National Science Foundation
Office of Polar Programs
Alexandria, Virginia

ENVIRONMENTAL DOCUMENT CONCURRENCE

Activity:
Collection of Aggregate at McMurdo Station, Antarctica

[MCST2101.IEE]

I have read the attached document and concur with the findings and recommendation. I concur that the proposed activity can commence.

PAUL R SHEPPARD

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Date: 2021.09.09 11:31:41 -04'00'

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Date

National Science Foundation
Office of Polar Programs
Alexandria, Virginia

**ENVIRONMENTAL DOCUMENT AND
FINDING OF NO MORE THAN
MINOR OR TRANSITORY ENVIRONMENTAL IMPACT**

Collection of Aggregate at McMurdo Station, Antarctica

[MCST2101.IEE]

FINDING

The United States Antarctic Program (USAP) proposes to collect aggregate (harvested rock and sediment) as part of station operations. Aggregate is used to maintain roads and walkways, prepare a working surface for the ice pier, and construct load-bearing pads for buildings and equipment. Aggregate is routinely required to support facility maintenance as well as construction and modernization activities; these types of activities are expected to continue into the future.

Based on the analyses in this environmental document, National Science Foundation (NSF) Office of Polar Programs (OPP) has determined that implementing the proposed activity would have no more than a minor or transitory impact on the Antarctic environment within the meaning of NSF's implementing regulations for the Protocol on Environmental Protection to the Antarctic Treaty. Therefore, a comprehensive environmental evaluation will not be prepared.

We recommend this activity proceed on the basis of implementing the Proposed Alternative (Alternative A). This alternative would designate all historically used areas for aggregate collection, with refined area boundaries, to ensure future needs are met. All historically used areas are within the previously disturbed footprint of McMurdo Station.

Erin Heard 3 September 2021

Recommending Official Date
Erin Heard
McMurdo Station Manager
Office of Polar Programs

Polly A. Penhale 3 September 2021

Recommending Official Date
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1.0 INTRODUCTION

The United States (U.S.) Antarctic Program (USAP) operates McMurdo Station on Ross Island to support scientific research in Antarctica. As part of station operations, aggregate (harvested rock and sediment, previously referred to in McMurdo as “fines”) is routinely required to support facility maintenance and construction activities. Historically, aggregate has been collected during the austral summer within the previously disturbed footprint of McMurdo Station.

Aggregate is used to maintain roads and walkways, prepare a working surface for the ice pier, and construct load-bearing pads for buildings and equipment. These types of routine operations at the station are expected to continue into the future, concurrent with construction activities related to the modernization of McMurdo Station, including the Antarctic Infrastructure Modernization for Science (AIMS) project.

Past aggregate environmental impact documentation includes seven documents that designate different collection areas and methods used over the past 16 years. Table 1-1 provides a summary of prior environmental impact assessment (EIA) documents. This Initial Environmental Evaluation (IEE) for aggregate collection serves as a comprehensive and cohesive document by synthesizing information and considerations from the prior seven documents, evaluating alternatives, and establishing an action plan to meet future needs.

This IEE is prepared in accordance with applicable provisions of Annex I, Article 3 of the Protocol on Environmental Protection to the Antarctic Treaty (the Protocol); the Guidelines for EIA in Antarctica (Antarctic Treaty Secretariat [ATS] 2016); the Antarctic Conservation Act, as amended by the Antarctic Science Tourism and Conservation Act of 1996, 16 U.S. Code § 2401 et seq.; and implementing regulations set forth in 45 Code of Federal Regulations (C.F.R.) Part 641, Environmental Assessment Procedures for National Science Foundation (NSF) Actions in Antarctica.

Table 1-1. Summary of EIA Coverage for Collection of Aggregate

Title	Document Number	Scope of Analysis	Comments
Final CEE for Continuation and Modernization of McMurdo Station Area Activities (NSF 2019)	MCAN1900.CEE	1. Use existing areas – reference existing IEEs 2. Quantity identified in Section 3 tables by year: 3200 m^3 to 39,500 m^3/yr (total: 93,155 m^3 / 121,840 yd^3) 3. Ongoing: 3060 m^3 / 4000 yd^3 (10-yr total: 30,600 m^3 / 40,000 yd^3) 4. 10-yr total (construction plus continuing operations): 123,755 m^3 / 161,840 yd^3	• Implicitly assumes volume capacity available • Totals not calculated in CEE but can be with information from CEE
IEE: Collection of Rock Fines (Riprap) at McMurdo Station, Antarctica (NSF 2014)	MCST1201.IEE.AM1	1. Continued use of 2011 plus new area (across road from Reds 2004 ROER area) 2. Focus on riprap collection in 2014–2015 3. Dozer and explosives use (800–1300 lbs)	• Establishes use of a fifth area • Use of dozer and explosives

Continued on the next page…

Table 1-1. Summary of EIA Coverage for Collection of Aggregate

Title	Document Number	Scope of Analysis	Comments
Collection of Rock Fines at McMurdo Station, Antarctica (NSF 2011)	MCST1201.IEE	1. Continued use with estimated quantity available: Reds 2004 ROER (41,800 yd^3), Gray's Chute (106,400 yd^3), Haz Yard (13,900 yd^3), Larryville Rubble Pile (31,400 yd^3) 2. Undefined annual amount to be collected (141,100 m^3 total) 3. 'Scraping' (dozer with claw ripper) to collect; also explosives use 4. 'Other equipment' to crush and sort	• Establishes four existing areas • Use of dozer, explosives and 'other equipment' to crush and sort
Continued Gathering of Fines for McMurdo Station Operations (NSF 2010)	MCST0800.R01.AM1	1. Extends time period of 2007 ROER 2. Adds new area 3. Proposed harvest: 20,000 m^3 total over 3 years 4. Historic average rate: 11,500 m^3/yr 5. Fines and riprap	
Continued Gathering of Fines for McMurdo Station Operations (NSF 2007)	MCST0800.R01	1. Harvest for 3 years 2. 7500 to 9000 m^3 for 2007–2008 3. 12,000 m^3 for 2008–2009 and 2009–2010 4. Historic average rate: 11,500 m^3/yr 5. Fines and riprap	
Gathering Fines Adjacent to Fortress Rocks for Maintenance and Improvement to the Former Landfill and Waste Processing Area, McMurdo Station, Antarctica (NSF 2004)	MCST0500.R02	1. Gathering gray fines adjacent to former Fortress Rocks Landfill 2. Material for maintenance to the landfill cover 3. Create more usable space in Fortress Rocks	
Gathering Red Fines from an Area Behind the Ridgeline to the North East of McMurdo Station (NSF 2003)	MCST0400.R04	1. Additional collection area because of diminishing amounts in current areas 2. Needed for supporting construction and safety-related maintenance	

Key: CEE = Comprehensive Environmental Evaluation; EIA = environmental impact assessment; IEE = Initial Environmental Evaluation; lbs = pounds; m^3 = cubic meter; NSF = National Science Foundation; ROER = Record of Environmental Review; yd^3 = cubic yard; yr = year

2.0 PURPOSE AND NEED

The purpose of the proposed activity is to ensure future aggregate needs are met for both typical USAP operational requirements (e.g., road maintenance; ice pier construction; and traction for prevention of slips, trips, and falls onto ice) and construction and modernization projects at McMurdo Station. The activities requiring the use of locally available aggregate are expected to continue as long as the station remains operational. As discussed in the Final Comprehensive Environmental Evaluation (CEE) for Continuation and Modernization of McMurdo Station Area Activities (NSF 2019), aggregate will also be required for construction undertaken during the next 15 to 20 years as part of the AIMS project and other modernization projects at McMurdo Station.

3.0 PROPOSED ACTIVITY

USAP proposes to collect aggregate for future needs from three alternative sets of designated areas: all historically used areas (Alternative A), four areas specified by the Operations Team (Alternative B), or the locations currently designated by the last EIA document dealing with aggregate (NSF 2019; Alternative C).

It is not anticipated that the aggregate would be gathered from all areas simultaneously but rather in an organized manner depending on a number of factors, such as the type, quantity, and quality of the material needed. Depending on the requirements and nature of the recovered aggregate, other equipment may be used to crush or screen the aggregate. After screening, material may be hauled to the area where it is needed or stockpiled for future use. The amount of material that would be collected during each austral summer would depend on the weather, type, and quantity of aggregate needed and available resources (e.g., equipment, staff, and explosives).

The proposed activity (Alternative A) would designate all historically used areas for aggregate harvesting to ensure future needs are met.

4.0 BACKGROUND

4.1 Aggregate Types and Purposes

Two types of aggregate, referred to as “gray” and “red,” are needed at the station and are available in the McMurdo area. Each type has distinct physical properties and is recovered from different areas. Gray aggregate, a basalt, is the more substantial material. It is the denser, higher-strength material of the two and is used for projects requiring high load-bearing capacities (e.g., building foundations) and in areas prone to surface water runoff and wind erosion. Red aggregate (felsitic scoria) is lighter, has a lower specific gravity, and is used primarily for ice pier maintenance, sanding roads and walkways, and construction projects with minimal structural engineering requirements. In general, aggregate used at McMurdo Station needs to be replaced due to windblown losses, loss resulting from snow removal, and loss due to erosion from surface water runoff.

Aggregate at McMurdo Station is primarily recovered by extracting surficial weathered material on slopes and hillsides. Explosives have also been used to gather aggregate, most notably during the 2019–2020 austral summer in the Gray’s Chute area, as part of AIMS preparation work.

4.2 Naming Convention

To date, aggregate collection areas have been inconsistently identified by colloquial names, which has led to confusion. The following revised naming convention is proposed to establish a systematic and logical naming convention to clarify materials and collection area locations (Table 4-1); it is also identified and discussed in Section 7.6, Mitigation Measures.

Table 4-1. Crosswalk Between Historical Names and Proposed Naming Convention

Proposed Naming Convention	Historical/Common Name	Material Type	Alternatives			Comments
			A	*B*	*C*	
GR-1	Surveyor's Quarry	Gray/Red	✓	✓		Sites Used in the Past 2 Years
G-2	Gray's Chute	Gray	✓	✓	✓	Sites Used in the Past 2 Years
GR-3	2004 Previous	Gray/Red	✓	✓		Sites Used in the Past 2 Years
G-4	Arrival Heights Ridge	Gray	✓			Historically Used Site
R-5	Red's 2014 ROER	Red Fines	✓	✓	✓	Historically Used Site
R-6	Big Basin Range	Red	✓			Historically Used Site
GR-6	(2010) 08 Audit	Gray/Red	✓			Historically Used Site
GRRp-7	Haz Yard Rock Quarry	Gray/Red/Riprap	✓		✓	Historically Used Site
G-8	2005 ROER	Gray	✓		✓	Historically Used Site
GR-9	Larryville Rubble Pile	Gray/Red	✓			Historically Used Site

5.0 ALTERNATIVES TO THE PROPOSED ACTIVITY

5.1 Alternatives Analyzed in the IEE

5.1.1 Alternative A: Designate all areas historically used for aggregate collection for future use, with refined area boundaries

As depicted in Figure 5-1, aggregate has historically been gathered from at least 10 known areas in the vicinity of McMurdo Station. Use of some areas has been discontinued over time due to limited potential for the efficient recovery of aggregate. Slopes in some portions of historical areas have become too steep to safely operate heavy equipment. However, new and alternative techniques for aggregate collection may make those sites safe and viable sources for aggregate in the future. As part of adoption of this alternative as the proposed activity, creation of an Aggregate Management Plan would be recommended (Section 7.6, Mitigation Measures).

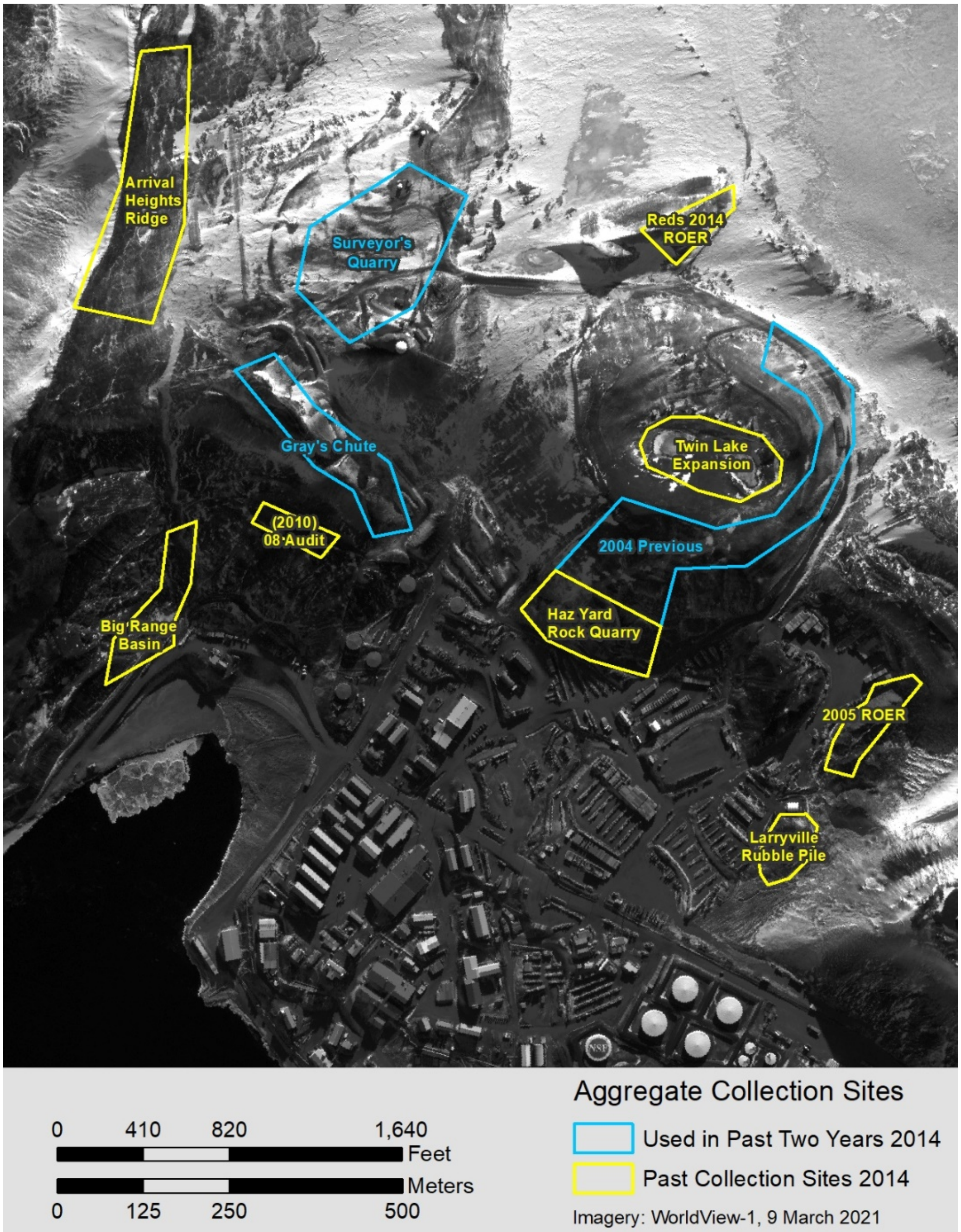

Figure 5-1. Past and Present Aggregate Collection Areas from IEE Collection of Rock Fines at McMurdo Station, Antarctica

The boundaries of the past and present aggregate collection areas, as shown in Figure 5-1, were traditionally delineated with desktop tools and imagery and without field validation. To more accurately recognize past and present boundaries, the surveyor on-site at McMurdo Station was tasked with field-verifying all locations during the 2020–2021 austral summer season. Figure 5-2 shows the refined, field-verified polygons that were created from the survey effort and uses the revised naming convention. These new polygons do not represent a change to the collection areas, rather they represent more accurate boundaries of all the previously used areas that had been approximated on figures in the past.

Figure 5-2. Past and Present Aggregate Collection Areas from IEE Based on 2020–2021 Austral Summer Ground-truthing and with Revised Naming Convention

5.1.2 Alternative B: Designate a small subset of areas

The Operations Team has stated that a subset of all areas would be required to support currently known future aggregate needs. These four areas (as illustrated in Figure 5-3) represent a reduced subset of all previously designated aggregate gathering areas and a change from the areas designated in the last environmental impact document that discussed aggregate collection (NSF 2019).

Figure 5-3. Reduced Subset of Four Areas Designated for Aggregate Collection

5.1.3 Alternative C: No Action Alternative – Continued operation of aggregate collection in currently approved areas according to the latest EIA document (NSF 2019)

This alternative would continue currently approved aggregate operations outlined in the CEE, as illustrated in Figure 5-4 (NSF 2019).

Figure 5-4. Aggregate Harvesting Areas from McMurdo CEE

5.2 Alternatives Considered but Not Further Evaluated

Import sterile aggregate to McMurdo for any additional aggregate requirements

This alternative is likely cost prohibitive, and the impact to the environment of shipping aggregate to the continent is assumed to be greater in magnitude than harvesting locally. Due to the anticipated cost, it is eliminated from further consideration.

6.0 INITIAL ENVIRONMENTAL REFERENCE STATE

This section briefly describes the initial environmental reference state most relevant to the collection of aggregate in the vicinity of McMurdo Station. Baseline conditions at McMurdo Station, extending beyond the scope of this document, are also comprehensively presented in the Final CEE for Continuation and Modernization of McMurdo Station Area Activities (NSF 2019). Conditions have generally remained the same since that time.

6.1 Physical Conditions

McMurdo Station is located on a mostly ice-free area on a peninsula of Ross Island, adjacent to the McMurdo Sound portion of the Ross Sea. The terrain on Ross Island consists of high ridges and sloping hills of barren volcanic rock, frozen soil with permafrost, and ice and snow fields. Many of the permanent snow fields have disappeared or are receding (NSF 1991). Land areas of McMurdo Station are generally ice-free during the austral summer. The developed, previously disturbed footprint of McMurdo Station is approximately 2.5 km^2 (1 mi^2). McMurdo Station is characterized as heavily disturbed as a result of human activities (Kennicutt et al. 2010).

Soils consist of volcanic cinders and granular rock. The permeable surficial soils consist of gravel with sands and silt (NSF 2019). Subsurface soils typically are impermeable because they contain ice from refrozen snowmelt within the interstitial pores. Aggregate at McMurdo Station is recovered primarily by extracting surficial weathered material on slopes and hillsides (NSF 1991). Surface layer soils at McMurdo Station, primarily in active operational areas, are contaminated with petroleum products as a result of historical spills (Affleck et al. 2014a). It is unlikely that contamination extends into subsurface sediment layers because ice in the voids generally prevents downward migration (NSF 1991).

Surface water runoff consists of snowmelt. Most snowfall at the station sublimates or melts during the summer. Snowmelt runoff is channeled through a network of diversion ditches, culverts, pipes, and plastic lining that was constructed to divert water around the center of McMurdo Station and into Winter Quarters Bay and McMurdo Sound from four primary discharge points (NSF 2019). The snowmelt runoff drainage area is approximately 5.1 km^2 (2 mi^2) and includes portions of a glacier adjacent to the station that may thaw and contribute to runoff. Flow rates in runoff channels exhibit large daily and seasonal variability. The major flow paths are typically filled with snow and ice in the winter months, and are manually cleared before the austral summer. Extreme flows of snowmelt runoff occur that exceed the capacity of the drainage system, causing water to overflow channel banks, resulting in massive soil erosion (Affleck et al. 2014a).

Petroleum materials used for USAP are refined products; crude oil is not stored or used at McMurdo Station (NSF 1991). A spill prevention plan was developed and implemented for McMurdo Station operations (NSF 1991). Spill prevention plans have been updated over the years as fuel storage and transport structures have been updated to meet modern standards. However, spills have occurred historically, resulting in petroleum contamination of surface soils throughout McMurdo Station (Kennicutt et al. 2010, Klein et al. 2012). The largest spill volumes were associated with fuel storage facilities and fuel handling operations, whereas spills associated with general maintenance and construction activities, most similar to the proposed activity, tend to be small volumes that are effectively contained. Snowmelt runoff has the potential to erode and transport sediments contaminated with residues from spilled fuels, solvents, and paints (Affleck et al. 2014a). For example, Affleck et al. (2014a) showed that concentrations of metals in snowmelt runoff were elevated during the first flush when flow began in receiving channels where significant operational or day-to-day activities occurred. In other places, elevated concentrations occurred during the first significant flow, and the concentrations for selected petroleum hydrocarbons (polycyclic aromatic hydrocarbons) were elevated during the first peak flow. Given that the snowmelt runoff contained elevated concentration of metals and certain petroleum hydrocarbon components, some of which were above the thresholds for chronic limits for aquatic water quality in saltwater, prevention and mitigation are crucial for reducing contamination at McMurdo Station (Affleck et al. 2014a).

6.2 Visual Character

The intrinsic value of Antarctica, including its wilderness and aesthetic values, shall be fundamental considerations in the planning and conduct of activities in the Antarctic Treaty area. Although McMurdo Station is not considered wilderness like most of the continent, the aesthetic value of the area should be preserved to the greatest extent practicable. Activities at McMurdo Station shall be planned and conducted to avoid degradation or substantial risk to the wilderness and aesthetic values of the area.

Aesthetics and visual resources are comprised of natural and human-made features (Figure 6-1, Figure 6-2). The visual character of undeveloped areas around McMurdo Station include multiple natural elements within the landscape (e.g., landforms, water surfaces, etc.), while developed and disturbed areas are characterized by a composition of mostly human-made and sometimes natural elements (e.g., buildings, fences, roadways, traffic, topography, etc.). Developed areas are further defined by the size, form, material, and function of buildings, structures, roadways, and infrastructure, all of which are subjected to ongoing operational demands and modernization activities (NSF 2019). In general, McMurdo Station is a highly disturbed area composed of industrial to academic style facilities typical of a remote, self-supporting research campus. These natural and human-made features form an observer's impression of an area or the landscape character, which can dominate the primary landscape or blend into the surrounding environment. Attributes used to describe the visual resource value of an area include landscape character, aesthetic value, and uniqueness.

McMurdo Station is a singular area of development within Antarctica with the mission to support research and associated support activities for continental Antarctica, which is reflected in its overall visual character. The aggregate harvesting areas are north and northeast of this developed area, sitting at a higher elevation and blending into the surrounding landscape. Past aggregate harvesting activities at these locations have resulted in some landform changes. However, regrading efforts associated with collection activities have blended these aggregate harvesting areas after use into the natural landscape surrounding McMurdo Station.

The wilderness and aesthetic values for McMurdo Station include the views and viewsheds of McMurdo Station (including the aggregate harvesting areas) from McMurdo Sound, for all visitors to the area including national Antarctic programs, distinguished visitors, and tourists. Personnel working at McMurdo Station also appreciate views and the greater landscape character of this area. They appreciate views from McMurdo Station and the trails and roads surrounding McMurdo Station.

McMurdo Sound is less than 1 km (0.6 mi) from the nearest aggregate harvesting area. When the weather is clear, the distance from the aggregate harvesting areas is visible from McMurdo Sound. However, the topography, naturally mountainous terrain surrounding McMurdo Station, and the purposefully blended landscape (after harvesting activities) makes it difficult to visually identify the aggregate harvesting areas.

Figure 6-1. Views from McMurdo Station to McMurdo Sound (NSF 2015)

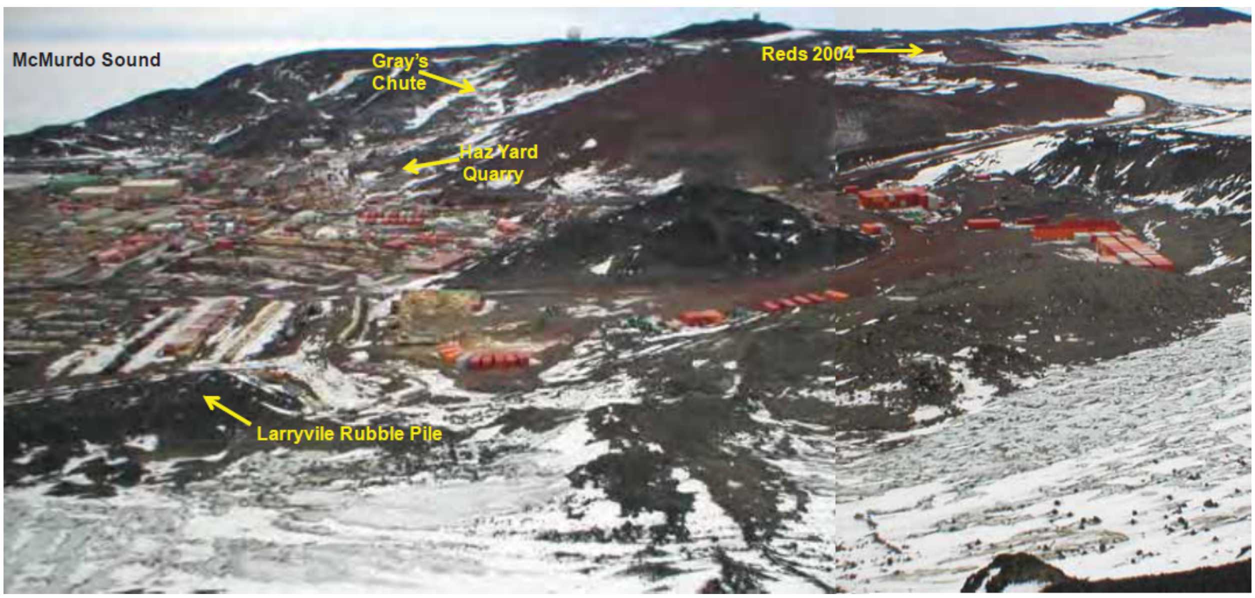

Figure 6-2. Location of Some of the Aggregate Harvesting Areas Relative to McMurdo Sound (NSF 2011)

7.0 ENVIRONMENTAL IMPACTS, MITIGATION MEASURES, AND MONITORING PROCEDURES

7.1 Introduction

The environmental impacts resulting from the collection of aggregate include: (1) physical disturbances; (2) air emissions; (3) visual impacts; and (4) accidental releases (i.e., spills or leaks from heavy equipment used for aggregate collection and screening equipment).

Terrain alteration caused by collection of aggregate in the designated areas would not significantly change the existing land use conditions at McMurdo Station. All aggregate collection sites have been historically disturbed by similar activities. While various invertebrates, mosses, lichens, birds, and marine mammals exist on and around Ross Island, these species are generally not present in the immediate vicinity of the station due to the lack of undisturbed habitat. The land surfaces in aggregate collection areas do not generally represent local fauna or flora habitat, so the physical disturbances resulting from the proposed activity are not expected to adversely impact the terrestrial ecology.

Air emissions are expected during the collection of aggregate, including exhaust emissions from the operation of equipment and vehicles, fugitive dust from the handling of aggregate, and emissions from intermittent use of explosives. All of these would be released to the ambient air but would quickly disperse and are not expected to affect local air quality. Mitigations to minimize dust would include compacting road surfaces, spraying roads and construction sites with water, reducing vehicle speeds, and limiting the size of areas being actively disturbed.

Potential impacts associated with the routine use of explosives for facility operations and research purposes were previously assessed in the environmental impact document titled "Continued Use of Explosives to Support Operations and Scientific Research in Antarctica" (NSF 2006); this analysis is included by reference.

Mitigating measures would be implemented in areas adjacent to snowmelt runoff streams to reduce sediment transport. These may include best management practices (BMPs) typically used at McMurdo Station, such as grading channel slopes and placing riprap or structural supports along the banks of channels.

Other mitigation measures are presented for the purpose of formalizing long-term and ongoing general operating procedures, some of which are included in existing plans, policies, and environmental reviews. Mitigation measures applicable to the collection of aggregate and identified in the Final CEE for Continuation and Modernization of McMurdo Station Area Activities are also incorporated by reference (NSF 2019).

7.2 Impacts from Aggregate Collection Activities

7.2.1 Physical Disturbance to Snow/Ice Environment

Aggregate is collected from several locations in support of both ongoing annual maintenance operations as well as construction activities associated with an extended program to modernize infrastructure at McMurdo Station (NSF 2019). Maintenance operations at McMurdo Station require 3060 m^3 (4000 yd^3) of aggregate each year for existing operations. During the 15- to 20-year construction phase of modernization projects, an average of approximately 10,690 m^3 (13,980 yd^3) of aggregate, ranging from 1250 m^3 (1635 yd^3) to 35,935 m^3 (47,000 yd^3), will be required per year for new construction projects. An additional undefined amount of aggregate could be needed for emergency purposes. No single location at McMurdo Station contains enough aggregate to meet the identified volume requirements over the planning horizon. Consequently, numerous aggregate collection sites have been and would continue to be required to satisfy operational and construction-related demands.

Aggregate is harvested by using a bulldozer or similar equipment to scrape the weathered surficial materials from slopes and hilltops. Subsurface aggregate is not harvested because it contains ice in the particle voids, which makes it more difficult to harvest without explosives. Per the 2019 CEE (NSF 2019), explosives may be used as needed to quarry fill and fine materials. Typically, after the aggregate has been extracted and mounded into a pile, it is screened to segregate fines (less than 5 cm [approximately 2 in] diameter) from larger aggregate (up to 2 m [6.5 ft] diameter) or hauled to a suitable screening or storage site. Once aggregate is sieved to the required size and certified for use on building foundations, it is placed and compacted as necessary (depending on results of soil density testing) to establish the required strength and grade for construction. Aggregate extraction operations follow environmental protection guidelines to minimize fugitive dust, fuel use, and area disturbed. Guidelines include minimizing the area disturbed at any one time, compacting road surfaces, operating vehicles at low speeds, and spraying water over disturbed areas.

Potential environmental impacts related to physical disturbances to the snow/ice environment associated with aggregate collection at McMurdo Station, presented by proposed alternatives in this section, have been identified and incrementally evaluated in the Supplemental Environmental Impact Statement (SEIS; NSF 1991), subsequent IEEs, the CEE (NSF 2011, 2014, 2019), and Table 1-1. These evaluations identified alterations of the terrain and increased erosion of aggregate due to changes to runoff patterns and volumes as the primary physical impacts to the snow/ice environment associated with aggregate collection.

Technical reports focusing on or including aggregate collection have been prepared over the years. The U.S. Army Corps of Engineers (USACE) prepared a rock material management report for McMurdo Station (Knuth and Melendy 2011). While the report provides recommendations for the long-term harvesting of aggregate, such as alternative methods to annual material usage, establishing a rock quarry at McMurdo Station to centralize material collection operations, and purchasing a crusher to make better use of collected material, it does not provide a comprehensive review of material collection and uses, identify specific BMPs to reduce potential impacts to the environment, provide a focused plan for the future, or evaluate the extent (volume) of the resource compared to the foreseeable volume requirements. Measures identified in Section 7.6, Mitigation Measures, follow recommendations identified in these prior technical reports, IEEs, and the 2019 CEE. Additional updated measures are also identified.

Alternative A: Use of Historical Aggregate Sites

Under Alternative A, aggregate harvesting would occur at all historically used sites (Table 4-1; Figure 5-2). Impacts associated with terrain alterations would be minimal for all action alternatives because all aggregate harvesting activities would be within the current McMurdo Station footprint, all of which has been altered historically. Terrain alteration caused by collection of aggregate in the designated areas would not significantly change the existing land use conditions at McMurdo Station. Terrain alterations mostly consist of residual scrape patterns (rows) from bulldozer or other heavy equipment operations that persist for the duration of the aggregate harvesting operations within an austral summer period. Once the available aggregate has been harvested from an individual site, the site is contoured to match the surrounding terrain to the extent possible following standard practices.

Changes to the contour of the landscape would not substantially alter the snowmelt runoff patterns. Runoff from the aggregate harvest sites is and would continue to be controlled using a series of diversion ditches, culverts, pipes, and plastic lining material, as well as catchment basins, to reduce erosion and control the transport of eroded soils. Generally, drainage improvement projects slow the runoff flows and minimize or eliminate scouring and erosion of drainage channels. BMPs, including grading channel slopes and riprap bank stabilization, would be used to minimize the potential for erosion due to snowmelt flows.

Aggregate collection operations follow standard practices as presented in prior EIA documents (e.g., NSF 2019) to minimize fugitive dust, fuel use, and area disturbed. Practices include minimizing the area disturbed at any one time, compacting road surfaces, operating vehicles at low speeds, and spraying water over disturbed areas. However, despite the runoff control measures, some of the aggregate eroded from the quarry sites could be transported via runoff to Winter Quarters Bay. Discharges of snowmelt runoff would represent a source for anthropogenic loadings of suspended soil particles to the bay. The extent to which runoff from the quarry sites would represent additional loadings of petroleum hydrocarbons is unknown; it would depend on the level of contamination at the aggregate quarry and the duration of aggregate harvesting at the site.

Additionally, dust would be generated during aggregate collection. Dust can be transported by local winds to adjacent areas outside of the aggregate site boundaries. Deposition of fugitive dust on snow increases the melt rate, with the potential for exposing more soils to erosional forces of wind and surface water flows. Fugitive dust could also be deposited on the sea ice in Winter Quarters Bay and eventually sink to the seabed once the seasonal sea ice melts, representing an additional source of sediment loading to the bay. Additionally, fugitive dust could be blown onto the sea ice in McMurdo Sound, which could accelerate sea ice melt and might affect the duration sea ice routes are viable for travel during the austral summer.

In general, the SEIS (NSF 1991), subsequent IEEs (NSF 2011, 2014), and the CEE (NSF 2019) all concluded that impacts of aggregate harvesting on the physical condition of the snow/ice environment would be minor. Because Alternative A would involve aggregate collection at sites that have been used historically, it would not involve disturbances to any previously undisturbed areas within McMurdo Station. As discussed above, some physical impacts to the snow/ice environment would occur outside of the aggregate site boundaries due, for example, to offsite transport of eroded aggregate by snowmelt runoff. However, the contribution of aggregate generated by the aggregate quarry process to sediment loading to Winter Quarters Bay is expected to be minor in comparison to the entire watershed. Consequently, physical impacts to the snow/ice environment would be minor and consistent with those discussed above. Mitigation measures proposed in Section 7.6, Mitigation Measures, would be applicable to all activities under this alternative.

Alternative B: Use of Subset of Aggregate Sites

Under Alternative B, aggregate harvesting would occur at four sites (Table 1-1; Figure 5-3). The types of activities and associated physical impacts to the snow/ice environment would be minor and similar to those discussed above. The four aggregate collection sites identified for Alternative B overlap to a large extent with the historically used sites in Alternative A. Similar to Alternative A, this alternative would involve aggregate collection at sites that have been used historically, but it would not involve disturbances to any previously undisturbed areas within McMurdo Station. Similar to Alternative A, some physical impacts to the snow/ice environment would occur outside of the aggregate site boundaries due to offsite transport of eroded aggregate by snowmelt runoff. However, the contribution of aggregate generated by the aggregate quarry process from the four collection sites to sediment loading to Winter Quarters Bay is expected to be minor in comparison to the entire watershed. Consequently, physical impacts to the snow/ice environment would be minor and consistent with those discussed above. Mitigation measures proposed in Section 7.6, Mitigation Measures, would be applicable to all activities under this alternative.

Alternative C: No Action - Continued Operation of Currently Approved Sites

Under Alternative C, aggregate harvesting would occur at the five sites currently approved in the 2019 CEE (Figure 5-4; Table 4-1). Four of the sites overlap with sites identified for Alternative B; the fifth site corresponds closely to the historically used site (GR-9 [Larryville Rubble Pile]) included in Alternative A. The types of activities and associated physical impacts to the snow/ice environment would be minor and consistent with those discussed in the 2019 CEE (NSF 2019). Mitigation measures proposed in Section 7.6, Mitigation Measures, would be applicable to all activities under this alternative.

7.2.2 Impacts to Wilderness and Aesthetic Values and Visual Quality

Impacts to wilderness and aesthetic values and visual resources and their quality is evaluated by using the degree of visible change that a proposed activity may cause, taking into account the value and sensitivity of the visual environment. Impacts to this resource occur if changes in the existing environment are visually incompatible with the valued visual character, affect a large number of viewers, or modify the visual character of an area that contributes to the public's appreciative enjoyment of the environment, also considered a valued visual resource. Additionally, impacts to disturbed areas typically have a lesser impact while natural areas incur a greater impact.

The regulatory guidance for wilderness and aesthetic values include Annex I, Article 3 of the Protocol, which states that, "[t]he protection of the Antarctic environment […] and the intrinsic value of Antarctica, including its wilderness and aesthetic values […] shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area" (ATS 1991).

Additionally, the 2015 McMurdo Station Master Plan outlines a specific visual character regarding the centrally developed area. Its overall mission sets a standard for all land used within and surrounding McMurdo Station that reflects the professional nature of NSF and the scientific activities carried on within the station.

Alternative A: Use of Historical Aggregate Sites

Under Alternative A, harvesting activities would only occur at previously used harvesting areas (Figure 5-2) for the duration of the austral summers to support the construct of the AIMS projects from 2019 to 2026 and the Master Plan's projects from 2027 to 2033, totaling to 14 years of major construction (1250 to 38,995 m^3 of fill; NSF 2019), then tapering off to standard operations support (3060 m^3 of fill; NSF 1991).

Long-term, medium impacts to wilderness and aesthetic values and visual resources are likely to occur from potential changes to the landform after the aggregate has been harvested for the proposed construction projects. Due to the quantity of fill required, it is likely that the amount of aggregate collected would clear enough land to visually change the topography and potentially the natural skyline. It is likely these changes would only be recognizable to those familiar to the McMurdo Station area. Carefully choosing where the most aggregate is harvested could mitigate visual impacts from McMurdo Sound and other popular lookout areas as the mountainous terrain and distance naturally buffers direct visual access to some of the harvesting areas.

Additionally, when the modernization projects have been completed, the demand for aggregate would significantly decrease. Changes in landform are still expected; however, impacts would likely be unnoticeable, as mitigation measures to regrade these areas would blend the harvested areas into the surrounding visual landscape.

Aggregate collection activities could be visually distracting to the area since there is an overall, uniquely stark character of the visual landscape. Distance, weather, and some degree of topography would buffer and/or prevent visual impacts to some extent; however, some short-term, low-intensity impacts to wilderness and aesthetic values and visual resources are likely.

Alternative B: Use of Subset of Aggregate Sites

Under Alternative B, aggregate harvesting would occur at four previously used sites (Table 1-1; Figure 5-3). The types of impacts from construction and harvesting activities would be the same as Alternative A. While the scope of impacts would proportionately decrease associated with the reduced number of sites, the magnitude of impacts on wilderness and aesthetic values and visual resources could be more concentrated at each site. By focusing aggregate harvesting to fewer areas, there could be an increase to the intensity and duration of the visual impacts resulting from more focused activity and changes to the terrain.

Alternative C: No Action - Continued Operation of Currently Approved Sites

Under Alternative C, the impacts to wilderness and aesthetic values and visual resources would be comparable to Alternatives A and B but would occur at sites identified in the 2019 CEE (NSF 2019). Operations would maintain the current level and type of use; therefore, current impacts would be unchanged from those previously described. In summary, these impacts would be confined to the harvesting areas only for the duration of the activity. Thereafter, mitigations to regrade the disturbed land to match the surrounding landscape would reduce impact to a lower intensity associated with aggregate harvesting for operational needs. Long-term changes in the landform should be considered and likely monitored to best evaluate the degree of visual changes in the landscape as aggregate harvesting activities continue (NSF 2019).

7.2.3 Air Emissions

Emissions would be released to the atmosphere during the collection of aggregate from the designated areas including fugitive dust from the aggregate extraction, transport, screening, and storage; exhaust emissions from the operations of equipment and vehicles; and residues resulting from the intermediate use of explosives to fracture frozen rock materials.

Exhaust emissions from heavy equipment and trucks would be consistent with routine equipment operations in the McMurdo Station area and would not adversely affect local air quality. The quantity of fuel combustion emissions is directly proportional to the volume of fuel consumed and would be documented each year in the Annual Report for the USAP Master Permit.

The proposed activity would generate air emissions from generators, heaters, heavy equipment, vehicles, and other ancillary equipment during the establishment and operation of excavation areas, installation of sensors and cables, excavation activities, waste disposal, and long-term data collection and maintenance. Emissions from the combustion of petroleum hydrocarbon fuels and fuel evaporation byproducts would be released to the atmosphere.

Emissions from the intermittent use of explosives (i.e., particulates, carbon monoxide, sulfur dioxide, hydrogen sulfide, and nitrogen oxides) would be released to the ambient air but would quickly disperse and are not expected to affect the local air quality. Therefore, resulting impacts would be minor and transitory. Potential impacts associated with the routine use of explosives for research and facility-operating purposes were previously assessed in the environmental document titled “Continued Use of Explosives to Support Operations and Scientific Research in Antarctica” (NSF 2006). Actual explosive use data and estimated emissions are reported each year in the Annual Report for the USAP Master Permit.

USAP conducts comprehensive monitoring routinely and uses a variety of data to assess impacts from land use, air quality, hazardous material use and storage, waste management, and releases that affect existing conditions. As an example, Lugar (1994) monitored air quality at McMurdo Station (the largest single air emission source for USAP) during the 1992–1993 and 1993–1994 austral summers. Data showed that station operations had less than a minor or transitory impact on local air quality. USAP is expected to continue implementing mitigation measures to minimize any adverse impacts. Dust reduction mitigations would include compacting roadways, spraying water on construction and roadways, and maintaining low vehicle speeds.

The use of mechanized equipment and associated fuel combustion would result in the unavoidable release of exhaust byproducts into the atmosphere during aggregate extraction activities. However, the multi-year time frame of these activities would allow emissions to effectively disperse and only cause a localized impact that is consistent with normal emissions at McMurdo Station. Thus, emissions would not degrade local or regional air quality.

Alternative A: Use of Historical Aggregate Sites

Under Alternative A, aggregate would be harvested from at least 10 historically used sites (Table 4-1; Figure 5-2).

Under this alternative, air emissions would continue to be minimal and transitory. Use of heavy machinery, generators, and periodic use of explosives would not contribute significantly to the local or regional air quality. Emissions from aggregate harvesting would likely increase from historic levels. However, other modernization efforts analyzed in the 2019 CEE describe efficiencies gained through modernization activities, including an anticipated reduction of the vehicle fleet, which would result in reduced fuel use and, thus, a reduction in associated air emissions from ongoing science and operational activities. Therefore, an increase from aggregate harvesting would likely be somewhat offset by decreases due to modernization and optimization reductions in air emissions.

Alternative B: Use of Subset of Aggregate Sites

Under Alternative B, aggregate harvesting would occur at four sites (Table 1-1; Figure 5-3). These sites largely overlap historically used sites. However, since this is a smaller area, emissions would likely be less than under Alternative A. Thus, emissions would continue to be no more than minor and transitory.

Alternative C: No Action - Continued Operation of Currently Approved Sites

Under Alternative C, aggregate harvesting would occur at the five sites currently approved in the 2019 CEE (Figure 5-4). Four of the sites overlap with sites identified for Alternative B; the fifth site corresponds closely to the historically used site (GR-9 [Larryville Rubble Pile]) included in Alternative A. As such, air emissions are likely to be less than under Alternative A and similar to Alternative B. Consequently, impacts would be no more than minor and transitory.

7.2.4 Releases to Snow/Ice Environment

Accidental releases typically involve unplanned events such as leaks or spills of petroleum products (hydraulic fluid or fuel) or glycol (coolant). Based on historical trends, spills from equipment operations typically are due to mechanical failures and result in relatively small release amounts. All spills are documented and reported, consistent with 45 C.F.R. § 671. All spills are cleaned up to the maximum extent practicable and, to minimize the potential risks of future spills, activity-specific BMPs have been developed by USAP for typical equipment maintenance and operation. Impacts associated with a spill would be localized.

Alternative A: Use of Historical Aggregate Sites

Because this alternative would involve aggregate collection at sites that have been used historically, it would not involve potential releases to any previously undisturbed areas within McMurdo Station. As discussed above, any releases would consist of small volumes of fuel or lubricants that would be confined to a small area and cleaned up. Consequently, impacts to the snow/ice environment from releases associated with aggregate collection would be no more than minor and consistent with those discussed above.

Alternative B: Use of Subset of Aggregate Sites

Physical impacts from releases to the snow/ice environment from aggregate collection activities would be no more than minor and comparable with those discussed above for Alternative A.

Alternative C: No Action - Continued Operation of Currently Approved Sites

Physical impacts from releases to the snow/ice environment would be minor and consistent with those discussed in the 2019 CEE (NSF 2019).**Cumulative Impacts**

Typical construction- and demolition-related impacts would be minimized to the extent practicable, as would impacts from future construction projects. All foreseeable projects at McMurdo Station were evaluated in the 2019 CEE (NSF 2019). The cumulative effects of physical disturbances from Alternatives A, B, and C would remain localized, and disturbances would mostly occur within the existing station footprint. In addition, proposed mitigation measures (Section 7.6; Table 7-1), comparable measures identified in the AIMS CEE (NSF 2019), and incorporation of the subject project into the existing monitoring program (Section 7.7; Table 7-1) would further minimize cumulative impacts.

Air emissions: Cumulative air emissions impacts are not anticipated from activities presented in Alternatives A, B, and C of this document and all foreseeable projects at McMurdo Station evaluated in the 2019 CEE. Any releases to ambient air would quickly disperse and are not expected to affect the local air quality.

Accidental releases: Cumulative accidental release impacts are not anticipated from activities presented in Alternatives A, B, and C of this document and all foreseeable projects at McMurdo Station evaluated in the 2019 CEE. Cumulative impacts would be no more than minor because any accidental releases or spills associated with the proposed activity would likely consist of small volumes of fuel or lubricants that would be confined to a small area and cleaned up, thereby minimizing potentials for additive or synergistic effects associated with other previous, ongoing, or foreseeable future activities.

Dust: Cumulative fugitive dust impacts are not anticipated from activities presented in Alternatives A, B, and C of this document and all foreseeable projects at McMurdo Station evaluated in the 2019 CEE. Impacts are expected to be less than minor or transitory by implementing measures to limit fugitive dust by limiting the area disturbed, spray water on disturbed areas, and limiting vehicle speeds.

Fauna and flora: Cumulative impacts to local fauna and flora are not anticipated from activities presented in Alternatives A, B, and C of this document and all foreseeable projects at McMurdo Station evaluated in the 2019 CEE.

Noise: Cumulative impacts from noise are not anticipated from activities presented in Alternatives A, B, and C of this document and all foreseeable projects at McMurdo Station evaluated in the 2019 CEE.

Wilderness and aesthetic values and visual resources: Physical disturbance to local topography is expected from the currently proposed alternatives. In combination with all foreseeable projects at McMurdo Station evaluated in the 2019 CEE, the cumulative impact is minor, as aggregate collection is limited to previously disturbed areas. These areas are contoured to the landscape of the natural environment following collection activities each season.

Water quality: Cumulative impacts to water quality are not anticipated from activities presented in Alternatives A, B, and C of this document and all foreseeable projects at McMurdo Station evaluated in the 2019 CEE. Aggregate collection would represent a minor source for sediment loading to Winter Quarters Bay. However, based on existing information, there is no evidence that past, present, and foreseeable future activities result in excessive sediment loading causing degradation or adverse changes to water quality. Thus, the proposed activity would not contribute to significant cumulative impacts to water quality.

7.4 Unavoidable Impacts

Unavoidable impacts are those that are inherent to the proposed activity and cannot be fully mitigated or eliminated if the proposed activity is implemented. For the proposed activity, unavoidable impacts include the continued physical disturbance of the currently and historically used aggregate harvesting locations and air emissions caused by the combustion of fuel in equipment used to support the proposed activity. While mitigation is proposed to contour harvesting sites similar to the natural environment and a portion of material used for operations may be recyclable and reused, aggregate used for modernization efforts would be largely irretrievable.

7.5 Summary of Impacts

The potential environmental impacts associated with the aggregate collection activities (both operations and modernization requirements) have been reviewed as independent activities in a number of prior EIA documents (Table 1-1) and associated studies. The 2019 Final CEE for Continuation and Modernization of McMurdo Station Area Activities (NSF 2019) most recently evaluated aggregate harvesting for the modernization projects as well as, indirectly, ongoing operational needs. The scope and intensity of the aggregate collection remain consistent with past typical efforts and associated evaluations within the McMurdo Station area.

The environmental impacts resulting from the proposed activity include physical disturbance, air emissions, changes to the visual character, and potential accidental releases. The scope and scale of each impact category has been considered with respect to the use and benefit of proposed mitigation measures that would be incorporated into and considered part of the proposed activity (Table 7-1).

Table 7-1. Summary of Environmental and Operational Impacts Associated with the Collection of Aggregate

Output	Environmental and Operational Impacts							
	Affected Environment	***Duration***	***Extent***	***Intensity***	***Impact Probability***	***Overall Rating****	***Mitigation Measures***	***Monitoring Action (Program)***
Physical Disturbance to Ground Surface	Soil	Long-term	13,750 m^3/year	Moderate and Disturbed	Certain in historically used locations	3	• Rock material use database • Keep equipment in working order • Continue rock material loss mitigation • Reduce aggregate requirements • Development of Aggregate Management Plan	Compare aerial imagery to identify if collection areas are extending (*Aerial Imagery*). Conduct on-site inspections (*On-site Observation*).
Emissions	Air	Short-term	Localized	Low	Unlikely	1	• Limit equipment use • Implement fugitive dust control plan • Limit disturbance area size • Dust control • Limit disturbance to designated collection areas	Identify trends regarding amount of equipment use (*Operations Data*). Compare against thresholds (*Dust*; *On-site Observation*).
Alter Drainage Patterns	Soil/Water	Long-term	Localized	Low	Certain	3	• Identify and implement drainage improvements to reduce surface runoff and erosion potential • Identify and implement erosion control measures	Establish an erosion control monitoring program.
Alter Visual Character	Visual Resources	Long-term	Localized	Low	Probably	3	• Consider visual quality in site contouring and utilization • Implement a long-term viewshed monitoring program • Development of Aggregate Management Plan	Compare aerial imagery to identify if collection areas are extending (*Aerial Imagery*). Conduct on-site inspections (*On-site Observation*).
Accidental Releases	Soil	Short-term	Localized	Low	Unlikely	2	• Utilize spill prevention procedures and resources	Track spill data (*Spill Reports*). Monitor surface water quality (*Surface Water*).

Key: m^3 = cubic meter

Notes: *Overall Ratings: 1 = minor, short-term effect; 2 = minor effect that continues for a limited period of time after the activity is completed; 3 = minor, localized long-term effect

7.6 Mitigation Measures

All USAP projects are reviewed to determine their anticipated environmental impact, with the aim of avoiding, minimizing, and/or mitigating those impacts. Throughout USAP operations, a series of BMPs and mitigation measures have been developed and integrated into both unique and routine USAP activities, such as demolition, construction, remodeling, scientific drilling, aggregate recovery, explosives use, remotely deployed equipment recovery, field camp size management, non-native species prevention, spill prevention and response, and waste and wastewater management. Mitigation measures would continue to be integrated into USAP's actions throughout implementation of the proposed activity.

The collection of aggregate as a USAP operational requirement has been reviewed in several environmental analysis documents (Table 1-1) to varying degrees. The collection of aggregate for modernization projects was reviewed in the 2019 CEE (NSF 2019). However, a comprehensive environmental review of the aggregate harvesting activities has not been completed until now.

Evaluations of the aggregate collection program have also been completed by USACE (Knuth and Melendy 2011) and others. As a result of the full suite of reviews, a series of BMPs and mitigation measures have been developed and integrated, with the aim of avoiding, minimizing, and/or mitigating potential adverse effects. Knuth and Melendy (2011) further recommended development of an overarching management plan noting, "Rock material use in McMurdo is essential but, to date, has been lacking a management plan to meet Station needs and satisfy environmental goals." Consequently, it is recommended that a new Aggregate Management Plan be prepared that covers foreseeable needs for the next 10 years (or other appropriate time frame). This recommended measure and associated approach is described herein.

General Measure, Development of an Aggregate Management Plan: Develop an Aggregate Management Plan that covers foreseeable needs for a defined planning horizon (e.g., 10–15 years). The Aggregate Management Plan shall include the following overarching topics:

1. Identify the availability of resources (how much aggregate is available) at historically and currently used sites and identify whether, based on modernization and operational program data, other locations should be potentially considered.
2. Characterize acceptable methods for harvesting and processing the aggregate.
3. Establish criteria to better define and efficiently utilize individual sites, including but not limited to: ease of access, equipment and technology required (i.e., explosives), quantity of aggregate available, and environmental considerations. Prioritize locations based on evaluation criteria for operational use and/or modernization use. Certain methods of extraction (e.g., scraping) may be more efficient at specific areas.
4. Identify equipment needs to maximize efficiency of collection operations.
5. Identify all BMPs and standard practices to minimize the environmental effects of the activity, as described in the following sections and implement a monitoring and reporting procedure to further evaluate the efficacy of existing and proposed measures.
6. Provide guidance and methods for closing sites. For example, a goal for keeping the minimal number of collection sites open at any one time, permanently closing sites where the resource has been exhausted.

Measures described in Sections 7.6.1, Physical Disturbance to the Snow/Ice Environment, through 7.6.3, Air Emissions, present specific measures to be implemented associated with the proposed activity and incorporated into any future Aggregate Management Plan.

The effectiveness of mitigation measures associated with impacts in EIAs are monitored as part of a comprehensive monitoring strategy conducted by USAP, which includes both field audits and longer term studies related to, for example, land use and disturbance, fuel use, hazardous material use and storage, and releases to the environment. Section 7.7, Environmental Monitoring, describes the USAP environmental monitoring program.

7.6.1 Physical Disturbance to the Snow/Ice Environment

Excavation of material for road maintenance and building foundations would be minimized by reusing previously excavated aggregate and limiting excavation areas. Aggregate would be collected using excavators, front-end loaders, and bulldozers and transported in dump trucks. During excavation, aggregate would be screened to segregate different sizes of material. USAP procedures would continue to be followed to limit fugitive dust (e.g., limit the area disturbed, spray water on disturbed areas, and limit vehicle speed) and to harvest only from established and approved areas.

BMPs should include identifying suitable areas within each aggregate collection area for screening, crushing, and stockpiling aggregate that are not close to runoff channels and/or have relatively reduced potential for inundation by runoff; methods for constructing temporary berms to minimize potentials for erosion of aggregate by wind or runoff; construction of temporary catchment basins; practices to maximize recycling of existing materials and other technologies to reduce harvesting requirements; and practices to keep equipment in good working condition.

These BMPs should be considered in conjunction with recommendations provided by USACE studies (Affleck et al. 2014a, 2014b) and the CEE (NSF 2019):

> Given the variability of the snowmelt runoff and extreme flow rates at McMurdo Station, one way to mitigate erosion is by implementing preventive approaches, such as best management practices or erosion control systems. These systems are often built to trap sediment and to control or attenuate flow in the receiving channels before the runoff exits into Winter Quarters Bay at McMurdo Sound. Some channels have steep side slopes and require appropriate design slopes or stabilization techniques. We recommend the following to mitigate erosion:
>
> - A new plan for runoff by finding a better route for drainage, eliminating several existing flow paths, and merging flow into one primary drainage path
> - Controlling the flow with the installation of settling ponds, weirs, and check dams to slow down the flow
>
> Given the proper implementation in the unique environment, these systems can improve water quality and reduce pollutant discharges by allowing elevated level of contaminants to degrade given time.

Modified from Knuth and Melendy (2011):

- Start a database of rock material use to better understand Station material needs. These data would require the use of technology such as geofencing or Fleet Operations staff to count buckets as they use them each day.
- Keep equipment in working order to maximize efficiency of collection activity.
- Continue rock material loss mitigation and establish/enforce policies to avoid overuse of infrastructure, etc.
- Review and identify opportunities to reduce aggregate requirements, such as mats on the ice pier.

7.6.2 Wilderness and Aesthetic Values and Visual Quality

In addition to the 2015 McMurdo Station Master Plan, the following guidelines should be considered to minimize impacts to visual resources:

- Maintain current mitigations and BMPs for aggregate harvesting, and incorporate practices into the proposed Aggregate Management Plan. Based on usage increases over time, consider visual quality in the management planning of the proposed activity.
- Complete and orient human-made elements (e.g., roadways, stockpile areas, facilities, exterior spaces, etc.) and aggregate harvesting activities to present a visually cohesive image to users, visitors, and offsite views into the site. Consider how best to site the elements and activities to minimize impacts to and/or highlight visual quality.
- Maximize views, viewsheds, and site vistas through cohesive integration of site features that blend into the overall visual landscape surrounding McMurdo Station.
- Mitigate aesthetic and visual impacts through positioning of aggregate harvesting activities in less visually accessible areas (from McMurdo Sound) and regrading landform to mimic the landscape surrounding McMurdo Station.
- Implement a long-term monitoring program specifically addressing views, viewsheds, and site vistas. This would document and monitor changes in the landscape from regrading practices and potentially climate change. Additionally, this type of monitoring program could potentially benefit future research.

7.6.3 Air Emissions

Air emissions from extraction equipment (e.g., fuel combustion byproducts) would be minimized to the extent possible by limiting equipment use to the level necessary. Personnel would continue implementation of the fugitive dust control plan, which should also be incorporated into the future development of an Aggregate Management Plan. Fugitive dust would further be minimized by limiting the disturbance area size, spraying water on the area, and limiting vehicle speed to the extent practicable. Limiting explosive use to the minimum amount necessary and utilizing blast mats would also reduce fugitive dust and ensure that explosives use for aggregate collection is included in the blast management plan as presented in the CEE for modernization projects (NSF 2019). Air emissions would continue to be tracked each year. Equipment would be shut down when not in use, and all equipment would be repaired and serviced in accordance with their recommended maintenance schedules. Utilizing energy-efficient or energy-conserving equipment would further minimize the amount of fuel used by the proposed activity. These emission reduction measures would be briefed to the personnel responsible for implementing the proposed activity.

7.7 Environmental Monitoring

In accordance with Article 5 of Annex I of the Protocol, USAP conducts a comprehensive monitoring program of key environmental parameters to assess and verify the impacts of activities conducted in Antarctica. Since 2005, USAP has used the guidance in the Practical Guidelines for Developing and Designing Environmental Monitoring Programmes in Antarctica (Council of Managers of National Antarctic Programs [COMNAP] 2005) to assist in developing robust environmental monitoring. The environmental monitoring program also verifies that projected impacts in EIAs, such as those identified in this IEE associated with the collection of aggregate, as well as construction activities associated with AIMS projects (NSF 2019), are consistent with actual impacts and mitigation measures are effective. Environmental impacts and impact sources that are monitored include land use and disturbance, fuel use, hazardous material use and storage, waste management, and releases to the environment. The monitoring program also confirms that those impacts are localized and do not constitute a major adverse impact on the environment.

Project-specific impacts and associated mitigation measures, including the recommended development of an Aggregate Management Plan, will be incorporated into the existing monitoring program to verify the efficacy of measures and identify potential additional measures. Emissions from the proposed activity should be estimated and tracked. Accidental releases that may occur would be reported, including lost equipment or operational materials determined to be irretrievable. Information on spills (e.g., location, quantity, and material) would be recorded, reported, and added to the USAP spill-tracking database. In addition, it is recommended that development and implementation of a proposed activity-specific monitoring program, including the use of geospatial tools to track exposures and variations over time, be incorporated into the proposed Aggregate Management Plan that could provide the following: information needed to evaluate the effectiveness of runoff BMPs, photo-monitoring of changes to the viewshed from fixed photo points to monitor long-term changes, and a monitoring framework to evaluate the effectiveness of site utilization and closures.

8.0 GAPS IN KNOWLEDGE AND UNCERTAINTIES

8.1 Uncertainties in Methodology

Uncertainties may exist with respect to equipment available, harvesting technique, operations, and, as a result, impacts that could affect the surrounding environment. The extended planning horizon for the modernization projects includes uncertainty on the actual amounts of aggregate required and project needs. Although the general timing of modernization activities has been developed, specific demolition and construction sequences could evolve over time. Operational demands over time could be reduced with improvements in application, environmental management (e.g., drainage and loss minimization) and availability of new equipment and technology. In addition, ongoing aggregate collection has been subjected to multiple environmental reviews, which have included standardized best management practices, but the efficacy and regularity of measures cannot be confirmed. In addition, deposition of fugitive dust on snow increases the melt rate, with the potential for exposing more soils to erosional forces of wind and surface water flows. Fugitive dust could also be deposited on the sea ice, and eventually sink to the seabed in Winter Quarters Bay once the seasonal sea ice melts, representing an additional source of sediment loading to the bay. The scope and intensity of this process is unknown. Most of the identified uncertainty can be addressed with measures defined in Section 7.2, Impacts from Aggregate Collection Activities, implementation of the proposed Aggregate Management Plan, and incorporation of proposed activities and associated mitigation measures into the existing USAP monitoring program.

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APPENDIX A: ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Units of Measure

cm	centimeter
ft	feet
in	inch
km^2	square kilometer
lbs	pounds
m	meter
mi	mile
mi^2	square mile
m^3	cubic meter
yd^3	cubic yard
yr	year

Abbreviations and Acronyms

AIMS	Antarctic Infrastructure Modernization for Science
ATS	Antarctic Treaty Secretariat
BMP	best management practice
CEE	Comprehensive Environmental Evaluation
C.F.R.	Code of Federal Regulations
COMNAP	Council of Managers of National Antarctic Programs
EIA	environmental impact assessment
IEE	Initial Environmental Evaluation
NSF	National Science Foundation
Protocol	Protocol on Environmental Protection to the Antarctic Treaty
ROER	Record of Environmental Review
SEIS	Supplemental Environmental Impact Statement
U.S.	United States
USACE	United States Army Corps of Engineers
USAP	United States Antarctic Program