National Science Foundation
Office of Polar Programs
Alexandria, Virginia

ENVIRONMENTAL DOCUMENT CONCURRENCE

Activity:
Palmer Pier Replacement, Palmer Station, Antarctica

[PLST2101.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

National Science Foundation
Office of Polar Programs
Alexandria, Virginia

ENVIRONMENTAL DOCUMENT AND
FINDING OF NO MORE THAN
MINOR OR TRANSITORY ENVIRONMENTAL IMPACT
Palmer Pier Replacement, Palmer Station, Antarctica
[PLST2101.IEE]

FINDING

The United States Antarctic Program (USAP) proposes to construct a new pier at Palmer Station to replace the existing pier that is at the end of its useful life. The new pier is needed to provide a safe and reliable pier for the unloading of critical supplies and personnel from marine vessels which is necessary to carry out National Science Foundation's (NSF) scientific mission. The new pier would have a pile-supported concrete deck, a modern energy absorbing fender system, and well as on-pier power and lighting. The existing pier would be demolished and materials reused as much as practicable. Any materials that cannot be reused would be disposed of offsite. A new sewer outfall would be constructed, as the current outfall is within the footprint of the proposed new pier.

Based on the analyses in this environmental document, 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.

October 25, 2021
Recommending Official Date
Michael O. Gencarelli
USAP Planning Manager
Office of Polar Programs

October 25, 2021
Recommending Official Date
Polly A. Penhale
Senior Advisor,
Environment
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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
ACA	Antarctic Conservation Act
ASC	Antarctic Support Contract
ASMA	Antarctic Specially Managed Area
ASPA	Antarctic Specially Protected Area
ATS	Antarctic Treaty Secretariat
BioLab	Biology Laboratory
BMP	Best Management Practice
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources
CFR	Code of Federal Regulations
cy	cubic yards
DTH	down the hole
EIA	Environmental Impact Assessment
ESA	Endangered Species Act
ft	foot/feet
gal	gallon
GWR	Garage, Warehouse, and Recreation Building
IBA	Important Bird Area
IEE	Initial Environmental Evaluation
IHA	Incidental Harassment Authorization
IWC	International Whaling Commission
km	kilometer
LMG	*Lawrence M. Gould*
L	liter
LTER	Long Term Ecological Research
m	meter
MARPOL 73/78	International Convention for the Prevention of Pollution from Ships
mi	mile
MLD	mixing level depth
MMPA	Marine Mammal Protection Act
MSD	marine sanitation device
MSL	mean sea level
NBP	*Nathaniel B. Palmer*
NMFS	National Marine Fisheries Service
nmi	nautical mile
NSF	National Science Foundation
NOAA	National Oceanic and Atmospheric Administration
PPE	personal protective equipment
PSO	protected species observer
PTS	permanent threshold shift
R&M	R&M Consultants, Inc.

TTS	temporary threshold shift
UCDW	upper circumpolar deep-water
USAP	United States Antarctic Program
U.S.C	United States Code
WAP	western Antarctic Peninsula

1.0 BACKGROUND

1.1 PROJECT INTRODUCTION

Palmer Station (64˚46.45'S, 64˚03.25'W) is located on Anvers Island, Antarctica and is one of three scientific research stations in Antarctica operated by the United States that are occupied year-round (**Appendix A, Figures A-01 through A-03**). It was originally constructed in 1968 and is operated by the National Science Foundation (NSF) for the United States Antarctic Program (USAP). There are multiple structures, fuel tanks, and other support facilities distributed on the approximately 15-acre site (**Appendix A, Figure A-04 and Photos 1 through 4**).

All cargo deliveries and personnel transfer operations are conducted by marine vessel due to the lack of an air strip or commercial air service to Palmer Station. Two NSF research vessels, the *Nathaniel B. Palmer (NBP)* and the *Lawrence M. Gould (LMG)*, access Palmer Station. The nearest major port facility is Punta Arenas, Chile, which is approximately 1770 km (1100 mi) north of Palmer Station (**Appendix A, Figure A-01**). As further described below, the existing pier is at the end of its useful life and replacement of the structure is proposed.

1.1.1 PURPOSE AND NEED

The purpose of the project is to provide a safe and reliable pier for the unloading of personnel and critical supplies from marine vessels at Palmer Station, which is necessary for NSF to effectively carry out its scientific mission.

The existing pier is constructed of sheet piles arranged to form interconnected cells. Sheet piles are long structural sections of steel with interlocking edges that are driven into the ground to create a continuous wall (**Appendix A, Photo 5**). This circular sheet pile structure (cellular bulkhead) is backfilled with gravel, cobbles, and boulders (**Appendix A, Photo 6)**. The 8.2-m (27-ft) diameter pier was constructed in 1967 and is at the end of its useful life (typically 50 years). Corrosion has resulted in the deterioration of the existing structure. There is severe sheet pile section loss in places, and it has been patched numerous times over the years. The pier is now in critical need of replacement.

Of the two research vessels currently utilized at Palmer Station, only the *LMG* has regular use of the pier. Larger vessels such as the *NBP* can only moor during high tide and typically only do so in emergency situations. Replacement of the existing pier would allow for regular use by the *NBP* and potentially other research vessels for an estimated 50 to 75 years, depending on maintenance.

1.2 REGULATORY COMPLIANCE

USAP activities are conducted in accordance with applicable international and domestic agreements and laws including, but not limited to, the Antarctic Treaty of 1959 (Antarctic Treaty), the Protocol on Environmental Protection to the Antarctic Treaty (Protocol; Antarctic Treaty Secretariat [ATS] 1991), and the Antarctic Conservation Act, as amended by the Antarctic Science, Tourism, and Conservation Act of 1996, 16 United States Code (U.S.C) § 2401 *et seq*. (ACA). The ACA implements the provisions of the Antarctic Treaty and the Protocol. The ACA conserves and protects the native mammals, birds, and plants of Antarctica and the ecosystems of which they are a part.

Article 8 and Annex 1 of the Protocol introduce and describe the Environmental Impact Assessment (EIA) process, providing categories of environmental impacts according to their significance. Potential impacts associated with the proposed activity are anticipated to incur a no more than minor or transitory impact to the environment; therefore, documentation of existing conditions and anticipated impacts is being evaluated herein under an Initial Environmental Evaluation (IEE) in accordance with the requirements as set forth in the ACA regulations and the Protocol.

The IEE will be used in support of other regulatory processes, including addressing National Environmental Policy Act (NEPA) requirements and Marine Mammal Protection Act (MMPA) requirements. NEPA, the Council on Environmental Quality Regulations (40 Code of Federal Regulations (CFR) Parts 1500 -1508) and National Oceanic and Atmospheric Administration (NOAA) policy and procedures[1] require all proposals for major federal actions to be reviewed with respect to environmental consequences on the human environment (NOAA 2016; NOAA 2017). The National Marine Fisheries Services' (NMFS) consideration whether to issue an Incidental Take Authorization (ITA) allowing take of marine mammals, consistent with provisions under the MMPA and incidental to the applicant's lawful activities, is a major federal action triggering NMFS independent NEPA compliance obligations.

Additionally, NMFS is required to review applications and, if appropriate, issue ITAs pursuant to the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361 et seq.). An authorization for incidental take of marine mammals shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for taking for subsistence uses (where relevant). NMFS evaluated NSF's request for an ITA and made the required findings under the MMPA and determined issuing an Incidental Harassment Authorization (IHA) was appropriate. NMFS criteria for determining whether to grant or deny an applicant's request is available at https://www.fisheries.noaa.gov/topic/laws-policies#marine-mammal-protection-act.

2.0 DESCRIPTION OF PROPOSED ACTIVITY

2.1 OVERVIEW

This project would replace the existing pier with a new pile-supported concrete deck pier, a modern energy absorbing fender system, as well as on-pier power and lighting (**Appendix A, Figure A-05**). Upland civil earthwork would consist of site improvements adjacent to the pier to facilitate movement of equipment and cargo from the pier to upland facilities. The existing wastewater line and outfall would be relocated to accommodate the new pier. The deck for the pier would be supported by steel pipe piles, which would be drilled into the shallow bedrock. These piles would be filled with gravel and topped with a pile cap. A retaining wall would be installed along the shoreline at the location where the pier comes into contact with (i.e. abuts) the shoreline (pier abutment) and would extend to the northwest and along the northeastern edge of the pier (**Appendix A, Figure A-05**). The steel pile supported fender system along the eastern pier edge will also be installed for small boat moorage. At this time, piles for a wave attenuator are planned for installation; however, the wave attenuator itself would be installed at a future date.

2.2 PROPOSED ACTIVITY

2.2.1 MOBILIZATION TO PALMER STATION

All equipment and supplies would be transported to Palmer Station via barge or the *LMG*. The majority of equipment and materials would be mobilized from Seattle, Washington, where the construction barge would be located. Construction equipment would likely include two cranes, excavator, dozer, skid steer, several forklifts, welder, impact hammer, vibratory hammer, down the hole (DTH) hammer, and other smaller specialized tools (**Appendix A, Photos 7 through 12 and 15**). A separate cargo supply vessel will meet the construction barge at Palmer Station and remain onsite for approximately three days to offload additional construction material, primarily fill material. Components to assemble a modular work platform would also be included on the construction barge as well as a small skiff to transport crew between the barge and the station and a work boat. Initial mobilization of equipment and materials from the U.S. is scheduled for October 2021. The distance from Seattle to Palmer Station is approximately 8717 nmi and the trip would take an estimated 57 days. The barge would be accompanied by a tugboat (crew of five) and the journey would be made in four legs. The tugboat would take on water, fuel, and supplies at each port of call en route. Upon arrival at Palmer Station, the tugboat would be tied by to the barge or anchored in the vicinity of Hero Inlet for the duration of the project in the event the barge would need to be moved. No independent trips are anticipated. The 26-member construction crew would travel aboard the *LMG* from Punta Arenas, Chile to Palmer Station in late November 2021. The *LMG* will make three more visits to Palmer Station between November 2021 and April 2022 transporting cargo with the possibility of construction personnel from Punta Arenas to the Station.

2.2.2 PIER REPLACEMENT

The following is a description of the activities anticipated to occur during construction of the replacement pier in the order in which they are expected to occur. Pile installation/removal activities to support construction of the new pier are anticipated to be the most prominent and time-consuming construction activity.

2.2.2.1 TEMPORARY CRANE ASSEMBLY PAD

Upon arrival at the site, the construction contractor (Contractor) would moor the construction barge against the existing pier using soft lines to the existing moorage points. Once moored, the Contractor would deploy anchors and spuds (type of anchor) to further secure the barge. Select equipment would be unloaded from the barge to the existing pier and relocated upland for construction of the temporary crane assembly pad.

The pier replacement work would largely be performed by two cranes, one based on the barge and one based on land. The existing sheet pile pier cannot be relied upon to transfer heavy, pier-building equipment off the barge utilizing ramps. Based on the weights of the land-based crane components and the safe working radius (reach) of the barge-based crane, a temporary crane assembly pad is required in order to facilitate the land-based crane offload and assembly. The Contractor's Crane Assembly Pad Construction Plan is included in **Appendix C** for reference.

The temporary crane assembly pad would be mostly constructed of coarse aggregate material including crushed stone and gravel imported in bulk bags via a separate gravel barge. Bulk bags are also known as super sacks or flexible intermediate bulk containers and are made of woven polypropylene material (i.e. plastic) for strength and durability. It is estimated that 1376 cubic meters (m^3; 1800 cy) of material is needed to construct the pad. The aggregate material would, at a minimum, meet cleanliness requirements under the Protocol and ACA.

The bagged aggregate would be transferred directly from the cargo supply vessel to the existing pier and moved to a staging area. The bulk bags would then be opened as needed to create a pile of aggregate material. Once a sufficient pile is developed, the Contractor would begin pushing material into the water with a dozer to the southern end of the pad. Material would continue to be placed until the southern end of the crane pad is developed and an elevation of zero (i.e. water level at 1.03 m [3.38 ft] MSL) or higher is reached. It is estimated that approximately 70% of the material would be deposited below the waterline (1260 cy or 963 m^3). At this point, unopened bags of aggregate would be placed on the pad. Once the appropriate elevation has been reached, aggregate placement (loose and bagged) would cease and crane mats would be laid out to match the existing pier elevation. It is important to note there is no plan to place the bulk bags in the water, only loose aggregate material.

Once the land-based crane has been offloaded from the barge and assembled, it would be moved into position to assist with deconstruction of the existing pier. The temporary crane pad would be located largely within the footprint of the new pier. Much of the loose aggregate material placed for the crane pad would be left in place on the seaward side of the new pier abutment where riprap armor (rock used to protect shoreline structures) is prescribed as well as along the edge of the boat ramp where the aggregate would aid in wave protection (see **Appendix A, Figure A-05** for riprap placement locations). No riprap will be imported for this project. Rock will be sourced from the imported aggregate material as well as the demolition of the existing pier and other upland areas as described in the following sections. The portion of the temporary crane pad fill material, bagged and above the waterline, would be salvaged for reuse as pile fill or used elsewhere on-site during construction. Loose fill would be removed from below the waterline to the extent practicable but would be limited by the reach and capabilities of the equipment. It is estimated that approximately 50% of the total crane pad fill aggregate material would be recovered.

2.2.2.2 DEMOLITION OF THE EXISTING PIER

The existing pier, consisting of steel sheet piles backfilled with gravel, cobbles, and boulders, would be demolished and materials reused as much as practicable to construct the new pier facility. An excavator, skid steer, and dozer would be used to remove and repurpose fill material from the existing bulkhead pier. Salvaged gravel fill material may be used in uplands for site grading/contouring or as pile fill (see **Appendix A, Figure A-05** for locations where grading will occur). Depending on the size, boulders removed from the existing pier may be placed along the bottom of the new retaining wall and/or the existing boat ramp to protect against wave scour (erosion at the base of the structure). Should larger rock formations/bedrock be encountered, they would be broken using a rock breaker attachment on the excavator. The existing sheet piles would be extracted with a vibratory hammer or cut off at the mud line. Material that cannot be reused would be stockpiled in an upland location and later loaded onto the barge for offsite disposal outside the Antarctic Treaty area. The foam-filled marine fenders located at the end of the existing pier would be removed.

2.2.2.3 PILE INSTALLATION

Pile installation for the new pier would begin once the existing pier facility is removed. Temporary template piles would be installed first to develop a support structure to ensure proper placement of the permanent piles. The template piles serve as a grid and would not be installed in the same locations as the permanent piles. The permanent piles would support the pier, pier abutment, retaining wall, three of the six fenders, and future wave attenuator (**Appendix A, Figure A-05**). Only the three fenders on the eastern side of the pier are supported by dedicated piles. The three fenders on the face of the pier would be supported by structural pier piles. The primary technique for installing temporary and permanent piles would be DTH drilling. The DTH drill/hammer acts on a shoe at the bottom of the pile and uses a pulsing/rotating mechanism to break up rock below the pile while simultaneously installing the pile through the rock formation. Rotating bit wings extend below the pile and remove the broken rock fragments as the pile advances. The pulsing sounds produced by the DTH method reduces sound propagation because the noise is primarily contained within the steel pile and below ground. Because the shoreline and upland areas are comprised of rocky or exposed bedrock, the piles would be socketed in place. This involves drilling into the rock to create a socket deeper and larger than the pile diameter. Once the pile is set, the remaining void space is filled with a high-performance cement-based sealing grout (refer to **Appendix C** for specifications). The piles would likely be hammered (impact-driven) for short periods of time to seat (set) the piles in the sockets. Once permanent piles are installed, the temporary template piles would be removed with a vibratory hammer or cut off at the mudline. **Table 2-1** details the number and size of the piles needed for each structure as well as the socket depth and diameter. **Figure A-05 (Appendix A)** identifies pile locations. **Section 2.2.2.5** provides more detail on these pier structures.

TABLE 2-1: PILE SUMMARY

Structure	Diameter of Pile[a]	Socket Depth (feet)	Number of Piles
Pier Abutment	32- or 36-in steel piles	30	4
Pier	36-in steel piles	20	Up to 18[b]
Retaining Wall	Steel H-piles inserted in pre-drilled 24-in diameter hole	10	Up to 9[b]
Wave Attenuator	24-in steel piles	20	2
Fenders[c]	24-in steel piles	20	3
Template Piles	24-in steel piles	10	16[d]

a Dimensions provided in United States customary units to match design; metric units not provided.
b Includes two additional piles as a contingency for design flexibility.
c Only the three fenders on the eastern side of the pier are supported by dedicated piles. The three fenders on the face of the pier would be supported by structural pier piles (**Appendix A, Figure A-05**)
d Includes additional piles for contingency during construction.

2.2.2.4 ROCK CHIPPING

Rock chipping may be required to level the sea bottom at pile locations to ensure accurate pile location and alignment. Rock chipping would first be attempted using the DTH hammer and appropriate bit(s) to flatten the surface for pile installation. This method could be used at every pile location, but this is not expected to occur. If the DTH hammer is not able to flatten the surface at the pile location, the excavator with rock breaking attachment (as previously discussed) would be used. If rock chipping is necessary, it would occur on the same days as DTH drilling.

2.2.2.5 PIER STRUCTURES

Construction of the pier abutment and retaining wall would require bedrock excavation using the excavator/rock breaker. Trench excavation would begin about 0.9 m (3 ft) seaward of the retaining wall alignment and extend to 1.5 m (5 ft) landward for approximately 16.8 m (55 ft). The retaining wall would be constructed along the shoreline at the new pier location, landward of the pier abutment (**Appendix A, Figure A-05**). The retaining wall would be constructed using a series of stacked horizontal pre-cast concrete planks between the retaining wall piles. Upland fill would be placed on the landward side of the retaining wall, as required, to close any gaps below the planks. Where the retaining wall extends beyond the pier abutment, riprap armor stone would be placed on the seaward side of the retaining wall at a 50% slope to aid in wave protection. The pier abutment would consist of steel pipe piles with armor stone placed between the piles at a 50% slope.

Concrete caps would be installed on top of the piles and welded in place. Precast concrete deck panels would be set and grouted in place on top of the caps, followed by railing installation. The grout is the same high-performance cement-based sealing grout to be used for pile installation (refer to **Appendix C** for specifications). A total of three prefabricated fenders would be installed on the pier from the pier deck (**Appendix A, Figure A-05**).

2.2.2.6 INSTALLATION OF ANODES

Sacrificial anodes are included in the design in order to protect the major submerged steel components from corrosion. A sacrificial anode is made of a different metal alloy than the structure it is protecting and preferentially corrodes to protect the structure from corrosion. These aluminum alloy anodes would be installed below the waterline by divers. Installation would involve welding using hand-held equipment.

2.2.3 SEWER LINE RELOCATION

The existing sewer outfall is within the footprint of the proposed pier (**Appendix A, Photo 14**). A new outfall would therefore be constructed and most of the existing pile-supported sewer line would be relocated. Because the existing sewer line outfall is in the same area as the crane assembly pad and ultimately the new pier, the first priority would be to create a temporary bypass for the existing sewer line until the new permanent alignment is constructed (**Appendix A, Figure A-05**). The alignment for the temporary sewer bypass would be determined in the field with the intent to purposely be routed overland to outfall near where the new, permanent outfall would be constructed and to avoid rock outcrops (no rock removal is planned for the temporary bypass). The temporary bypass would be constructed of flexible 6-in tubing/piping, starting at the treatment plant, and will have a pump with a cistern, powered by station power. The system would be maintained in operation at all times while the new line is being constructed. Approximately 70.1 m (230 linear ft) of new sewer line would be installed as part of the sewer line relocation and would discharge to the water, above the waterline, via a new outfall west of the new pier. Portions of the new sewer line would require that a trench be excavated through the bedrock to provide clearance for the pile-supported line and maintain gravity flow through the system (see sewer line bedrock trenching in **Appendix A, Figure A-05 and Photo 13**). This trench excavation may be done with an excavator using a breaker attachment or drilling holes and using a high expansion grout agent such as Dexpan® to create a non-explosive, controlled expansion to fracture the rock. After fracturing, the demolished rock and debris, including grout, would be collected. The Safety Data Sheet for Dexpan® is included in **Appendix C**. Although excavation (trenching) is required in certain areas of the alignment, the sewer line will be placed aboveground on pipe supports and not buried. Mechanical means would be used as much as possible for rock breaking and excavation. The method of drilling holes and using expanding grout would occur if the equipment cannot successfully break/remove the rock. The existing sewer lines near the dock would be demolished once the relocation is complete and operational.

2.2.4 POWER AND LIGHTING

The project would provide a new power pedestal with modifications to the existing power feeder from the Biological Lab (BioLab) as well as power for the fuel system heat trace and pier lighting (**Appendix A, Figure A-05**). The power and lighting system would include a power center, power stations for refrigerated containers, and an outlet for welding/hand tool use. Exterior pier lighting would consist of light poles, floodlights, small area lights, catwalk lights, navigation/marker lights and low-level pedestals. No communications or surveillance is included.

2.2.5 SITE GRADING, UPLAND WORK, AND EXCESS MATERIAL

Portions of the upland areas would be graded to improve access and use of the pier facility (identified as resurfaced area in **Appendix A, Figure A-05**). A filled and graded upland site would be required to provide vehicle access to the pier and a boat parking area of approximately, 12.1-m by 12.1-m (40-ft by 40-ft). The boat parking area would replace the existing boat parking grid (**Appendix A, Figure A-05**). This upland site is adjacent to the pier and bounded on the east by the boat launch ramp, on the northeast by several existing buildings, and on the northwest by the relocated sewer line. A vertical adjustment of the upper portion of the concrete boat launch ramp would be required (identified as boat ramp modification in Appendix A, Figure A-05) and two bedrock outcrops would be removed, as needed, for site grading. Construction methods previously discussed for bedrock excavation would be used. In general, strategic placement of the excess fill is anticipated and rocks greater than 0.5 m (18 in) in diameter would be salvaged and placed for toe and shore protection for the boat launch ramp and retaining wall. Any remaining fill could be used in the graded area north of the pier (identified as resurfaced area in Appendix A, Figure A-05) or used to fill in holes and even out surfaces along existing roads and pads within the Station. Any unused fill would be loaded onto the barge and removed at the end of the project.

2.2.6 DEMOBILIZATION

Upon completion of the project, the contractor would remove all unused material and equipment brought to the Station. Most material will be stored on barge for the duration of the project except when in use. Demobilization would begin with the final inspection followed by transfer of all remaining equipment, material, and waste onto barge and securing all cargo. Upon final acceptance of project, the construction barge and tugboat will disembark. Demobilization is expected to take between 10 and 14 days.

2.3 PROJECT DURATION

The construction window is limited due to sea ice. As such, a majority of the construction is anticipated to occur between 1 November 2021 and April 2022. Project completion would occur once final as-built drawings have been approved and is scheduled for 28 August 2022.

TABLE 2-2: PROJECT DURATION

Activity	Begin [a]	End [a]
Mobilization [b]	7/14/2021	1/5/2022
Tugboat and barge depart port	10/27/2021	10/27/2021
Site Development	12/24/2021	2/28/2022
Install temporary sewer bypass	12/24/2021	4/28/2022
Crane pad construction	1/1/2022	4/14/2022
Transfer crane to shore and assemble	1/3/2022	4/18/2022
Demolition	1/6/2022	4/7/2022
Construction	1/25/2022	4/7/2022
Bedrock excavation (as needed)	--	--
Retaining wall/abutment	2/2/2022	2/27/2022
Pier pile installation	2/28/2022	4/27/2022
Fender systems	4/28/2022	4/29/2022
Install wave attenuator piles	4/14/2022	4/17/2022
Miscellaneous pier work	4/18/2022	4/28/2022
Upland site grading	4/7/2022	4/10/2022
Sanitary sewer line and outfall	4/7/2022	4/13/2022
Cathodic protection [c]	4/22/2022	6/21/2022
Contractor Demobilization	Approximately 10 - 14 days from date construction is completed	
Final inspection and project acceptance		
Load and prepare barge for departure		
Depart Palmer Station		
Final closeout (Onsite work complete)	7/8/2022	8/18/2022
Project completion	9/25/2022	

a Time frames are based on 95% construction schedule and may be modified based on field conditions and/or logistics.
b Mobilization includes multiple site preparation activities.
c Leidos/ASC to install anodes, not construction contractor.

3.0 ALTERNATIVES TO THE PROPOSED ACTIVITY

3.1 NO ACTION ALTERNATIVE

The alternative to take no action must also be evaluated during development of the IEE. Under the No Action alternative, the existing pier would remain in place and no improvements would be made. The anticipated impacts associated with construction of the new pier would not be incurred. The station users would continue to use the pier until it is determined structurally unsound, inoperative, and/or unsafe for further use. If access becomes limited or prohibited as a result of pier failure, difficulties in reaching or leaving the station in the event of an emergency could occur and the station users would be unable to access research facilities. Degradation of water quality could also occur as the pier deteriorates and unstable material erodes away. Reduced access to Palmer Station would have a negative impact on scientific research efforts, which conflicts with the purpose and mission of the facility and the USAP.

3.2 ALTERNATIVES CONSIDERED BUT NOT ANALYZED

A total of three discrete alternatives, including the proposed activity, were developed up to a 15% design stage. Each alternative was designed to meet comparable size, design loads, vessels/moorage, and other minimum design criteria. In order to identify a preferred alternative, each option was compared with respect to

- function/performance,
- environmental factors,
- relative construction cost, and
- maintenance considerations.

The two alternatives eliminated from further consideration are summarized in the following sections. The third alternative, identified as the preferred option, is now considered the proposed activity.

3.2.1 SHEET PILE BULKHEAD

This alternative would replace the existing pier with a similar sheet pile bulkhead structure; however, the new design would connect the sheet piles with king piles, which are steel beams instead of pipes, and use anchors tied into the shore for added stability and structural integrity. The structure would then be backfilled with imported material. A mooring dolphin (a mooring point that extends above water level and is not connected to shore) and fender system was included in the design to protect the pier from ship and ice impact.

Although this option provided somewhat higher load capacity (not required), resistance to wave/ice uplift, and ice impact protection, factors associated with constructability, environmental impacts, and maintenance (**Table 3-1**) resulted in the elimination of this alternative.

TABLE 3-1: SHEET PILE BULKHEAD – PROS AND CONS

Pros	Cons
Slightly higher load capacity	Large volume of costly imported fill required
Resists wave/ice uplift	Higher potential for delays leading to increased wildlife impacts
Stable/resists ice impact	Most tidelands fill impact (0.33 acres)
	High number of sheet piles
	Wave amplification
	Medium-high cost

3.2.2 COMBINATION BULKHEAD AND PILE-SUPPORTED DOCK

This alternative considered using a combination approach, which included a bulkhead at the shore end with a pile-supported concrete deck extending from the face of the bulkhead. The intent of this alternative was to capture the benefits of both options. A bulkhead structure constructed at the shore end could provide protection from wave activity and shore ice. By combining this option with a pile-supported structure, the volume of fill material would also be reduced. Despite some identified benefits to this alternative, cost, potential impacts to marine mammals, the amount of fill placed in the marine environment (tideland fill), and potential design challenges (**Table 3-2**) resulted in the elimination of this alternative.

TABLE 3-2: COMBINATION BULKHEAD AND PILE-SUPPORTED DOCK – PROS AND CONS

Pros	Cons
Bulkhead portion is stable/resists ice impact	Challenging bulkhead/pile-supported dock interface
Various construction types may allow phasing	Costly imported fill required
	Higher potential for delays leading to increased wildlife impacts
	Highest number of piles
	Tideland fill impact (0.26 acres)
	Highest cost

4.0 EXISTING ENVIRONMENTAL CONDITIONS

4.1 GEOGRAPHIC SETTING/ENVIRONMENTAL SETTING

Palmer Station (64°46.45'S, 64°03.25'W), one of three continuously occupied scientific research stations operated by the NSF for the USAP, is located on the southwestern coast of Anvers Island. Anvers Island is the largest and most southerly island in the Palmer Archipelago and is separated from the northwestern edge of the Antarctic Peninsula by Gerlache Strait (**Appendix A, Figure A-02**). The research station is situated on a rocky, ice-free bluff at Gamage Point that is bound by Hero Inlet to the south, Arthur Harbor to the north and west, and the Marr Ice Piedmont to the east (**Appendix A, Figure A-03**).

Palmer Station is located within the Antarctic Specially Managed Area (ASMA) No. 7, Southwest Anvers Island and Palmer Basin (ATS. 2019a). This ASMA includes several Restricted Zones, two Antarctic Specially Protected Areas (ASPAs), and four Antarctic Important Bird Areas (IBAs). While Palmer Station is not located within any of the Restricted Zones, ASPAs, or IBAs, it is located across Hero Inlet from the Bonaparte Point Restricted Zone. While most Restricted Zones include a 50-m (164-ft) marine buffer, Bonaparte Point does not include one due to the need to maintain boat access to Hero Inlet (ATS 2019a). The Area is situated within Environment B – Antarctic Peninsula mid-northern latitudes geologic and Environment E – Antarctic Peninsula, Alexander and other islands, based on the Environmental Domains Analysis for Antarctica (Resolution 3 (2008). Areas of ice-free ground classified as Region 3 – Northwest Antarctic Peninsula under the Antarctic Conservation Biogeographic Regions classification (Resolution 3 (2017)) lie within the Area (ATS. 2019a).

4.2 PALMER STATION FACILITY DESCRIPTION

Palmer Station, which features laboratory space and a sea water aquarium, supports a wide array of scientific research in diverse fields including, but not limited to, climate systems, marine biology, astrophysics, and glaciology and is one of 28 locations designated as a Long Term Ecological Research (LTER) site by NSF (NSF 2020a; NSF LTER 2020). Over the past five decades, several structures have been constructed at the station such as the BioLab, which houses the dining facilities, offices, laboratory space, the aquarium, and dorms and the Garage, Warehouse, and Recreation (GWR) Building, which houses the garage, station power plant, warehouse space, store, clinic, dorms, and lounge. Additional structures located at Palmer Station include, but are not limited to, the Carpentry/Trade Shop, Earth Station with satellite link, Terra Lab, Clean Air Facility, Boat House, and fuel tanks (NSF 2016). The station supports approximately 40 personnel during the austral summer months and roughly 20 personnel during the winter (NSF 2016, NSF 2020a).

Although the primary mission of Palmer Station is to foster scientific research, Palmer Station personnel and researchers welcome a limited number of tourists every year, as part of USAP's educational outreach efforts, primarily during the austral summer. In recent years, the average number of cruise ships has been limited to approximately 8-10 per season (NSF 2018). In addition to cruise ships, a number of yachts also visit the area. While NSF does not limit the number of yachts that visit each season, unscheduled visits to Palmer Station are only allowed on a case by case basis and if the visit will not interfere or inhibit the work of staff and researchers. Based on tourism data from 2003-2016, an average of 6500 tourists visit Southwest Anvers Island and Palmer Basin annually, though only roughly one-third opt for an on-shore visit (ATS 2019a).

4.3 CLIMATIC CONDITIONS

The southwestern coast of Anvers Island, where Palmer Station is located, has a cold, Antarctic maritime climate. Compared to the rest of Antarctica, the climate in the area is relatively mild with an annual mean temperature of -3°C (26.6°F). Monthly average temperatures range from -10°C (14°F) during the austral winter months of July and August to 2°C (36°F) during the austral summer months of January and February (NSF 2020a). Since the mid-twentieth century, the area has experienced rapid warming with an observed atmospheric temperature increase of approximately 3°C (5.4°F; Meredith and King 2005).

Precipitation events are common at Palmer Station, which annually receives an average of 4 m (13 ft) of snow and 76 cm (30 in) of rain. Persistent light to moderate winds with speeds of approximately 10-11 knots are common (ATS 2019a), though storm systems frequently bring high winds that can reach 70 knots or more (NSF 2020b).

Sea ice extent and duration in the region exhibits a high level of inter-annual variability. In general, however, sea ice coverage and duration has been rapidly decreasing. Sea ice records from Palmer Station indicate that the seasonal duration of sea ice has decreased by an average of 92 days, or approximately three months, for the time period from 1979-2012 (Ducklow et al. 2013).

4.4 MARINE WATER QUALITY

The Palmer LTER site, which includes the southern portion of Anvers Island and Palmer Station, divides the marine environment into three separate regions based on depth: coastal, shelf, and slope (Palmer LTER 2020a). The marine environment surrounding Palmer Station is classified as coastal (Palmer LTER 2020b), which has water depths of 0-300 m (0-984 ft; Palmer LTER 2020a). The shelf region, which is located adjacent to the coastal region and has an interconnected ecosystem, has depths ranging from 300-1000 m (984-3281 ft; Palmer LTER 2020a).

Geography, sea ice seasonality and extent, and glacial meltwater heavily influence the coastal marine environment of Arthur Harbor and Hero Inlet. The Antarctic Peninsula, which has a north-south orientation, is directly exposed to westerly atmospheric and oceanic circulation patterns. The Antarctic Circumpolar Current is adjacent to the continental shelf along the western Antarctic Peninsula (WAP) and conveys warmer, nutrient-rich upper circumpolar deep-water (UCDW) to the area (Ducklow et al. 2013; ATS 2019a). In the austral summer, glacial meltwater dictates the mixing level depth (MLD) and creates a distinguishable divide between the coastal and continental shelf regions with the coastal marine environment extending out nearly 40 km (25 mi) from the coast. The MLD during the austral summer is approximately 5-10 m (16-33 ft) deep for the coastal marine environment while the mid-shelf/slope region has a MLD of approximately 25-50 m (82-164 ft) or deeper (Ducklow et al. 2013). Wind-driven mixing is known to occur in the protected waters of Arthur Harbor (Schram et al. 2015), which when combined with buoyancy loss due to sea ice production, increases the depth of the MLD during the winter months (Ducklow et al. 2013). Glacial meltwater has been shown to increase the turbidity of nearshore waters while also adding macronutrients such as phosphate, nitrate, and silicate to the marine water environment (Dierssen et al. 2002). Diatom communities frequently occur at the edge of the ice and are known to have high rates of sedimentation (Ducklow et al. 2007).

The pH in Arthur Harbor has been shown to exhibit little variability throughout the austral fall and winter. In the austral spring and summer, an abrupt increase in pH occurs as sea ice retreats and phytoplankton activity increases. Research conducted in Arthur Harbor from May 2012 to May 2013 recorded a baseline pH of 8.09, which increased to 8.62 in mid-November roughly corresponding to the peak of phytoplankton activity. These increases were accompanied by a decrease in the levels of dissolved inorganic carbon. In addition to phytoplankton, benthic macroalgae (seaweed) may also contribute to pH increases in Arthur Harbor (Schram et al. 2015).

Summer surface water temperatures have increased by more than 1°C (1.8°F) since the mid-twentieth century, which has been accompanied by an increase in salinity. Increased surface water temperatures and salinity would likely result in decreasing sea ice production trends in future years. Seasonal salinity is greatest during the austral winter (Meredith and King 2005).

Despite the remote location of the Antarctic Peninsula, pollution does impact the region. One recent study estimated a mean concentration of 1794 plastic items per square km (0.4 square mi) in the marine environment surrounding the Antarctic Peninsula (Lacerda et al. 2019). The predominant types of plastic found in the region were polyurethane and polyamide, though small quantities of polyethylene and polypropylene were also identified. The same study also found paint fragments in the marine environment in quantities that were approximately 30 times greater than that of plastics (Lacerda et al. 2019). While rare, oil spills have occurred in the region. In 1989, the ship *Bahia Paraiso* sank in Arthur Harbor, roughly 2 km (1.2 mi) from Palmer Station, spilling approximately 600,000 L (158,503 gal) of arctic diesel fuel (Kennicutt et al. 1992; Harris et al. 2015). This spill impacted the nearshore marine environment for several years following the accident (Harris et al. 2015).

4.5 Topography, Geology, and Soils

Anvers Island is bisected by a southwest-northeast trending fault line that divides the island into two distinct tectonic blocks (Birkenmajer 1999). The western section of the island, including Palmer Station, is on the Anvers-Melchior Tectonic Block. It consists of three distinct geologic groups:

- Volcanic rocks found in coastal areas near Palmer Station and Cape Monaco that may belong to the Lower Cretaceous Antarctic Peninsula Volcanic Group and consist of tuffs, agglomerates, and rocks formed from basaltic and andesitic lavas
- Intrusive igneous rock formations from the Paleocene to early Miocene that consist of granite, diorite, and tonalite
- Horneblende- and pyroxene-bearing dykes (Birkenmajer 1999)

The Marr Ice Piedmont, the glacier located directly east of Palmer Station, is a defining feature of southwestern Anvers Island and is approximately 64 km (40 mi) long and in places, nearly 32 km (20 mi) wide (Montaigne 2009) (**Appendix A, Figure A-03**). The glacier, which has retreated roughly 300 m (984 ft) since 1975, occupies the low-lying coastal areas and rises from the coastline to an elevation of approximately 1000 m (3281 ft). As the glacier retreats, portions of Anvers Island have been revealed as separate islands. In 2014, the collapse of an ice bridge near Palmer Station revealed an island that was originally believed to be a spit of land connected to Anvers Island (Rejcek 2014). While the Marr Ice Piedmont dominates the southwestern coastline of Anvers Island, rocky outcrops, ice-free promontories, and small islands are interspersed amongst the ice cliffs. Gamage Point, as well as Bonaparte Point, which is located directly across Hero Inlet from Gamage Point, are both ice-free promontories located in the area (ATS 2019a). These ice-free areas provide a wide range of habitats for vegetation growth (Smith and Corner 1973).

In general, soils in Antarctica are comprised of a surface layer (gravel, stones, or boulders) and an active layer. The seasonally thawed active layer, which lies above permafrost, consists of unconsolidated material and ranges in depth from a few centimeters up to 1 m (3 ft) depending on location. Coastal Antarctic soils, unlike inland Antarctic soils, tend to be nutrient rich due to the presence of bird and plant communities (Lambrechts et al. 2019; Teixeira et al. 2013). Guano, feathers, eggshells, and bird remains create ornithogenic soils that contain organic matter rich in nitrogen, phosphorus, and carbon (Teixeira et al. 2013).

The underwater terrain immediately adjacent to Palmer Station is dominated by glacially-carved bays, fjords, and channels (Ducklow et al. 2012). In 2005, the ocean floor surrounding Palmer Station was mapped, revealing previously unknown pinnacles that rise to a depth of 6 m (20 ft) below the water surface (Woods Hole Oceanographic Institution [WHOI] 2005). A few kilometers beyond the WAP coast, the seafloor abruptly deepens, reaching depths of 200-300 m (656-984 ft) below the water surface (Ducklow et al. 2013). The coastal region eventually transitions into the continental shelf, which is approximately 200 km (124 mi) wide and has an average depth of 430 m (1411 ft; Ducklow et al. 2012). The seafloor in the WAP region ranges from sand or mud bottoms devoid of algae to rocky bottoms covered in algal growth (Barrera-Oro 2002). Topography and bathymetry information is provided in **Appendix A, Figure A-06**.

4.6 BIOLOGICAL RESOURCES

4.6.1 MARINE MAMMALS

Twelve cetacean and five pinniped species can be found in the vicinity of the project (**Table 4-1**). Five of the cetacean species are listed as endangered under the Endangered Species Act (ESA): blue, fin, sei, sperm, and southern right whales. None of the pinnipeds are ESA-listed. Abundances shown in **Table 4-1** are based on a thorough review of the best available information. Data on marine mammal abundance or density in the Antarctic are difficult to obtain given the remote location therefore, some abundance and density estimates have been extrapolated across broad regions. Distribution, life history, and nearshore and offshore densities of each species are discussed in detail in the Marine Mammal Assessment (**Appendix B**). **Tables 4-2 and 4-3** summarize specific sightings of marine mammals in the project vicinity (**Appendix A, Figures A-03 and A-04**). Figure A-07 (Appendix A) shows previously identified Elephant seal colony and haul out locations in the project vicinity. Observations were conducted by staff posted at Palmer Station between 2019 and 2020. Observations taken three times a day for six minutes each. These sightings are discussed in applicable species-specific subsections in the Marine Mammal Assessment included in **Appendix B**.

TABLE 4-1: ABUNDANCE AND STATUS OF MARINE MAMMAL SPECIES POTENTIALLY PRESENT IN THE PROJECT AREA

Common Name	Species	Estimated Abundance		ESA Status[a]	MMPA Status[b]	Frequency of Occurrence in Project Area
		Number	Data Sources			
Cetaceans						
Antarctic Minke Whale	*Balaenoptera bonaerensis*	7395[c]	Reilly et al. (2004)	NL	NS	Common Nearshore and Offshore
		360,000-730,000[d]	International Whaling Commission (IWC; 2019)			
Arnoux's Beaked Whale	*Berardius arnuxii*	599,300[e]	Kasamatsu and Joyce (1995)	NL	NS	Rare
Blue Whale	*Balaenoptera musculus*	2300[f]	IWC (2019)	E	D	Rare Offshore
Fin Whale	*Balaenoptera physalus*	38,200[g]	Wursig et al. (2018)	E	D	Nearshore and Offshore
		1725[h]	National Oceanic and Atmospheric Administration (NOAA; 2015)			
		1492[c]	Reilly et al. (2004)			

Common Name	Species	Estimated Abundance		ESA Status[a]	MMPA Status[b]	Frequency of Occurrence in Project Area
		Number	Data Sources			
Hourglass Dolphin	*Lagenorhynchus cruciger*	144,300[d]	Kasamatsu and Joyce (1995)	NL	NS	Rare
Humpback Whale	*Megaptera novaeangliae*	6500[g]	Bettridge et al. (2015)	NL	NS	Common Nearshore
		42,000[h]	NOAA (2015)			
		34,000-52,000[d]	IWC (2019)			
		11,786	Felix et al. (2021)			
Killer Whale	*Orcinus orca*	50,000[i]	Wursig et al. (2018)	NL	NS	Common
		25,000[j]	Jefferson et al. (2008)			
Long-finned Pilot Whale	*Globicephala melas edwardii*	200,000[k]	NOAA (2018)	NL	NS	Rare Offshore
Southern Bottlenose Whale	*Hyperoodon planifrons*	500,000[j]	Jefferson et al. (2008)	NL	NS	Rare Offshore
Sei Whale	*Balaenoptera borealis*	626[h]	NOAA (2015)	E	D	Uncommon Offshore/ Extralimital
Southern Right Whale	*Eubalaena australis*	43[c]	Reilly et al. (2004)	E	D	Rare
		25,000-30,000[l]	Wursig et al. (2018)			
		12,000[d]	IWC (2019)			
Sperm Whale	*Physeter macrocephalus*	12,069[h]	NOAA (2015)	E	D	Uncommon Offshore/Extralimital
Pinnipeds						
Antarctic Fur Seal	*Arctocephalus gazella*	21,190[m]	Wursig et al. (2018)	NL	NS	Common
		2,700,000[n]	Wursig et al. (2018)			
Crabeater Seal	*Lobodon carcinophaga*	3,187,000[o]	Southwell et al. (2012)	NL	NS	Common
		5-10 million[p]	Wursig et al. (2018)			
Southern Elephant Seal	*Mirounga leonina*	413,671[q]	Erickson and Hanson (1990); Hindell et al. (2016)	NL	NS	Common
		749,385[l]	Hindell et al. (2016)			
Leopard Seal	*Hydruga leptonyx*	13,200[o]	Southwell et al. (2012)	NL	NS	Common
		220,000[j]	Jefferson et al. (2008)			
Weddell Seal	*Leptonychotes weddellii*	302,000[o]	Southwell et al. (2012)	NL	NS	Common
		+1,000,000[l]	Wursig et al. (2018)			

a NL = not listed; E = Endangered; T = Threatened
b NS = not strategic; S = strategic; D = Depleted
c Scotia Sea and northern Antarctic Peninsula
d Abundance in all of the Southern Hemisphere
e Abundance of all beaked whales south of the Antarctic Convergence, mostly consisting of Southern bottlenose whales
f Abundance in partial area of Antarctic feeding grounds
g South of 30.7°S
h South of 60°S
i Minimum global abundance estimate for killer whales
j Abundance south of the Antarctic convergence
k Abundance in all Antarctic waters
l Total global abundance
m Abundance in South Shetland Islands only
n Abundance in South Georgia area
o Antarctic Pack Ice Seals program survey 1998/1999; aerial surveys along the Antarctic Peninsula

p Circumpolar abundance
q South Georgia Stock of Elephant Seals only

TABLE 4-2: MARINE MAMMAL OBSERVATIONS IN HERO INLET OR HAULED OUT AT GAMAGE OR BONAPARTE POINTS NEAR PALMER STATION FOR SPECIFIC MONTHS 2019-2020

Species	Summer Observations 2019[a]			Winter Observations 2019[b]			Summer Observations 2019-2020[c]		
	#	% Swimming	% Hauled Out	#	% Swimming	% Hauled Out	#	% Swimming	% Hauled Out
Humpback Whale	0	N/A	N/A	0	N/A	N/A	2[d]	100%	N/A
Antarctic Fur Seal	73	16%	84%	70	21%	79%	241	4%	96%
Crabeater Seal	20	5%	95%	9	44%	56%	24	4%	96%
Southern Elephant Seal	1	0%	100%	0	N/A	N/A	278	1%	99%
Leopard Seal	3	33%	67%	3	100%	0%	2	100%	0%
Weddell Seal	8	0%	100%	6	0%	100%	39	0%	100%
Unidentified Seal Species	0	N/A	N/A	0	N/A	N/A	1	100%	0%

a Observations conducted from 21 January 2019 through 28 March 2019.
b Observations conducted from 30 March 2019 through 10 October 2019.
c Observations conducted from 12 October 2019 through 31 March 2020.
d Observed outside of Hero Inlet between Bonaparte Point and Janus Island.

TABLE 4-3: MARINE MAMMAL OBSERVATIONS IN ARTHUR HARBOR FOR SPECIFIC MONTHS 2019-2020

Species	Summer Observations 2019[a]	Winter Observations 2019[b]	Summer Observations 2019[c]
Antarctic Minke Whale	0	1	1
Humpback Whale	20	18	0
Antarctic Fur Seal	11	3	1
Crabeater Seal	51	66	7
Southern Elephant Seal	0	3	3
Leopard Seal	15	12	0
Weddell Seal	0	0	0
Unidentified Seal Species	0	0	3

a Observations conducted from 21 January 2019 through.28 March 2019
b Observations conducted from 30 March 2019 through 10 October 2019.
c Observations conducted from 12 October 2019 through 31 March 2020.

4.6.2 MARINE SPECIES

Sea ice and glacial meltwater profoundly influence the ecological and biogeochemical processes of the marine environment with the inter-annual variations of sea ice influencing the life cycle of most marine organisms (Palmer LTER 2020a). As sea ice retreats during the austral summer, phytoplankton blooms are common in the coastal regions near Palmer Station (Ducklow et al. 2013). The primary production of phytoplankton blooms are dependent on an infusion of warm, nutrient-rich UCDW and timing of sea ice retreat (Steinberg et al. 2012). Phytoplankton growth in the region, which has average primary production rates similar to those found in subtropical locations, starts as early as October and continues throughout the austral summer into the autumn. In addition, nano- and picoplankton such as cryptomonads play a role in the WAP marine environment (Ducklow et al. 2007; Ducklow et al. 2012).

Copepods, euphausiids, and salps are the primary zooplankton found in waters off the coast of the WAP. Mixing of neritic (shallow water, near shore) and pelagic (deep water, open ocean) zooplankton occurs in the region, though the distribution of each type varies depending on location in relation to the coast and open ocean. Neritic species found in the region include *Thysanöessa macrura* and *Limacina helicina* (Ducklow et al. 2007). While *Euphausia superba* is the predominant krill species in the Antarctic marine ecosystem and along the continental shelf region of the WAP, including the inner shelf near Palmer Station, the coastal region of the WAP is the preferred habitat for the krill species *Euphausia crystallorophias* (Ducklow et al. 2013).

Fish communities in the west Antarctic Peninsula continental shelf region are a combination of both neritic and mesopelagic (intermediate-depth, open ocean) fauna due to the oceanic circulation patterns, which brings an infusion of warmer UCDW to the area (Donnelly and Torres 2008; Ducklow et al. 2007; Steinberg et al. 2012). The distribution of neritic and mesopelagic fauna in the continental shelf and coastal region is dependent on the subsurface temperature and salinity with neritic fish species preferring the colder, less-saline waters of the WAP coastal region (Steinberg et al. 2012). Studies in the WAP coastal and continental shelf region have found several species of fish from the following families: Bathydraconidae, Channichthyidae, Harpagiferidae, Nototheniidae, Rajidae, Trichiuridae, and Zoarcidae (Barrera-Oro 2002; Dearborn et al. 1972). Greater numbers of fish are found in the benthic zones with rocky bottoms and algal growth, which provides abundant food and shelter from predators such as penguins (Barrera-Oro 2002). The benthic zone is the ecological region at the bottom of a body of water, including the sediment surface and sub-surface layers (seabed).

The rocky shores of the region provide a rich marine habitat where a diverse flora of benthic macroalgae (seaweed) are able to flourish and includes all three types of macroalgae: brown, red, and green algae (Wiencke and Amsler 2012; Dombrov 2019). Brown macroalgae, such as *Desmarestia anceps* and *Desmarestia menziesii*, are the dominant species in the shallow waters of the western Antarctic Peninsula (Ducklow et al. 2013), though other macroalgae species, such as the red macroalgae species *Gigartina skottsbergii* and *Plocamium cartilagineum* (Huang et al. 2007; Amsler et al. 2015), also occur.

The Antarctic Peninsula region hosts diverse communities of mollusks, including approximately 85 species of shelled gastropods and 45 species of bivalves of which 6 shelled gastropod species and 1 bivalve species are considered endemic (Linse et al. 2006). In the subtidal zones surrounding Palmer Station, gastropods are commonly associated with brown and red macroalgae species such as *Desmarestia anceps* and *Gigartina skottsbergii*. Gastropod species identified in these subtidal zones include, but are not limited to, *Skenella umbilicata*, *Margarella Antarctica*, *Cyclostrema meridionale*, *Eatoniella caliginosa*, *Laevilacunaria Antarctica*, and *Omalogyra antarctica* (Amsler et al. 2015).

Benthic communities of echinoderms are known to exist in shallow, hard bottom, nearshore waters of the WAP. Several species have been identified in the region and include, but are not limited to *Odontaster validus*, *Granaster nutrix*, *Lysasterias perrieri*, *Adelasterias papillosa*, *Psolicrux coatsi*, *Psolus carolineae*, and *Sterechinus neumdyeri* (White et al. 2012). In Arthur Harbor, communities of other echinoderms such as *Labidiaster annulatus*, which eat other invertebrates such as mollusks, and *Ophionotus victoriae*, which live on mud and mixed bottom surfaces, have also been observed. Sponges, coelenterates, ectoprocts, and ascidians have been found in waters near Arthur Harbor (Dearborn et al. 1972). Near Palmer Station, communities of gammaridean amphipods such as *Metaleptamphopus pectinatus* are associated with macroalgal species (Huang et al. 2007).

4.6.3 Birds

The southwest Anvers Island and Palmer Basin region is one of the most biologically diverse in Antarctica (ATS 2019a). Eleven species of birds breed in the Palmer Basin region (ATS 2019a), though only eight species are known to breed within a 1.5 km radius of Palmer Station, which is the approximate audible range that noise from the station can be detected (W. Fraser personal communication). Breeding colonies of birds are present on ice-free areas along the coast of Anvers Island, as well as on many of the offshore islands within the area. Palmer Basin is also an important foraging area for birds, including species that do not breed in Arthur Harbor, Hero Inlet, or offshore islands near Palmer Station. **Table 4-4** presents the bird species known to breed, feed, and frequent the Palmer Station region and their abundance. Bird species and abundances shown in **Table 4-4** are based on observations from staff posted at Palmer Station from 2019-2020, the ASMA No. 7 Management Plan (ATS 2019a), and a thorough review of the best available information. Since data on bird species abundance in the Antarctic are primarily based on bird census data at specific locations that count either breeding pairs or active nests, breeding pair data has been limited to locations in the Antarctic Peninsula region to the extent practicable.

Table 4-4: Abundance of Bird Species Potentially Present in The Project Area

Common Name	Species	Estimated Abundance		
		Estimated Global Population	Breeding Pairs	Data Sources
Species known to breed within 1.5 km of Palmer Station				
Adélie Penguin	*Pygoscelis adeliae*	10,000,000	—	BirdLife International (BirdLife; 2021a)
		—	3,790,000[a]	Lynch and LaRue (2014)
		—	390[b]	Lynch et al. (2010)
Kelp Gull	*Larus dominicanus*	3,300,000-4,300,000	N/A	BirdLife (2021b)
		—	437[c]	González-Zevallos et al. (2013)
Wilson's Storm Petrel	*Oceanites oceanicus*	8,000,000-20,000,000	—	BirdLife (2021c)
Southern Giant Petrel	*Macronectes giganteus*	95,600-108,000	—	BirdLife (2021d)
		—	161[c]	González-Zevallos et al. (2013)
South Polar Skua	*Catharacta maccormicki*	6000-15,000	—	BirdLife (2021e)
		—	335[c]	González-Zevallos et al. (2013)
Brown Skua	*Catharacta antarctica*	26,000-28,000	—	BirdLife (2021f)
Antarctic Tern	*Sterna vittata*	—	44,500[d]	Tree and Klages (2004)
		—	248[c]	González-Zevallos et al. (2013)
Snowy Sheathbill	*Chionis albus*	—	27[c]	González-Zevallos et al. (2013)
Species known to feed in the Arthur Harbor/Hero Inlet region (not known to breed within 1.5 km of Palmer Station)				
Chinstrap Penguin	*Pygoscelis antarcticus*	8,000,000	—	BirdLife (2021g)
		—	4486[c]	González-Zevallos et al. (2013)

Common Name	Species	Estimated Abundance		
		Estimated Global Population	Breeding Pairs	Data Sources
Gentoo Penguin	*Pygoscelis papua*	774,000	—	BirdLife (2021h)
		—	6270[c]	González-Zevallos et al. (2013)
Gentoo Penguin	*Pygoscelis papua*	—	2719[b]	Lynch et al. (2010)
		—	585[e]	Dunn et al. (2019)
Imperial Shag	*Leucocarbo atriceps*	Unknown[f]	—	BirdLife (2021i)
Arctic Tern	*Sterna paradisaea*	3,000,000	—	Bird Conservancy of the Rockies (Bird Conservancy; 2021)
Species known to frequent the Arthur Harbor/Hero Inlet region (not known to breed within 1.5 km of Palmer Station)				
Antarctic Petrel	*Thalassoica antarctica*	10,000,000-20,000,000	—	Franeker et al. (1999)
		—	A few nests to more than 200,000 per colony	Australian Antarctic Program (AAP; 2017)
Cape Petrel	*Daption capense*	2,000,000+	—	BirdLife (2021j)
Snow Petrel	*Pagodroma nivea*	4,000,000+	—	BirdLife (2021k)
Southern Fulmar	*Fulmarus glacialoides*	4,000,000	—	BirdLife (2021l)

a Abundance in Antarctica. Approximately 21% of the population breeds on the Antarctic Peninsula.
b Nest numbers from Petermann Island, 2007/2008 census numbers.
c Northern part of Danco Coast, 2010/2011 survey numbers
d Total global population of breeding pairs
e Nest numbers from Goudier Island, Port Lockroy, 2012/2013 census numbers
f According to BirdLife International, the population has not been quantified due to a recent taxonomic split.

Bird colonies with breeding populations within 1.5 km of Palmer Station are primarily located on Bonaparte Point/Kristie Cove and off-shore islands including Litchfield Island, Humble Island, Elephant Rocks, Torgersen Island, and Shortcut Island/Shortcut Point (ATS 2019a). Litchfield Island has been designated as Antarctic IBA No. 086 due to the presence of a South Polar skua population with 50 breeding pairs on the island (ATS 2019a). **Table 4-5** lists known bird colonies within 1.5 km of Palmer Station and their breeding status by location. Figure A-07 (Appendix A) shows bird nesting areas near Palmer Station. Breeding seasons vary by species, though the breeding, nesting, and rearing season for most bird species in the Palmer Station area is during the austral spring, summer, and/or autumn from approximately the beginning of October through the end of May (W. Fraser personal communication). The breeding seasons for specific bird species are shown in **Table 4-6**.

TABLE 4-5: KNOWN BIRD COLONIES ON ISLANDS AND REGIONS APPROXIMATELY 1.5 KM FROM PALMER STATION

Island/Region[a]	Location from Palmer Station	Protection	Bird Species	Breeding Population
Bonaparte Point/Kristie Cove	100 m south	Restricted Zone within ASMA No. 7	Southern Giant petrel	Yes
			Kelp gull	Yes
			South Polar skua	Yes
			Wilson's Storm petrel	Yes
Torgensen Island	1 km west	Within ASMA No. 7/SW half of island is a Restricted Zone	Adélie penguin	Yes
			South Polar skua	Yes
			Brown skua	Yes
			Wilson's storm petrel	Yes
			Chinstrap penguin	No
			Gentoo penguin	No
Elephant Rocks	1 km west	Restricted Zone within ASMA No. 7	Southern Giant petrel	Yes
			Imperial shag	No[b]
			Kelp gull	Yes
Shortcut Island/Shortcut Point	1 km southeast	Restricted Zone within ASMA No. 7	Southern Giant petrel	Yes
			Kelp gull	Yes
			South Polar skua	Yes
			Antarctic tern	Yes
Litchfield Island	1.3 km west	ASPA No. 113 within ASMA No. 7[c]	Southern Giant petrel	Yes
			Kelp gull	Yes
			South Polar skua	Yes
			Wilson's Storm petrel	Yes
			Southern Giant petrel	Yes
			Antarctic tern	Yes
			Hybrid skua	Yes
			Brown skua	Historical[c]
			Imperial shag	No
			Chinstrap penguin	No
			Gentoo penguin	No
			Snow petrel	No
			Cape petrel	No
			Antarctic petrel	No
			Southern fulmar	No

a All information referenced from the Management Plan for ASMA No. 7 except where noted.
b Historically, Imperial shags were known to breed on Elephant Rocks (Harris et al. 2015). While they no longer breed on Elephant Rocks, they are known to still roost there (ATS 2019a).
c Bird information for Litchfield Island from Harris et al. (2015). Brown skua commonly bred on Litchfield Island until an outbreak of fowl cholera in 1979.

TABLE 4-6: BREEDING BIRD SPECIES TYPICALLY FOUND WITHIN 1.5 KM PALMER STATION AND THEIR BREEDING SEASONS

Bird Species[a]	IUCN Red List Status[b]	Breeding Season	Breeding Season Source
Adélie Penguin	Least Concern	October-February	Ellenbroek (2017)
Kelp gull	Least Concern	September-March	Miskelley (2013)
Wilson's Storm Petrel	Least Concern	November-April	Southey (2013)
Southern Giant Petrel	Least Concern	October-May	Szabo (2013)
South Polar Skua	Least Concern	November-January	Hemmings (2013a)
Brown Skua	Least Concern	September-February	Hemmings (2013b)
Antarctic Tern	Least Concern	September-April	Sagar (2013)
Snowy Sheathbill	Least Concern	December-March	Montgomery (1998)

a While Blue-eyed/Imperial shags, Chinstrap penguins, and Gentoo penguins are known to breed in the Palmer Basin, they are not known to breed within a 1.5 km radius of Palmer Station.
b International Union for Conservation of Nature (IUCN; BirdLife 2018)

While multiple bird species are known to feed in the Arthur Harbor/Hero Inlet region, most feed aerially (on land or near the water surface). Only the Adélie, Gentoo, and Chinstrap penguins are known to dive deeper for their food (W. Fraser personal communication). **Table 4-7** lists the number of penguins, by species, that were observed swimming or hauled out during the 2019 and 2019-2020 summer seasons. These observations were taken three times a day for six minutes each by staff posted at Palmer Station.

TABLE 4-7: PENGUIN OBSERVATIONS IN ARTHUR HARBOR/HERO INLET OR HAULED OUT AT GAMAGE OR BONAPARTE POINTS NEAR PALMER STATION DURING THE SUMMER

Species	Summer Observations 2019[a]			Summer Observations 2019-2020[b]		
	#	No. Swimming	No. Hauled Out	#	No. Swimming	No. Hauled Out
Gentoo penguin	23	3	20	71	16	55
Adélie penguin	12	7	5	17	8	9
Chinstrap penguin	0	0	0	2	0	2
Penguins (species not identified)	22	22	0	40	31	9

a Observations conducted from 21 January 2019 through 28 March 2019.
b Observations conducted from 12 October 2019 through 31 March 2020.

4.6.4 Terrestrial Flora and Fauna

Due to the maritime climate, the WAP region has temperature conditions and moisture availability that permits a large variety of vegetation to flourish compared to the rest of the continent. These include bryophytes (mosses and liverworts), lichens, and the only two vascular plant species native to Antarctica (*Deschampsia antarctica* and *Colobanthus quitensis*). The distribution of vegetation in the region is dependent on surface conditions with bryophytes largely occupying moist ground surfaces and lichens and some mosses preferring drier ground surfaces. *Deschampsia antarctica* (Antarctic hairgrass) and *Colobanthus quitensis* (Antarctic liverwort) grow primarily on sheltered, north-facing slopes near sea level. Due to recent warming trends, populations of these vascular plant species are proliferating with the distribution expanding into recently exposed surface areas (ATS 2019a).

Communities of fruticose and crustose lichen, as well as moss sub-formation, have been observed in the Arthur Harbor region, primarily in areas with a rocky or stony ground surface. Crustose lichens form crusts against their substrate. Fruticose lichens can be pendant or hair-like, are generally upright, and shrubby or cupped. Cushion-forming mosses, including species of *Dicranoweisia* and *Andreaea,* were predominantly observed in sheltered north-facing areas while fruticose lichen communities such as *Himantormia* and *Unsnea* were found in drier, more exposed habitats (Smith and Corner 1973). Other lichens that have also been observed in dry, rocky areas in the region include species of the fruticose lichen *Pseudephebe* and the foliose lichen *Umbilicaria* (ATS 2019a). Foliose lichens have two easily distinguishable sides and can be flat, leafy, or convoluted and full of bumps and ridges. Rocky areas near the shoreline that are influenced by nitrogen inputs from penguin and petrel colonies often host brightly colored crustose and foliose lichen sub-formation communities including species such as *Amandinea*, *Buellia*, *Caloplaca*, *Haematomma*, *Lecanora*, *Lecidea*, and *Xanthoria* (ATS 2019a). Other crustose lichen species that have been observed in the region include *Haematomma erythromma*, *Mastodia tesselata*, *Rinodina petermanii*, Xanthoria *elegans*, and species of *Verrucaria* (Smith and Corner 1973).

The immediate vicinity surrounding Palmer Station is developed and primarily consists of gravel that is devoid of vegetation. The distal end of Gamage Point, which is frequented by line handlers when securing ships, has known colonies of the moss species *Sanionia uncinata* and the vascular plant species *Deschampsia antarctica* (N. van Gestel personal communication). Other areas of Gamage Point, including the area directly behind Palmer Station and the cliffs on the northern shore, are also known to be vegetated with *Deschampsia antarctica*, *Colobanthus quitensis*, and a variety of moss species (N. van Gestel personal communication). As the Marr Ice Piedmont has retreated away from Palmer Station, newly exposed terrestrial landscapes have been colonized by a variety of vegetation (ATS 2019a).

Vegetated areas on Anvers Island and the other small islands near Palmer Station provide ideal habitat for a variety of invertebrates including, but not limited to, springtails and mites. One mite common to the Antarctic Peninsula, *Alaskozetes antarcticus*, is found on the sides of dry rocks. Other mite species can be found in areas of fructose lichens, mosses, Antarctic Hairgrass, and even bird nests. Moss beds and the underside of rocks are favored habitat for the most common springtail in the area, *Cryptopygus antarcticus*. Springtails have also been found in bird nests (ATS 2019a).

The southernmost, free living true insect, the wingless midge *Belgica antarctica*, can be found in a range of terrestrial habitats in the ASMA No. 7 such as moss, algae, and nutrient-rich areas near elephant seal wallows and penguin colonies. The seabird tick, *Ixodes uriae*, is found in the area as well, primarily beneath well-drained rocks near seabird nests and Adélie penguin colonies (ATS 2019a).

5.0 IDENTIFICATION AND PREDICATION OF IMPACTS AND MITIGATION MEASURES OF THE PROPOSED ACTIVITY

5.1 INTRODUCTION

The following section identifies the potential impacts predicted to result from the activities associated with the proposed project. Mitigation measures such as best management practices (BMPs), which would be incorporated during construction are also discussed. Direct and indirect impacts are discussed in **Section 5.3** and cumulative impacts are discussed in **Section 5.4**.

5.2 DATA SOURCES AND METHODOLOGY

The primary guidance for this impact assessment came from the Guidelines for EIA in Antarctica as stated in **Section 1.2** (ATS 2016). Research scientists with specific knowledge of the local flora and fauna were consulted to identify potentially impacted species, impact potential, and mitigation strategies. Subject matter specialists were contracted to provide an assessment of underwater acoustic levels resulting from the proposed project as well as to assess the impact to marine mammals to assist in determining impacts. Other publicly available research articles and sources of information about Palmer Station and the vicinity were sought, when needed, to provide more understanding and background and are cited herein.

A direct impact is a change in an environmental resource or value resulting from an action or activity via a direct cause and effect relationship. Impacts may result from physical changes or releases to the environment. Other impacts such as personnel safety or impacts to the function of Palmer Station are considered here.

5.3 IMPACTS

5.3.1 PHYSICAL DISTURBANCES

5.3.1.1 TOPOGRAPHY AND HYDROGRAPHY

Land surface changes to topography include the potential removal of two bedrock outcroppings west of the existing boat parking grid to facilitate site grading (**Section 2.2.5**). Construction of the retaining wall and pier abutment (**Section 2.2.2.5**), and sewer line (**Section 2.2.3**) would require excavating trenches through bedrock. If bedrock outcroppings within the pier footprint are higher than expected, underwater rock chipping may be required to provide workable surfaces for pile installation.

The temporary crane pad (**Section 2.2.2.1**) would require an estimated 1376 m^3 (1800 cy) of imported aggregate fill material to construct. It is anticipated that 50% of this imported material can be recovered once the crane is in position and the assembly pad is no longer necessary. The non-recovered material would remain on the sea floor. The larger rock would provide scour protection along the retaining wall and pier abutment and it is likely that the smaller particles would succumb to tidal scour over time.

The existing pier would be demolished, and excavated material would be reused on-site where possible or removed upon project completion (**Section 2.2.2.2**). Large rocks would be used within the riprap areas designated along the retaining wall, pier abutment, and boat ramp. The existing pier demolition includes extracting the sheet piles, if possible, utilizing a vibratory hammer. If sheet piles cannot be removed, they will be cut off at the sea floor so that the pile is flush with the surrounding sea floor.

Construction of the new pier requires the use of template piles. Once the permanent piles are installed, the template piles would also be removed, if possible, with a vibratory hammer. If this method proves unsuccessful, they too would be cut off at the sea floor. A single 60.96 cm (24 in) diameter template pile, cut off at the sea floor, would result in a surface area of 0.09 m^2 (1.02 ft^2) of steel pipe at the sea floor.

Areas of excavation, fill, and pile installation would result in changes to the existing topography and hydrography near Palmer Station. These impacts are considered minor in terms of their magnitude given the limited footprint. The duration of these impacts is considered long-term given that these changes would persist after construction is complete and until such time as they may be changed in the future. Mitigation measures include limiting excavation areas, to the fullest extent possible, as part of the design for this project, and utilizing coarse fill material meant to withstand easy transport thereby limiting the expansion of the fill area.

Indirect impacts associated with changes in topography and hydrography listed here include disturbances to vegetation or benthic communities within and adjacent to the areas of fill and excavation. Impacts are most likely to be seen below the water surface as the areas of disturbance on land are previously disturbed and not vegetated. Indirect impacts may also arise from the change in substrate material with the introduction of any steel piles that may be cut off at the sea floor. The impact to benthic communities is discussed in **Section 5.3.3.2**. Water quality impacts associated with excavation and placement of fill below the water surface are discussed in the following Marine Water Quality Section.

5.3.1.2 MARINE WATER QUALITY

Impacts to water quality can occur from work occurring below the water surface as well as from runoff or spills from construction above the water surface. In-water fill may increase turbidity as sediments enter the water column and travel beyond the limits of fill placement. Instances of fill below the water surface for this project include the temporary crane pad (**Section 2.2.2.1**), pile installation (**Section 2.2.2.3**), and the retaining wall and riprap (**Section 2.2.2.5**). Mitigation measures include the use of coarse fill material meant to withstand easy transport through the water column. BMPs such as sandbags, absorbent socks, and tarps will be used to secure dirt stockpiles to prevent stormwater and/or snowmelt runoff as well as wind from transporting sediment into adjacent marine waters.

Driving piles into the marine bottom would stir up sediments that would lead to higher turbidity levels. This increase would be temporary, and the suspended sediments should settle back to the marine floor within a few minutes to several hours (**Marine Mammal Assessment, Appendix B**). Drilling fluids and rock cuttings generated during drilling would be redirected back into the water. Drilling fluid would be comprised of potable water only. Rock cuttings would be comprised of native rock and may create a temporary increase in turbidity.

The presence of construction equipment at Palmer Station would result in an increased risk of oil or lubricant spills. The sewer line relocation has the potential to cause a release and other products such as grout will be utilized that could impair water quality. **Section 5.3.2.6** discusses accidental releases in more detail including mitigation measures to be used.

Indirect impacts from marine water quality impacts include impacts to the benthic community and the marine and terrestrial species that feed on them. Impacts to marine species are discussed in **Sections 5.3.3.1 and 5.3.3.2**.

General water quality impacts such as increases in turbidity associated with construction are considered less than minor or transitory. Potential water quality impacts resulting from spills may be more significant but also less likely to occur with BMPs in place.

5.3.2 Releases to the Environment

5.3.2.1 Air Emissions

The barge, cranes, excavator, and other construction equipment running combustion engines would result in an increase in air emissions at Palmer Station for the duration of construction. These emissions are not expected to result in an overall reduction in the ambient air quality of the area. Most of the equipment will be diesel-powered. To the extent practicable, diesel-powered equipment would meet Tier 3 or Tier 4 exhaust emission standards for nonroad engines as defined by United States CFR Title 40, parts 89 and 1039. These standards reduce the emissions of particulate matter, nitrogen oxides, carbon monoxide, and nonmethane hydrocarbons in diesel exhaust. The equipment used is expected to be in proper working order prior to arrival at Palmer Station and would be maintained so as to prevent unnecessary air emissions.

Construction activities may generate fugitive dust emissions. These activities include grout mixing and placement, grading, rock chipping, and cutting or chipping concrete panels or caps. Mitigation measures to help reduce or eliminate air emissions include wet cutting techniques for cutting concrete and prohibition of open burning. Water may be sprayed on surfaces to eliminate fugitive dust if needed. Indirect impacts could include deposition of dust on nearby land and water surfaces, but this would likely be kept to a minimum with the mitigation measures described.

Air emissions associated with this project are expected to result in less than minor or transitory impacts to air quality.

5.3.2.2 Wastewater

Palmer Station maintains an on-site wastewater treatment system, meeting Antarctic Treaty requirements, that consists of only maceration of solids before the waste stream is discharged into Hero Inlet. This system would be utilized by construction staff while working at Palmer Station. The temporary bypass of the sewer line as well as the new sewer line installation have the potential to result in minor releases of macerated sewage waste to the environment during construction. All sewer line work would occur between the maceration only treatment system and the outfall. Any land surface release would be considered a spill and would be reported. Production of wastewater on the barge and tugboat would be kept to a minimum as all construction personnel would primarily utilize services at Palmer Station while the barge is docked. The tugboat and construction barge would be equipped with a United States Coast Guard-approved marine sanitation device (MSD) system capable of treating wastewater generated onboard the vessel. Untreated wastewater from construction vessels including the cargo supply ship and the *LMG* would comply with the ACA and would not be released within 22.2 km (12 nmi) of land. The number of construction personnel on-site would not exceed the number of staff typically located at the station. There should be no increase in wastewater output over normal conditions and therefore no negative impacts resulting from the project. There are a number of items prohibited or regulated at the station to avoid impacts to wastewater and environmental receptors (e.g., avian products [raw or cooked]). The net output from the system after construction would be the same. The system capacity would not be altered, only the location of the outfall to accommodate the new pier (see **Section 2.2.3** for more info on the sewer line relocation). Indirect impacts to wastewater impacts include impacts to the marine water quality should a spill occur. The Contractor would have spill response kits on hand which would be employed should a spill occur. This should prevent any such spills from entering the marine environment. Any spill would be reported allowing for further investigation of potential transport.

Mitigation measures include utilization of the temporary bypass until construction of the new line is completed as well as the use of spill response kits should an accidental spill occur. No hazardous materials/fluids would be disposed of into the wastewater system.

The project is not expected to result in any impact due to the release of wastewater to the environment beyond what occurs during normal station operations. Any impact that may occur is considered less than minor and transitory.

5.3.2.3 NOISE/ACOUSTIC RELEASES

There are numerous noise-generating activities associated with this project:

- Pile installation
- Below-water excavation to prepare surface for pile installation
- Demolition of the existing pier
- Bedrock excavation for the retaining wall, sewer line, and pier abutment
- General construction and heavy equipment

The primary source of underwater noise would be pile driving. An acoustic assessment was prepared for the project, which identified and analyzed the in-water noise impacts from three different possible methods of pile driving: vibratory hammer, impact hammer, and DTH drilling. Vibratory hammers produce vertical vibrations that are transferred through the pile to the ground which reduces friction and allows the pile to be driven into the ground. Impact hammers work like a traditional hammer and drop a heavy weight from a height onto the top of the pile, forcing it into the ground. DTH drilling, as described in **Section 2.2.2.3**, uses an attachment at the end of a drill to break up rock into small flakes, allowing the pile to be driven into the ground. All three methods (vibratory hammer, impact hammer, and DTH drilling) were considered in the noise assessment as construction techniques that could be used depending on site conditions. Rock chipping may be utilized to prepare the sea bottom at pile locations to ensure accurate pile location and alignment. Rock chipping may also be utilized for bedrock excavation associated with construction of the retaining wall, sewer line, and pier abutment. Rock chipping was not considered separately from DTH drilling in the acoustic assessment performed for this project because the area of ensonification for DTH drilling is larger than for rock chipping and both activities would occur on the same day. Vibratory driving may be used to remove the template piles and sheet piles associated with the existing pier but not to install new piles.

The acoustic assessment performed for this project evaluated underwater noise only in order to assess impacts to marine mammals. Specific impacts to marine mammals resulting from noise generating activities are discussed in **Section 5.3.3.1**. In addition to the underwater noise impacts on marine species, the above ground noise generation has the potential to impact birds and other fauna found near Palmer Station as well as Palmer Station staff and construction personnel. Impacts to birds are addressed specifically in **Section 5.3.3.3**.

Construction personnel are expected to wear personal protective equipment (PPE) to mitigate against occupational noise exposure. During construction, non-Antarctic Support Contract (ASC) scientific staff are not expected to be present at Palmer Station but would conduct research aboard the research vessels. Noise impacts to researchers are possible within 1.5 km (0.93 mi) of the construction area (W. Fraser, personal communication). It is recommended that PPE be available for all staff to reduce noise exposure, particularly for staff performing work outside during noise generating activities.

Noise generated by the project is likely to result in impacts, which would be no more than minor or transitory given that they would end with the cessation of noise generating activities.

Construction would be limited to one construction season (November through June) and workdays would be limited to 12-hour shifts, 7 days a week. The reduced timeframe and work hours will reduce the length and duration of the noise impacts.

5.3.2.4 NON-NATIVE SPECIES

The introduction of personnel, equipment, construction materials, and imported fill carries the risk of introducing non-native species to Antarctica. Non-native species include insects and microorganisms, as well as vectors such as seeds and soil. Non-native species introduction prevention procedures apply to work at Palmer Station, including work done through ASC and subcontractors. The project would adopt the guidelines set out by ATS (2019b) which identified pathways of non-native species introduction such as:

- cargo (including aggregate materials),
- construction equipment,
- personal clothing and gear,
- procured items,
- food, and
- mail.

Indirect impacts associated with the introduction of non-native species include impacts to terrestrial and marine species native to Palmer Station including the adjacent Gamage Point and Hero Inlet. Research suggests that climate change increases the risk of establishment of non-native species, making the prevention of their introduction even more important (Newman et al. 2014).

Mitigation measures to be implemented to prevent the introduction of non-native species would include cleaning and inspecting all cargo, construction equipment, gear, clothing, and personal equipment for the presence of non-native species and organic matter before shipping and loading on the shipping vessels. Ballast water would be discharged only outside the Antarctic Treaty area, at reception facilities, or as otherwise permitted under Annex I of the International Convention for Prevention of Pollution from Ships (MARPOL 73/78) and Resolution 3 (ATS 2006). Aggregate rock (fill) imported for this project is required to be cleaned and sterilized prior to shipment to Antarctica.

The potential impact to local microbiological habitats from the introduction of non-native species can be significant given that the impact can be long-term and spread beyond the local environment. Incorporating the prescribed guidance measures into standard operating procedures for construction should reduce this to a minor risk.

5.3.2.5 SOLID WASTE

The ACA requires training and education of personnel to comply with waste management requirements and procedures. Construction personnel would attend a solid waste orientation and follow provisions of the ACA and direction by Palmer Station staff. No polychlorinated biphenyls, non-sterile soil, polystyrene beads, chips (packaging materials), or pesticides would be imported or used. Any waste, including hazardous waste, generated during construction would be stored in containers and removed from the site by barge. Demolished materials would be considered for future use at Palmer Station. Any remaining material that cannot be reused locally would be returned with the barge. With these measures in place, no solid waste impacts are anticipated.

5.3.2.6 ACCIDENTAL RELEASES

Construction vehicles and equipment would adhere to the guidance detailed in ASMA No. 7 Management Plan including taking steps to prevent the accidental release of fuel or chemicals and ensure that spill kits are available and secondary containment units are used. Safety measures to be utilized include proper storage of all chemical and petroleum products and regular inspections of equipment, hoses, and fuel storage containers. Waste Regulations (45 CFR § 671) would be followed including regular inspections of storage containers.

The Contractor anticipates two major fueling events over the course of construction. Each event is expected to transfer approximately 37,854 L (100,000 gal) of diesel fuel. The transfer would occur by running a hose between the support vessel and the deck of the barge. Refueling is anticipated to occur over two days at a rate of 1211 L (320 gal) per minute. During this time, no work would be conducted from the barge in order to observe necessary safety protocols and ensure fueling operations are conducted properly. Secondary containment would be utilized for all fuel storage and fueling activities and spill response material would be located and available for immediate deployment. Spill response material would include absorbent pads, socks, protective gear, and a rope mop skimmer. ASC trained staff will be on-site to provide fuel spill response including installing a 152.4 m (500 ft) boom as a precautionary measure prior to fuel transfer.

The sewer line installation may require using a high expansion grout agent such as Dexpan® to create a non-explosive, controlled expansion to fracture the rock (see **Section 2.2.3** for more discussion on the use of Dexpan®). The Safety Data Sheet for Dexpan®, included in **Appendix C**, indicates toxicity levels in aquatic environments occur at levels far higher than what would be expected to occur from the quantities and use specified for this project. After fracturing, the demolished rock and debris, including grout, would be collected. An absorbent sock would be employed around the demolition area to promote absorption of any stray material and aid in collection efforts. If Dexpan® or similar product is used, the surplus material and its container would be segregated for special disposal considerations. Any hazardous wastes would be disposed of outside the Antarctic Treaty area in accordance with pertinent regulations and permits.

Indirect impacts from accidental releases include impacts to water quality as well as impacts to marine species and birds. These impacts could be long term in duration depending on the material released.

This project has the potential to release hazardous material into the environment, particularly diesel fuel. The impact from such spills would be a major impact, but this impact can be effectively minimized by following established BMPs such as ensuring spill containment and response materials are in place.

5.3.3 Disturbances to Biological Resources

5.3.3.1 Marine Mammals

As described in **Section 4.6.1**, 12 cetacean and five pinniped species can be found in the vicinity of the project. Five of the cetacean species are listed as endangered under the ESA: blue, fin, sei, sperm, and southern right whales. None of the pinnipeds are ESA-listed. Sources of direct impacts to marine mammals include auditory injury or disturbance due to underwater noise from DTH drilling, vibratory and impact pile installation and removal, and possibly rock chipping, as well as physical disturbance to marine mammals from project vessels and human presence in the vicinity of the pier. Unavoidable impacts to marine mammals during construction are anticipated; therefore, an IHA for the incidental taking of marine mammals pursuant to Section 101(a)(5)(A) of the MMPA is required. Under the MMPA, "take" means to harass, hunt, capture, or kill any marine mammal or attempt such actions. For the purposes of the IEE, the estimated exposures to increased underwater noise due to construction provide the basis for assessing the extent, duration, intensity, and significance of effects according to the EIA guidelines (ATS 2016).

When the MMPA was enacted in 1972, Congress made several findings concerning the conservation of marine mammals, including, but not limited to, indicating that "certain species and population stocks of marine mammals are, or may be, in danger of extinction or depletion as a result of man's activities" (16 U.S.C. 1361(1)) [and] "such species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part[…]" (16 U.S.C. 1361(2)) [and that] “marine mammals…[are] resources of great international significance…[that] should be protected and encouraged to develop to the greatest extent feasible commensurate with sound policies of resource management and that the primary objective of their management should be to maintain the health and stability of the marine ecosystem[….]” (16 U.S.C. 1361(6)). These and other findings in Section 2 of the MMPA speak to the need to maintain a broad scope in marine mammal protection that considers species- and ecosystem-level impacts

To serve these broader goals, Section 101(a) of the MMPA prohibits the incidental taking of marine mammals. The incidental take of a marine mammal falls under three categories: mortality, serious injury, or harassment (i.e., injury and/or disruption of behavioral patterns). Harassment[2] is any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment) or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns (Level B harassment). Disruption of behavioral patterns includes, but is not limited to, migration, breathing, nursing, breeding, feeding or sheltering. However, Sections 101(a)(5)(A) and (D) of the MMPA provide exceptions to the prohibition on take, which give NMFS the authority to authorize the incidental but not intentional take of small numbers of marine mammals, provided certain determinations are made and statutory and regulatory procedures are met. ITAs may be issued as either (1) regulations and associated Letter of Authorization (LOA) or (2) IHAs, when a proposed action does not have the potential for serious injury and/or mortality or where any such potential can be avoided through required mitigation measures. Regulations may be issued for a maximum period of five years and IHAs may be issued for a maximum period of one year.

Under the No Action Alternative described in Chapter 3.1, NMFS would not issue the IHA to NSF authorizing take of small numbers of marine mammals. As a result, the exceptions to the prohibition on take of marine mammals per the MMPA would not apply, and NSF would not construct the new replacement pier as described in the IHA application. There would be no direct or indirect impacts to marine mammals or their habitat resulting from no action. The marine mammal species and their habitat conditions would remain substantially similar to the conditions described in **Section 4.6.1** and the Marine Mammal Assessment (**Appendix B)**.

The potential sources of physical disturbance to marine mammals during Palmer Pier construction activities are associated with the physical presence of humans on the pier, construction vessels present within Hero Inlet, and noise introduced into the air from drilling and pile driving activities. Vessels or humans would not be permitted to intentionally approach marine mammals on sea or land during the project. Mortality and serious injury of marine mammals due to vessel strikes is not expected in Hero Inlet due to the slow speed of the single working tug and the required use of Protected Species Observers (PSOs) as a required mitigation measure. Project activities can be shut down by the PSO if the activity presents any immediate threat or harm to a marine mammal.

Direct impacts on marine mammals due to the Palmer Pier construction project may result from underwater noise from DTH and pile driving. The extent of potential auditory impacts to marine mammals during in-water construction activities were evaluated based on the area that may be ensonified (filled with sound) by underwater noise and the potential for marine mammals to occur in this area using published studies and recent observation data in Hero Inlet near Palmer Station. The estimated area that would be ensonified above behavioral thresholds by source is calculated based on the distance from the Palmer Pier to the edge of the NMFS thresholds for each species for Level A and Level B threshold (**Marine Mammal Assessment, Appendix B)**. Shutdown zones will be implemented during pile or sheetpile installation and removal activities. If marine mammals are observed within the shutdown zone, DTH drilling, or pile-driving or removal activities would be delayed until they move out of the area. If a marine mammal is seen by the PSOs above water and then dives below, the contractor would wait before resuming construction activities as specified in the IHA. If no marine mammals are seen in that time, work would resume based on the assumption the animal has moved away from the shutdown area. While this will not prevent MMPA "takes" from occurring, it will prevent any serious injury to a marine mammal from a close approach.

The duration of potential effects is, in part, based on the project schedule for in-water construction. The project Contractor assumes that installation of approximately one to two piles would occur over a 12-hour workday. To be precautionary, this assessment assumes that two pile installation activities would occur simultaneously using DTH drilling. The corresponding noise assessment assumes one 36-in pile would be installed to a 20-ft socket depth while a second 36-in pile would be installed to a 30-ft socket depth. Brief impact pile driving of about 10 strikes may be used to seat the piles.

Seals have been observed hauled out at Gamage Point (near Palmer Pier) but ATS (2019a) shows the closes haul out location at Bonaparte Point (approximately 135-150 m [442-492 ft] from Palmer Pier). In-air noise generated during construction activities at the pier should attenuate in air to <100dB, or less than levels that exceed NMFS established Level B thresholds, before reaching the opposite side of Hero Inlet where seals may be on shore. A 2016 Final Rule for construction of a Navy Pier (81 FR 52614) estimated the greatest possible distances to airborne noise during installation of a 24" steel pile (using a source level of 111 dB re 20 microPascals) as 168.3 m to the 90 dB threshold for harbor seals and 53.2 m for all other seals. A 2019 Final Rule published for construction of the Liberty Development in Alaska estimated airborne noise during impact pile driving as 93 dB re 20 microPascals at 160 m from the source (84 FR 70274). It is unlikely that animals hauled out across Hero Inlet will be exposed to levels above the NMFS Level B threshold for disturbance. Therefore, construction noise is not expected to disturb hauled out animals across Hero Inlet or similar distances away. Any animals hauled out closer to Palmer Station would be subject to the 50-m shutdown zone and therefore pile driving activities would not commence until the animal moved out of the area. Further, disturbance of hauled out seals or animals in the Hero Inlet waters due to the physical presence of vessels and equipment does not automatically imply that harassment has occurred. If disturbed, seals may leave the haulout area briefly, but would be expected to return. There is recognition that minor and brief changes in behavior such as this do not generally have biologically significant consequences for marine mammals (NRC 2005). Given the limited vessel traffic, slow vessel speed or stationary nature of the support vessels, and that other construction activities would be on land at the pier, only negligible impacts would be expected due to disturbance from human or vessel activities.

Temporary behavioral changes or avoidance of the affected area is the most common response of marine mammals to increased noise levels. Marine mammal exposures to underwater noise generated during construction activities would possibly result in the potential for Level A and Level B takes as determined by established criteria (NMFS 2018). However, the relatively short duration of these exposures is not expected to result in anything more than biologically insignificant to minor, transitory effects to any of the marine mammal species that may be taken during this project. Avoidance responses may be initially strong if the marine mammals move away from the source or weak if animal movement is only slightly deflected away from the source. This type of behavioral response might further protect animals from elevated sound exposures.

The biological significance of potential behavioral disturbances is difficult to predict, especially if the detected disturbances seem minor. However, it is likely that impacts or responses to elevated sound sources would be short-term, localized, and would have no biological significance to reproduction and survival rates or population trends. While increased underwater sound levels from project activities have the potential to result in Level A (i.e., permanent threshold shift) harassment to certain species, the potential for this effect is minimized through mitigation. No serious injury or mortality of marine mammals is expected from project activities. A more detailed assessment of the impacts to marine mammals can be found in the Marine Mammal Assessment (**Appendix B**) developed to support the IHA Application.

Indirect impacts associated with impacts to marine mammals include decreased predation on other marine species. This impact is likely minor and transitory, particularly in relation to other direct impacts on marine organisms addressed in **Section 5.3.3.2.**

These mitigation measures are recommended to minimize and avoid adverse impacts to marine mammals and are based on the best guidance available:

- Implementation of a soft-start procedure (see below) to reduce the total number of animals potentially exposed to increased noise levels from pile installation
- Implementation of a 12-hour workday followed by a 12-hour period without increased noise from the project allowing for acoustic "recovery" throughout each 24-hour period
- The use of PSOs for monitoring ensonified areas and a shutdown procedure that would reduce the total amount of time and exposure that a marine mammal is potentially exposed to noise levels that exceed the Level A thresholds established by NMFS

Soft-start protocols will be finalized during consultation with the NOAA/NMFS during ESA consultation and in conjunction with the IHA permitting process under the MMPA. Soft-start (or ramp-up) procedures are typically defined as a brief interval of pile driving at reduced energy followed by a waiting period where pile driving stops. This is repeated several times before the equipment can be used at full energy.

See the Marine Mammal Assessment (**Appendix B)** for further details on these mitigation measures including monitoring protocols and reporting requirements.

5.3.3.2 Marine Species

In addition to marine mammals, other marine species including fish, invertebrates, microorganisms and plant life account for the underwater ecosystem around Palmer Station. The benthic community along the seafloor may be displaced or covered as a result of sediments stirred up during pile driving activities or during the placement of fill below the water surface for the temporary crane pad and additional riprap placement as wave protection against the boat ramp, retaining wall, and pier abutment. Portions of the fill material from the temporary crane pad may also disperse over time as a result of wave action. A study on the variability of phytoplankton biomass along the West Antarctic Peninsula found that sediments in the water column reduce irradiance and resulted in lower abundance of phytoplankton (Kim et al. 2018). Suspended sediments are likely to dissipate within a single tidal cycle (**Marine Mammal Assessment**, **Appendix B**). Kim et al. (2018) found significant seasonal variation in phytoplankton abundance from year to year, corresponding to other disturbance variables including the amount of suspended sediments in the water column. This would suggest phytoplankton numbers may be only seasonally affected by increased sediment loads associated with this project. Ice scour and high wind and wave events are common disturbance events for benthic communities and much research has looked at the colonization and succession of these communities (Barnes and Conlan 2007). Many Antarctic benthic organisms are found in widely distributed sites around the Antarctic continent (Clarke 1996). The Southern Ocean contains a high level of species abundance (Barnes and Conlan 2007, Barnes and Brockington 2003) although the authors note that the ability to make generalizations on larval abundance suffers from a lack of existing data. It is difficult therefore, to determine the rate at which the benthic community within and adjacent to the project will recover but the capacity for recovery is assumed and the footprint of impact is relatively small. Therefore, the impacts are expected to be minor and potentially long-term.

Removal of the existing pier would also result in the displacement of microalgae, macroinvertebrates, and other benthic organisms that have colonized the surface of the pier and the pier abutment. A review by Barnes and Conlan (2007) describes two patterns of nearshore colonization on hard substrata: slow and continuous (i.e., 2% cover after 21 months) versus interannual mass events (major build-up of organisms after nearly a decade). Barnes and Brockington (2003) state that while the High Antarctic sees very low rates of colonization, maritime Antarctic Islands are characterized by continuous colonization and summer ice scour structures communities. Barnes and Conlan (2007) noted a lack of experiments detailing recolonization hypothesizing that ice scour makes such studies difficult. The monitoring plan proposed for this project (see **Section 5.6**) includes documentation of the recolonization of the benthic environment on the newly built pier and fill areas. This data may help advance understanding of the recolonization rates and processes for benthic organisms along the WAP.

The sewer outfall is another area where marine organisms congregate. In a review of disturbance and recovery of Antarctic benthic communities, Barnes and Conlan (2007) reported that the benthic footprint resulting from sewage outfalls from coastal research stations was found to extend up to 2 km from the source. The proposed outfall is approximately 28.3 m (93 ft) from the existing outfall and both outfalls terminate above the water. The movement of this outfall may result in a short-term impact until organisms adjust to the new location, but it is not anticipated that any long-term shifts in the types or quantity of organisms would occur as a result of the sewer outfall relocation; therefore, any impact is expected to be minor.

Fish species in the project vicinity would be impacted in a manner similar to that discussed for marine mammals. It is expected that species found in the vicinity of the pier are tolerant to noise levels associated with a seasonally active marine station. Noise impacts would be temporary and would be limited to the duration of construction. Popper et al. (2019) concluded that fish exposed to pile driving sounds may show alarm responses including an increase in swim speed as well as changes to ventilation and heart rate. These transient startle responses are not expected to result in adverse impacts as fish often rapidly return to normal behavior. The specific noise levels to which fish react and a further treatment of the impacts from this project are described in the Marine Mammal Assessment (**Appendix B**). Fish are likely to respond to pile-driving activities by temporarily avoiding the area and therefore impacts are expected to be less than minor.

Not much information is available on the effects of underwater noise on krill and zooplankton (Erbe et al. 2019). A study reported by McCauley et al. (2017) showed a two- to three-fold decrease in zooplankton abundance in response to air gun sounds as far as 1.2 km away. Pinkerton et al. (2020) reports a three-fold seasonal change in zooplankton abundance with increases occurring through the summer. This suggests that while a three-fold reduction in zooplankton abundance may result from this project, this is not larger than typical seasonal variations in zooplankton abundance and therefore may only result in a minor or transitory impact.

Indirect impacts associated with impacts to marine species include impacts to birds and marine mammals that feed on these organisms. The Marine Mammal Assessment (**Appendix B**) provides a further treatment of indirect impacts to marine mammals from impacts to prey species and found the impacts to be less than minor. Mitigation measures include the use of coarse fill material meant to withstand easy transport through the water column.

5.3.3.3 BIRDS

Impacts to birds are most likely to stem from noise generated during construction. A long-term scientist at Palmer Station provided information on the bird species likely to be affected by construction of this project. The audible range over which normal noise levels coming from Palmer Station can be detected by humans and the bird species found in the area is 1.5 km (0.93 mi; W. Fraser, personal communication). **Table 5-1** includes the birds most likely to be found within 1.5 km (0.93 mi) of Palmer Station. The table also identifies the breeding status of each species during the construction time frame, the species population status, feeding model and location, and how sensitive to disturbance the species is.

TABLE 5-1. BIRD SPECIES TYPICALLY FOUND WITHIN 1.5 KM OF PALMER STATION

Bird Species Within 1.5 km of Palmer Station (Nov 1-May 15)[a]	Breeding	Non-Breeding	Population Status	Feeding Model/Feeding Locally	Sensitivity to Disturbance
Kelp Gull	X		Stable	Aerial/Yes	High
Wilson's Storm Petrel	X		Unknown	Aerial/Yes	High
Southern Giant Petrel	X		Stable	Aerial/Yes	High
South Polar Skua	X		Decreasing	Aerial/Yes	High
Brown Skua	X		Decreasing	Aerial/Yes	High
Antarctic Tern	X		Stable	Aerial/Yes	High
Arctic Tern		X	Unknown	Aerial/Yes	High
Adelie Penguin	X		Decreasing	Diving/Yes	Moderate
Chinstrap Penguin		X	Increasing	Diving/Yes	Moderate
Gentoo Penguin		X	Increasing	Diving/Yes	Moderate
Snowy Sheathbill	X		Stable	Aerial/Yes	Low
Blue-eyed Shag		X	Decreasing	Aerial/Yes	Low

a Source: (W. Fraser personal communication)

Many factors influence the potential for impacts to bird species. These species typically breed some distance from the station but feed more locally. Those species that utilize diving in their search for food (feeding model) would be affected by both the above and below water noise generation. The sensitivity to disturbance metric reflects observations from four decades of research showing how these species have responded to human activities (W. Fraser, personal communication). Noise from construction activities can impact the behavior and physiology of birds by masking the signals used for communication, mating, and hunting (Bottalico et al. 2015). Ultimately an increase in noise or the presence of noise may lead to a decrease in bird density as birds leave the area where their signals are masked (Bottalico et al. 2015). As noise levels increase or distance to noise decreases, increased impacts to bird include temporary hearing loss (temporary threshold shift, TTS) and permanent hearing loss (permanent threshold shift, PTS).

Very little is known about underwater hearing in marine birds, with research only reported for three species: long-tailed ducks (Clangula hyemalis), great cormorants (Phalacrocorax carbo) and more recently, gentoo penguins (*Pygoscelis papua*) (Sorensen et al. 2020). Based on research reported in Sorensen et al. (2020), gentoo penguins responded to underwater noise bursts at received SPLs between 100 and 120 dB re 1 μPa RMS. A "graded reaction to the noise bursts" was exhibited by the penguins, ranging from no reactions at 100 dB to strong reactions to 120 dB re 1 μPa. A "strong reaction" was defined as a "startle response" or greater than 90% change of swim direction and change of speed. Due to limited information on marine bird hearing, it is not possible to estimate the potential distance at which behavioral disturbance could occur during DTH drilling or pile installation/removal. However, it is reasonable to assume some level of behavioral disturbance will occur during in-water construction due to underwater noise.

Airborne noise may also result in behavioral disturbance. Dooling and Popper (2016) report that above 60 dBA, masking may occur. No data is available for TTS in birds caused by multiple impulse noise such as that produced by pile driving but studies show that PTS can occur at 125 dBA (Dooling and Popper 2016). As stated in **Section 5.3.3.1**, pile driving noise should attenuate to below this level before reaching across Hero Inlet. Results from Alaska show levels reducing to 93dB at 160m from the source (84 FR 70274). It is expected that bird species will avoid areas closer to the construction noise while pile-driving and other noise producing activities occur in order to avoid acute impacts such as hearing loss.

The ACA defines "take" as "to kill, injure, capture, handle, or molest a native mammal or bird" "or to attempt to engage in such conduct." Disturbance of concentrations of native birds or mammals is classified under the ACA as "harmful interference." Because behavioral disturbance of bird species that may be found in the area could occur due to temporary in-air or underwater noise during construction, the project will apply for an ACA permit due to harmful interference. No taking of birds is expected as a result of this project.

Noise impacts, while far reaching, are expected to be no more than minor disturbance to a selected few species. Temporary impacts to bird behavior or avoidance of the project area are anticipated to be the most common response to increased noise levels. However, the relatively short duration of these noise levels is expected to result in no more than minor or transitory impacts. Avoidance responses would vary by species; however, this type of behavioral response might further protect birds from elevated noise. Although some birds dive to feed, penguins are more likely to be affected by noise than other bird species. Adélie penguins, while not a global species of concern as shown in **Table 4-6**, are considered to be in decline locally. Therefore the soft-start procedures described in **Section 5.3.3.1** as well as the 50-m shutdown zone for pile driving and 10-m shutdown zone for heavy equipment movement in water will be applied to penguins in addition to marine mammals.

Indirect impacts from impacts to birds include a potential decrease in predation of marine organisms such as fish and zooplankton within the vicinity of Palmer Station. This impact is likely minor and transitory, particularly in relation to other direct impacts on marine organisms addressed in **Section 5.3.3.2.**

Potential mitigation measures include limiting the loudest activities to the evening hours when species such as penguins are typically not feeding (W. Fraser, personal communication). This is dependent upon the Contractor's schedule and ability to accommodate. The work schedule does include 12-hour workdays and 12-hour noise "recovery" periods as described in **Section 5.3.3.1.**

5.3.3.4 TERRESTRIAL FLORA AND FAUNA

Construction personnel would receive training regarding the requirements of the ASPAs and Restricted Zones within ASMA No. 7. Personnel would not enter Restricted Zones or ASPAs. Personnel would not approach any animals (birds or mammals) or collect or trample vegetation (including moss and lichen). Personnel would not collect and export material such as animal or plant parts, bones, feathers, rocks, etc. Personnel access would be limited to the barge, tugboat, construction areas, and facilities associated with Palmer Station.

Impacts to vegetation such as lichens and moss should be minimal as construction is limited largely to the previously disturbed areas of Palmer Station. There is an area near the tie-up location for the *LMG* on Gamage Point where the moss *Sanionia uncinata* and the vascular plant *Deschampsia antarctica* are found (N. van Gestel, personal communication). This area is outside of the construction zone for this project. The construction barge would initially anchor utilizing the existing moorings at Gamage Point but would set up anchors to the seaward side of the barge. Once completed, this project would eliminate the need for the *LMG* to be tied-off at this location, potentially preventing future degradation of this vegetation.

Indirect impacts from impacts to terrestrial flora and fauna include potential introduction of non-native species and impacts to other species such as birds that feed on local vegetation. Impacts resulting from the introduction of non-native species are discussed in **Section 5.3.2.4**. Impacts to birds from loss of vegetation is not directly discussed in **Section 5.3.3.3** given the low likelihood that terrestrial vegetation will be impacted by this project. Mitigation measures include restricting personnel access to areas outside the construction area, providing training to construction personnel as stated above, and providing staff member escorts to construction personnel in vegetated areas should access be needed.

5.3.4 OTHER

5.3.4.1 STATION FUNCTION AND ACCESS

A total of 24 construction personnel would utilize the existing facilities at Palmer Station for office space, crew quarters, laundry, meals, phone, and internet for the duration of the project. The Palmer Station Master Plan (NSF 2016) states that the population of the station is not expected to exceed 46 people during the austral summer. This would allow a staff of 22 people to continue working at the station through construction. No researchers would be residing at Palmer Station during construction, although some research is expected to be carried out onboard research vessels. The construction barge would be docked at the station during the entirety of construction and would restrict station access during that time period. No tour visits to Palmer Station would be allowed during the period of construction. This impact is considered less than minor or transitory given that the impact will end when construction is completed.

Indirect impacts associated with impacts to station function and access include impacts to scientific research which is discussed in **Section 5.3.4.3**. No mitigation measures are proposed.

5.3.4.2 VISUAL DISTURBANCES

Wilderness and aesthetic values associated with Antarctica have been previously characterized as areas without permanent improvements or visible evidence of human activity (NSF 2015). Visible changes resulting from this project include removal of the existing pier, construction of a new pier, surface grading, and sewer line relocation. See **Section 2.2** for a description of these activities as well as **Figure A-05** (**Appendix A**). However, this project is limited to the existing Palmer Station footprint and would not expand the area of disturbance or development except for the larger size of the new pier relative to the current one. For this reason, this impact is considered less than minor or transitory.

During construction there would be two large cranes as well as other construction equipment, which would temporarily impact the visual characteristics of Palmer Station. This equipment would be located only within the project area shown on **Figure A-04** (**Appendix A**) and would be located at the station only for the duration of the project.

No indirect impacts are anticipated as a result of impacts to the visual characteristics of Palmer Station. Mitigation measures include limiting the extents of excavation to the fullest extent possible during design.

5.3.4.3 IMPACTS TO SCIENTIFIC RESEARCH AND OTHER USES OR VALUES

The primary function of Palmer Station is to support Antarctic scientific research. Full utilization of the station by scientists and staff would be reduced during construction due to accessibility, the presence of construction staff, and the limits on available accommodations. Many projects with field components would be supported using the *NBP* or *LMG,* which would function as floating research platforms, allowing a very limited amount of scientific research to continue while not impacting construction activities. The impacts described in **Sections 5.1 through 5.4** may impact scientific research projects.

Current investigations for the Palmer LTER are focused on the following

- physical forcing (solar, atmospheric, oceanic, and sea ice) with emphasis on ecological consequences of annual and inter-annual variation;
- ecology and population biology of marine bacteria and archaea, phytoplankton, zooplankton, seabirds, and whales;
- biogeochemical cycling of carbon and nitrogen;

- ecosystem responses to climate mitigation; and
- physical/chemical/biological modeling linking ecosystem processes to environmental forcing (NSF 2015).

Much of this research occurs within the broader study area of the Palmer LTER regional grid and Palmer Basin grid. Most of the impacts noted in **Sections 5.1-5.4** are limited to the construction area but the noise impacts to marine mammals extend as far as 18 km (11.2 mi; **Marine Mammal Assessment**, **Appendix B**). One of the primary values of ASMA No. 7 is its importance for long-term studies of natural variability in Antarctic ecosystems and the impact of world-wide human activities on Antarctica and on the physiology, populations, and behavior of its plants and animals (ATS 2019a). Impacts to these long-term ecosystem research include changes in species numbers and behaviors as a result of this project. Data collected during this time period and potentially after would likely need to account for human-induced impacts. Studies cited throughout Section 5.3 highlighted the lack of information regarding human-induced impacts to Antarctic species. This project would provide a valuable opportunity to collect this information in order to better inform future impact analysis.

Other scientific research projects currently underway at Palmer Station that will be impacted include data and samples for seismology and air sampling projects. Thirteen research projects (including LTER) will experience a deferral of work as a result of pier construction activities (J. Johnson personal communication). Remote weather systems, tide gauge, and waterwall datasets at Palmer Station will be interrupted by pier construction (J. Johnson personal communication).

5.4 CUMULATIVE IMPACTS

The cumulative impacts analysis must consider not only the impacts and effects from the proposed activity, but also from the effects and impacts of past, present, and future actions in the region. In order to fully evaluate the cumulative effects, three factors were considered:

- Temporal and/or spatial overlap with other activities that might result in impacts
- Likely pathways or processes of accumulation for assessed impacts
- Effects that may result from proposed activity that may contribute to cumulative impacts

Past projects include the development of Palmer Station, which began in the 1960s with the construction of the pier, the BioLab, and the GWR. Additional structures and facilities were constructed in the following decades with the boat ramp, which was built in 2013, being the most recent significant construction project (NSF 2016). These past development projects at Palmer Station have had long-term, direct impacts to the environment such as loss of vegetation and habitat. When considered with the current project, minor, cumulative impacts associated with the loss of terrestrial and aquatic habitats may occur, but none are anticipated to exceed the threshold of significance.

Three current projects and activities in the vicinity of Palmer Station were identified and determined to not contribute to the cumulative impacts. **Table 5-2** identifies each project or activity and provides an explanation of the cumulative impacts determination.

TABLE 5-2: CURRENT PROJECTS AND ACTIVITIES NEAR PALMER STATION[a]

Project/Activity	Cumulative Impacts Determination
Commercial Fishing	Palmer Station is located within the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) Management Area 48.1, which had a total krill catch of 155,907 tonnes (171,858 tons) in 2019 (Meyer et al. 2020). Based on a large-scale krill biomass survey conducted in 2019, which estimated a krill biomass of 60 million tonnes (66.1 million tons), commercial fishing has a minimal impact on krill populations and is unlikely to have a direct impact on cumulative impacts to marine species (Meyer et al. 2020). Any other impacts, such as noise or air emissions, are anticipated to be short-term and transitory.
Palmer LTER	Impacts from the current Palmer LTER are largely short-term and localized. The Palmer LTER is unlikely to contribute to the cumulative impacts, though the pier construction would have a direct impact on research (**Section 5.1.4.1**).
Tourism	Cruise ships and yachts currently operate in the Palmer Basin, though visits to Palmer Station are limited by NSF (**Section 4.2**). Ships may contribute to short-term, transitory impacts in Arthur Harbor and the Palmer Basin, but are not anticipated to directly contribute to cumulative impacts at Palmer Station.

a Includes Arthur Harbor, Hero Inlet, and the Palmer Basin.

In 2016, NSF published the Palmer Station Master Plan, which provides an overview of potential future development aimed at maintaining a facility capable of supporting scientific research for the foreseeable future. Potential development projects included in the master plan are listed in **Table 5-2** and may be amended or altered based on available funding or the needs of USAP (NSF 2016). Specific projects in the master plan were divided into a total of nine development phases, which would help preserve the functionality of Palmer Station during redevelopment. Select structures and utilities slated for demolition would be preserved until their replacement structures have been constructed while other structures may remain onsite and be repurposed. Construction of a new pier, which is a Phase 1 activity and the subject of this IEE, would help improve the safety and efficiency of future station construction projects (NSF 2016), making future development more feasible.

TABLE 5-3: POTENTIAL FUTURE DEVELOPMENT AT PALMER STATION

Development Phase [a]	Action	Facility
Phase 1	Build	Palmer Pier
	Relocate	Storage containers
Phase 2	Build	New fuel tanks
		Fuel distribution network
Phase 3	Demolish	Fuel tanks and associated Pump House
Phase 4	Build	Hazardous waste processing
		Hazardous waste storage
		Power plant/garage
		Water treatment
		Wastewater treatment
		Water tank
		Seawater intake
		Utility distribution network between new buildings and GWR
Phase 5	Demolish	First floor GWR
	Build	New lodging building
	Extend	Utilities to lodging
Phase 6	Relocate	Aquariums GWR first floor
		Provide temporary utilities
Phase 7	Demolish	Aquarium
		Carpentry shop
Phase 8	Build	Central services/labs
		Boathouse
		Permanent utilities
Phase 9	Renovate	GWR
	Demolish	BioLab and associated shipping containers
		Existing Boathouse

a Source: The Palmer Station Master Plan (NSF 2016).

The proposed activity was considered with the projects listed in the master plan to determine the potential for cumulative impacts. Unless specifically stated in the analysis below, past and current projects when considered together with the proposed project are not anticipated to contribute to cumulative impacts in the following categories:

- **Topography/Hydrography**: Multiple phases of the future development listed in the master plan would result in topographic changes due to activities such as grading. Cumulative impacts to the topography are expected to be minimal since any topographic changes would likely be limited to the current boundaries of Palmer Station and involve areas of prior disturbance. Phase 4, which includes construction of a new seawater intake, may result in hydrography changes. The excavation area for a new seawater intake is likely to be small and cumulative impacts to hydrography are expected to be minimal.
- **Marine Water Quality**: Future development projects are primarily surface projects, which have the potential to impact water quality through surface runoff or spills. Impacts to marine water quality during pier construction are likely to be short-term, though a spill could potentially result in impacts that are longer lasting. If BMPs are utilized to minimize the risk of spills or runoff during pier construction and

future projects, cumulative impacts are unlikely. The installation of a seawater intake in Phase 4 would likely impact water quality during construction but would likely be short-term and not contribute to cumulative impacts. Construction of a wastewater treatment facility, which is listed as a potential Phase 4 project, would likely be designed to separate solids from the waste stream and deactivate organics, which would be an improvement over the current maceration-only wastewater treatment system and likely result in an improvement in the water quality of the surrounding marine environment (NSF 2016).

- **Air Emissions**: Most future development in the master plan would result in air emissions due to either fugitive dust emissions from construction activities or from emissions from non-road vehicles such as graders or excavators. Air emissions from future construction projects would be short-term in nature and limited to the duration of individual projects. Cumulative air emission impacts are not anticipated.
- **Wastewater**: Any wastewater impacts associated with pier construction and installation of a new wastewater outfall are anticipated to be short-term in nature. Any wastewater impacts are likely to resolve prior to future development and cumulative wastewater impacts are not anticipated.
- **Noise/Acoustic Releases**: Noise releases for pier construction and future development projects are likely to be limited to the duration of the project. No cumulative noise impacts are anticipated.
- **Non-Native Species**: The introduction of construction personnel or equipment carries the risk of introducing non-native species to the area. If a non-native species were introduced to the site, it could have long-term consequences that would be compounded if additional non-native species were introduced during future development. As discussed in **Section 5.1.2.4**, measures would be taken to minimize the risk of introducing non-native species during pier construction. With proper adherence to mitigation measures during pier construction and future development, the probability of introducing non-native species to the region is relatively low and cumulative impacts are unlikely to occur.
- **Solid Waste**: Solid waste produced during the construction of the new pier would be properly stored in containers and returned to the barge. Materials recovered during demolition would be either loaded on to the barge for eventual disposal or reused. Future development would also produce solid waste, especially during demolition activities, which would have to be disposed of properly. Negative cumulative impacts are not anticipated to occur for solid waste that is removed from the site and shipped for proper disposal elsewhere.
- **Accidental Releases**: Phase 2 includes building new fuel tanks and a fuel distribution network and Phase 3 includes demolishing the old fuel tanks and associated pump house. Impacts from these activities would revolve around the potential for spills and releases associated with fuel storage and delivery. If any substance were to be released to the environment, the effects could be long-lasting. Cumulative impacts are possible if there were accidental releases of substances into the environment from the pier construction project or future development projects, but the risk can be effectively managed through the use of BMPs.
- **Marine Mammals**: Impacts to marine mammals would primarily result from noise-generating activities which are expected to be short-term and mostly limited to the duration of the project. Current/ongoing projects including commercial fishing, research activities, and tourism may also have the potential to impact marine mammals either directly or indirectly should prey availability or habitat be affected. The majority of potential development projects listed in the master plan are surface projects that are unlikely to have a direct impact on marine mammals. Although unavoidable take of marine mammals is anticipated (as authorized by the IHA), the takes requested for this project would result in no more than a negligible impact to any of the marine mammal species that may be taken. Cumulative impacts are possible depending on the timing, duration, and extent of the activities listed in **Table 5-2** if any unanticipated long-term impacts are incurred by the project.
- **Marine Species**: The majority of potential development projects listed in the master plan are surface projects that are unlikely to have a direct impact on marine species. Phase 4 includes construction of a new seawater intake, which would likely result in site-specific impacts to marine species, including possible displacement of benthic communities. The seawater intake is unlikely to be located near the

wastewater outfall that is being constructed as part of the proposed activity and cumulative impacts are not anticipated.

- **Birds**: During pier construction, as well as future development phases, impacts to bird species would mostly result from noise generation, which is expected to be short-term and mostly limited to the duration of the project. While noise impacts to bird species may resolve prior to the next development phase, some bird species may be susceptible to long-term impacts stemming from back-to-back construction seasons. Cumulative impacts are possible depending on the timing and/or duration of future development phases.
- **Flora**: Construction of the new pier is anticipated to result in minimal, short-term impacts to flora, with impacted populations expected to recover. Potential future development at Palmer Station is likely to result in flora impacts, including construction of new structures that may cause long-term impacts. It is expected that flora populations impacted during pier construction would recover following completion of the project. If disturbances continued to happen on a seasonal basis, the opportunity for recovery for each species may be compromised.
- **Station Function and Access**: As is the case with the current project, future development of Palmer Station is likely to result in short-term reductions in station function and access during construction. Any reductions in station function and access would be limited to the duration of the development/project phase and no cumulative impact is anticipated. Upon completion, construction of the pier and additional future development is likely to have a positive, cumulative impact as Palmer Station is redeveloped to meet the current and future needs of USAP.
- **Visual Disturbances**: Pier construction is anticipated to result in minor, long-term changes to the visual characteristics in the area due to a larger pier size and removal of bedrock outcrops. Proposed future development phases would contribute additional impacts to the visual characteristics at Palmer Station when select structures are demolished, relocated, or consolidated and new ones are constructed, resulting in over positive, long-term, cumulative impacts due to an improvement in the visual environment.

5.5 IMPACT SUMMARY

The findings of this IEE indicate that the activities associated with the proposed activity to reconstruct the pier at Palmer Station would result in no more than minor or transitory environmental impacts. See **Table 5-4** for a summary of the impacts described in **Sections 5.3 and 5.4**.

Notable potential impacts are

- introduction of non-native species,
- disturbance to marine mammals and birds from underwater noise,
- disturbance to bird species from construction noise,
- loss of marine benthic habitat, and
- pollution from accidental releases (including fuel and/or sewage).

The introduction of non-native species and marine pollution from oil spills, while potentially significant in nature, can be almost eliminated as a possibility if the Contractor follows BMPs and the guidelines identified in **Sections 5.1.2.4** and **5.1.2.6**. Noise impacts, while far reaching, are not expected to result in permanent impacts. The impacts to the benthic community around the existing pier and associated structures such as the boat ramp and sewer outfall, while potentially more than minor or transitory, are expected to be short-term since it is anticipated that the new structures would be colonized. Therefore, this impact is considered no more than minor or transitory.

TABLE 5-4: IMPACT SUMMARY TABLE

Activity	Action	Environmental Aspect	Environmental Impact	Impact Type	Duration[a]	Extent[b]	Intensity[c]	Probability[d]	Reversibility/Resilience[e]	Significance[f]	Mitigation
Temporary crane assembly pad construction	Fill below water surface	Marine water quality	Increased turbidity from deposition of fill	Direct Indirect	Long-term	Local	Low	Likely	System likely to recover	1	Coarse material would be used to reduce erosion potential.
		Marine species	Fill material placed over existing benthic communities	Direct Indirect	Long-term	Local	High	Likely	System could recover	2	Coarse material would be used to reduce erosion potential
		Hydrography	Changes to underwater surface elevations and substrate	Direct Indirect	Long-term	Site-specific	Low	Possible	System could recover	2	50% of fill material would be reclaimed for use elsewhere, if possible, or removed from site.
Demolition of existing bulkhead pier	Mechanical excavation	Noise; Marine mammals; Birds	Above and below water noise generation that could impact nearby marine mammals, birds, and personnel at Palmer Station	Direct; Indirect	Short-term	Local	Medium	Likely	System likely to recover	2	Measures such as soft-start procedures, PSOs, and shutdown zones would be used.
	Vibratory hammer			Direct; Indirect	Short-term	Local	High	Likely	System likely to recover	2	
	Rock chipping			Direct; Indirect	Short-term	Local	Low	Possible	System likely to recover	2	
	Stockpiled material	Solid waste	Potential for environmental release while stockpiled	Direct; Indirect	Short-term	Site-specific	Low	Unlikely	Full recovery possible	1	Proper BMPs would be utilized to secure stockpiles until reuse on-site or shipment off-site.
	Sheet pile removal	Noise; Marine mammals; Birds	Noise generation	Direct; Indirect	Short-term	Local	Medium	Likely	System likely to recover	2	Measures such as soft-start procedures, PSOs, and shutdown zones would be used.
		Hydrography; Marine species	Change to seafloor composition	Direct; Indirect	Long-term	Site-specific	Low	Likely	System could recover	1	Full removal using vibratory hammer will be attempted first.
	General	Marine species	Loss of benthic community formed on existing pier and associated appurtenances	Direct: Indirect	Long-term	Site-specific	Medium	Likely	System could recover	2	New pier would provide new substrate for colonization.
Upland earthwork	Demolition and grading	Topography; Visual disturbance	Removal of surface bedrock	Direct	Long-term	Site-specific	High	Likely	No recovery likely	1	Limits of excavation would be minimized to the fullest extent practicable.
		Noise; Birds	Noise generation	Direct	Short-term	Local	Medium	Likely	System likely to recover	2	Noise-generating activities may be timed to minimize impacts including 12-hour workdays.
		Marine water quality	Runoff from stockpiles may enter water	Direct	Short-term	Local	Low	Possible	System likely to recover	1	BMPs would be utilized to prevent runoff from stockpiles.
Template piles	Driving	Marine water quality	Increased turbidity	Direct	Short-term	Local	Low	Likely	System likely to recover	1	No mitigation suggested at this time.

Activity	Action	Environmental Aspect	Environmental Impact	Impact Type	Duration[a]	Extent[b]	Intensity[c]	Probability[d]	Reversibility/Resilience[e]	Significance[f]	Mitigation
		Noise; Marine mammals; Birds	Noise generation	Direct	Short-term	Local	High	Likely	System likely to recover	2	Measures such as soft-start procedures, PSOs, and shutdown zones would be used.
Template piles	Removal	Marine species; Hydrography	Change to seafloor composition	Direct Indirect	Long-term	Site-specific	Low	Possible	System could recover	1	Full removal using vibratory hammer will be attempted first.
Permanent piles	Rock chipping	Noise; Marine mammals; Birds	Noise generation	Direct	Short-term	Local	Medium	Likely	System likely to recover	2	Measures such as soft-start procedures, PSOs, and shutdown zones would be used.
	Driving	Noise; Marine mammals; Birds	Noise generation	Direct	Short-term	Local	High	Likely	System likely to recover	2	Measures such as soft-start procedures, PSOs, and shutdown zones would be used.
		Marine water quality	Release of process wastewater	Direct	Short-term	Local	Medium	Likely	System likely to recover	1	Only potable water would be used.
	General	Marine water quality; Marine species	Increased turbidity during installation	Direct	Short-term	Local	Low	Likely	System likely to recover	1	Process water and drill fluids would be discharged to water. No hazardous materials would be discharged.
Anodes	Installation	Marine mammals; Birds; Noise	Underwater noise generation	Direct	Short-term	Local	Medium	Possible	System likely to recover	1	Measures such as soft-start procedures, PSOs, and shutdown zones would be used.
Retaining wall and pier abutment	Bedrock excavation	Noise; Birds	Noise generation	Direct	Short-term	Local	Medium	Likely	System likely to recover	2	Noise-generating activities may be timed to minimize impacts including 12-hour workdays.
		Topography; Visual disturbance	Change in topography and visual characteristics	Direct	Long-term	Site-specific	Low	Likely	No recovery likely	1	Limits of excavation would be minimized to the fullest extent practicable.
	Riprap armor	Hydrography; Marine species	Change in seafloor composition	Direct	Long-term	Site-specific	Medium	Likely	System could recover	2	Coarse material would be used to reduce erosion potential
Concrete Panels and Pile caps	Cutting and chipping	Air emissions	Fugitive dust emissions	Direct	Short-term	local	Low	Possible	Full recovery possible	1	Wet cutting techniques would be used.
Pier	General	Visual disturbance	Change in visual characteristic	Direct	Long-term	Site-specific	Low	Likely	System not likely to recover	1	The new pier would alter and minimally expand the developed footprint of the station.
	Grout mixing and rock cutting	Air emissions	Fugitive dust emissions	Direct	Short-term	Local	Low	Possible	Full recovery possible	1	Wet cutting techniques would be used.
	Grouting of concrete panels	Accidental releases	Potential to release grout into the environment	Direct	Short-term[g]	Local	Low	Possible	System likely to recover	1	BMPs would be utilized to prevent accidental releases and only pre-approved materials would be used.

Activity	Action	Environmental Aspect	Environmental Impact	Impact Type	Duration[a]	Extent[b]	Intensity[c]	Probability[d]	Reversibility/Resilience[e]	Significance[f]	Mitigation
Sewer line	Mechanical excavation	Noise; Birds	Noise generation	Direct	Short-term	Local	Medium	Likely	System likely to recover	2	Noise-generating activities may be timed to minimize impacts including 12-hour workdays.
		Topography; Visual disturbance	Removal of surface bedrock	Direct	Long-term	Site-specific	Low	Likely	No recovery likely	2	Limits of excavation would be minimized to the fullest extent practicable.
Sewer line	High expansion grout	Accidental releases	Potential release of grout into environment	Direct Indirect	Short-term[g]	Local	Low	Possible	System likely to recover	1	BMPs would be utilized to prevent accidental releases and only pre-approved materials would be used.
		Noise; Birds	Noise generation	Direct	Short-term	Local	Low	Possible	System likely to recover	2	Noise-generating activities may be timed to minimize impacts; 12-hour workdays.
	Temporary bypass and new line installation	Accidental release	Potential release of wastewater	Direct Indirect	Short-term	Local	Low	Unlikely	System likely to recover	1	Proper installation techniques and monitoring would limit opportunities and extent of potential spills.
Construction personnel	General	Non-native species	Introduction of non-native species	Direct Indirect	Short-term[g]	Local	Low	Unlikely	System could recover	2	Personnel would receive training and would be required to clean and inspect gear/belongings prior to travel to Antarctica.
		Wastewater	Barge and tug wastewater	Direct Indirect	Short-term	Local	Low	Unlikely	System likely to recover	1	Wastewater would not be discharged within 12 nmi of land.
		Terrestrial flora and fauna; Birds	Interference with native species	Direct	Short-term	Local	Low	Unlikely	Full recovery possible	1	Personnel would receive training to prevent harassment or interference with native species, access to restricted zones would be prohibited, and staff escort would be used when access to vegetated areas is needed.
Construction equipment	General	Station function; Scientific research	Reduction in station function and limited scientific personnel on-site	Direct; Indirect	Short-term	Site-specific	Low	Likely	Full recovery possible	1	Research to be performed from research vessels.

Activity	Action	Environmental Aspect	Environmental Impact	Impact Type	Duration[a]	Extent[b]	Intensity[c]	Probability[d]	Reversibility/Resilience[e]	Significance[f]	Mitigation
	Routine maintenance & refueling	Accidental releases	Potential release of oils and lubricants	Direct Indirect	Short-term[g]	Local	Low	Unlikely	System could recover	1	BMPs for proper maintenance including spill response supplies and secondary containment. No work would be conducted from barge during major fueling events.
	Normal operations	Air emissions	Emissions from construction equipment	Direct	Short-term	Local	Low	Likely	System likely to recover	1	BMPs for proper maintenance of construction equipment to reduce emissions.
		Visual disturbance	Construction equipment on-site	Direct	Short-term	Site-specific	Low	Certain	Full recovery possible	1	Unavoidable temporary impact.
		Solid waste	Increased production of waste from construction	Direct	Short-term	Site-specific	Low	Unlikely	Full recovery possible	1	All waste would be transported off-site by barge at the end of construction.
Construction equipment	Normal operations	Accidental releases	Potential release of oils and lubricants	Direct Indirect	Short-term[g]	local	Low	Unlikely	System could recover	2	Banned substances would not be transported to Palmer station. BMPs would be utilized during construction to prevent releases of allowed substances.
		Non-native species	Introduction of non-native species	Direct Indirect	Short-term[h]	Regional	Low	Unlikely	System could recover	2	Contractor would verify that no non-native soils, plants, or animals are included in any shipped equipment and materials.
		Noise	Noise impacts to humans and birds	Direct	Short-term	Site-specific	Medium	Possible	System could recover	1	PPE to be worn by personnel at Station; 12-hour workdays.

a Short-term = Length of construction to 1 year; Long-term = Greater than 1 year
b Site-specific = Project area; Local = Larger than project area but less than 10 km; Regional = Greater than 10 km
c Low, Medium, or High
d Certain, Likely, Possible, Unlikely, or Uncertain
e No recovery likely, System could recover, System likely to recover, Full recovery possible
f 1 = Less than a minor or transitory impact; 2 = No more than a minor or transitory impact; 3 = More than a minor or transitory impact
g Although the potential for accidental releases associated with construction would exist only for a short period of time, the overall effect of any releases could be felt much longer
h Although the potential for introducing non-native species would exist only for a short period of time, the overall effect of any introduction could be felt much longer

5.6 ENVIRONMENTAL MONITORING PLAN

Environmental monitoring is critical in ensuring that anticipated impacts resulting from the proposed activity are in alignment with the findings of the IEE. The Protocol requires appropriate monitoring of key environmental indicators. As a result, USAP has developed a monitoring program for this project that follows guidance in the *Antarctic Environmental Monitoring Handbook: Standard techniques for monitoring in Antarctica* (COMNAP and SCAR 2000) and the *Practical Guidelines for Developing and Designing Environmental Monitoring Programmes in Antarctica* (COMNAP 2005).

This section details recommended monitoring and management practices for potential impacts identified in **Section 5.5**. The Palmer Station Manager (the designated responsible environmental position) would designate one (or multiple) Station staff to document general site conditions, the presence of certain species, and other information as outlined below. The staff would be familiar with this monitoring plan, the proposed activity and project area, as well as any identified sensitive or protected areas. Efforts to maintain consistency in observation locations and daily routines is expected.

- **Introduction of Non-Native Species**: The introduction of non-native species into Antarctica poses a major threat to local ecosystems and native species. Guidelines and resources have been developed to prevent introduction as well as handling, removal, and management of non-native species (if identified; ATS 2019b). The Contractor would have primary responsibility for ensuring that all procured materials, including fill/gravel, are free of non-native species. All cargo, construction equipment, gear, clothing, and personal equipment would be checked for the presence of non-native species and organic matter (e.g., soil) before shipping and before loading on to shipping vessels as well as before mobilizing to Palmer Station (**Section 5.3.2.4**). Any observation or indication of the presence of non-native species would be reported to the Station Manager and ASC Environmental immediately.
- **Disturbance to Marine Mammals from Construction Noise**: Temporary disturbances to marine mammals from underwater noise associated with construction (pile installation) is anticipated. Due to this unavoidable impact, an IHA application has been submitted to NOAA/NMFS for incidental take. The IHA would have specific monitoring protocols for PSOs during in-water noise generating activities. The PSOs are responsible for monitoring the appropriate observation and shutdown zones, documenting takes (marine mammal presence within the observation zones) and coordinating construction shutdowns with the site superintendent should a marine mammal enter the shutdown zone. These specific monitoring and mitigation requirements are summarized in **Section 5.3.3.1** and detailed in **Appendix B**. In addition to IHA-required monitoring, documentation, and reporting, the designated Palmer Station staff would also be required to independently look for marine mammals in the general project vicinity. Sighting details (species, location, number, sex, behavior, etc.) would be recorded similar to previous observation data. The intent of this monitoring effort is to ensure that marine mammal observations are being conducted throughout project construction regardless of whether pile installation and other in-water noise generating activities are occurring. Marine mammal observations would continue for one year beyond construction completion to identify potential changes in species occurrence. Results of these continued observations would be evaluated after one year to determine whether they should be continued and for what duration.
- **Disturbance to Bird Species from Construction Noise:** Temporary impacts to bird behavior or avoidance of the project area may occur in response to increased noise levels during construction (including increased activity during mobilization/demobilization). Based on previous bird observations, it is recommended that designated Palmer Station staff observe bird species for six minutes, three times per day as part of wildlife monitoring. Sighting details (species, location, number, behavior, reactions, etc.) would be recorded. Bird species observations would be documented from a consistent location based on daily conditions. Information on the types of species known to occur in the project area are included in **Section 4.6.3** It is necessary that this monitoring effort be continued

after construction is complete to help identify potential patterns and/or effects to bird presence and activity in the general project vicinity as a result of the project or other environmental conditions. Feedback would be solicited from the scientific community regarding the extent of monitoring for bird presence and activity. Any evidence of disturbance or injury would be reported to the Palmer Station Manager immediately. In addition to observations by Station staff, the PSO is also required to monitor the area for penguins as well as marine mammals and initiate shut down procedures should a penguin be observed within the shutdown zone.

- **Loss of Marine Benthic Habitat:** Areas of excavation, fill, and pile installation may result in temporary and/or permanent loss of marine benthic habitat. Long-term effects may be expected locally but are not anticipated given the general abundance of adjacent, quality habitat. The relocation of the sewer outfall may also create a change in the location of desirable benthic habitat. It is not practicable to conduct regular underwater assessments during construction. A pre-construction underwater assessment of the benthic environment within the project area would be conducted prior to construction. A follow-up assessment would be conducted after construction is complete. An evaluation of the changes to the underwater environment and available benthic habitat would determine if continued monitoring is needed.
- **Pollution from Spills**: Although this assessment has identified fuel and sewage as the most likely sources of pollution, spills could involve any designated pollutant (fuel, oil, glycol, lab chemicals, or sewage). Immediate and effective responses to spills is critical in avoiding and/or minimizing impacts to the environment. USAP has developed spill reporting and response procedures and the Contractor has a project-specific spill response plan in place. Visual and olfactory indicators of a spill may include sheen, odor, improperly disposed of containers (fuel, oil, etc.), soil staining or discoloration, and misplaced debris. Any indication of a release would be reported immediately to the Palmer Station Manager to identify the source and appropriate cleanup response.
- **Vegetation**: Although the immediate vicinity surrounding Palmer Station is heavily disturbed and primarily consists of gravel that is devoid of vegetation, some species of moss and lichen occur on the distal end of Gamage Point. The Station staff would scan the project area (including Gamage Point, if accessible) for vegetation and note the location, type, and condition (if found). Monitoring the condition of the vegetation and any potential impacts would be a responsibility of the designated Palmer Station staff. Reference photos of the vegetation would be taken monthly, beginning prior to construction. The Palmer Station Manager and ASC Environmental would be notified immediately if damage to existing vegetation occurs.

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APPENDIX A
FIGURES AND PLAN SHEETS

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APPENDIX B

MARINE MAMMAL ASSESSMENT

APPENDIX C
CONTRACTOR-PROVIDED PLANS

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