150,000	400,000
F (no action)		0	0	0	0

Using models developed by the U.S. EPA (references 8 and 9), Table 6-3 summarizes the annual emissions for characteristic air pollutants [sulfur oxides (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), exhaust hydrocarbons, and particulate matter (PM)] for each re-supply traverse alternative. Additional air emissions data for other fuel combustion byproducts are provided in Appendix C.

Table 6-3. Annual Air Emissions From Surface Re-supply Traverses

Alternative	Cargo Transported (kg)	Fuel Use (liters)	Fuel Combustion Byproducts (kg)				
			Sulfur Oxides	Nitrogen Oxides	Carbon Monoxide	Exhaust Hydro-carbons	Particulates
A, D, or E	800,000	750,000	49.8	27.0	9.9	1.4	2.2
B	400,000	375,000	25.6	13.7	5.0	0.7	1.1
C	400,000	375,000	47.8	21.7	8.2	1.1	1.9
LC-130 Aircraft Transporting an Equivalent Quantity of Cargo							
A, D, or E	800,000	1,200,000	1,358	10,734	7,208	3,210	2,953
B or C	400,000	600,000	688	5,440	3,653	1,627	1,496

Exhaust emissions resulting from the combustion of fuel during re-supply traverse activities are expected to be transitory and dissipate as minor concentrations along the 2000-km traverse route. The exhaust emissions are not expected to adversely impact human health or the environment. For comparison, McMurdo Station, which uses 10 times more fuel in one year than the optimally configured traverse (Alternative A), was monitored continuously and found to be well below U.S. Ambient Air Quality Standards (reference 10). This suggests that if the stationary sources at McMurdo Station do not adversely impact air quality, the mobile sources on the traverse which use far less fuel would also not create adverse impact air quality. Table 6-3 also presents the estimated air emissions from LC-130 aircraft assuming the aircraft are used to transport the same quantity of cargo as the re-supply traverse. In addition to the fuel savings, traverse activities emit far less quantities of air emissions than LC-130 aircraft.

Although most gaseous fuel combustion emissions dissipate in the atmosphere, carbonaceous aerosols (black carbon) have been detected in Antarctica at very low concentrations downwind of exhaust emission sources (references 11, 12, 13). The potential impacts from the deposition of carbonaceous aerosols and other combustion-related particulates may be realized through alterations of the surface albedo, and modifications of snow and ice chemistry. Because traverse activities are transient, particulate emissions although potentially detectable on a short-term basis are not expected to accumulate to levels which would alter the physical and chemical properties of the terrain and create adverse impacts.

Emissions resulting from the use of explosives (e.g., crevasse mitigation) may also be released to the environment. The primary emission byproducts released from explosives include sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and hydrogen sulfide (H_2S). The impacts resulting from the projected annual use of 10,750 kg of explosives by the USAP were previously evaluated and found not to have more than a minor or transitory effect on the environment (reference 14). During the most recent reporting period for the *USAP Master Permit* (reference 15), a total of 6,400 kg of explosives were used by the USAP throughout Antarctica, yielding emissions of CO (331 kg), NO_x (165 kg), SO_2 (6.37 kg) and H_2S (12.7 kg). If explosives are needed intermittently to support future traverse activities, it is not expected that the total quantity used in the USAP will exceed 10,750 kg per year.

6.3.3 Releases to Snow/Ice Environment

In addition to air emissions, it is expected that other substances may be released to the snow-covered ice sheet as a result of re-supply traverse activities. These releases may include the discharge of wastewater (greywater) in areas where such discharges are permitted and the release of minor materials such as marker flags that cannot be practically retrieved. Accidental releases such as spills to the environment may also occur during traverse activities.

6.3.3.1 Wastewater Discharge

Based on available resources and if practical, wastewater from personnel support operations would be containerized and transported to a supporting USAP facility for disposition. Wastewater would consist of blackwater (i.e., urine and human solid waste) and greywater containing freshwater (made from melted snow and trace residues of soap, food particles, cleaning materials, and personal care products. If needed, wastewater could be discharged to ice pits in snow accumulation areas along the traverse route as allowed by the Antarctic Treaty and the NSF Waste Regulation (45 CFR §671). Optimum wastewater management techniques would be implemented based on available resources (e.g., storage containers, cargo space) and could include a combination of discharge for greywater and containerization for urine and human solid waste. Wastewater would not be discharged to ice-free areas.

Using a model developed for the *USAP Master Permit*, it is estimated that each person at a remote location in Antarctica generates on average 6.88 liters of wastewater (blackwater and greywater) per day. If it is necessary to discharge wastewater in the field, a hole would be dug in the snow at least one meter deep to ensure the waste is isolated from the surrounding environment. The discharged wastewater would become frozen in the ice sheet and thus immobile. Wastewater contains numerous constituents and several general parameters have been used to characterize the pollutant loadings. Pollutant loadings were calculated using per capita loading factors developed for the *USAP Master Permit* (reference 3) and the traverse population. Table 6-4 summarizes the volume of wastewater that may be generated during re-supply traverse activities and associated pollutant loadings.

Table 6-4. Projected Wastewater Generated During Surface Re-supply Traverse Activities

Alternative	Population (person-days/yr) [1]	Wastewater Generated (liters/yr)	Possible Number of Discharge Locations per year
A, D, or E	1,080	7,430	180
B or C	540	3,715	90
Pollutant Loadings (kg/yr) [2]			
Alternative	**Total Suspended Solids**	**Biological Oxygen Demand**	**Ammonia Nitrogen**
A, D, or E	51	108	6
B or C	25	54	3

Notes:
[1] A person-day represents one overnight stay.
[2] Pollutant Loading Factors - Total Suspended Solids (0.047 kg/person-day); Biological Oxygen Demand (0.100 kg/person-day); Ammonia Nitrogen (0.006 kg/person-day)

The combined volume of wastewater projected to be discharged to snow and ice from all field camps operated by the USAP on an annual basis is 45,800 liters (reference 3). If all of the wastewater generated during traverse activities were discharged, the volume released would be a small fraction (i.e., less than 16 percent) of the total volume discharged from all USAP field camps. The impact is therefore expected to be negligible.

6.3.3.2 Other Materials

Minor releases of other materials to the environment are expected to occur occasionally during the implementation of a re-supply traverse. Flags marking the trail, hazards, and other landmarks will remain in the field and will eventually disintegrate or become lost when covered with snow and ice. The occurrence of these releases will be random and their impact is expected to be negligible. Materials released to the environment will be acknowledged each year in the *Annual Report for the USAP Master Permit*.

6.3.3.3 Accidental Releases

Within the Antarctic Treaty, there are a series of operating agreements under which all Antarctic facilities operate including the Protocol on Environmental Protection, which provides guidelines for spill contingency planning. U.S. activities in Antarctica are not only governed by these treaty provisions, but also by direct U.S. regulations as set forth in the Antarctic Conservation Act. These regulations, which require permitting for all activities conducted in Antarctica, also require specific environmental protection practices including spill response and cleanup. Additionally, the USAP voluntarily has adopted pertinent sections of several other U.S.-based regulatory standards as both a practical and "best management practice" approach. These include the National Environmental Policy Act (NEPA), the Resource Conservation and Recovery Act (RCRA), Occupational Safety and Health Agency (OSHA) regulations, and others. Pertinent U.S. environmental legislation specific to oil spills include both U.S. Environmental Protection Agency and U.S. Coast Guard requirements promulgated in response to the Oil Pollution Act of 1990.

Accidental releases may include spills or leaks primarily involving liquids, the unrecoverable loss of equipment, or the dispersal and loss of materials and wastes due to high winds. Since accidental releases are not planned, their frequency, magnitude, and composition cannot be projected in advance. Existing USAP measures will continue to be implemented to prevent accidental releases to the Antarctic environment. In the event of an accidental release, specific procedures and resources will be available to facilitate cleanup and removal of contaminated media (snow, ice) to the maximum extent practical (see Chapter 7, Mitigating Measures). In addition, traverse operations would utilize procedures contained in the *Field Camp Oil Spill Response Guidebook* (reference 16) for spill response actions. All accidental releases would be documented and reported consistent with the requirements of 45 CFR §671 and the *USAP Master Permit*.

During re-supply traverse missions, it is anticipated that fuel and other hazardous materials identified as Designated Pollutants in 45 CFR §671 would be handled or transferred on a daily basis thereby creating a potential for accidental releases. In general, accidental releases occur most often during equipment refueling activities caused by mechanical failures or operator error. During recent proof of concept traverse activities, comprehensive mitigating measures were applied to refueling procedures successfully preventing spills or other accidental releases.

The risk of an accidental release to the Antarctic environment may also be realized from the catastrophic failure of a fuel tank, other storage container, or a vehicle used during a traverse. The containers used on the traverse will be structurally compatible with their contents and able to withstand the physical and environmental conditions to be encountered during the traverse. The USAP will utilize tanks and drums that are suitable for use in Antarctic conditions and compliant with industry standards designed to protect hazardous material containers exposed to handling and transportation stresses.

Fuel tanks would be regularly inspected to detect leaks or potential weaknesses in the containers and empty vessels would be available if emergency transfers were necessary. Although, the benefits of double walled tanks are well known, for traverse applications, double walled tanks are not desirable because it is difficult to reliably detect failures of the inner wall in double wall systems and initiate corrective actions.

Containers that may be temporarily stored on the snow surface will be staged in a manner so that they can be effectively located and recovered without damaging the container upon retrieval. Despite the implementation of spill prevention measures, a minimal risk still exists from the failure or loss of a tank, drum, container, or conveyance (hose, pump) or a serious vehicle failure and the subsequent release of hazardous materials to the environment.

If an accidental release occurs, the extent of localized impacts would depend on the type and quantity of material spilled and the surrounding environmental setting. Consistent with established spill response procedures, primary mitigation would involve source control followed by cleanup including the removal of contaminated snow and ice and the use of sorbent materials if the spill occurred on an impermeable surface. Contaminated snow and sorbents would be packed into drums and removed as waste.

If fuel or other liquid Designated Pollutants (lubricant, coolant) are accidentally released to snow covered surfaces, the material would be expected to migrate vertically in the immediate area of the spill, potentially limiting the effectiveness of spill cleanup actions, and resulting in a long-term but localized impact. In locations with a relatively impermeable surface or subsurface layer a more effective cleanup can be achieved, thereby minimizing impacts. Accidental releases involving the catastrophic and irretrievable loss of equipment, fuel, other Designated Pollutants, or wastes in a crevasse would result in a long-term impact unless the condition of the lost materials permit subsequent recovery. Because implementation of the proposed re-supply traverse capability will not involve areas with seasonal sea ice, open water bodies, or local flora and fauna, impacts associated with an accidental release would be expected to remain localized (horizontally, but not vertically in most cases).

6.3.4 Impacts to McMurdo Station Operations

McMurdo Station is the logistical hub for most of the USAP's operations in Antarctica excluding work done on the peninsula supported by Palmer Station and work performed on research vessels. The proposed capability including the expertise and equipment to operate and support re-supply traverse activities would be based at McMurdo Station. McMurdo Station is likely to provide the following types of support:

- Temporary services for traverse personnel (berthing, food service)
- Maintenance and repair of traverse equipment
- Field support (food, emergency equipment and caches, consumable supplies, waste containers)
- Bulk fuels and fuel transfer facilities
- Waste management
- Weather services
- Communications support
- Airlift support (LC-130, Twin Otter, helicopter)
- Medical support

The logistical and personnel resources needed to support the level of re-supply traverse activities described in this environmental review are currently within the capabilities of McMurdo Station operations. The most significant resources available at McMurdo Station that would be needed to support re-supply traverse activities would involve equipment storage and maintenance functions. Advanced resource planning and careful scheduling would be used to avoid or minimize potential conflicts. Field services (e.g., communications, food, fuel caches) that may be needed to support traverse activities are within levels of support currently provided for numerous field activities each year. Environmentally sound fuel transfer infrastructure would need to be further developed as part of preparations for fuel-delivery surface traverses. The support provided by the annual re-supply vessel, annual fuel tanker, and associated cargo and fuel handling resources, airlift capability, and waste management services coordinated by McMurdo Station have sufficient capacity to accommodate the needs of re-supply traverses.

The use of traverse routes by nongovernmental organizations (NGOs) may potentially impact McMurdo Station operations if the Station has to provide search and rescue (SAR) to these parties in emergency situations. Except in emergencies, the U.S. Government does not support private Antarctic expeditions, and the NSF requires full cost recovery when it gives emergency assistance. Antarctic Treaty and Environmental Protocol requirements enforced by an expedition's country of origin are expected to ensure that any such NGO activities will be planned responsibly.

6.3.5 Impacts to Other USAP Operations

In addition to McMurdo Station, the development and implementation of surface traverse capabilities by the USAP could potentially impact other operations in the USAP. Even though McMurdo Station would serve as a central supply hub for proposed traverse operations, it is expected that the traverse equipment and cargo would be staged at Williams Field, a separate facility and aircraft skiway located on the McMurdo Ice Shelf 10 km from McMurdo Station. Facilities located at Williams Field and currently used to support airlift operations would also be expected to be available for staging proposed traverse operations.

Williams Field runway facilities do not typically operate during the first part of the austral summer season. If Williams Field is used to support traverse activities, additional resources may be needed to install and operate the fuel supply hoseline to McMurdo Station and operate the fuel storage and distribution facilities approximately 12 weeks earlier than the current schedule. Since the seasonal sea ice runway would be operational at the same time, these fuel-handling resources would essentially be duplicated. The primary impacts resulting from the concurrent operation of these facilities would be a slight increased risk of fuel spills and the additional fuel management resources needed to simultaneously operate and inspect two systems for spills and leaks.

Operations at the USAP facilities receiving materials transported by surface re-supply traverse may be impacted differently than if the materials were transported by aircraft. For example, at the Amundsen-Scott Station, the quantity of cargo that may arrive via a single traverse would greatly exceed the quantity of cargo that could be delivered by several aircraft in a day. This impact would be offset by the fact that the cargo would be handled by the traverse crew instead of Station personnel and the cargo itself would be much easier to handle since it would not have to be unloaded from aircraft whose engines must remaining running while at the South Pole.

6.3.6 Impacts to Scientific Research in the USAP

The use of surface traverse capabilities in Antarctica will have localized physical impacts such as terrain alteration and air emissions affecting the snow and ice along the traverse route itself. The route of any traverse will be carefully selected to avoid areas of ongoing scientific research and Antarctic Specially Protected Areas (ASPAs), or other sensitive areas controlled by management plans. Major traverse routes in use will be thoroughly documented so that future scientific research may be designed to avoid these areas if potential conflicts are anticipated. If a new traverse route is planned which comes in proximity to a sensitive area, a supplemental review will be performed of the proposed action to identify potential receptors and mitigating measures including redirection of the traverse route.

Physical disturbances and environmental releases such as air emissions and accidental spills resulting from traverse operations have the potential to affect various types of research such as air monitoring, seismic studies, or investigations requiring undisturbed snow and ice. Traverse activities and surface-based surveys will be planned to avoid areas known to be used for these purposes, but trace levels of residues from traverse operations may be permanently deposited in the snow and ice along the route. Past and active traverse routes used by the USAP would be delineated and mapped so that future scientific research efforts that require undisturbed snow or ice can be designed to avoid potential conflicts in areas of known disturbance.

The availability of surface traverse capabilities in the USAP will yield a positive impact to scientific research by providing an alternative cargo transport mechanism to supplement airlift resources particularly for the transport of large or heavy cargo items. For example, the use of traverse capabilities to re-supply the Amundsen-Scott Station would allow the transport of large instruments, such as telescopes or towers that cannot be performed using current airlift resources. In addition, the balanced use of airlift and traverse transport mechanisms will free-up limited airlift resources thereby allowing aircraft to become more available to support new research opportunities.

6.3.7 Impacts to Social Conditions

As described in Section 2, there is a long and diverse history of the use of surface traverses by numerous nations in Antarctica for re-supply and science-related purposes. The development and use of a traverse capability by the USAP would add to this history and potentially impact some of the social conditions in Antarctica.

The use of a surface traverse route and the associated presence of human activity will result in physical disturbances to the terrain which may be considered a temporary and localized visual impact to the aesthetic and wilderness values of the Antarctic landscape. This type of visual impact may be most noticeable following the performance of re-supply traverses which may use groomed, marked routes on a reoccurring and periodic basis. In general, these physical disturbances would tend to disappear gradually depending on the frequency the route is used and as snow accumulates.

Several decades ago, the United States largely abandoned the use of surface traverses favoring aircraft transport. The U.S. has realized that there is not a single mode of personnel and cargo transport which is effective for every type of cargo. The USAP intends to develop an effective traverse capability to supplement the existing airlift resources and rejoin the Antarctic Treaty nations who continue to use this effective mode of transport.

If the USAP establishes one or more traverse routes, there is the potential that they may be used by other nations or NGOs. The extended use of these routes could increase the environmental impacts. As with all other locations within Antarctica, there is no ownership of the land and all entities are free to operate ships, aircraft, and surface vehicles for peaceful purposes. While the presence of an established traverse route could be used to support operations, research, exploration, or tourism by non-USAP entities, there are many risks which must be managed in order for the venture to be successful. Surface field operations in Antarctica must plan for the physical obstacles, environmental conditions, and logistical support needs that must be considered if a traverse route is to be used. Preparations to meet these challenges will require significant time and resources to ensure success. In addition to the required resources, the length of travel time needed to traverse long distances, combined with the relatively short austral summer season may serve to discourage entities from using established traverse routes except as needed to support ongoing operations or scientific research.

All actions proposed by Antarctica Treaty signatory nations are subject to the environmental impact assessment requirements of the Protocol on Environmental Protection to the Antarctic Treaty (Protocol). Specifically, the assessment procedures set out in Annex I, Environmental Impact Assessment, must be applied to decisions about any activities undertaken in Antarctica pursuant to scientific research programs, tourism and all other governmental and non-governmental activities for which advance notice is required under Article VII (5) of the Antarctic Treaty. Annex I describes the different impact categories as well as the requirements for document circulation and review.

In 1994 the Treaty countries made further recommendations on tourism and non-government activities. This "Guidance for Visitors to the Antarctic" is intended to help visitors become aware of their responsibilities under the treaty and protocol. The document concerns the protection of Antarctic wildlife and protected areas, the respecting of scientific research, personal safety and impact on the environment. Regulations have also been written for the organizers of tourist and private ventures that are subject to U.S. legislation and require prior notification of the trip to the organizer's national authorities, assessment of potential environmental impacts, the ability to cope with environmental emergencies such as oil spills, self-sufficiency, the proper disposal of wastes and respect for the Antarctic environment and research activities. The guidelines outline detailed procedures to be followed during the planning of the trip, when in the Antarctic Treaty area and on completion of the trip.

6.3.8 Indirect or Second Order Impacts

The primary indirect or second order impact that may be realized as a result of the development and implementation of surface traverse capabilities is related to a reduction in the level of airlift resources currently allocated to support re-supply missions. As shown in the example to use traverse capabilities to supplement current airlift resources for the re-supply of the Amundsen-Scott Station, approximately 70 LC-130 flights representing 400 flight hours may become available through the use of surface traverse capabilities (Alternatives A and E). The USAP could use these airlift resources to enhance support to existing or spawn new research opportunities in Antarctica while providing a more efficient mode of transport for certain types of cargo.

As previously described, the existing logistical and personnel support systems of the USAP at McMurdo Station have sufficient capacity to support the efforts associated with the development and use of surface traverse capabilities without significant conflicts.

6.3.9 Cumulative Impacts

A cumulative impact is the combined impact of past and present activities as well as those which may occur in the foreseeable future. The primary cumulative impacts that will result from the use of traverse capabilities by the USAP would be associated with repeated use of traverses for re-supply purposes. Potential cumulative impacts would result from the repeated deposition of particulate exhaust emissions on snow and ice surfaces and the release of wastewater and other substances in the environment. Although these impacts would be highly localized to the traverse route and therefore minor, the effects would be persistent and more than transitory. The cumulative impacts would remain relatively isolated and would not be expected to adversely impact human health or the Antarctic environment. Similarly, the use of surface traverse capabilities would not be significant when combined with the impacts from other activities typically performed at various field locations in Antarctica.

6.3.10 Unavoidable Impacts

Unavoidable impacts are those which are inherent to the proposed action and cannot be fully mitigated or eliminated if the action is completed. Unavoidable impacts resulting from the use of surface traverse capabilities include the physical disturbance of the surface along the traverse route, the release of fuel combustion byproducts from the operation of traverse and personnel support equipment, and the temporary occupation of wilderness areas.

6.4 Environmental Impacts Associated with Science Traverses

To identify and evaluate potential impacts associated with scientific traverses and surface-based surveys, the International Trans Antarctic Scientific Expedition (ITASE) traverse recently conducted by the USAP between Byrd Surface Camp and the South Pole was selected as a representative example of a typical scientific traverse. The analysis of environmental impacts focuses on physical disturbance, air quality, releases to the environment and impacts to McMurdo Station operations, other USAP facilities, scientific research, and social conditions in the Antarctic. Additional impacts that are addressed include indirect or second order impacts, cumulative impacts, and unavoidable impacts.

6.4.1 Physical Disturbance to Snow/Ice Environment

The nature and extent of science traverse and surface-based survey activities will be defined by the intended research and will generally involve the physical disturbance of snow and ice areas. Areas characterized in this CEE and potentially impacted by science-related traverse activities include the Ross Ice Shelf, Transantarctic Mountains, and Polar Plateau. Research activities conducted in other environmental settings (e.g., coastal areas, dry land) will require supplemental environmental review.

It is expected that science-related traverses would typically proceed on undeveloped routes in the areas intended for the research but could also use routes established by other entities (i.e., nations) for other purposes. Because science-related traverses are not expected to be used repeatedly, a science traverse would probably try to circumnavigate and avoid crevasses as opposed to filling them for mitigation. Should crevasse mitigation be necessary for safe passage, explosives may be used to expose the crevasse and native snow and ice would be used to fill the void. The effects associated with filling crevasses (i.e., terrain alteration) are expected to be negligible and localized to the traverse route.

Other types of environmental disturbances that would be expected to occur as a result of the proposed action include the generation of noise and vibrations from the traverse vehicles, generators, and ancillary equipment. Individually or combined, these disturbances are not expected to result in a significant impact because they would occur in extremely remote inland areas, with no receptors, and no ecologically sensitive wildlife habitats.

6.4.2 Air Emissions

During the use of USAP traverse capabilities for science-related applications, emissions from the combustion of petroleum hydrocarbon fuels will be released to the atmosphere. These emissions will originate from the internal combustion engines on tractors used to haul trailers, generators and heaters operated for personnel support, and ancillary equipment such as snowmobiles. Table 6-5 presents the estimated operating time and fuel consumption amounts for equipment used to perform a typical scientific traverse.

Table 6-5. Projected Operating Time and Fuel Consumption for a Typical Science-related Traverse

Equipment	Annual Operating Time (hours) [1]	Fuel Combustion Rate (L/hr)[2]	Annual Fuel Consumption (liters)	
			Diesel	Gasoline
2 - Tractors (Challenger 55)	1,000	30	30,000	0
2 - Snowmobiles	500	1	0	575
1 - Generator (30 kW combined capacity)	500	12	6,000	0
4 – Heaters	2,000	1.5	3,000	0

Notes:
[1] Days of operation includes time weather delays and equipment maintenance.
[2] Fuel consumption rate for tractors based on data presented in the *US ITASE 2002-2003 Field Report* (Appendix B). Fuel consumption rates for other equipment based on manufacturer specifications and average operating conditions.

Table 6-6 summarizes the annual emissions for characteristic air pollutant emissions (i.e., sulfur oxides, nitrogen oxides, carbon monoxide, exhaust hydrocarbons, and particulate matter) for each science-related traverse performed. Additional air emissions data for other fuel combustion byproducts are provided in Appendix C.

Table 6-6. Air Emissions From a Typical Science-related Traverse

Fuel Use (liters)	Fuel Combustion Byproducts (kg)				
	Sulfur Oxides	Nitrogen Oxides	Carbon Monoxide	Exhaust Hydrocarbons	Particulates
40,000	21	7.8	3.1	0.4	0.8

Exhaust emissions resulting from the combustion of fuel during relatively short-term scientific traverse activities are expected to be transitory and dissipate as the traverse proceeds along the route. The exhaust emissions are not expected to adversely impact human health or the environment. For comparison, fuel combustion emissions at McMurdo Station, the USAP's largest station and logistical support hub, were measured and determined to have no significant impact on air quality (reference 10). Carbonaceous aerosols (black carbon) have also been measured downwind of exhaust emissions sources in Antarctica (references 11, 12, 13) and, while detected at low concentrations, were found to have no significant impact on the surface albedo or snow and ice chemistry. These observations suggest that because science-related traverse activities use far less fuel than stations operations, gaseous and particulate emissions although potentially detectable are not expected to accumulate to levels which would alter the physical and chemical properties of the terrain or create adverse impacts.

Emissions (SO_2, NO_x, CO, and H_2S) from explosives used to mitigate crevasse hazards during scientific traverses or surface-based surveys may also be released to the environment. It is highly unlikely that explosives will be needed since explosives were not use during four recent years of ITASE traverse activities. If explosives are needed, it is not expected that the quantity of explosives used would be significant.

6.4.3 Releases to Snow/Ice Environment

In addition to air emissions, it is expected that other substances may be released to the snow-covered ice sheet as a result of re-supply traverse activities. These releases may include the discharge of wastewater (greywater) in areas where such discharges are permitted and the release of minor materials such as marker flags that cannot be practically retrieved. Accidental releases such as spills to the environment potentially could also occur during traverse activities.

6.4.3.1 Wastewater Discharge

Based on available resources and if practical, wastewater from personnel support operations would be containerized and transported to a supporting USAP facility for disposition. Wastewater would consist of blackwater (i.e., urine and human solid waste) and greywater containing freshwater made from melted snow and trace residues of soap, food particles, cleaning materials, and personal care products. If needed, wastewater could be discharged to ice pits in snow accumulation areas along the traverse route as allowed by the Antarctic Treaty and the NSF Waste Regulation (45 CFR §671). Optimum wastewater management techniques would be implemented based on available resources (e.g., storage containers, cargo space) and could include a combination of discharge for greywater and containerization for urine and human solid waste. Wastewater would not be discharged to ice-free areas.

Using a model developed for the *USAP Master Permit*, it is estimated that each person at a remote location in Antarctica generates on average 6.88 liters of wastewater (blackwater and greywater) per day. If it is necessary to discharge wastewater in the field, a hole would be dug in the snow at least one meter deep to ensure the waste is isolated from the surrounding environment. The discharged wastewater would become frozen in the ice sheet and immobile. Table 6-7 provides estimates of the volume of wastewater that may be generated and discharged and associated pollutant loadings.

Table 6-7. Projected Wastewater Generated During a Typical Science-related Traverse

Population (person-days) [1]	Wastewater Generation Volume (liters)	Possible Number of Discharge Locations per year
520	3,600	40
Pollutant Loadings [2]		
Total Suspended Solids (kg)	**Biological Oxygen Demand (kg)**	**Ammonia Nitrogen (kg)**
25	50	3

Notes:
[1] A person-day represents one overnight stay
[2] Pollutant Loading Factors:
Total Suspended Solids (0.047 kg/person-day)
Biological Oxygen Demand (0.100 kg/person-day)
Ammonia Nitrogen (0.006 kg/person-day)

6.4.3.2 Other Materials

Minor releases of materials to the environment are expected to occur occasionally during the implementation of a re-supply traverse. Flags marking the trail, hazards, and other landmarks will remain in the field and will eventually disintegrate or become lost when covered with snow and ice. Other types of traverse-related materials that may be released on a random basis include cables or anchoring devices. The type and quantity of these releases will be dependent on the type of field research activities performed. Supplemental environmental reviews will be performed for science-related activities which involve the deployment of specialized pieces of equipment which will not or can not be retrieved. Materials released to the environment will be acknowledged each year in the *Annual Report for the USAP Master Permit*.

6.4.3.3 Accidental Releases

Within the Antarctic Treaty, there are a series of operating agreements under which all Antarctic facilities operate including the Protocol on Environmental Protection, which provides guidelines for spill contingency planning. U.S. activities in Antarctica are not only governed by these treaty provisions, but also by direct U.S. regulations as set forth in the Antarctic Conservation Act. These regulations, which require permitting for all activities conducted in Antarctica, also require specific environmental protection practices including spill response and cleanup. Additionally, the USAP voluntarily has adopted pertinent sections of several other U.S.-based regulatory standards as both a practical and "best management practice" approach. These include the National Environmental Policy Act (NEPA), the Resource Conservation and Recovery Act (RCRA), Occupational Safety and Health Agency (OSHA) regulations, and others. Pertinent U.S. environmental legislation specific to oil spills include both U.S. Environmental Protection Agency and U.S. Coast Guard requirements promulgated in response to the Oil Pollution Act of 1990.

Accidental releases may include spills or leaks primarily involving liquids, the unrecoverable loss of equipment, or the dispersal and loss of materials and wastes due to high winds. Since accidental releases are not planned, their frequency, magnitude, and composition cannot be projected in advance. Existing USAP measures will continue to be implemented to prevent accidental releases to the Antarctic environment. In the event of an accidental release, specific procedures and resources will be available to facilitate cleanup and removal of contaminated media (snow, ice) to the maximum extent practical (see Chapter 7, Mitigating Measures). In addition, traverse operations would utilize procedures contained in the *Field Camp Oil Spill Response Guidebook* (reference 16) for spill response actions. All accidental releases would be documented and reported consistent with the requirements of 45 CFR §671 and the *USAP Master Permit*.

During science-related traverse missions, it is anticipated that fuel and other hazardous materials identified as Designated Pollutants in 45 CFR §671 would be handled or transferred on a daily basis thereby creating a potential for accidental releases. In general, accidental releases occur most often during equipment refueling activities caused by mechanical failures or operator error. During recent ITASE traverses performed by the USAP, comprehensive mitigating measures were applied to refueling procedures successfully preventing spills or other accidental releases.

The risk of an accidental release to the Antarctic environment may also be realized from the catastrophic failure of a fuel tank, other storage container, or a vehicle used during a traverse. Results from the analysis of previous spills and container failures in the USAP will be used to design and specify equipment and procedures which minimizes the risk of releases during surface traverse activities. The containers used for traverse activities will be structurally compatible with their contents and able to withstand the physical and environmental (e.g., temperature) conditions to be encountered during the traverse. Bulk storage tanks would be regularly inspected to detect leaks or potential weaknesses in the containers and empty vessels would be available if emergency transfers were necessary.

It is expected that either full or empty mobile storage tanks or drums used to transport fuel and other bulk liquids needed for the operation of the traverse equipment may be stored on a traverse route. Containers temporarily stored on the snow surface will be staged in a manner so that they can be effectively located and recovered without damaging the container upon retrieval.

Since the equipment used to conduct a science-related traverse may not be configured to transport all of the fuel and other consumable supplies needed for an extended traverse mission, airlift support may be used to periodically re-supply the traverse. Re-supply may occur directly from LC-130 aircraft which land near the traverse equipment or through the retrieval of supplies airdropped or placed in field caches along the traverse route. To minimize the risk of accidental releases resulting from the use of temporary field caches of fuel or other materials, the materials will be placed on the snow surface in a manner to protect the contents and facilitate effective retrieval without damage to the container.

Airdropped materials may be accidentally released to the environment if the containers are damaged or land in conditions where the materials are lost and cannot be recovered. During the 2002-2003 ITASE traverse activities, a total of 96 drums of fuel on 24 pallets were airdropped at four sites along the traverse route. Although the airdrop parachutes failed on five of the 24 deployments causing the pallets to be buried in the snow, all drums were recovered intact with no discernible loss of fuel.

Despite the implementation of spill prevention measures, a minimal risk still exists from the failure or loss of a tank, drum, container, or conveyance (hose, pump) or a serious vehicle or airdrop failure and the subsequent release of hazardous materials to the environment. If an accidental release occurs, the extent of localized impacts would depend on the type and quantity of material spilled and the surrounding environmental setting. Consistent with established spill response procedures, primary mitigation would involve source control followed by cleanup including the removal of contaminated snow and ice and the use of sorbent materials if the spill occurred on an impermeable surface. Contaminated snow and sorbents would be packed into drums and removed as waste.

If fuel or other liquid Designated Pollutants (lubricant, coolant) are accidentally released to snow covered surfaces, the material would be expected to migrate vertically in the immediate area of the spill, potentially limiting the effectiveness of spill cleanup actions, and resulting in a long-term but localized impact. In locations with a relatively impermeable surface or subsurface layer a more effective cleanup can be achieved, thereby minimizing impacts. Accidental releases involving the catastrophic and irretrievable loss of equipment, fuel, other Designated Pollutants, or wastes in a crevasse would result in a long-term impact unless the condition of the lost materials permit subsequent recovery. Because implementation of science-related traverses addressed by this environmental review will not involve areas with seasonal sea ice, open water bodies, or local flora and fauna, impacts associated with an accidental release would be expected to remain localized (horizontally, but not vertically in most cases).

6.4.4 Impacts to McMurdo Station Operations

McMurdo Station is the logistical hub for most of the USAP's operations in Antarctica excluding work done on the peninsula supported by Palmer Station and work performed on research vessels. The proposed capability including the expertise and equipment is an enhancement of the resources that McMurdo Station has provided in the past to support science-related traverse activities. McMurdo Station is likely to provide the following types of support:

- Temporary services for traverse personnel (berthing, food service)
- Maintenance and repair of traverse equipment
- Field support (food, emergency equipment and caches, consumable supplies, waste containers)
- Bulk fuels
- Waste management
- Weather services

- Communications support
- Airlift support (LC-130, Twin Otter, helicopter)
- Medical support

The logistical and personnel resources needed to support the level of science-related traverse activities described in this environmental review are currently within the capabilities of McMurdo Station operations. The most significant resources available at McMurdo Station that would be needed to support any type of traverse activities would involve equipment storage and maintenance functions. Advanced resource planning and careful scheduling would be used to avoid or minimize potential conflicts. Field services (e.g., communications, food, fuel caches) that may be needed to support traverse activities are within levels of support currently provided for numerous field activities each year.

6.4.5 Impacts to Other USAP Operations

It is anticipated that McMurdo Station will serve as the central supply hub for most USAP science-related traverse activities. Depending on the nature of the intended research, other facilities (e.g., Amundsen-Scott Station, Byrd Surface Camp) may be used as supply depots or locations where equipment may be temporarily stored. The stops at these facilities would be integral to the research and planned accordingly, therefore no adverse impacts to facility operations would be expected.

6.4.6 Impacts to Scientific Research in the USAP

The use of surface traverse capabilities in Antarctica will have localized physical impacts (i.e., terrain alteration, air emissions) on the snow and ice along the traverse route itself. The route of any traverse will be carefully selected to avoid areas of ongoing scientific research and Antarctic Specially Protected Areas (ASPAs), or other sensitive areas controlled by management plans. Traverse routes in use will be thoroughly documented so that future scientific research may be designed to avoid these areas if potential conflicts are anticipated. If a new traverse route is planned which comes in proximity to a sensitive area (e.g., ASPA), a supplemental review will be performed of the proposed action to identify potential receptors and mitigating measures including redirection of the traverse route.

Physical disturbances and environmental releases (e.g., air emissions, accidental spills) resulting from traverse operations have the potential to affect various types of research such as air monitoring, seismic studies, or investigations requiring undisturbed snow and ice. Traverse activities and surface-based surveys will be planned to avoid areas known to be used for these purposes, but trace levels of residues from traverse operations may be permanently deposited in the snow and ice along the route. Past and active traverse routes used by the USAP would be delineated and mapped so that future scientific research efforts that require undisturbed snow or ice can be designed to avoid potential conflicts in areas of known disturbance.

The availability of surface traverse capabilities in the USAP will yield a positive impact to scientific research by providing an alternative cargo transport mechanism to supplement airlift resources particularly for the transport of large or heavy cargo items. For example, the use of traverse capabilities to re-supply the Amundsen-Scott Station would allow the transport of large instruments, such as telescopes or towers that cannot be performed using current airlift resources. In addition, the balanced use of airlift and traverse transport mechanisms will decrease the reliance on aircraft thereby allowing the USAP airlift resources to become available for other purposes.

Surface traverse capabilities will also provide a platform to potentially supplement a greater variety of scientific research projects or advanced surface-based survey activities in Antarctica. As documented in the recent ITASE experience, the availability of surface traverse capabilities can provide researchers with a mobile, interactive venue for research along geographical corridors similar to that afforded by large field camps but without the limitations of fixed camp-based data collection efforts. For example, conducting traverse-based research on a routine basis will allow the high-resolution sampling of glaciological parameters (in particular, accurate snow accumulation and temperature measurements), subglacial geology (through high resolution seismics), meteorology, climate sciences, and aeronomy. It is expected that the availability of surface traverse resources may result in a paradigm shift in the scientific community, and that scientists will propose innovative investigations that cannot yet be predicted.

6.4.7 Impacts to Social Conditions

As described in Chapter 2, there is a long and diverse history of the use of surface traverses by numerous nations in Antarctica for science-related purposes. The development and use of a traverse capability by the USAP would add to this history and potentially impact some of the social conditions in Antarctica.

The use of surface traverses to conduct surface-based scientific research and the associated presence of human activity will result in physical disturbances to the terrain which may be considered a temporary and localized visual impact to the aesthetic and wilderness values of the Antarctic landscape. Visual impacts resulting from science-related traverses or surface-based surveys would be expected to be barely noticeable, since the route may be traveled only once or much less frequently than re-supply traverse missions. The physical disturbances would be expected to disappear gradually after the traverse is completed as snow continues to accumulate along the traverse route.

For the past several decades, the United States preferred the use of aircraft resources to support scientific activities at field sites and largely abandoned the use of surface traverses. The U.S. has realized that for some types of research there is a developing need to collect data on smaller distance scales which may not be effectively supported solely by airlift resources. The USAP intends to develop traverse capabilities to effectively provide a support mechanism for surface-based research and rejoin the Antarctic Treaty nations who continue to use these resources as an integral component of scientific studies.

6.4.8 Indirect or Second Order Impacts

The use of surface traverse capabilities by the USAP for science-related research purposes is not anticipated to result in any significant indirect or second order impacts. The scope of this CEE focuses on the use of traverse equipment to provide a mobile platform for the performance of research investigations. Potential impacts associated with the research methods proposed for use on science-related traverse missions will undergo separate environmental reviews.

6.4.9 Cumulative Impacts

A cumulative impact is the combined impact of past and present activities as well as those which may occur in the foreseeable future. Similar to other scientific research activities performed by the USAP each year, science-related traverse activities or surface-based surveys will, by design, generally take place in undisturbed areas on a short-term basis. Therefore, no significant cumulative impacts are expected from these activities.

6.4.10 Unavoidable Impacts

Unavoidable impacts are those which are inherent to the proposed action and cannot be fully mitigated or eliminated if the action is completed. Unavoidable impacts resulting from the use of surface traverse capabilities include the physical disturbance of the surface along the traverse route, the release of fuel combustion byproducts from the operation of traverse and personnel support equipment, and the temporary occupation of wilderness areas.

6.5 Summary of Impacts

The potential impacts from the use of surface traverse capabilities for either re-supply or scientific purposes have been identified and evaluated consistent with the Guidelines for Environmental Impact Assessment in Antarctica (reference 17). Table 6-8 summarizes the criteria used to evaluate the significance of the potential impacts relative to the extent, duration, intensity, and reversibility of each activity as well as the probability of its occurrence. Table 6-9 summarizes all potential environmental and operational impacts that may be caused by re-supply traverse activities, and Table 6-10 summarizes the impacts that may be caused by scientific traverses and surface-based surveys.

Table 6-8. Criteria for Assessment of Potential Impacts on the Environment

		Criteria of Assessment			
Impact	**Environment**	**Low (L)**	**Medium (M)**	**High (H)**	**Very High (VH)**
EXTENT	*Air* *Snow/ice* *Terrestrial* *Aesthetic & Wilderness*	*Local extent* Action results in an isolated impact and confined to the site where the action occurred	*Partial extent* Action is isolated but possibly may migrate and affect surrounding area	*Major extent* Initially the action is isolated but likely to migrate and affect surrounding environment	*Entire extent* Large-scale impact along the entire traverse; migration will cause further impact
DURATION	*Air* *Snow/ice* *Terrestrial* *Aesthetic & Wilderness*	*Short term* Several weeks to one season; short compared to natural processes	*Medium term* Several seasons to several years	*Long term* Decades	*Permanent* Environment will suffer permanent impact
INTENSITY	*Air* *Snow/ice* *Terrestrial* *Aesthetic & Wilderness*	*Minimal Affect* Natural functions and processes of the environment are not affected	*Affected* Natural functions or processes of the environment are affected, but on a moderate or short-term basis	*High* Natural functions or processes of the environment are affected and changed	*Extensive* Natural functions or processes of the environment are fully disrupted and adversely impacted
REVERS-IBILITY	*Air* *Snow/ice* *Terrestrial* *Aesthetic & Wilderness*	*Reversible* Impacts are reversible; the affected environment will return to its initial state	*Affected* Impacts are essentially irreversible but are isolated and do not significantly interact with the surrounding environment	*High* Impacts are irreversible and may alter the surrounding environment over the long term	*Irreversible* Impacts will result in permanent changes and adversely affect the environment
PROB-ABILITY		Impact should not occur under normal traverse operations and conditions	Impact possible but unlikely	Impact likely or probable to occur during traverse operations	Impact inherent to the proposed action and unavoidable

Table 6-9. Summary of Environmental and Operational Impacts from Re-supply Traverses

Activity	Duration of Activity	Output	Environmental and Operational Impacts (legend Table 6-8)						Mitigating Measures (Table 7-1) [1]
			Affected Environment	Extent	Duration	Intensity	Reversibility	Probability	
Crevasse Mitigation	As Needed (mitigation only required during initial route development)	Emissions from the use of explosives	Air	L	L	L	L	H	2.2
			Snow/Ice	L	L	L	M	H	2.2
		Physical Disturbance– terrain alteration	Snow/Ice	L	L	L	M	H	2.2
		Physical Disturbance - noise, vibration, EM radiation	Snow/Ice	L	L	L	L	M	2.2
			Other Research Projects	L	L	M	L	L	2.2 7.1 - 7.2
Operation of Tractors	Daily, 120 days per austral summer	Exhaust Emissions	Air	L	L	L	L	VH	3.1 - 3.2
			Snow/Ice	L	H	L	M	VH	3.1 - 3.2
		Physical Disturbance – terrain alteration	Snow/Ice	L	L	L	M	VH	2.1
		Physical Disturbance - noise, vibration, EM radiation	Snow/Ice	L	L	L	L	VH	2.1
			Other Research Projects	L	L	L	L	VH	7.1 - 7.2
			Wildlife	L	L	L	L	L	7.3
		Visual Indicators – markers, groomed surfaces	Aesthetic & Wilderness Values	L	L	L	M	H	8.1 - 8.3
Power Generation	Daily, 120 days per austral summer	Exhaust Emissions	Air	L	L	L	L	VH	3.1 – 3.2
			Snow/Ice	L	M	L	M	VH	3.1 – 3.2

Table 6-9. Summary of Environmental and Operational Impacts from Re-supply Traverses

Activity	Duration of Activity	Output	Environmental and Operational Impacts (legend Table 6-8)						Mitigating Measures (Table 7-1) [1]
			Affected Environment	Extent	Duration	Intensity	Reversibility	Probability	
Personnel Support	As Needed (up to 120 days per austral summer)	Wastewater discharge (no discharge unless waste cannot be containerized)	Snow/Ice	L	L	L	M	M	4.1 – 4.2
Fuel Storage and Handling	Daily, 120 days per austral summer	Accidental Releases/Spills	Snow/Ice	M	M	M	M	M	4.4 – 4.6
Hazardous Materials Management	Daily, 120 days per austral summer	Accidental Releases/Spills	Snow/Ice	L	M	M	M	L	10.1 – 10.4
Waste Management	Daily, 120 days per austral summer	Accidental Releases/Spills	Snow/Ice	L	M	L	M	L	11.1 – 11.3
Field Logistics (field caches, airdrops)	Austral summer (120 days)	Physical Disturbance	Snow/Ice	L	M	L	L	M	4.3
		Release of Irretrievable Materials	Snow/Ice	L	M	L	M	L	4.3, 4.7
		Accidental Releases/Spills	Snow/Ice	L	M	M	M	L	4.3, 4.7
Logistics Support - McMurdo Station	Year-round	Increased equipment maintenance, storage, field ops support	McMurdo Station Operations	L	L	L	M	VH	5.1 – 5.2

Table 6-9. Summary of Environmental and Operational Impacts from Re-supply Traverses

Activity	Duration of Activity	Output	Environmental and Operational Impacts (legend Table 6-8)						Mitigating Measures (Table 7-1) [1]
			Affected Environment	Extent	Duration	Intensity	Reversibility	Probability	
Logistics Support – Other USAP Facilities	Austral summer (120 days)	Equipment and cargo staging, fuel distribution	Facility Operations	L	M	M	L	H	6.1

Note:
[1] Mitigating measures involving traverse design and planning (1.1-1.3) and impact monitoring (9.1-9.5) will be applied to each activity as appropriate.

Table 6-10. Summary of Environmental and Operational Impacts from Typical Science-Related Traverses

Activity	Duration of Activity	Output	Environmental and Operational Impacts (legend Table 6-8)						Mitigating Measures (Table 7-1) [1]
			Affected Environment	Extent	Duration	Intensity	Reversibility	Probability	
Operation of Tractors	As Needed Based on Research (one austral summer or less)	Exhaust Emissions	Air	L	L	L	L	VH	3.1 – 3.2
			Snow/Ice	L	M	L	M	VH	3.1 – 3.2
		Physical Disturbance – terrain alteration	Snow/Ice	L	L	L	M	VH	2.1
		Physical Disturbance - noise, vibration, EM radiation	Snow/Ice	L	L	L	L	VH	2.1
			Other Research Projects	L	L	L	L	VH	7.1 – 7.2
			Wildlife	L	L	L	L	L	7.3
Crevasse Mitigation	As Needed (mitigation will only be used if crevasses cannot be avoided)	Emissions - Explosives	Air	L	L	L	L	L	2.2
			Snow/Ice	L	L	L	M	L	2.2
		Physical Disturbance– terrain alteration	Snow/Ice	L	L	L	M	L	2.2
		Physical Disturbance - noise, vibration, EM radiation	Snow/Ice	L	L	L	L	L	2.2
			Other Research Projects	L	L	L	L	L	2.2 7.1 – 7.2
Power Generation	As Needed Based on Research (one austral summer or less)	Exhaust Emissions	Air	L	L	L	L	H	3.1 – 3.2
			Snow/Ice	L	L	L	M	H	3.1 – 3.2

Table 6-10. Summary of Environmental and Operational Impacts from Typical Science-Related Traverses

Activity	Duration of Activity	Output	Environmental and Operational Impacts (legend Table 6-8)						Mitigating Measures (Table 7-1) [1]
			Affected Environment	Extent	Duration	Intensity	Reversibility	Probability	
Personnel Support	As Needed Based on Research (one austral summer or less)	Wastewater discharge (no discharge unless waste cannot be containerized)	Snow/Ice	L	L	L	M	M	4.1 – 4.2
Fuel Storage and Handling	As Needed Based on Research (one austral summer or less)	Accidental Releases/Spills	Snow/Ice	L	L	M	M	M	4.4 – 4.6
Hazardous Materials Management	Daily, 120 days per austral summer	Accidental Releases/Spills	Snow/Ice	L	L	M	M	L	10.1 – 10.4
Waste Management	As Needed Based on Research (one austral summer or less)	Accidental Releases/Spills	Snow/Ice	L	L	L	M	L	11.1 – 11.3

Table 6-10. Summary of Environmental and Operational Impacts from Typical Science-Related Traverses

Activity	Duration of Activity	Output	Environmental and Operational Impacts (legend Table 6-8)						Mitigating Measures (Table 7-1) [1]
			Affected Environment	Extent	Duration	Intensity	Reversibility	Probability	
Field Logistics (field caches, airdrops)	As Needed Based on Research (one austral summer or less)	Physical Disturbance	Snow/Ice	L	L	L	L	H	4.3
		Release of Irretrievable Materials	Snow/Ice	L	L	L	M	L	4.3, 4.7
		Accidental Releases/Spills	Snow/Ice	L	L	M	M	M	4.3, 4.7
Logistics Support - McMurdo Station	As Needed Based on Research	Increased Equipment maintenance, storage, field ops support	McMurdo Station Operations	L	L	L	M	H	5.1 – 5.2
Logistics Support – Other USAP Facilities	As Needed Based on Research (one austral summer or less)	Equipment and cargo staging, fuel distribution	Facility Operations	L	L	L	L	L	6.1

Note:
[1] Mitigating measures involving traverse design and planning (1.1-1.3) and impact monitoring (9.1-9.5) will be applied to each activity as appropriate.

7.0 MITIGATION OF ENVIRONMENTAL IMPACTS AND MONITORING

7.1 Introduction

Mitigating measures represent specific actions that may be taken to reduce or avoid potentially adverse impacts to the environment or related impacts to the USAP. This chapter of the Comprehensive Environmental Evaluation (CEE) describes measures that will be taken or are under consideration to mitigate (i.e., reduce or avoid) impacts to the environment and USAP operations resulting from the development and use of surface traverse capabilities. This section also describes the activities that will be conducted to monitor and document impacts of traverses that may be performed as a result of the proposed action and, if appropriate, trigger corrective action.

7.2 Mitigating Measures

A list of mitigating measures applicable to re-supply and science-related traverses and surface-based surveys is presented in Table 7-1. The mitigating measures relate to the potential impacts discussed in Chapter 6, and include a series of measures that would be implemented during the planning and design phases of traverse activities.

The mitigating measures have been designed to be flexible and address a variety of conditions that may be encountered. Some of the proposed mitigating measures have already been incorporated into various field procedures used by the USAP. In addition, Table 7-1 includes mitigating measures which are applicable to the environmental requirements of the *USAP Master Permit* such as the management of Designated Pollutants (i.e., hazardous materials), the management and disposition of all hazardous and nonhazardous wastes, the control of substances released to the environment, and the monitoring of environmental conditions and impacts.

The most significant series of mitigating measures are initiated during the planning and preparation stages of a traverse or surface-based survey activity and well before the actual field work is underway. Frequently more than a year in advance, the specific goals of a traverse are compiled, resource specifications and procedures needed to accomplish the mission are developed, equipment is procured and staged, and personnel are trained. During the planning and preparation stages, features are built into the design of the proposed traverse activity to ensure that the resources needed to conduct the traverse and mitigate potential impacts are appropriately available. Organizational impacts related to USAP facilities that may be involved in the proposed action may be effectively mitigated through advanced planning, scheduling, and allocation of resources and facilities.

Prior to the initiation of traverse activities, the USAP will develop an impact monitoring strategy to detect, if any, temporal and spatial changes caused by traverse operations. Environmental impact assessment would be conducted during all phases of operations, particularly during the planning phases to ensure that resources are adequately available to support mitigating measures and minimize environmental impacts. Through a regular process the USAP performs a preliminary review of proposed actions, including operations and research activities, to identify potential environmental impacts and to identify those impacts which have not been previously evaluated in environmental documents such as Records of Environmental Review (ROERs), Initial Environmental Evaluations (IEEs), and Comprehensive Environmental Evaluations (CEEs). Where warranted, further environmental evaluation, development of specific mitigating measures and subsequent documentation is performed. Proposed activities involving surface traverses will also undergo this review, and activities in a different environmental setting or having the potential to yield impacts that have not been identified in this CEE will be subject to a supplemental environmental evaluation.

Table 7-1. Summary of Mitigating Measures

Aspect	Mitigating Measure
Traverse Design and Planning (1.0)	1.1 Traverse route: • The surface route selected for traverse operations should be designed to meet the goals of the mission (re-supply, scientific research) and minimize disturbances to the environment • The route should be located in areas where traverse operations and unplanned events such as accidental releases will not adversely impact the sensitive regions of the surrounding environment. Maintain a minimum distance of 250 meters from Antarctic Specially Protected Areas (ASPAs) • If a traverse route is located near a marine environment, ASPA, or other sensitive area, perform a supplemental environmental review to determine the impact of proposed activities
	1.2 Equipment, personnel support resources, and staffing: • The size and number of tractors and trailers/sleds should be appropriate to support the goals of the mission (e.g., re-supply, scientific research) and the environmental conditions (e.g., slope, snow cover) expected during the traverse • The number of personnel assigned to the traverse should be appropriate to meet the goals of the mission and provide an adequate margin of safety • Utilize tractors of proven design and operability characteristics (e.g., maintenance) for surface applications. Tractors should be designed to minimize energy use and production of exhaust emissions • Trailers should be optimally configured for the conditions (e.g., high axles, skis or tracks aligned to those of the lead tractor) • Facilities needed for personnel support and research (e.g., power generation, water production equipment) should be designed to minimize energy use and the production of exhaust emissions. Consider using solar energy or alternative fuels to diesel or gasoline (e.g., propane) • Traverse support equipment (e.g., trailers, personnel modules) should be designed to adequately accommodate the storage of all Designated Pollutants (i.e., hazardous materials) used during the traverse • Traverse support equipment and resources (e.g., containers) should be provided to adequately contain and store all wastes generated during the traverse • Traverse equipment and resources for material transfers (e.g., refueling) should be designed for that purpose and incorporate spill prevention features • Traverse operating procedures will be designed to include regular inspections (e.g., at least daily) to prompt rapid response if a release or pending container failure is detected. • Traverse support equipment and resources should be provided to enable spill response (e.g., shovels, absorbents, waste drums) and the adequate transfer and containment of material from any damaged or leaking vessel • Utilize procedures contained in the *Field Camp Oil Spill Response Guidebook* for spill response actions and develop supplements as needed to address traverse activities • Provide spill response training to traverse personnel
	1.3 Traverse planning should address the following activities and incorporate additional mitigating measures as appropriate to minimize or avoid impacts to the environment:

Table 7-1. Summary of Mitigating Measures

Aspect	Mitigating Measure
	• Operation of personnel support facilities • Wastewater management • Deployment, use, and decommissioning of field caches • Use of airdrops • Establishment of temporary support camps or stopover location
Physical Disturbance to Snow/Ice Environment (2.0)	2.1 Minimize the amount of terrain alteration or disturbance during operation of personnel support modules by confining activities to areas on or immediately adjacent to the designated traverse route
	2.2 Mitigate crevasse hazards through avoidance, if possible. If physical crevasse hazard mitigation (i.e., filling) is necessary, minimize impacts by: • Limiting the extent of crevasse exposure (i.e., removal of snow bridges) to the length required for safe operations and filling crevasses only to the extent needed to allow safe passage by the traverse equipment • Filling crevasses with surrounding native materials
Air Emissions (3.0) Releases to the Snow/Ice Environment (4.0)	3.1 Perform regular preventive maintenance on traverse equipment, based on operating hours or other maintenance criteria, to sustain optimal performance and reduce emissions.
	3.2 Shutdown equipment when not in use to minimize exhaust emissions and utilize engine heaters or equivalent devices to minimize idling of diesel-powered equipment, if practical
	4.1 Prohibit wastewater discharges in areas where the ice-flow may terminate in ice-free or blue ice areas of high ablation
	4.2 Limit wastewater discharges to the maximum extent practical and containerize and transport the wastewater to a supporting USAP facility for disposition. In areas where wastewater is discharged: • Limit wastewater discharges to one disposal pit per support module location • Limit wastewater discharges to urine and greywater • If wastewater is to be discharged to an ice sheet, the disposal pit should be at least one m deep to effectively isolate the waste from the surrounding environment • Prohibit the discharge of wastewater on the surface of the terrain • Prohibit discharge of materials containing Designated Pollutants (e.g., chemicals, fuel wastes, lubricants, glycol) • Record the approximate volume of wastewater discharged at each location during support module operations
	4.3 Use of caches or temporary storage areas: • If equipment, materials, or supplies are cached along the traverse route, store the materials in a manner to prevent them from becoming encrusted in snow and ice (e.g. store on pallets) and possibly damaged upon retrieval • Mark and document storage locations to prevent the materials from becoming lost or irretrievable • If airdrops of fuel, materials, or supplies are conducted to support traverse operations, recover all packaging materials (e.g., pallets, parachutes) • Inspect airdropped containers for signs of damage and remediate any spills or leaks immediately
	4.4 Material transfers: • Develop and implement a consistent approach for material transfers (e.g., refueling) and equipment maintenance operations that incorporates spill prevention

Table 7-1. Summary of Mitigating Measures

Aspect	Mitigating Measure
	techniques including the use of containment devices • Drain portable pumps, hoses, and nozzles after use and store in appropriate containment structures • Following all fuel transfers and equipment maintenance operations, inspect adjacent areas for signs of spills or leaks and remediate immediately
	4.5 Inspect the following daily to detect leaks or damage: • Bulk fuel storage tanks, pipelines, valves, distribution pumps, and hoses • Equipment (generator, heater) tanks, fuel lines • Vehicles (e.g., fuel tanks, oil pans, hydraulic lines, coolant systems) • Storage containers (e.g., drums containing fuel, oil, glycol)
	4.6 Cleanup leaks or spills immediately following their detection to the maximum extent practical, manage resulting contaminated materials as Antarctic Hazardous waste, and report all spills and remedial actions as required by 45 CFR §671
	4.7 Report all lost equipment or instruments as required by 45 CFR §671
Impacts to McMurdo Station Operations (5.0)	5.1 Plan traverse operations and support activities sufficiently in advance to minimize impacts to McMurdo Station operations
	5.2 Conduct traverse staging operations at a location which will not conflict with normal station operations
Impacts to Other USAP Operations (6.0)	6.1 Incorporate scheduled traverse operations into the planning process to ensure affected USAP facility operations and potential conflicts can be adequately identified
Impacts to Scientific Research in the USAP (7.0)	7.1 Prohibit traverse operations in ASPAs unless specifically required for scientific research and conducted in accordance with applicable restrictions
	7.2 Avoid traverse operations near known sensitive scientific areas (e.g., air, seismic monitoring) unless required for scientific research
	7.3 Avoid disturbing wildlife and maintain at a minimum the following separation from animals or receptors: 250 meters (tractors), 150 meters (snowmobiles), 15 meters (on foot)
Impacts to Social Conditions (8.0)	8.1 Avoid traverse operations near historic sites and monuments and maintain minimum vehicle separation of 50 meters when moving
	8.2 Minimize the amount of disturbed snow surface by having vehicles follow the path of the lead vehicle as much as possible
	8.3 Preserve the aesthetic value of the areas surrounding traverse routes by limiting the placement of markers and flags to those quantities needed to maintain safe operations
	8.4 Avoid the discharge of wastewater to the maximum extent practical
	8.5 Deny use of USAP resources by NGOs
Impact Monitoring (9.0)	9.1 Perform an environmental review of all planned traverse field operations and research efforts to identify those activities which may have the potential to yield impacts to the environment. Develop appropriate mitigating measures with traverse planners accordingly
	9.2 Develop a comprehensive monitoring plan for traverse activities which identifies the temporal and spatial parameters to be measured to assess impacts
	9.3 Incorporate traverse activities into the *Permit Reporting Program* to document

Table 7-1. Summary of Mitigating Measures

Aspect	Mitigating Measure
	activities conducted each year that can be used to evaluate environmental impacts (e.g., fuel combustion, waste generation, environmental releases)
	9.4 Audit USAP traverse activities as a whole annually to (1) verify that activities are being performed as planned, (2) collect data to provide a comparison of the measured or observed impacts to the predicted impacts, and (3) suggest or develop corrective actions as necessary to mitigate increased or unexpected impacts
	9.5 Record the locations of traverse activities, including description and quantity of: • materials remaining in the field (e.g., caches) • releases to the environment from operations • releases to the environment from scientific research • accidental releases (e.g., spills)
Hazardous Material Management (10.0)	10.1 Store all materials containing hazardous materials (i.e., Designated Pollutants) in containers which are compatible with the contents and are structurally adequate to accommodate the handling and stresses associated with transport on the traverse
	10.2 Utilize bulk fuel storage tanks specifically designed for transportation applications which include protection against structural damage if filled tanks are transported over rough terrain
	10.3 Limit materials containing Designated Pollutants (e.g., fuel, oil, glycol) used for traverse activities and personnel support operations to the types and amounts needed, including adequate safety margins
	10.4 Minimize the storage of materials containing Designated Pollutants in the field during the austral winter. If Designated Pollutants, equipment, supplies, or wastes are temporarily stored along the traverse route during the operating season or during the austral winter: • Mark and document storage locations to prevent the materials from becoming lost • Store containers (e.g., tanks, drums) in a manner to prevent them from becoming encrusted in snow and ice and possibly damaged upon retrieval • Store containers in a manner to prevent accidental releases to the environment • Regularly inspect bulk storage tanks to detect leaks and potential weaknesses in the containers • Provide empty vessels so that primary storage tanks can be emptied if a leak or potential weakness in the container is detected • Recover and return all items to a supporting USAP facility for disposition by the end of the following austral summer season
Waste Management (11.0)	11.1 Provide resources (e.g., containers) to manage all wastes generated during the traverse consistent with the requirements of the *Waste Management Plan and Users Guidance* and: • Contain all wastes to avoid releases to the environment (e.g., light objects being scattered by the wind) • Segregate and label Antarctic Hazardous waste and nonhazardous waste streams • Secure wastes during transport
	11.2 Inspect Antarctic Hazardous waste containers for leakage or deterioration on a weekly basis and document the inspections per the *NSF Waste regulation* (45 CFR §671.11(b))
	11.3 If practical, containerize all sanitary wastewater and greywater for transport to a supporting facility. If transport of sanitary wastewater is not practical, only discharge urine and greywater (per 45 CFR 671) and containerize human solid waste

Table 7-1. Summary of Mitigating Measures

Aspect	Mitigating Measure
	(see mitigating measure 4.2)
	11.4 Minimize the storage of nonhazardous wastes and Antarctic Hazardous wastes in the field during the austral winter. If wastes are temporarily stored along the traverse route during the operating season or during the austral winter: • Mark and record storage locations to prevent the materials from becoming lost • Store containers (e.g., tanks, drums) in a manner to prevent them from becoming encrusted in snow and ice and possibly damaged upon retrieval • Store containers in a manner to prevent accidental releases to the environment • Return all wastes cached during the austral winter to a supporting USAP facility for disposition by the end of the following austral summer season

7.3 Environmental Reporting and Review

All activities associated with the use of surface traverses that relate to potential environmental impacts and compliance with U.S. environmental regulations will be documented and systematically evaluated. For example, the U.S. Waste Regulation (45 CFR §671) is applicable to all U. S. activities in Antarctica. The Waste Regulation establishes requirements for the issuance of Permits and associated reporting with respect to the management of Designated Pollutants (i.e., hazardous materials), the management and disposition of wastes generated in Antarctica, and release of any substances into the environment. Pursuant to the Waste Regulation, NSF has issued the *USAP Master Permit* (reference 3) to the civilian support contractor, Raytheon Polar Services Company (RPSC) for the period 1 October 1999 through 30 September 2004. The current Permit is expected to be renewed on 1 October 2004. Traverse activities conducted in Antarctica will be subject to the terms and conditions of the applicable *USAP Master Permit.*

By 30 June of each year, RPSC (the Permit holder) prepares the *Annual Report for the USAP Master Permit* documenting activities conducted for the previous 12-month period at permanent stations and individual outlying facilities and field sites, regarding waste management and releases to the environment. All traverse activities related to wastes and releases will be included in the Annual Report. In addition, the Permit holder will conduct an annual review to verify that the activities described in the Master Permit including those associated with any traverses are accurate and representative. Any revised conditions and significant changes will be identified and documented accordingly in subsequent *Amendments to the USAP Master Permit.*

The Permit holder has established a formal process to gather data needed for Permit reporting purposes known as the *Permit Reporting Program*. The program was designed to collect Permit-related information in an efficient and consistent manner addressing all activities conducted under the Permit at each permanent station and each individual outlying facility operated in the USAP. Relevant information pertaining to traverse activities will be included in the *Permit Reporting Program* for subsequent use in the *Annual Report for the USAP Master Permit* and the *Amendments to the USAP Master Permit*.

Data obtained through the *Permit Reporting Program* will also be used to characterize activities and conditions that are used both to assess and monitor environmental impacts. For example, Permit-related parameters that are reported and evaluated each year include fuel consumption and associated air emissions, waste generation and disposition, and planned and accidental releases to the environment. These parameters will be reviewed to identify conditions which are significantly different than those described in the *USAP Master Permit*. Data pertaining to traverses and regularly obtained through the *Permit Reporting Program* will be evaluated based on the conditions and potential impacts assessed in this Comprehensive Environmental Evaluation.

8.0 GAPS IN KNOWLEDGE AND UNCERTAINTIES

8.1 Introduction

The scope of this environmental review was designed to primarily focus on the operational aspects of conducting traverse activities in Antarctica. Specialized activities specific to a single project (e.g., instrument deployment, sample collection, construction of a new facility) and not in common with general traverse activities will require subsequent characterization and supplemental environmental review. This chapter describes several basic assumptions associated with the USAP's intention to develop and implement a traverse capability and identifies data gaps or uncertainties that may affect this evaluation of impacts.

8.2 Basic Assumptions

The development and use of surface traverse capabilities is certain to provide measurable benefits to the USAP. The traverse capabilities that are being considered represent a known and viable transport mechanism that would be used to optimally complement, not replace, existing airlift resources. The availability of both surface traverse and airlift transport capabilities would allow the USAP to select an efficient and environmentally sensitive method which is best suited for the intended mission.

For many years, other nations have successfully performed traverses to re-supply inland facilities in Antarctica using equipment and procedures similar to the proposed action. It has also been proven that traverses are a useful tool for the performance of scientific research, as indicated by the history of Antarctic traverses by many nations, including those performed recently as part of the extensive International Trans Antarctic Scientific Expedition (ITASE).

The extent that the USAP may utilize the proposed traverse capabilities in a given year is dependent on the variable logistical and research needs of the program. Similarly, the extent of field support resources that will be provided will be dependent upon the specific needs of the traverse mission. It is expected that McMurdo Station resources would provide most of the support to future USAP traverse operations, and some traverse missions may also utilize USAP field support resources such as airlift transported supplies, field caches, or airdrops. The levels of external support evaluated in this environmental review are representative of the available USAP resources expected to be used to support traverse activities for the foreseeable future. Because these support activities must be planned and scheduled well in advance, activities involving impacts which are substantially different that those identified in this environmental review would be assessed separately.

This environmental review focuses on the mechanical aspects of performing traverse or surface-based survey activities for re-supply or science-related purposes. These activities are comparable to the vast Antarctic traverse experience of the international community. There is no indication that the basic parameters used to characterize these traverse activities or associated support activities will change significantly from the conditions identified and evaluated in this review. Future traverse activities which would be performed under operating conditions or environmental settings that are significantly different than those described in this CEE would undergo supplemental environmental review. Therefore, there are no major data gaps or uncertainties related to the development and implementation of traverse capabilities that could materially affect the conclusions of this environmental review.

8.3 Uncertainties

The technical information related to the proposed action and evaluated in this environmental review was derived from two examples, a McMurdo to South Pole re-supply proof of concept traverse currently under evaluation, and the operational performance data from the recent ITASE traverse performed by the USAP. Based on data from these examples, potential environmental impacts for traverse operations were identified and evaluated relevant to the environmental conditions defined in this CEE. Uncertainties may exist with respect to the performance of traverse activities that occur under conditions different than those as characterized by the examples.

Traverse operating conditions which have the potential to influence the evaluation of environmental impacts include the route, equipment, and logistical approach. Impacts associated within a range of operating conditions have been characterized in this review; therefore, any variations are not expected to significantly affect the output of the activities or alter the conclusions. The following identifies possible data gaps or uncertainties in these areas.

The specific route that may be utilized in the future for either re-supply or scientific research missions is dependent on the specific needs of the USAP at the time the traverse is planned. This environmental review focused on potential impacts in three broad snow or ice-covered areas including the Ross Ice Shelf, the Transantarctic Mountains, and the Polar Plateau. Proposed traverse activities in areas significantly different than these such as Antarctic Specially Protected Areas or ice-free areas would require supplemental environmental review. Along a specific route, the extent of terrain alteration activities that may be needed for a traverse is dependent on the local environmental conditions including crevasses, sastrugi, and snow drifts. The number and size of crevasses that may require mitigation by filling for safe passage cannot be predicted nor can the extent of surface grooming needed for safe and efficient passage of the traverse equipment.

The number, type, size, and configuration of traverse equipment that would comprise a particular traverse activity are dependent on the needs of the mission. The configuration of equipment evaluated in this environmental review is representative of typical USAP traverse activities in the foreseeable future. It is expected that the configuration of future traverse missions would incorporate factors currently under proof of concept evaluation and would utilize operating experience gained from previous traverse missions performed by the U.S. and others.

Each surface traverse conducted by the USAP will require development of a customized operating strategy designed to meet the specific objectives of the mission. Operating parameters that may affect the nature and intensity of proposed traverse activities and influence related impacts include:

- Number of traverse trips (single, roundtrip, multiple)
- Operating schedule (total duration, number of travel hours per day)
- Number of people (operators, scientists)
- Number of traverse stops (temporary camps, rest stops, research locations)
- Substances released to the environment (exhaust emissions, wastewater discharge)
- Field maintenance and repair activities
- Use of temporary field storage areas for traverse equipment, fuel, or supplies

There is a large range and combination of operating parameters that may be considered for any particular traverse mission. The operating parameters evaluated in this environmental review are representative of typical USAP traverse activities for the foreseeable future.

8.4 Estimation Methods

Uncertainty is inherent in the methods that were used in this environmental review to estimate releases to the environment. Generic models were used to estimate fuel combustion exhaust emissions from traverse equipment and the potential discharge of wastewater in snow and ice-covered areas.

Generic emissions models were used to estimate exhaust gas emissions since actual testing data for traverse equipment operating under Antarctic conditions are not available. Emission factors were selected to best represent the type and size of equipment being characterized. In general, these models are used by regulatory authorities and risk assessors to provide estimates of exhaust emissions. Because these models do not account for fuel combustion efficiencies or emission standards that may be met by currently available equipment, the emission factors generally represent a conservative estimate, therefore actual emissions are expected to be less.

The projected quantity of wastewater that could potentially be discharged and the resulting pollutant loadings were quantified using per capita wastewater production rates developed for field operations and described in the *USAP Master Permit*. These models are applied to USAP operations throughout Antarctica for Permit reporting purposes and are reviewed each year. Inaccuracies in the estimates derived from these models are not expected to affect the conclusions derived from this environmental review. To the maximum extent practical, wastewater discharges will be avoided.

9.0 CONCLUSIONS

9.1 Introduction

This Comprehensive Environmental Evaluation (CEE) identified the potential impacts associated with the development and implementation of surface traverse capabilities by the USAP. The scope of the proposed action is unique because it encompasses all traverse operations that may be performed by the USAP not just those exclusively for a specific purpose (re-supply, science-related research), only for a designated period of time, or along a single route.

The USAP proposes to use surface traverse capabilities in conjunction with existing airlift resources to efficiently transport cargo and conduct field-related scientific research in a safe and environmentally responsive manner. Currently the USAP does not possess a robust and fully mature traverse capability. The traverse activities that the USAP has accomplished to date have been done on a very limited scale using available equipment that may not be the best suited for the intended application.

Potential environmental impacts associated with typical surface traverse activities were identified and evaluated using two scenarios. The first example involved the re-supply of the Amundsen-Scott Station from McMurdo Station using traverse methods currently undergoing engineering evaluation in a proof of concept study. To evaluate potential impacts associated with scientific traverses and surface-based surveys, the International Trans Antarctic Scientific Expedition (ITASE) of which the USAP is a participant was selected as a second representative example for the use of the traverse capability.

The methods used to identify and evaluate the impacts of the proposed activities are consistent with the *Guidelines for Environmental Impact Assessment in Antarctica* (reference 17) and are similar to those used in recent CEEs prepared for similar types of proposed activities in Antarctica, including the Draft *Comprehensive Environmental Evaluation for ANDRILL* (reference 18) and the *Comprehensive Environmental Impact Evaluation for Recovering a Deep Ice Core in Dronning Maud Land, Antarctica* (reference 19). In addition, the methods are consistent with those used for two preliminary assessments of the environmental impacts for traverse activities performed by the Australian National Antarctic Research Expedition, *Preliminary Assessment Of Environmental Impacts of Autumn Traverse From Mawson Station To LGB6, 250 Km To The South, To Depot Fuel For The PCMEGA Expedition In The 2002/03 Summer* (reference 20) and *Preliminary Assessment of Environmental Impacts PCMGA Expedition In The 2002/03 Summer* (reference 21).

9.2 Benefits of the Proposed Action

The proposed action is intended to supplement the USAP's current airlift capability to transport cargo and support in-field scientific research. Benefits realized by the implementation of a traverse capability include:

- The availability of a transport option that may be better suited than aircraft for certain types of cargo (e.g., size, weight), logistical needs, environmental conditions (e.g., severe weather), or in-field research requirements.
- Reduced fuel consumption for re-supply missions, since each tractor can haul approximately twice the cargo as a fully laden LC-130 for the same fuel investment. Less fuel consumed directly relates to fewer exhaust gas air emissions.
- Reduced reliance on airlift resources that may facilitate a reduction in the number of missions or allow the aircraft to become available for other purposes.

- Ability to operate under a broader range of Antarctic conditions than aircraft. If needed, traverse equipment may be able to operate earlier and later during an austral summer season than aircraft.
- Reduced station-based cargo handling support because re-supply traverse personnel may be used to load and unload cargo.
- Established traverse routes may provide proven corridors to facilitate and enhance in-field scientific research.
- Robust traverse capabilities may provide the resources needed to conduct more comprehensive in-field research.

9.3 Physical Disturbances to the Snow/Ice Environment

The traverse activities being considered in this environmental review would only occur on snow and ice covered areas. By the nature of the proposed action, traverse activities would unavoidably disturb the surface of the terrain. Although the disturbance would be primarily confined to the width of the traverse route, the impact may be more than minor since the route could extend hundreds of kilometers. The number of reoccurring traverses on a particular route remains unknown as it depends on the intended goals of the mission. Depending on the route, crevasses which cannot be avoided would be filled with native snow and ice to facilitate safe passage of the traverse equipment. The natural processes of wind action and snow accumulation will obliterate visual evidence of vehicle traffic over a short period of time resulting in only a temporary impact. Physical disturbance impacts caused by proposed USAP traverse activities on areas containing ice sheets, glaciers, and the Polar Plateau are therefore considered to be low.

Undoubtedly, the performance of surface traverses will cause physical disturbances to the Antarctic environment and alter the wilderness value. These disturbances will be transitory and consistent with present and historical uses of traverse resources to foster the progress of Antarctic exploration. It is expected that the physical benefits derived from the use of traverse resources by the USAP for scientific research and operational support will far exceed any diminishment of the pristine character of the environment.

9.4 Air Emissions

The combustion of fuel and the resulting release of exhaust byproducts to the atmosphere will be an unavoidable consequence of the proposed action to conduct surface traverse operations using mechanized equipment. Although the volume of fuel consumed and the resulting air emissions may be significant for a particular traverse mission, the exhaust gases and particulates are expected to rapidly dissipate in the atmosphere downwind along the extent of the traverse route. These emissions may be visually noticeable or detectable near their sources, but the emissions are not expected to pose a long-term or adverse impact to the air quality or surface albedo.

Exhaust emissions resulting from the combustion of fuel during traverse activities are expected to be transitory and dissipate as the traverse proceeds along the route. For comparison, the air quality at McMurdo Station, which uses considerably more fuel in one year than a typical traverse, was monitored continuously for a year and was found to be well below the Ambient Air Quality Standards in the United States. This suggests that if the stationary sources at McMurdo Station do not adversely impact the environment, likewise the mobile sources on the traverse which use far less fuel would not have an adverse impact. In addition, to transport the same quantity of cargo, traverse operations use less fuel and emit far fewer exhaust emissions than the LC-130 aircraft currently used by the USAP in Antarctica.

9.5 Releases to Snow/Ice Environment

Various types of materials or substances may be released to the snow and ice environment either intentionally or accidentally during the performance of traverse activities. Objects deployed in the field to support traverse operations such as route marker flags may become encrusted in snow, lost, or deteriorate over time. It is anticipated that wastewater produced by traverse personnel will be containerized and transported to the maximum extent practical to a supporting USAP station for disposition. If wastewater must be discharged, it will only be released in areas allowed by the Antarctic Treaty. Wastewater, if discharged, will become permanently frozen in the snow, isolated below the surface, and will not pose a threat to human health or the environment. It is anticipated that abandoned objects will not contain hazardous materials and will not pose an adverse impact to the environment.

Throughout the progress of traverse operations, substantial quantities of fuel may be handled and used to operate traverse equipment as well as being transported as cargo. An accidental release such as spills or leaks of fuel or other hazardous materials (lubricants, coolants) cannot be predicted but represents a potential impact to the environment. However, spill prevention measures have been incorporated into the design of the equipment and traverse operating procedures. If a spill is detected, control measures can be rapidly implemented to respond to the incident. Fuel or other hazardous materials, which may be accidentally released on snow-covered terrain, would be expected to migrate vertically through the snow firn until reaching an impermeable surface where the material would spread laterally. In general, the USAP manages and transports large quantities of hazardous materials such as fuel on a daily basis and significant releases to the environment are relatively rare. If a spill occurs during a traverse operation, it has potential to affect the environment on a long-term but localized basis and it is expected that the released material would be isolated, limiting further migration.

9.6 Other Impacts

Implementation of the proposed traverse capabilities is expected to moderately affect operations at certain USAP stations and field camps involved with the traverse activities. Major operational conflicts or impacts will be avoided through advanced planning and resource scheduling.

Scientific research performed in the USAP will also be affected through the implementation of traverse capabilities. The impacts to science will be largely positive resulting from the use of the traverse capability to supplement existing airlift resources and provide new opportunities for research. Traverse activities will disturb the terrain but these impacts will be documented so that future research may be designed to avoid potential interferences.

USAP traverse activities will affect the social condition of the Antarctic environment represented by its wilderness value. The use of the traverse capability by the USAP will be isolated to specific routes and will be analogous to the traverse activities performed by other nations that operate in Antarctica. It is expected that the benefits realized by the USAP's use of traverse capabilities will far outweigh the localized and largely transient diminishment of the wilderness quality of the Antarctic environment.

9.7 Summary

The development and use of traverse capabilities by the USAP is a significant operational and scientific undertaking representing a major commitment of resources and potentially resulting in observable or measurable environmental impacts. The expected scientific and operational benefits related to the USAP's use of traverse capabilities have been thoroughly evaluated and are deemed to be substantial. The outputs (environmental impacts) resulting from the performance of traverse activities are well known, understood by numerous organizations that operate in Antarctica, and have been addressed in this CEE.

The USAP intends to use this CEE to address the potential impacts associated with the mechanical aspects of performing science-related or cargo transport traverses in Antarctica. Impacts associated with unique operations, specialized research techniques, or traverse routes which occur in areas (i.e., environmental settings) that are significantly different than those characterized in this CEE would be evaluated in supplemental environmental reviews.

The environmental impacts resulting from the performance of traverse activities may be more than minor or transitory but are localized along the traverse route. As realized by numerous other operators in Antarctica, the impacts associated with the use of surface traverse capabilities are relatively benign compared to the substantial benefits this transport mechanism offers. Overall, the projected impacts associated with the USAP's use of traverse capabilities were determined to be more than minor or transitory but the impacts would not result in a widespread adverse impact to the Antarctic environment.

10.0 NONTECHNICAL SUMMARY

This Comprehensive Environmental Evaluation was prepared by the National Science Foundation to evaluate potential impacts resulting from the proposed development and implementation of surface traverse capabilities by the USAP. The purpose of developing a surface traverse capability will be to enhance the USAP's current logistical support mechanism for the re-supply of facilities in Antarctica, specifically to provide a more capable alternate transportation method to complement the existing airlift resources. A second, yet equally important purpose for the implementation of surface traverse capabilities, will be the use of the traverse as a platform to perform advanced surface-based scientific studies in Antarctica. Overall, the implementation of a traverse capability would yield numerous benefits to the USAP, including decreased reliance on aircraft resources, increased opportunities to expand science in Antarctica, including the South Pole, and reduction in the quantity of fuel consumed to transport cargo and reduced air emissions resulting from the combustion of fossil fuels.

The methodology and equipment to conduct surface traverses in Antarctica is currently available. Various Antarctic Treaty nations, including the United States, have successfully performed traverses to meet numerous logistical and scientific goals. Currently the USAP does not possess a robust and fully mature traverse capability and can only perform surface traverses on a limited basis using existing resources. The intended use of the traverse capability to be developed by the USAP will be analogous to the traverse activities currently being performed by other nations that operate in Antarctica and are expected to continue in the future.

Description of Proposed Activities

The scope of the proposed action analyzed in this CEE is unique because it encompasses all traverse operations that may be performed by the USAP. Traverses may be designed for either re-supply or science-related research purposes and may utilize more than one traverse route. Surface traverses used for re-supply missions would typically be conducted between two primary facilities, following improved and marked routes, and would be used more than once. Traverses used for scientific purposes would follow routes that were selected to support the intended research and may be used only once.

Both types of surface traverses will typically involve the use of several motorized tracked vehicles towing sleds or trailers which contain fuel for the traverse equipment, living and working modules for the traverse crew, cargo, and other materials. Both re-supply and scientific traverses may stop each day of travel for rest, equipment inspection or repair, and scientific research. Each traverse would have the resources and equipment to refuel tractors, perform routine maintenance, and collect wastes for subsequent disposition at supporting stations. In some cases, sanitary wastewater may be discharged in snow-covered areas as allowed by the Antarctic Treaty.

The scale of re-supply and science traverses may be significantly different. Re-supply missions would involve the transport of deliverable payloads as well as the fuel and consumable supplies needed during the trip. For example, in an optimally configured re-supply mission from McMurdo Station to the South Pole, six tractors would be used, each capable of delivering approximately 20,000 to 27,000 kg of cargo while consuming approximately 20,000 liters of fuel on a 30-day roundtrip journey. To transport an equivalent amount of cargo to the South Pole from McMurdo Station, LC-130 aircraft would consume slightly less than twice as much fuel.

Unlike a re-supply traverse mission, a research traverse may require fewer and smaller tractors to transport the equipment and supplies needed to support the traverse crew and perform the intended research. Scientific traverses may depend on airdrops or strategically placed caches for periodic replenishment of consumable supplies. A typical scientific traverse may be conducted over a period of 40 days, using two tractors each consuming approximately 14,000 liters of fuel over the duration of the mission.

In this environmental review, the USAP has considered several alternatives for the proposed action. For re-supply purposes, Alternative A is an optimally configured system of traverse vehicles whose frequency of operation would complement existing airlift support mechanisms. Other alternatives considered included the development of the traverse capability and use of it on a minimal frequency basis only (Alternative B), under reduced intensity operating conditions (Alternative C), using minimal field support resources such as caches, depots, or airdrops (Alternative D), or only on established routes (Alternative E). The No Action Alternative, that is, not developing a surface traverse capability, was also considered and was designated as Alternative F. Several other alternatives were identified but were eliminated from detailed analysis because they failed to meet the required level of performance.

For science-related traverse activities or surface-based surveys, it is expected that the field activities will be specifically designed to support the proposed research; therefore, there are no relevant alternatives other than performing the research as proposed or not doing it at all.

Environmental Impacts

In this CEE, the USAP has addressed the potential impacts associated with the mechanical aspects of performing science-related or cargo transport traverses in Antarctica. The environmental setting for proposed traverse activities that was defined in this CEE included snow- and ice-covered areas of the Ross Ice Shelf, Transantarctic Mountains, and the Polar Plateau. Impacts associated with unique operations, specialized research techniques, or traverse routes which occur in sensitive areas or areas that are significantly different than those characterized in this CEE would be evaluated in supplemental environmental reviews.

Potential environmental impacts associated with typical surface traverse activities were identified and evaluated using two scenarios. The first example involved the re-supply of the Amundsen-Scott Station from McMurdo Station using traverse methods currently undergoing engineering evaluation in a proof of concept study. To evaluate potential impacts associated with scientific traverses and surface-based surveys, the International Trans Antarctic Scientific Expedition (ITASE) of which the USAP is a participant was selected as a second representative example for the use of the traverse capability.

By the nature of the proposed action, traverse activities will undoubtedly disturb the surface of the snow and ice-covered terrain. This disturbance would be primarily confined to the width of the traverse route and would be influenced by the number of reoccurring traverses on a particular route. Crevasses which cannot be avoided would be filled with native snow and ice to facilitate safe passage of the traverse equipment. The natural processes of wind action and snow accumulation will quickly remove any visual evidence of vehicle traffic resulting in only temporary impacts.

The use of mechanized equipment and the associated combustion of fuel will result in the unavoidable release of exhaust byproducts to the atmosphere. Traverse equipment will use less fuel and produce significantly fewer air emissions than aircraft transporting an equivalent amount of cargo. The exhaust gases and particulates are expected to dissipate in the atmosphere downwind of the traverse route. These emissions may be visually noticeable or detectable near traverse vehicles, but the emissions are not expected to pose a long-term or adverse impact to the air quality, surface albedo, or snow and ice chemistry.

Few releases to the snow and ice environment are expected as a result of traverse activities. Measures will be taken to prevent accidental spills of fuel, oil, glycol, or other hazardous substances used to support traverse activities, including materials stored in the field or transported by airdrop. Materials released during the course of traverse operations may include inert materials such as marker flags that will become encrusted in snow and ice. Wastewater may be discharged at various stopping points along the traverse route in areas allowed by the Antarctic Treaty and if it is not practical to containerize the material for further disposition. If wastewater is released, it would be sanitary wastewater and generally less than 7 liters per person per day. Wastewater discharged in the field would be isolated below the surface, become permanently frozen in the snow, and would not pose a threat to human health or the environment.

Surface traverse activities may result in other impacts. Operations at certain USAP stations and field camps involved with the traverse activities may be affected, but major operational conflicts will be avoided through advanced planning and resource scheduling. It is expected that mostly positive impacts to scientific research performed in the USAP will result from the new research opportunities provided by the traverse capabilities. Impacts resulting from traverse activities will be documented so that future research performed in Antarctica may be designed to avoid potential interferences from physical disturbances or releases. USAP traverse activities will also affect the social condition of the Antarctic environment represented by its wilderness value although these impacts will be localized, and the benefits realized by the USAP's use of traverse capabilities will far outweigh the resulting temporary impacts. The use of surface traverses by the USAP will continue the long-standing tradition of Antarctic exploration, in-field scientific research, and support of various facilities on the continent that are routinely performed by other nations.

Mitigating Measures and Monitoring

This CEE describes a number of measures that will be taken to mitigate (reduce or avoid) impacts to the environment and USAP operations resulting from the development and use of surface traverse capabilities. These mitigating measures have been designed to be effective and practical by addressing various aspects of traverse operations including:

- Traverse Routes
- Traverse Resources (equipment, personnel support resources, staffing)
- Physical disturbances to the snow and ice environment
- Air emissions
- Releases to the snow and ice environment
- Impacts to USAP Facilities and operations
- Impacts to scientific research in the USAP
- Impacts to social conditions of Antarctica

Provisions for most of the mitigating measures are developed during the planning and preparation stages of a traverse or surface-based survey activity and well before the actual field work is underway. During the planning and preparation stages, features are built into the design of the proposed traverse activity to ensure that the resources needed to conduct the traverse and mitigate potential impacts are available. Organizational impacts related to USAP facilities that may be involved in the proposed action will be effectively mitigated through advanced planning, scheduling, and allocation of resources and facilities.

Prior to the initiation of traverse activities, the USAP will develop an impact monitoring strategy to detect, if any, temporal and spatial changes caused by the proposed action. Environmental impact assessment and monitoring would be conducted during all phases of traverse operations, particularly during the planning stages to ensure that resources are adequately available to support mitigating measures and minimize environmental impacts.

Conclusions

The development and use of surface traverse capabilities by the USAP is a significant operational and scientific undertaking in the USAP representing a major commitment of resources. The benefits as well as the environmental impacts resulting from the performance of traverse activities are well known, understood by numerous organizations that operate in Antarctica, and have been addressed in this CEE.

The operational and scientific benefits expected from the USAP's use of traverse capabilities are deemed to be substantial and include:

- Availability of a transport option that may be more suitable under certain conditions than the exclusive use of aircraft
- Reduced fuel consumption and combustion exhaust air emissions
- Reduced reliance on airlift resources
- Ability to operate under a broader range of Antarctic conditions
- Availability of resources to expand the scope of in-field scientific research

The environmental impacts resulting from the use of surface traverse capabilities include:

- Physical disturbance to the snow and ice environment
- Release of fuel combustion byproducts (air emissions) to the atmosphere
- Minor releases of abandoned materials such as trail marker flags
- Possible releases of wastewater to snow and ice areas
- Potential accidental releases of fuel or other hazardous materials, or catastrophic losses of equipment and materials
- Impacts to operations at McMurdo Station and other USAP facilities
- Impacts to the wilderness value of Antarctica

The environmental impacts resulting from the use of surface traverse capabilities may be more than minor or transitory but will be localized along a designated traverse route. As realized by numerous other operators in Antarctica, the impacts associated with surface traverses are relatively benign compared to the substantial benefits this transport mechanism offers. Overall, the projected impacts associated with the USAP's use of traverse capabilities were determined to be more than minor or transitory but the impacts would not result in a widespread adverse impact to the Antarctic environment.

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12.0 LIST OF RECEPIENTS

Via a website link, the draft Development and Implementation of Surface Traverse Capabilities in Antarctica Comprehensive Environmental Evaluation (CEE) was made available for review to all interested parities including Antarctic Treaty nations, international and U.S. Federal agencies, research institutions, private organizations, and individuals. Printed hard copies were provided to the following:

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13.0 GLOSSARY

The following definitions are provided for unusual words or unusual uses of words in this document. These are not necessarily general definitions of these words.

Ablation - Erosion of a glacier or ice sheet by processes such as sublimation (i.e., vaporation of ice to atmospheric water vapor) and wind erosion. Areas of ice ablation are areas where the rate of ice removal by sublimation and wind erosion is high enough that a net loss of ice occurs. Ice ablation results in blue ice formations, which are exposed blue glacial ice without the usual cover of snow.

Accretion - Build-up of snow and ice. Areas of snow accretion are areas where there is a net positive accumulation of snow from precipitation, after the effects of sublimation and wind erosion and deposition have been considered.

AN-8 - A type of turbine fuel with ice inhibitors. AN-8 can be used by diesel engines as well as helicopters and jet or turboprop aircraft. JP-8 is a similar grade of diesel fuel but is not certified for use in aircraft.

Antarctic Treaty - The Antarctic Treaty was signed in Washington, D.C. in 1959 and entered into force in 1961. It establishes a legal framework for the area south of 60 degrees South, which includes all of Antarctica, and reserves Antarctica for peaceful purposes and provides for freedom of scientific investigation. The Treaty does not recognize, dispute, or establish territorial claims and prohibits the assertion of new claims.

Arches - Corrugated metal arches which serve to shelter storage and operations areas at the Amundsen-Scott South Pole Station.

Austral - Of or pertaining to southern latitudes. The austral summer is the period, approximately November–February, when Antarctic temperatures are highest and when most USAP activities occur.

Baseline Conditions - The facilities and resources required to operate and maintain the Amundsen-Scott South Pole Station including improvements realized as a result of the SPSE and SPSM projects.

Biological Oxygen Demand – A measure of how much decay of dissolved organic compounds in wastewater can deplete the dissolved oxygen concentration.

Bladder (fuel) - A portable, flexible synthetic-material fuel tank that is designed for use at temporary or remote sites. Bladders are shaped like pillows and are laid on the ground, snow or ice, sometimes over an impermeable liner, and then filled with fuel.

Bulk Storage Tank – A large fuel storage tank used to resupply smaller day tanks or to supply large fuel users such as power plants and aircraft.

Cumulative Impacts - As defined by the President's Council on Environmental Quality (40 CFR 1508.7), a cumulative impact is "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

Day Tank - A small tank that provides fuel for heating or other needs at an individual building. Day tanks are usually filled several times a week.

Decommissioning - The removal of a structure, vehicle, or piece of equipment from service or use. For the purposes of this environmental impact assessment, decommissioning of a structure refers to its dismantling (i.e., demolition) and removal from the South Pole.

Designated Pollutants - Substances which exhibit hazardous characteristics as defined in 45 CFR Part 671.

Graywater - Slightly contaminated wastewater from dishwashing, bathing and similar activities. Graywater does not contain human waste.

Ice Sheet - Continental masses of glacial ice sometimes covered with surface snow. Almost the entire Antarctic continent is covered by ice sheets moving slowly from areas of snow accumulation to the sea or to areas of ice ablation.

Initial Environmental Evaluation (IEE) - An environmental document defined in Annex 1 to the Protocol on Environmental Protection to the Antarctic Treaty. The IEE is prepared to determine whether a proposed activity might reasonably be expected to have more than a minor or transitory effect on the environment. If the IEE indicates that the proposed activity is likely to have no more than a minor or transitory effect on the environment, the activity may proceed with the provision that appropriate monitoring of the actual impact should take place; otherwise, a Comprehensive Environmental Evaluation should be prepared.

International Geophysical Year (IGY) - July 1, 1957 to December 31, 1958, a cooperative endeavor by the world's scientists to improve understanding of the Earth and its environment. Much of the field activity took place in Antarctica where 12 nations established some 60 research stations.

LC-130 – Four engine turboprop aircraft equipped with skis and used by the USAP to transport personnel and cargo.

Loading (wastewater) – The rate (mass per time) at which a wastewater constituent is discharged. The loading of a constituent is determined by multiplying its concentration in the wastewater (mass per volume) times the wastewater discharge flow rate (volume per time).

National Environmental Policy Act (NEPA) of 1969 - NEPA makes it the policy of the federal government to use all practicable means to administer federal programs in an environmentally sound manner. All federal agencies are required to take environmental factors into consideration when making significant decisions (Findley and Farber, 1991).

Project IceCube - This project involves a one-cubic-kilometer high-energy neutrino observatory being built and installed in the clear deep ice below the South Pole Station.

Protocol on Environmental Protection to the Antarctic Treaty - The Protocol was adopted by the Antarctic Treaty parties in 1991 to enhance protection of the Antarctic environment. The Protocol designated Antarctica as a natural reserve and set forth environmental protection principals to be applied to all human activities in Antarctica, including science, tourism, and fishing.

Retrograde – As used by the USAP, the transport of any items (e.g., wastes, used equipment, research samples) to the United States or other countries for processing or disposition (e.g., disposal, recycling, analysis).

Sanitary Wastewater - For the purposes of this environmental impact assessment, wastewater includes all liquid wastes entering the sewage collection pipe systems, including those from living quarters, galleys, laboratories, and shops. It does not include hazardous waste streams or industrial chemicals which are collected separately and either recycled or disposed of in permitted facilities in the United States

Secondary Containment - Facilities (e.g., dikes or double walls) to contain the contents of a fuel tank or pipeline in case of rupture.

Shear Zone – An area affected by converging ice masses and often containing crevasses or areas of surface instability.

South Pole Station Modernization Project (SPSM) - The reconstruction of the Amundsen-Scott South Pole Station, consisting of a new elevated complex of modular buildings and a series of subsurface steel arches. SPSM follows the South Pole Safety and Environment Project (SPSE) which was a series of three construction projects involving the replacement of the most critical components of the station's infrastructure to ensure continued safe operations. The SPSE project was completed in FY 2001 and included the replacement of the Garage/Shops complex, the Power Plant, and Fuel Storage.

Traverse – As used in the context of this environmental impact assessment, the process of transporting cargo or equipment over the snow covered surface of the terrain using tracked vehicles and sleds.

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