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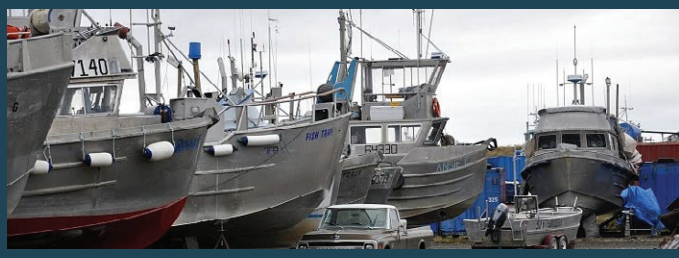
Agency

January 2023

Final Determination of the U.S. Environmental Protection Agency Pursuant to Section 404(c) of the Clean Water Act

Pebble Deposit Area, Southwest Alaska



Office of Water, Washington, DC
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U.S. Environmental Protection Agency
Office of Water

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CONTENTS

Executive Summary **ES-1**
Proposed Mine at the Pebble Deposit ES-3
2014 Proposed Determination ES-9
2022 Proposed Determination ES-10
The Final Determination ES-12
Overview of Prohibition and Restriction in the Final Determination ES-15
Prohibition ES-15
Restriction ES-16
Evaluation of Portions of the CWA Section 404(b)(1) Guidelines ES-20
Information about Other Adverse Effects of Concern on Aquatic Resources ES-20
Authority and Justification for Undertaking a CWA Section 404(c) Review at this Time ES-21
Conclusion ES-22
Section 1. Introduction **1-1**
Section 2. Project Description and Background **2-1**
2.1 Project Description 2-1
2.1.1 Overview of the Pebble Deposit 2-1
2.1.2 Overview of the 2020 Mine Plan 2-2
2.1.2.1 Mine Site 2-2
2.1.2.2 Evaluation of Location Options for a Mine Site at the Pebble Deposit 2-5
2.2 Background 2-8
2.2.1 Timeline of Key Events Related to the Pebble Deposit (1984–October 2021) 2-8
2.2.2 Re-initiation of Clean Water Act Section 404(c) Review Process (November 2021–Present) 2-17
2.2.3 Authority and Justification for Undertaking a Clean Water Act Section 404(c) Review at this Time 2-23
Section 3. Importance of the Region's Ecological Resources **3-1**
3.1 Physical Setting 3-2
3.2 Aquatic Habitats 3-3
3.2.1 Quantity and Diversity of Aquatic Habitats 3-3
3.2.2 Streams 3-6
3.2.3 Wetlands, Lakes, and Ponds 3-8
3.2.4 Importance of Headwater Stream and Wetland Habitats to Fish 3-10
3.3 Fish Resources 3-13
3.3.1 Species and Life Histories 3-13

3.3.2 Distribution and Abundance 3-20
3.3.2.1 Nushagak and Kvichak River Watersheds 3-20
3.3.2.2 South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek Watersheds 3-26
3.3.3 Habitat Complexity, Biocomplexity, and the Portfolio Effect 3-39
3.3.3.1 The Relationship between Habitat Complexity and Biocomplexity 3-39
3.3.3.2 The Portfolio Effect 3-44
3.3.4 Salmon and Marine-Derived Nutrients 3-50
3.3.5 Commercial Fisheries 3-52
3.3.6 Subsistence Fisheries 3-54
3.3.6.1 Use of Subsistence Fisheries 3-54
3.3.6.2 Importance of Subsistence Fisheries 3-59
3.3.7 Recreational Fisheries 3-60
3.3.8 Region's Fisheries in the Global Context 3-63
3.4 Summary 3-64
Section 4. Basis for Final Determination 4-1
4.1 CWA Section 404(c) Standards 4-1
4.2 Effects on Fishery Areas from Discharges of Dredged or Fill Material from Developing the Pebble Deposit 4-3
4.2.1 Adverse Effects of Loss of Anadromous Fish Streams 4-9
4.2.1.1 Extent of Anadromous Fish Streams That Would Be Permanently Lost at the Mine Site 4-9
4.2.1.2 Adverse Effects from Permanent Loss of Anadromous Fish Streams at the Mine Site 4-12
4.2.1.3 Adverse Effects from Permanent Loss of Ecological Subsidies to Anadromous Fish Streams Downstream of the Mine Site 4-16
4.2.1.4 Impacts on Other Fish Species 4-17
4.2.1.5 Conclusions 4-23
4.2.1.5.1 Adverse Effects of Loss of Anadromous Fish Streams at the Mine Site 4-23
4.2.1.5.2 Adverse Effects of Loss of Anadromous Fish Streams Elsewhere in the SFK, NFK, and UTC Watersheds 4-23
4.2.2 Adverse Effects of Loss of Additional Streams that Support Anadromous Fish Streams 4-27
4.2.2.1 Extent of Additional Streams that Support Anadromous Fish Streams that Would Be Permanently Lost 4-27
4.2.2.2 Adverse Effects from Permanent Loss of Additional Streams that Support Anadromous Fish Streams 4-30
4.2.2.3 Impacts on Other Fish Species 4-31
4.2.2.4 Conclusions 4-32
4.2.2.4.1 Adverse Effects of Loss of Additional Streams at the Mine Site that Support Anadromous Fish Streams 4-32

4.2.2.4.2 Adverse Effects of Loss of Additional Streams Elsewhere in the SFK, NFK, and UTC Watersheds that Support Anadromous Fish Streams....4-33
4.2.3 Adverse Effects of Loss of Wetlands and Other Waters that Support Anadromous Fish Streams....4-36
4.2.3.1 Extent of Wetlands and Other Waters that Support Anadromous Fish Streams that Would Be Permanently Lost....4-37
4.2.3.2 Adverse Effects from Permanent Loss of Wetlands and Other Waters that Support Anadromous Fish Streams....4-38
4.2.3.3 Impacts on Other Fish Species....4-41
4.2.3.4 Conclusions....4-41
4.2.3.4.1 Adverse Effects of Loss of Wetlands and Other Waters at the Mine Site that Support Anadromous Fish Streams....4-42
4.2.3.4.2 Adverse Effects of Loss of Wetlands and Other Waters Elsewhere in the SFK, NFK, and UTC Watersheds that Support Anadromous Fish Streams....4-42
4.2.4 Adverse Effects from Changes in Streamflow in Downstream Anadromous Fish Streams....4-46
4.2.4.1 Methodology for Analyzing Streamflow Changes in Downstream Anadromous Fish Streams....4-47
4.2.4.2 Overview of Mine Site Operations that Affect Downstream Streamflow....4-49
4.2.4.3 Extent of Streamflow Changes in Downstream Anadromous Fish Streams....4-52
4.2.4.4 Downstream Anadromous Fish Habitats Affected by Streamflow Changes....4-53
4.2.4.5 Adverse Effects of Streamflow Changes in Downstream Anadromous Fish Streams....4-58
4.2.4.6 Impacts on Other Fish Species....4-62
4.2.4.7 Conclusions....4-65
4.2.4.7.1 Adverse Effects from Discharges of Dredged or Fill Material at the Mine Site that Result in Streamflow Changes in Anadromous Fish Streams....4-65
4.2.4.7.2 Adverse Effects from Discharges of Dredged or Fill Material Elsewhere in the SFK, NFK, and UTC Watersheds that Result in Streamflow Changes in Anadromous Fish Streams....4-66
4.2.5 Summary of Effects on Fishery Areas from Discharges of Dredged or Fill Material from Developing the Pebble Deposit....4-70
4.3 Compliance with Relevant Portions of the CWA Section 404(b)(1) Guidelines....4-70
4.3.1 Significant Degradation....4-71
4.3.1.1 Direct and Secondary Effects of the 2020 Mine Plan....4-72
4.3.1.1.1 Adverse Effects of Loss of Anadromous Fish Streams....4-72
4.3.1.1.2 Adverse Effects of Loss of Additional Streams that Support Anadromous Fish Streams....4-74

4.3.1.1.3 Adverse Effects of Loss of Wetlands and Other Waters that Support Anadromous Fish Streams....4-76
4.3.1.1.4 Adverse Effects from Changes in Streamflow in Downstream Anadromous Fish Streams....4-78
4.3.1.1.5 Conclusion....4-79
4.3.1.2 Cumulative Effects of Mine Expansion....4-80
4.3.1.2.1 Cumulative Effects of Loss of Anadromous Fish Streams....4-82
4.3.1.2.2 Cumulative Effects of Loss of Additional Streams that Support Anadromous Fish Streams....4-86
4.3.1.2.3 Cumulative Effects of Loss of Wetlands and Other Waters that Support Anadromous Fish Streams....4-91
4.3.1.2.4 Cumulative Effects of Additional Degradation of Streams, Wetlands, and Other Waters Beyond the Mine Site Footprint....4-91
4.3.1.3 Summary....4-93
4.3.2 Compensatory Mitigation Evaluation....4-94
4.3.2.1 Overview of Compensatory Mitigation Requirements....4-96
4.3.2.2 Review of Compensatory Mitigation Plans Submitted by the Pebble Limited Partnership....4-96
4.3.2.2.1 January 2020 Compensatory Mitigation Plan....4-96
4.3.2.2.2 November 2020 Compensatory Mitigation Plan....4-98
4.3.2.3 Summary Regarding Compensatory Mitigation Measures....4-102
4.4 Alternative Basis for EPA's Determination....4-102
Section 5. Final Determination....5-1
5.1 Prohibition....5-1
5.1.1 Defined Area for Prohibition....5-3
5.2 Restriction....5-7
5.2.1 Defined Area for Restriction....5-7
5.2.2 Applicability of the Restriction....5-12
5.3 When a Proposal is Not Subject to this Determination....5-13
Section 6. Other Concerns and Considerations....6-1
6.1 Other Potential CWA Section 404(c) Resources....6-1
6.1.1 Wildlife....6-1
6.1.2 Recreation....6-3
6.1.3 Public Water Supplies....6-6
6.2 Effects of Spills and Failures....6-7
6.2.1 Final Environmental Impact Statement Spill and Release Scenarios....6-7
6.2.1.1 Release of Concentrate Slurry from the Concentrate Pipeline....6-7
6.2.1.2 Tailings Releases....6-8
6.2.1.3 Untreated Contact Water Release....6-12
6.2.2 Tailings Dam Failure....6-12
6.3 Other Tribal Concerns....6-15

6.3.1 Subsistence Use and Potential Mining Impacts 6-16
6.3.2 Traditional Ecological Knowledge 6-20
6.3.3 Environmental Justice 6-23
Section 7. Conclusion 7-1
Section 8. References 8-1
Personal Communications 8-33

Appendix A. Review Process Consultation Letters
Appendix B. Additional Information Related to the Assessment of Aquatic Habitats and Fishes
Appendix C. Technical Evaluation of Potential Compensatory Mitigation Measures

List of Boxes

Box ES-1 Section 404 of the Clean Water Act ES-3
Box 3-1 Similarity of Aquatic Resources within the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek Watersheds 3-9
Box 4-1 Secondary Effects and Aquatic Resource Losses 4-6
Box 4-2 Key Definitions 4-7
Box 4-3 Water Resources Mapping At The Mine Site 4-29
Box 5-1. Applicability Data Requirements 5-4

List of Tables

Table 2-1 Bristol Bay Assessment timeline. 2-11
Table 3-1 Distribution of stream channel length classified by channel size (based on mean annual streamflow), channel gradient, and floodplain potential for streams and rivers in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. 3-7
Table 3-2 Acreage of wetland habitats in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds 3-8
Table 3-3 Fish species reported in the Nushagak and Kvichak River watersheds. 3-15
Table 3-4 Life history, habitat characteristics, and total documented stream length occupied for Bristol Bay's five Pacific salmon species in the Nushagak and Kvichak River watersheds. 3-18
Table 3-5 Documented fish species occurrence in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. 3-26
Table 3-6 Total documented anadromous fish stream length and stream length documented to contain different salmonid species in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds 3-27
Table 3-7 Highest reported index spawner counts in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek, based on mainstem aerial surveys 3-35
Table 3-8 Highest reported number of adult salmon in tributaries of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek, based on aerial surveys. 3-36
Table 3-9 Maximum estimated densities and total observed number of juvenile Pacific salmon in mainstem habitats of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek. 3-37
Table 3-10 Relative abundance of salmonids in off-channel habitats of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek 3-38

Table 3-11 Maximum estimated densities of resident fishes in mainstem habitats of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek....3-39
Table 3-12 Mean annual commercial catch (number of fish) by Pacific salmon species and Bristol Bay fishing district, 2010–2019....3-53
Table 3-13 Estimated ex-vessel value of Bristol Bay's commercial salmon catch by species, 2000–2019....3-54
Table 3-14 Harvest of subsistence fisheries resources in selected communities of the Bristol Bay watershed....3-56
Table 3-15 Estimated subsistence salmon harvest in communities of the Bristol Bay watershed, 2008–2017....3-58
Table 3-16 Estimated replacement value of 2017 Bristol Bay subsistence salmon harvest....3-59
Table 3-17 Estimated sport harvest by species in the Bristol Bay Sport Fish Management Area....3-61
Table 3-18 Estimated annual sport harvest and catch of fishes in the Kvichak River watershed and the Nushagak, Wood, and Togiak River watersheds, 2008–2017....3-63
Table 4-1 Length of anadromous fish streams permanently lost in tributaries to the North Fork Koktuli River associated with the 2020 Mine Plan....4-11
Table 4-2 Coho and Chinook salmon stream habitat permanently lost in the North Fork Koktuli River watershed associated with the 2020 Mine Plan....4-11
Table 4-3 Area of wetlands and other waters lost under the Pebble 2020 Mine Plan....4-37
Table 4-4 Change in average monthly streamflow between baseline and end-of-mine with water treatment plant discharge, 2020 Mine Plan....4-51
Table 4-5 Salmon species documented to occur in downstream reaches that would experience greater than 20 percent streamflow alterations under the Pebble 2020 Mine Plan....4-55
Table 4-6 Anadromous stream habitat that would be permanently lost in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds under the 2020 Mine Plan plus the Expanded Mine Scenario....4-83
Table 6-1 Summary description of Tailings Storage Facilities....6-9
Table 6-2 Harvest of subsistence resources for communities in the Nushagak and Kvichak River watersheds....6-16

List of Figures

Figure ES-1 The Bristol Bay watershed, composed of the Togiak, Nushagak, Kvichak, Naknek, Egegik, and Ugashik River watersheds and the North Alaska Peninsula. ES-2
Figure ES-2 Major waterbodies within the Nushagak and Kvichak River watersheds ES-4
Figure ES-3 Mine site hydrography ES-6
Figure ES-4 Mine site map ES-7
Figure ES-5 Mine site analysis area for wetlands and other waters ES-8
Figure ES-6 The Defined Area for Prohibition ES-17
Figure ES-7 The Defined Area for Restriction and Defined Area for Prohibition overlain on wetlands from the National Wetlands Inventory ES-18
Figure ES-8 The Defined Area for Restriction and Defined Area for Prohibition overlain on streams and waterbodies from the National Hydrography Dataset ES-19
Figure 2-1 Project area map 2-3
Figure 2-2 Optional locations for siting the Bulk Tailing Storage Facility evaluated within the FEIS 2-6
Figure 2-3 Optional locations for siting the Main Water Management Pond evaluated within the FEIS. 2-7
Figure 3-1 Diversity of Pacific salmon species production in the Nushagak and Kvichak River watersheds 3-22
Figure 3-2 Anadromous fish distribution in the Nushagak and Kvichak River watersheds 3-23
Figure 3-3 Rainbow Trout, Dolly Varden, and Arctic Grayling occurrence in the Nushagak and Kvichak River watersheds 3-24
Figure 3-4 Northern Pike, stickleback, and sculpin occurrence in the Nushagak and Kvichak River watersheds. 3-25
Figure 3-5 Reported Coho Salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds 3-28
Figure 3-6 Reported Chinook Salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds 3-29
Figure 3-7 Reported Sockeye Salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds 3-30
Figure 3-8 Reported Chum Salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds 3-31
Figure 3-9 Reported Pink Salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds 3-32
Figure 3-10 Rainbow Trout, Dolly Varden, and Arctic Grayling occurrence in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds 3-33
Figure 3-11 Bristol Bay salmon genetic lines of divergence linked to ecotypes 3-41
Figure 3-12 Productive habitats for Chinook and Sockeye salmon across the Nushagak River watershed shift over time 3-42
Figure 3-13 Kvichak River Sockeye Salmon populations 3-43

Figure 3-14 Seasonal catch plus escapement of Sockeye Salmon for each genetically distinct stock in Bristol Bay, Alaska, 2012–2021 3-46
Figure 3-15 Reporting group affiliation for 146 Sockeye Salmon populations in Bristol Bay 3-48
Figure 3-16 Subsistence harvest and harvest-effort areas for salmon and other fishes in the Nushagak and Kvichak River watersheds 3-57
Figure 3-17 Popular areas for recreational fishing in the Nushagak and Kvichak River watersheds 3-62
Figure 3-18 Streams, rivers, lakes, and documented salmon use in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds near the Pebble deposit 3-66
Figure 4-1 Mine site area fish distribution 4-4
Figure 4-2 Streams, rivers, and lakes with documented salmon use overlain with the Pebble 2020 Mine Plan 4-10
Figure 4-3 Streams, rivers, and lakes with documented salmon use in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan 4-18
Figure 4-4 Reported occurrence of Arctic Grayling, Rainbow Trout, and Dolly Varden in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan. 4-19
Figure 4-5 Reported occurrence of other resident fish species in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan. 4-20
Figure 4-6 Reported occurrence of Arctic Grayling, Rainbow Trout, and Dolly Varden overlain with the Pebble 2020 Mine Plan 4-21
Figure 4-7 Reported occurrence of other resident fish species overlain with the Pebble 2020 Mine Plan. 4-22
Figure 4-8 Streams, wetlands, and ponds lost under the Pebble 2020 Mine Plan 4-28
Figure 4-9 Streams and rivers with documented salmon use that would experience streamflow alterations greater than 20 percent of baseline average monthly streamflows as a result of the Pebble 2020 Mine Plan 4-54
Figure 4-10 Streams and rivers with occurrence of Arctic Grayling, Rainbow Trout, and Dolly Varden that would experience streamflow changes as a result of the Pebble 2020 Mine Plan 4-63
Figure 4-11 Streams and rivers with occurrence of other resident fish species that would experience streamflow changes as a result of the Pebble2020 Mine Plan 4-64
Figure 4-12 Mine site cumulative impacts under the Expanded Mine Scenario 4-81
Figure 4-13 Streams, rivers, and lakes with documented salmon use overlain with the footprints of the Pebble 2020 Mine Plan and the Expanded Mine Scenario 4-84
Figure 4-14 Streams, rivers, and lakes with documented salmon use in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan and the Expanded Mine Scenario 4-85

Figure 4-15 Reported Arctic Grayling, Rainbow Trout, and Dolly Varden occurrence overlain with the footprints of the Pebble 2020 Mine Plan and the Expanded Mine Scenario.....4-87
Figure 4-16 Reported occurrence of other resident fish species overlain with the footprints of the Pebble 2020 Mine Plan and the Expanded Mine Scenario 4-88
Figure 4-17 Reported Arctic Grayling, Rainbow Trout, and Dolly Varden occurrence in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan and the Expanded Mine Scenario.....4-89
Figure 4-18 Reported occurrence of other non-salmon fish species in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan and the Expanded Mine Scenario 4-90
Figure 4-19 Proposed Koktuli Conservation Area.....4-99
Figure 5-1 The Defined Area for Prohibition 5-5
Figure 5-2 The Defined Area for Restriction and Defined Area for Prohibition overlain on wetlands from the National Wetlands Inventory.....5-10
Figure 5-3 The Defined Area for Restriction and Defined Area for Prohibition overlain on streams and waterbodies from the National Hydrography Dataset.....5-11
Figure 6-1 Modeled extent of elevated metals downstream of pyritic tailings release 6-11
Figure 6-2 Subsistence use intensity for salmon, other fishes, wildlife, and waterfowl within the Nushagak and Kvichak River watersheds.....6-18

Acronyms and Abbreviations

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AFFI	Alaska Freshwater Fish Inventory
ANCSA	Alaska Native Claims Settlement Act
ANILCA	Alaska National Interest Lands Conservation Act
AS	Alaska Statute
ASA	Alaska Statehood Act
AWC	Anadromous Waters Catalog
BBA	Bristol Bay Assessment
BBAP	Bristol Bay Area Plan for State Lands
BBMA	Bristol Bay Sport Fish Management Area
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CILEA	Cook Inlet Land Exchange Act
CMP	Compensatory Mitigation Plan
CWA	Clean Water Act
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FEIS	Final Environmental Impact Statement
FMEA	Failure Modes Effects Analysis
FR	Federal Register
HUC	Hydrologic Unit Code
ITEK	indigenous traditional ecological knowledge
LEDPA	Least Environmentally Damaging Practicable Alternative
MCO	Mineral Closing Order
ML	metal leaching
MDN	marine-derived nutrients
MOA	Memorandum of Agreement
NDM	Northern Dynasty Minerals, Ltd.
NEPA	National Environmental Policy Act
NFK	North Fork Koktuli River
NHD	National Hydrography Dataset
NMFS	National Marine Fisheries Service
NPS	National Park Service
NWI	National Wetlands Inventory
PAG	potentially acid-generating
PLP	Pebble Limited Partnership
RAP	Riverscape Analysis Project
RFI	Request For Information
ROD	Record of Decision

SEC	U.S. Securities and Exchange Commission
Secretary	Secretary of the Army
SFK	South Fork Koktuli River
TEK	traditional ecological knowledge
TSF	tailings storage facility
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTC	Upper Talarik Creek
WMP	water management pond
WQC	water quality criteria
WTP	water treatment plant

Cover Photo Credits

Main photo: Upper Talarik Creek (Joe Ebersole, USEPA)
Thumbnail 1: Fishing boats at Naknek, Alaska (USEPA)
Thumbnail 2: Sockeye salmon in the Wood River (Thomas Quinn, University of Washington)
Thumbnail 3: Salmon drying at Koliganek (Alan Boraas, Kenai Peninsula College)
Thumbnail 4: Age-0 coho salmon in the Chignik watershed (Jonny Armstrong)

EXECUTIVE SUMMARY

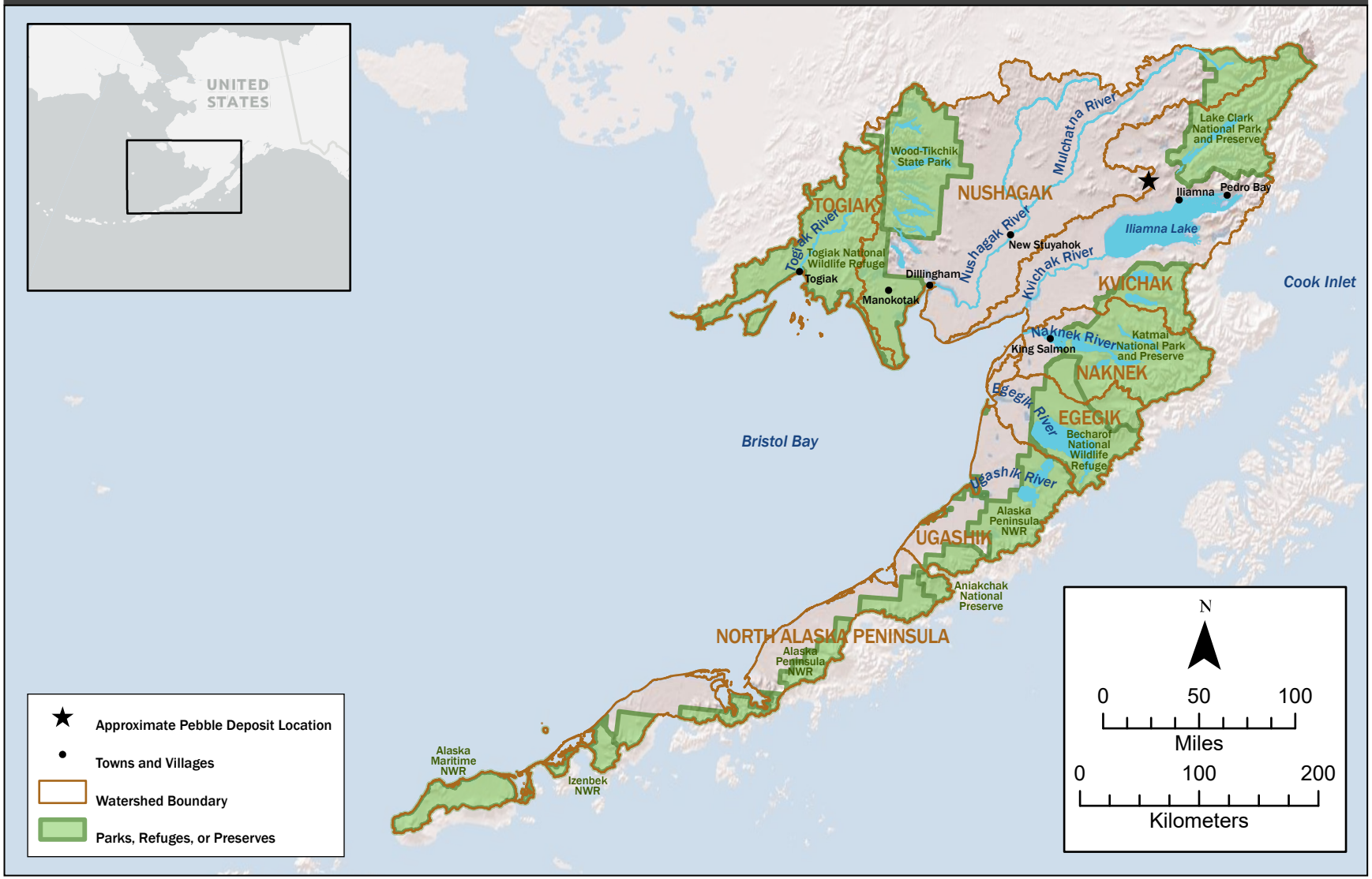
The U.S. Environmental Protection Agency (EPA) is prohibiting the specification of and restricting the use for specification of certain waters in the Bristol Bay watershed as disposal sites for certain discharges of dredged or fill material associated with development of a mine at the Pebble deposit, a large ore body in southwest Alaska. EPA is exercising its authority under Section 404(c) of the Clean Water Act (CWA) (Box ES-1) and its implementing regulations at 40 Code of Federal Regulations (CFR) Part 231 because the discharges of dredged or fill material associated with developing a mine evaluated in this final determination will have unacceptable adverse effects on anadromous[1] fishery areas in the Bristol Bay watershed. Development of a mine at the Pebble deposit has been the subject of study for more than two decades. This final determination is based on this extensive record of scientific and technical information and applies only to certain discharges of dredged or fill material associated with developing the Pebble deposit, not to any other resource development projects in the State of Alaska.

Alaska's Bristol Bay watershed (Figure ES-1) is an area of unparalleled ecological value, boasting salmon diversity and productivity unrivaled anywhere in North America. The Bristol Bay watershed provides intact, connected habitats—from headwaters to ocean—that support abundant, genetically diverse wild Pacific salmon populations. These salmon populations, in turn, help to maintain the productivity of the entire ecosystem, including numerous other fish and wildlife species. The region's salmon resources have supported Alaska Native cultures for thousands of years and continue to support one of the last intact salmon-based cultures in the world. Together, the Bristol Bay watershed's largely undisturbed aquatic habitats and productive salmon populations create this globally significant ecological and cultural resource.

The streams, wetlands, and other aquatic resources of the Bristol Bay watershed also provide the foundation for world-class, economically important, commercial and sport fisheries for salmon and other fishes. The Bristol Bay watershed supports the world's largest runs of Sockeye Salmon, producing approximately half of the world's Sockeye Salmon. These Sockeye Salmon represent the most abundant and diverse populations of this species remaining in the United States. Bristol Bay's Chinook Salmon runs are also frequently at or near the world's largest, and the region also supports significant Coho, Chum, and Pink salmon populations. Because no hatchery fishes are raised or released in the watershed, Bristol Bay's salmon populations are entirely wild and self-sustaining. Bristol Bay is remarkable as one of the last places on Earth with such bountiful and sustainable harvests of wild salmon. One of the main factors leading to the success of these fisheries is the fact that its diverse aquatic habitats are largely untouched and pristine, unlike the waters that support many other salmon fisheries worldwide.

[1] Anadromous fishes hatch in freshwater habitats, migrate to sea for a period of relatively rapid growth, and then return to freshwater habitats to spawn. For the purposes of this final determination, "anadromous fishes" refers only to Coho or Silver salmon (*Oncorhynchus kisutch*), Chinook or King salmon (*O. tshawytscha*), Sockeye or Red salmon (*O. nerka*), Chum or Dog salmon (*O. keta*), and Pink or Humpback salmon (*O. gorbuscha*).

Figure ES-1. The Bristol Bay watershed, composed of the Togiak, Nushagak, Kvichak, Naknek, Egegik, and Ugashik River watersheds and the North Alaska Peninsula. Only selected towns and villages are shown on this map.



Roughly 50 to 70 percent of Bristol Bay's Sockeye and large numbers of its Coho, Chinook, Pink, and Chum salmon are sustainably harvested in subsistence, commercial, and recreational fisheries before they can return to their natal lakes and streams to spawn. Thus, these salmon resources have significant nutritional, cultural, economic, and recreational value within and beyond the Bristol Bay region. The total economic value of the Bristol Bay watershed's salmon resources, including subsistence uses, was estimated at more than $2.2 billion in 2019 (McKinley Research Group 2021). The Bristol Bay commercial salmon fishery generates the most significant component of this economic activity, resulting in 15,000 jobs and an economic benefit of $2.0 billion in 2019, $990 million of which was in Alaska (McKinley Research Group 2021). Beyond their economic and environmental value, the diverse fishery and other aquatic and terrestrial resources of the Bristol Bay watershed, which depend upon the complex of healthy streams, wetlands, and other waters, are irreplaceable because they are inseparable from the cultures of the native people they support. Section 3 of this final determination provides an overview of the streams, wetlands, and other aquatic resources of the Bristol Bay watershed and discusses their role in supporting important subsistence, commercial, and recreational fisheries.

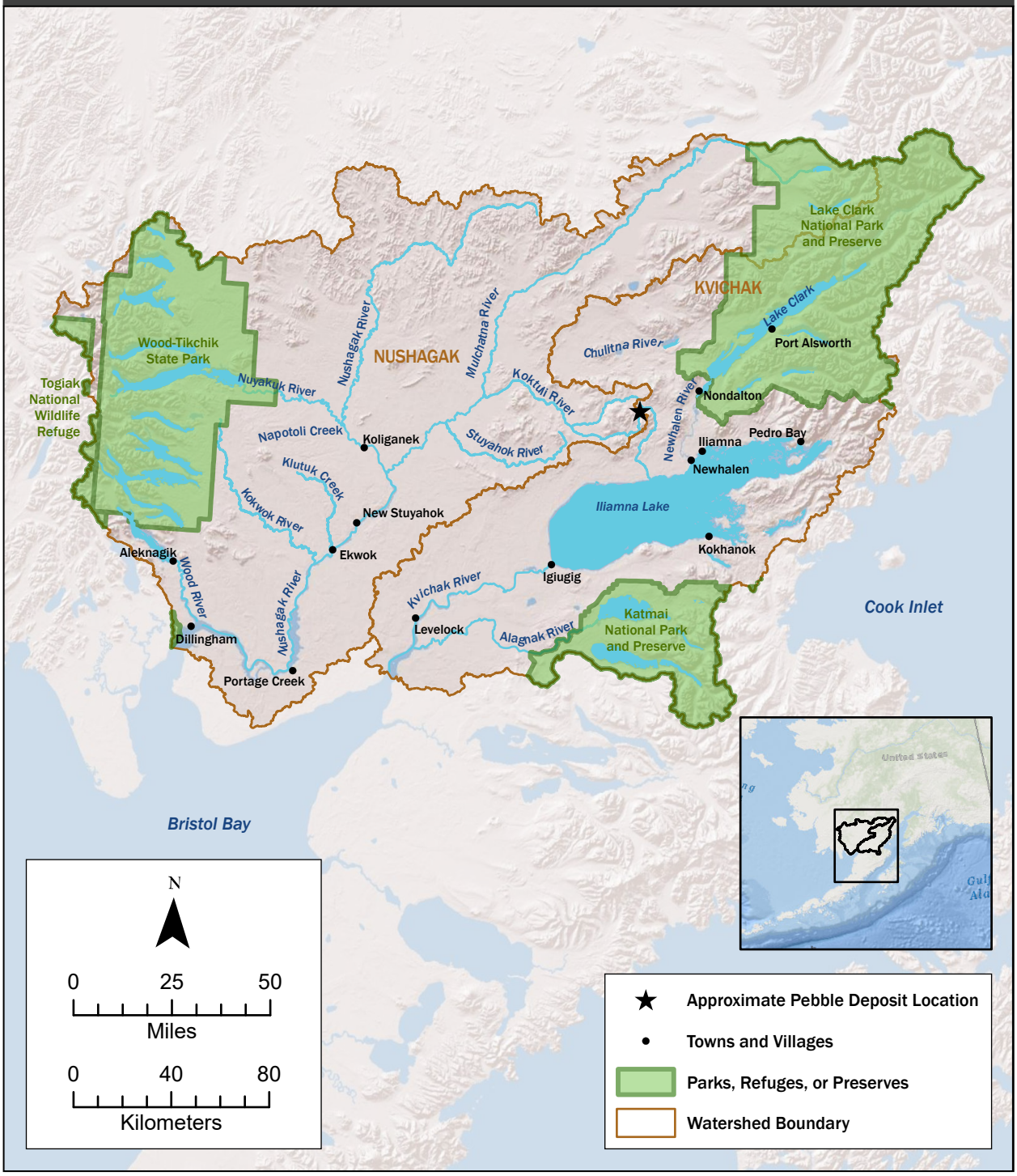
BOX ES-1. SECTION 404 OF THE CLEAN WATER ACT

The objective of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Section 404(c) of the CWA authorizes the U.S. Environmental Protection Agency (EPA) to (1) prohibit or withdraw the specification of any defined area as a disposal site, and (2) deny, restrict, or withdraw the use of any defined area for specification as a disposal site, whenever it determines, after notice and opportunity for public hearings, that the discharge of dredged or fill material into the area will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas. EPA has used its CWA Section 404(c) authority judiciously, having completed only 13 CWA Section 404(c) actions in the 50-year history of the CWA prior to this final determination.

Proposed Mine at the Pebble Deposit

The Pebble deposit, a large, low-grade deposit containing copper-, gold-, and molybdenum-bearing minerals, is located at the headwaters of the pristine Bristol Bay watershed. The Pebble deposit underlies portions of the South Fork Koktuli River (SFK), North Fork Koktuli River (NFK), and Upper Talarik Creek (UTC) watersheds, which drain to two of the largest rivers in the Bristol Bay watershed, the Nushagak and Kvichak Rivers (Figure ES-2).

Figure ES-2. Major waterbodies within the Nushagak and Kvichak River watersheds.



Since 2001, Northern Dynasty Minerals Ltd. (NDM) and subsequently the Pebble Limited Partnership (PLP)[2] have been conducting data collection and analysis as part of efforts to pursue the development of a large-scale mine at the Pebble deposit. Given current mining technology and the high density of water resources in the area, the discharge of dredged or fill material into waters of the United States is expected to be necessary to develop the Pebble deposit. Such discharges would require a CWA Section 404 permit from the U.S. Army Corps of Engineers (USACE). In December 2017, PLP submitted a CWA Section 404 permit application to USACE to develop a mine at the Pebble deposit, which triggered the development of an Environmental Impact Statement (EIS) pursuant to the National Environmental Policy Act (NEPA). In response to the CWA Section 404 permit review/NEPA review process, PLP submitted a revised permit application in June 2020 (the 2020 Mine Plan) (PLP 2020b).

In the 2020 Mine Plan, PLP proposes to develop the Pebble deposit as a surface mine at which 1.3 billion tons of ore would be mined over 20 years. The project consists of four primary elements: (1) the mine site situated in the SFK, NFK, and UTC watersheds (Figure ES-3); (2) the Diamond Point port; (3) the transportation corridor, including concentrate and water return pipelines; and (4) the natural gas pipeline and fiber optic cable. The first element, a fully developed mine site, would include an open pit, bulk tailings storage facility (TSF), pyritic TSF, a 270-megawatt power plant, water management ponds (WMPs), water treatment plants (WTPs), milling and processing facilities, and supporting infrastructure (Figure ES-4). Under the 2020 Mine Plan, PLP would progress through four distinct mine phases: construction, operations (also referred to as production), closure, and post-closure. The construction period would last approximately four years, followed by 20 years of operation. Closure, including physical reclamation of the mine site, is projected to take approximately 20 years. Post-closure activities, including long-term water management and monitoring, would last for centuries (USACE 2020a). The potential direct and indirect impacts from construction and operation of the 2020 Mine Plan on streams, wetlands, and other waters across the mine site area (Figure ES-5) have been evaluated in detail.

On July 24, 2020, USACE published a Notice of Availability for the Final EIS (FEIS) in the *Federal Register* (USACE 2020a), and on November 20, 2020, USACE issued its Record of Decision (ROD) denying PLP's CWA Section 404 permit application on the basis that the 2020 Mine Plan would not comply with the CWA Section 404(b)(1) Guidelines and would be contrary to the public interest (USACE 2020b). By letter dated November 25, 2020, USACE notified PLP that the proposed project failed to comply with the CWA Section 404(b)(1) Guidelines because, even after consideration of proposed mitigation measures, "the proposed project would cause unavoidable adverse impacts to aquatic resources which would result in Significant Degradation to aquatic resources" (USACE 2020b: Transmittal Letter, Page 1).

On January 19, 2021, PLP filed a request for an appeal of the USACE permit denial with USACE. USACE accepted the appeal on February 25, 2021, and review of the appeal is ongoing.

[2] PLP was created in 2007 by co-owners NDM and Anglo American PLC to design, permit, construct, and operate a long-life mine at the Pebble deposit (Ghaffari et al. 2011). In 2013, NDM acquired Anglo American's interest in PLP, and NDM now holds a 100 percent interest in PLP (Kalanchey et al. 2021).

Figure ES-3. Mine site hydrography. Figure 2-1 from PLP's June 8, 2020 Clean Water Act Section 404 permit application (PLP 2020b).

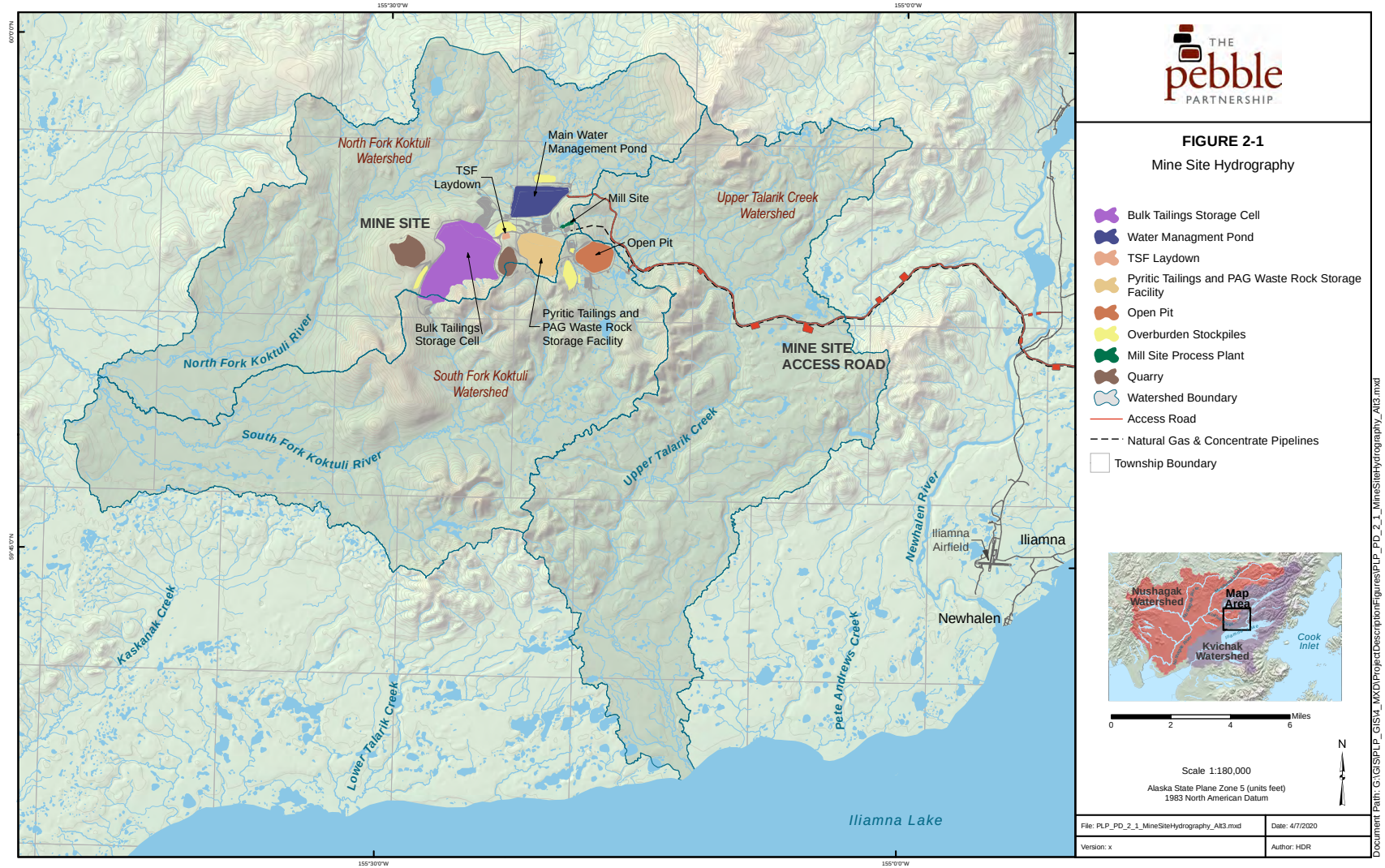


Figure ES-4. Mine site map. Figure 1-4 from PLP's June 8, 2020 Clean Water Act Section 404 permit application (PLP 2020b).

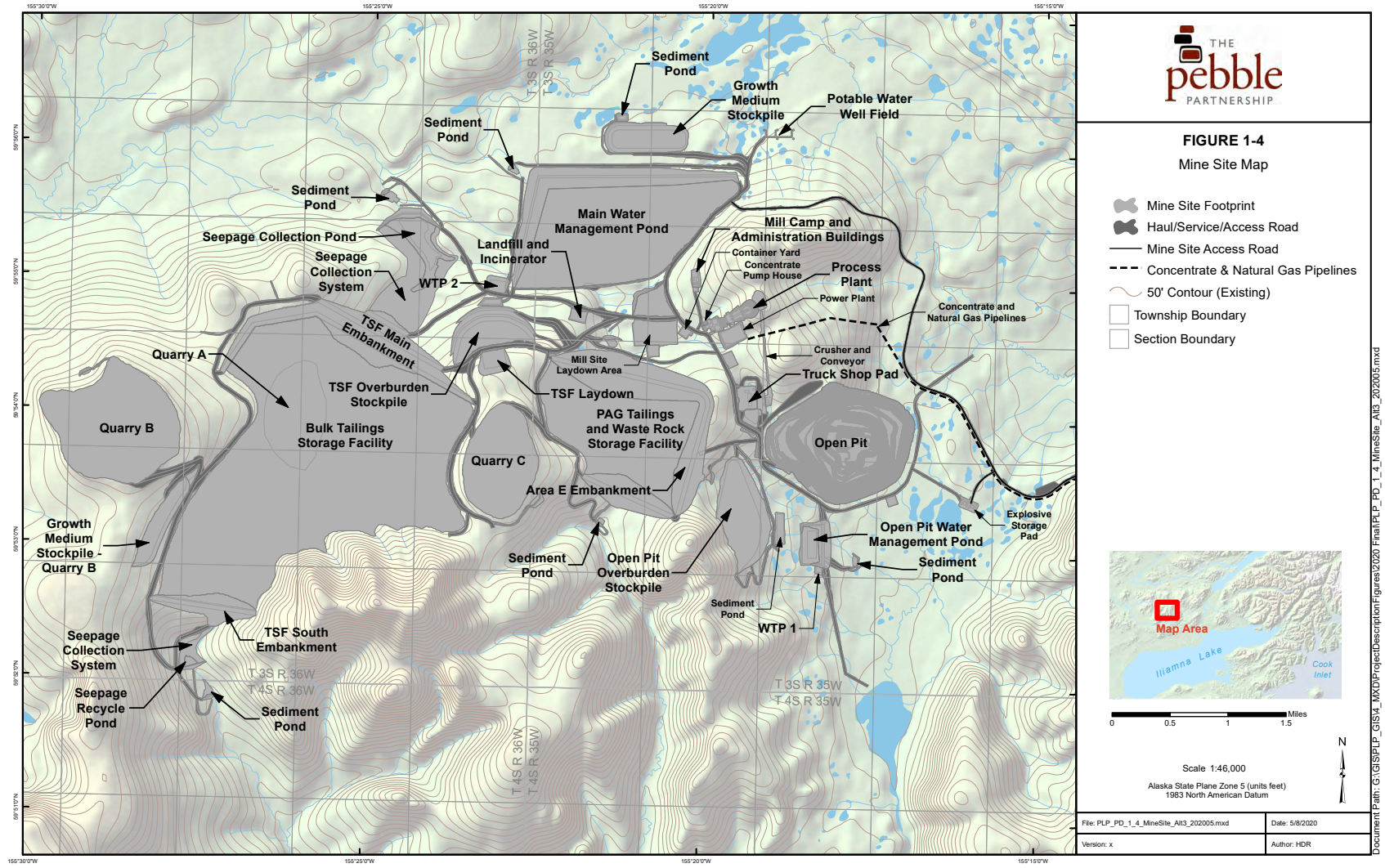
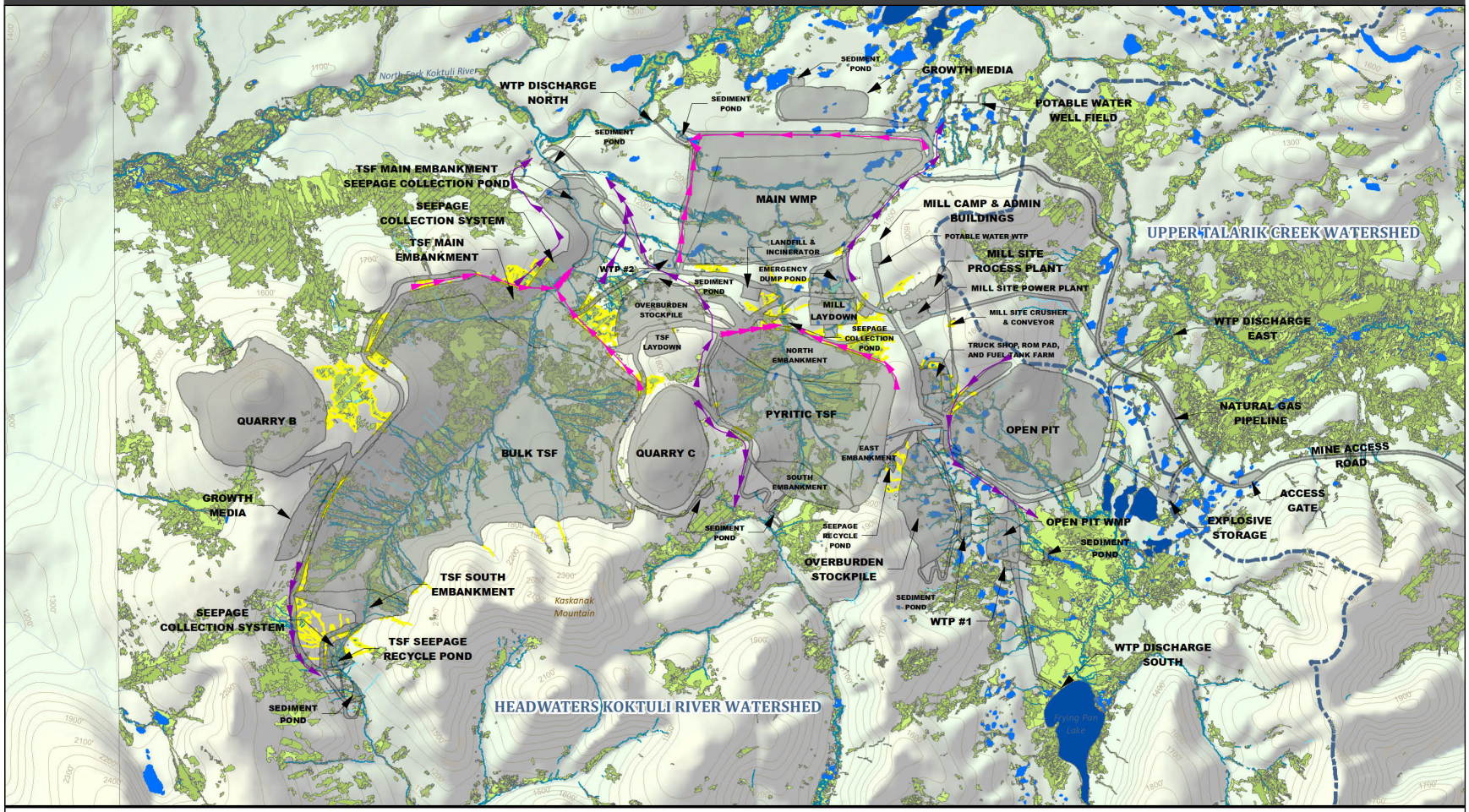


Figure ES-5. Mine site analysis area for wetlands and other waters. Figure 4.22-1 from the FEIS (USACE 2020a: Section 4.22).



The USACE permit denial addresses only PLP's specific permit application for the 2020 Mine Plan; it does not address any other potential plans to develop the Pebble deposit. Information regarding the Pebble deposit and the 2020 Mine Plan can be found in Section 2 of this final determination.

2014 Proposed Determination

For more than a decade, many Alaska Native communities in the Bristol Bay watershed; subsistence, commercial, and recreational fishing interests; conservation groups; and others have raised concerns about the potential impacts that a large-scale mine at the Pebble deposit could have on the region's socially, ecologically, and economically important fishery areas. Starting in May 2010, these groups and others began requesting that EPA use its CWA Section 404(c) authority to protect the region's fishery areas. In February 2011, EPA decided to conduct an ecological risk assessment before considering additional steps. In January 2014, after three years of study, two rounds of public comment, and independent, external peer review, EPA released its *Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*[3] (Bristol Bay Assessment or BBA) (EPA 2014). In July 2014, after careful consideration of available information, including the findings of the BBA and consultation with PLP and the State of Alaska, EPA Region 10 published a proposed determination under Section 404(c) of the CWA to restrict the use of certain waters in the SFK, NFK, and UTC watersheds as disposal sites for dredged or fill material associated with mining the Pebble deposit (2014 Proposed Determination) for public comment.

As a result of litigation brought by PLP, EPA Region 10's CWA Section 404(c) review process was halted in November 2014 until EPA and PLP resolved the case in a May 2017 settlement agreement. As a condition of that settlement agreement, EPA Region 10 initiated a process to propose to withdraw the 2014 Proposed Determination, and EPA ultimately withdrew the 2014 Proposed Determination in August 2019. In October 2019, 20 tribal, fishing, environmental, and conservation groups challenged EPA's withdrawal of the 2014 Proposed Determination. The ultimate result of the litigation that began in October 2019 was an October 29, 2021 decision by the U.S. District Court for the District of Alaska to vacate EPA's 2019 decision to withdraw the 2014 Proposed Determination and remand the action to the Agency for reconsideration.

The District Court's vacatur of EPA's 2019 decision to withdraw the 2014 Proposed Determination had the effect of reinstating the 2014 Proposed Determination and reinitiating EPA's CWA Section 404(c) review process. The next step in the CWA Section 404(c) review process required the Region 10 Regional Administrator to decide whether to withdraw the 2014 Proposed Determination or prepare a recommended determination within 30 days. On November 23, 2021, EPA Region 10 published in the *Federal Register* a notice extending the applicable time requirement through May 31, 2022, to provide sufficient time to consider available information and determine the appropriate next step in the CWA

[3] EPA conducted the BBA consistent with its authority under CWA Section 104(a) and (b). For more information about EPA's efforts in Bristol Bay or copies of the Bristol Bay Assessment, see http://www.epa.gov/bristolbay.

Section 404(c) review process. In its notice, EPA concluded that it should consider information that had become available since EPA issued the 2014 Proposed Determination before making a decision. Information regarding the 2014 Proposed Determination and the history of EPA's work in the Bristol Bay watershed can be found in Section 2 of this final determination.

2022 Proposed Determination

To determine the appropriate next step in this CWA Section 404(c) process, EPA Region 10 considered a wide array of information that had become available since it issued the 2014 Proposed Determination, including the following:

- More than 670,000 public comments submitted to EPA Region 10 in response to the 2014 Proposed Determination.
- PLP's CWA Section 404 permit application, including the 2020 Mine Plan (PLP 2020b).
- USACE's FEIS evaluating the 2020 Mine Plan, including the FEIS appendices, technical support documents, and references (USACE 2020a).
- The 12-week coordination process between EPA, the U.S. Fish and Wildlife Service, and USACE in spring 2020 to evaluate PLP's proposed project for compliance with the CWA Section 404(b)(1) Guidelines.
- USACE's ROD denying PLP's CWA Section 404 permit application for the 2020 Mine Plan, including the ROD supporting documents (USACE 2020b).
- NDM's *Pebble Project Preliminary Economic Assessment* dated September 9, 2021 (Kalanchey et al. 2021).
- Updated data regarding fishery resources in the Bristol Bay watershed.
- New scientific and technical publications.

In January 2022, consistent with its regulatory procedures for proposed determinations at 40 CFR 231.3(a), EPA Region 10 notified USACE, the Alaska Department of Natural Resources (ADNR), PLP, Pebble East Claims Corporation, Pebble West Claims Corporation, and Chuchuna Minerals[4] (the Parties) of EPA Region 10's intention to issue a revised proposed determination because, based on a review of information available to that date, it continued to believe that the discharge of dredged or fill material associated with mining the Pebble deposit could result in unacceptable adverse effects on important fishery areas. EPA Region 10 provided the Parties with an opportunity to consult with the Region and to submit information for the record to demonstrate that no unacceptable adverse effects would result

[4] EPA Region 10 notified Chuchuna Minerals because USACE's FEIS for the 2020 Mine Plan indicates that it is reasonably foreseeable for discharges associated with mining the Pebble deposit to expand in the future into portions of areas where Chuchuna Minerals holds mining claims.

from discharges associated with mining the Pebble deposit or that actions could be taken to prevent unacceptable adverse effects on important fishery areas.

ADNR, PLP, and Chuchuna Minerals submitted response letters asserting legal, policy, scientific, and technical arguments, and EPA met individually with PLP and Chuchuna Minerals. Based on the information provided to the Agency, ADNR, PLP, and Chuchuna Minerals did not demonstrate to the satisfaction of EPA Region 10 that no unacceptable adverse effects would occur as a result of the discharge of dredged or fill material associated with mining the Pebble deposit (Section 2.2.2). Thus, EPA Region 10 decided that the appropriate next step in this CWA Section 404(c) process was the publication of a revised proposed determination (the 2022 Proposed Determination).

In May 2022, EPA Region 10 published in the *Federal Register* a notice of availability for the 2022 Proposed Determination under Section 404(c) of the CWA to prohibit the specification of and restrict the use for specification of certain waters in the SFK, NFK, and UTC watersheds as disposal sites for the discharge of dredged or fill material associated with mining the Pebble deposit (87 FR 32021, May 26, 2022). The notice started a public comment period ending on July 5, 2022. On June 16 and 17, 2022, EPA Region 10 held three public hearings on the 2022 Proposed Determination: two in-person hearings in the Bristol Bay region (in Dillingham and Iliamna) and one virtual hearing. More than 186 people participated in the three hearings, 111 of whom provided oral statements.

EPA Region 10 received requests to extend the public comment period, as well as requests not to extend the public comment period. EPA Region 10 considered each of these requests and found good cause existed pursuant to 40 CFR 231.8 to extend the public comment period through September 6, 2022 (87 FR 39091, June 30, 2022).

On September 6, 2022, EPA Region 10 published in the *Federal Register* a notice to extend the period for the EPA Region 10 Regional Administrator to evaluate public comments. According to the notice, EPA found good cause existed pursuant to 40 CFR 231.8 to extend the time period provided in 40 CFR 231.5(a) to either withdraw the proposed determination or to prepare a recommended determination through no later than December 2, 2022, to help ensure full consideration of the extensive administrative record including all public comments (87 FR 54498, September 6, 2022). In addition to the testimony taken at the hearings, EPA Region 10 received more than 582,000 written comments during the public comment period.

EPA Region 10 completed its review of the extensive administrative record, including all public comments. The Regional Administrator determined that the discharge of dredged or fill material associated with developing the Pebble deposit would be likely to result in unacceptable adverse effects on anadromous fishery areas and, thus, prepared a recommended determination. The recommended determination, along with the administrative record, was transmitted to EPA's Assistant Administrator for Water on December 1, 2022, for review and final action.

The Final Determination

On December 2, 2022, the Assistant Administrator for Water notified the Parties[5] that she had received EPA Region 10's recommended determination and, consistent with EPA's CWA Section 404(c) regulations at 40 CFR 231.6, provided them the opportunity to notify EPA of their intent to take corrective action to prevent unacceptable adverse effects on anadromous fishery areas from certain discharges of dredged or fill material associated with developing the Pebble deposit.

ADNR and PLP submitted response letters asserting legal, policy, scientific, and technical arguments that each had previously raised during consultation with EPA prior to issuance of the proposed determination and in public comments on the proposed determination. EPA also met with ADNR and other representatives from the State of Alaska. USACE and Chuchuna Minerals also submitted response letters. None of the Parties identified corrective action to prevent unacceptable adverse effects satisfactory to the Assistant Administrator for Water. Section 2 of this final determination includes a summary of the Assistant Administrator for Water's consultation with the Parties.

Following review of EPA Region 10's recommended determination and the extensive administrative record supporting the Regional Administrator's decision, including all public comments, the Assistant Administrator for Water has determined that certain discharges of dredged or fill material associated with developing the Pebble deposit into certain waters of the United States will have unacceptable adverse effects on anadromous fishery areas and affirms the recommended determination.[6] Section 4 of this final determination provides the basis for EPA's findings regarding unacceptable adverse effects on anadromous fishery areas.

As demonstrated in the FEIS and ROD, construction and routine operation of the mine proposed in the 2020 Mine Plan would result in the discharge of dredged or fill material into waters of the United States, including streams, wetlands, lakes, and ponds overlying the Pebble deposit and within adjacent watersheds. The direct effects (i.e., resulting from placement of fill in aquatic habitats) and certain secondary effects of such discharges (i.e., associated with discharges of dredged or fill material, but not resulting from the actual placement of such material) would result in the total loss of aquatic habitats important to anadromous fishes. These losses would result from the construction and routine operation of the various components of the mine site, including the open pit, bulk TSF, pyritic TSF, power plant, WMPs, WTPs, milling/processing facilities, and supporting infrastructure. According to the FEIS and ROD, discharges of dredged or fill material to construct and operate the mine site proposed in the 2020 Mine Plan would result in the total loss of approximately 99.7 miles (160.5 km) of stream habitat, representing approximately 8.5 miles (13.7 km) of anadromous fish streams and 91 miles (147 km) of additional streams that support anadromous fish streams. Such discharges of dredged or fill material

[5] Consistent with EPA's regulations, the USACE representative who received this notification was the Chief of Engineers.

[6] EPA has made additional clarifications throughout this final determination based on EPA Office of Water's review of the recommended determination and administrative record, as well as final consultation with the Parties, conducted consistent with 40 CFR 231.6.

also would result in the total loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters in the SFK and NFK watersheds that support anadromous fish streams.

Additional secondary effects of the proposed discharges of dredged or fill material at the mine site would degrade anadromous fishery areas downstream of the mine site. Specifically, the stream, wetland, and other aquatic resource losses from the footprint of the 2020 Mine Plan would reverberate downstream, depriving downstream anadromous fish habitats of nutrients, groundwater inputs, and other ecological subsidies from lost upstream aquatic resources. Further, streamflow alterations from water capture, withdrawal, storage, treatment, or release at the mine site are another secondary effect of the discharge of dredged or fill material associated with the construction and routine operation of the 2020 Mine Plan. Such streamflow alterations would adversely affect approximately 29 miles (46.7 km) of anadromous fish streams downstream of the mine site due to greater than 20 percent changes in average monthly streamflow.[7] These streamflow alterations would result in major changes in ecosystem structure and function and would reduce both the extent and quality of anadromous fish habitat downstream of the mine. As recognized in the FEIS, all instances of complete loss of aquatic habitat and most impairment to fish habitat function would be permanent and "no other wild salmon fishery in the world exists in conjunction with an active mine of this size" (USACE 2020a: Page 4.6-9).

Although Alaska has many streams and wetlands that support salmon, individual streams, stream reaches, wetlands, lakes, and ponds play a critical role in supporting individual salmon populations and protecting the genetic diversity of Bristol Bay's wild salmon populations. The diverse array of watershed features across the region creates and sustains a diversity of aquatic habitats that support multiple populations of salmon with asynchronous run timings and habitat use patterns (i.e., biocomplexity, after Hilborn et al. 2003). These population differences are reflected in salmon genetic diversity and adaptation to local conditions within Bristol Bay's component watersheds (e.g., Quinn et al. 2012) and provide stability to the overall system (Schindler et al. 2010). Impacts of the 2020 Mine Plan are concentrated in the SFK and NFK watersheds, which are a part of the Nushagak River watershed. Recent analysis specific to the Nushagak River watershed underscores the important role that the streams, wetlands, lakes, and ponds across the entire Nushagak River watershed, including those that would be adversely affected by the 2020 Mine Plan, play in stabilizing the Nushagak River's productive Sockeye and Chinook salmon fisheries (Brennan et al. 2019). Similarly, both the Koktuli River (the SFK and NFK are tributaries to the Koktuli River) and UTC have been documented to support genetically distinct populations of Sockeye Salmon (Dann et al. 2012, Shedd et al. 2016, Dann et al. 2018). Loss of salmon habitats and associated salmon diversity in the SFK, NFK, and UTC watersheds would erode both the habitat complexity and biocomplexity that help buffer these populations from sudden and extreme changes in abundance, and ultimately maintain their productivity.

[7] Streamflow alterations would vary seasonally. Streamflow reductions exceeding 20 percent of average monthly streamflow would occur in at least one month per year in at least 13.1 miles (21.4 km) of anadromous fish streams downstream of the mine site, and operation of the 2020 Mine Plan would increase streamflow by more than 20 percent of baseline average monthly streamflow in at least 25.7 miles (41.3 km) of downstream anadromous fish streams due to WTP discharges.

In addition to supporting genetically distinct salmon populations, the streams and wetlands draining the Pebble deposit area provide key habitat for numerous other fish species and supply water, invertebrates, organic matter, and other resources to downstream waters (Meyer et al. 2007, Colvin et al. 2019, Koenig et al. 2019). This is particularly true in dendritic stream networks like the SFK, NFK, and UTC systems, which have a high density of headwater streams. As a result, headwater streams and wetlands play a vital role in maintaining diverse, abundant anadromous fish populations—both by providing important fish habitat and supplying the energy and other resources needed to support anadromous fishes in connected downstream habitats.

EPA has determined the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. In this regard, EPA makes independent unacceptability findings, each of which is based on one or more factors, including the large amount of permanent loss of anadromous fish habitat (including spawning and breeding areas); the particular importance of the permanently lost habitat for juvenile Coho and Chinook salmon; the degradation of and thus damage to additional downstream spawning and rearing habitat for Coho, Chinook, and Sockeye salmon due to the loss of ecological subsidies provided by eliminated streams, wetlands, and other waters; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK and NFK watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds. EPA has also determined that discharges of dredged or fill material associated with developing the Pebble deposit anywhere in the mine site area (Figure ES-5) within the SFK and NFK watersheds that would result in the same or greater levels of loss or streamflow changes as the 2020 Mine Plan also will have unacceptable adverse effects on anadromous fishery areas in these watersheds, because such discharges would involve the same aquatic resources characterized as part of the evaluation of the 2020 Mine Plan. These conclusions support the prohibition described in Section 5.1 of this final determination.

Further, EPA has determined the discharge of dredged or fill material for the construction and routine operation of a mine at the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds will have unacceptable adverse effects on anadromous fishery areas if the effects of such discharges are similar or greater in nature and magnitude to the adverse effects of the 2020 Mine Plan. In this regard, EPA makes independent unacceptability findings, each of which is based on one or more factors, including the pristine condition and ecological importance of anadromous habitat throughout the SFK, NFK, and UTC watersheds; how aquatic habitats across these three watersheds function similarly to support productive anadromous fishery areas; the large amount of permanent loss of anadromous fish habitat; the degradation of and thus damage to additional downstream spawning and rearing habitat for Coho, Chinook, and Sockeye salmon due to the loss of ecological subsidies provided by the eliminated streams, wetlands, and other waters; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds. This conclusion supports the restriction described in Section 5.2 of this final determination.

Overview of Prohibition and Restriction in the Final Determination

This final determination includes two parts: a prohibition and a restriction, which are described in more detail in Sections 5.1 and 5.2, respectively.

Prohibition

The EPA Assistant Administrator for Water has determined that the discharges of dredged or fill material for the construction and routine operation of the mine identified in the 2020 Mine Plan (PLP 2020b) at the Pebble deposit will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. Based on information in PLP's CWA Section 404 permit application, the FEIS, and the ROD, such discharges would result in the following aquatic resource losses and streamflow changes:

- The loss of approximately 8.5 miles (13.7 km) of documented anadromous fish streams (Section 4.2.1).
- The loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams (Section 4.2.2).
- The loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters that support anadromous fish streams (Section 4.2.3).
- Adverse impacts on approximately 29 additional miles (46.7 km) of anadromous fish streams resulting from greater than 20 percent changes in average monthly streamflow (Section 4.2.4).

EPA has also determined that discharges of dredged or fill material for the construction and routine operation of a mine to develop the Pebble deposit anywhere in the mine site area within the SFK and NFK watersheds that would result in the same or greater levels of loss or streamflow changes as the 2020 Mine Plan also will have unacceptable adverse effects on anadromous fishery areas in these watersheds, because such discharges would involve the same aquatic resources characterized as part of the evaluation of the 2020 Mine Plan.

Sections 4.2.1 through 4.2.4 describe the basis for EPA's determination that each of the above losses and changes to streamflow independently will have unacceptable adverse effects on anadromous fishery areas (including spawning and breeding areas).

Accordingly, the Assistant Administrator for Water prohibits the specification of waters of the United States within the Defined Area for Prohibition (Figures ES-6, ES-7, and ES-8) as disposal sites for the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan. For purposes of the prohibition, the "2020 Mine Plan" is (1) the mine plan described in PLP's June 8, 2020 CWA Section 404 permit application (PLP 2020b) and the FEIS (USACE 2020a); and (2) future proposals to construct and operate a mine to develop the Pebble deposit with discharges of dredged or fill material in the Defined Area for Prohibition that would result in the same or greater levels of loss or

streamflow changes as the mine plan described in PLP's June 8, 2020 CWA Section 404 permit application.[8] Because each of the losses or streamflow changes described in Sections 4.2.1 through 4.2.4 independently will have unacceptable adverse effects on anadromous fishery areas, future proposals to construct and operate a mine to develop the Pebble deposit that result in any one of these losses or streamflow changes will be subject to the prohibition.

Restriction

The Assistant Administrator for Water has determined that discharges of dredged or fill material associated with future proposals to construct and operate a mine to develop the Pebble deposit will have unacceptable adverse effects on anadromous fishery areas (including spawning and breeding areas) anywhere in the SFK, NFK, and UTC watersheds if the adverse effects of such discharges are similar or greater in nature[9] and magnitude[10] to the adverse effects of the 2020 Mine Plan described in Sections 4.2.1 through 4.2.4 of this final determination.

Accordingly, the Assistant Administrator for Water restricts the use of waters of the United States within the Defined Area for Restriction (Figures ES-7 and ES-8) for specification as disposal sites for the discharge of dredged or fill material associated with future proposals to construct and operate a mine to develop the Pebble deposit that would either individually or cumulatively result in adverse effects similar or greater in nature and magnitude to those described in Sections 4.2.1 through 4.2.4 of this final determination. Because each of the losses or streamflow changes described in Sections 4.2.1 through 4.2.4 independently will have unacceptable adverse effects on anadromous fishery areas, proposals to discharge dredged or fill material that result in any one of these losses or streamflow changes will be subject to the restriction. To the extent that future discharges are subject to the prohibition, the restriction will not apply.

[8] By clarifying that the "2020 Mine Plan" includes, for the purposes of the prohibition, future proposals to construct and operate a mine to develop the Pebble deposit with discharges of dredged or fill material in the Defined Area for Prohibition that would result in the same or greater levels of loss or streamflow changes as the mine plan described in PLP's June 8, 2020 CWA Section 404 permit application, EPA ensures that future applicants cannot circumvent the prohibition by proposing small changes in the location of discharges within the mine site that would not result in any change to the levels of aquatic resource loss or streamflow change, or that would result in greater levels of aquatic resource loss or streamflow change. In doing so, EPA gives full effect to the purpose of the prohibition to prevent adverse effects at the mine site that EPA has already determined are unacceptable.

[9] *Nature* means type or main characteristic (see Cambridge Dictionary available at: https://dictionary.cambridge.org/us/dictionary/english/nature).

[10] *Magnitude* refers to size or importance (see Cambridge Dictionary available at: https://dictionary.cambridge.org/us/dictionary/english/magnitude).

Figure ES-6. The Defined Area for Prohibition at the 2020 Mine Plan mine site. Figure based on information from PLP (2020b), USGS (2021a), and USGS (2021b).

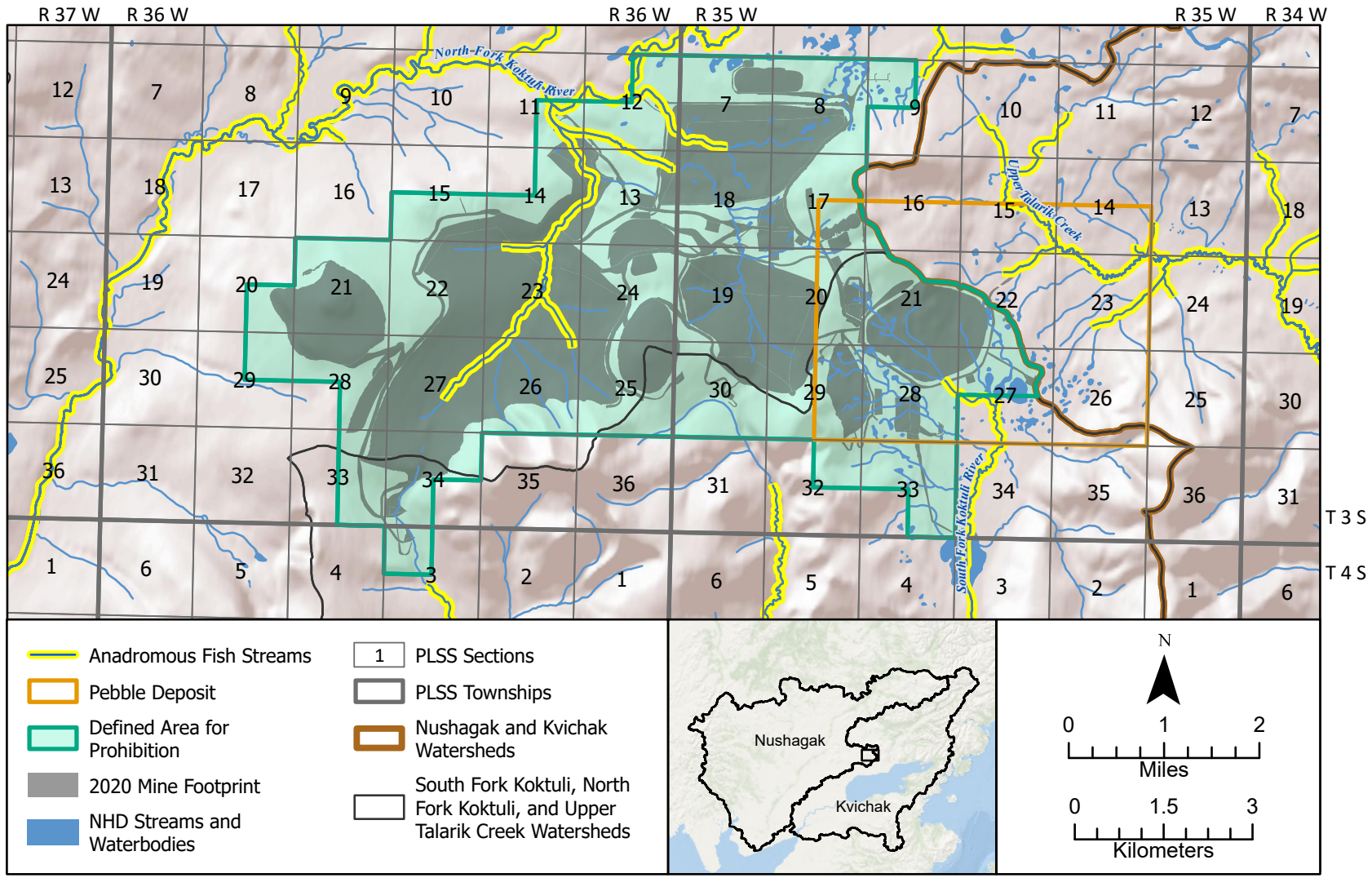


Figure ES-7. The Defined Area for Restriction and the Defined Area for Prohibition overlain on wetlands from the National Wetlands Inventory (USFWS 2021).

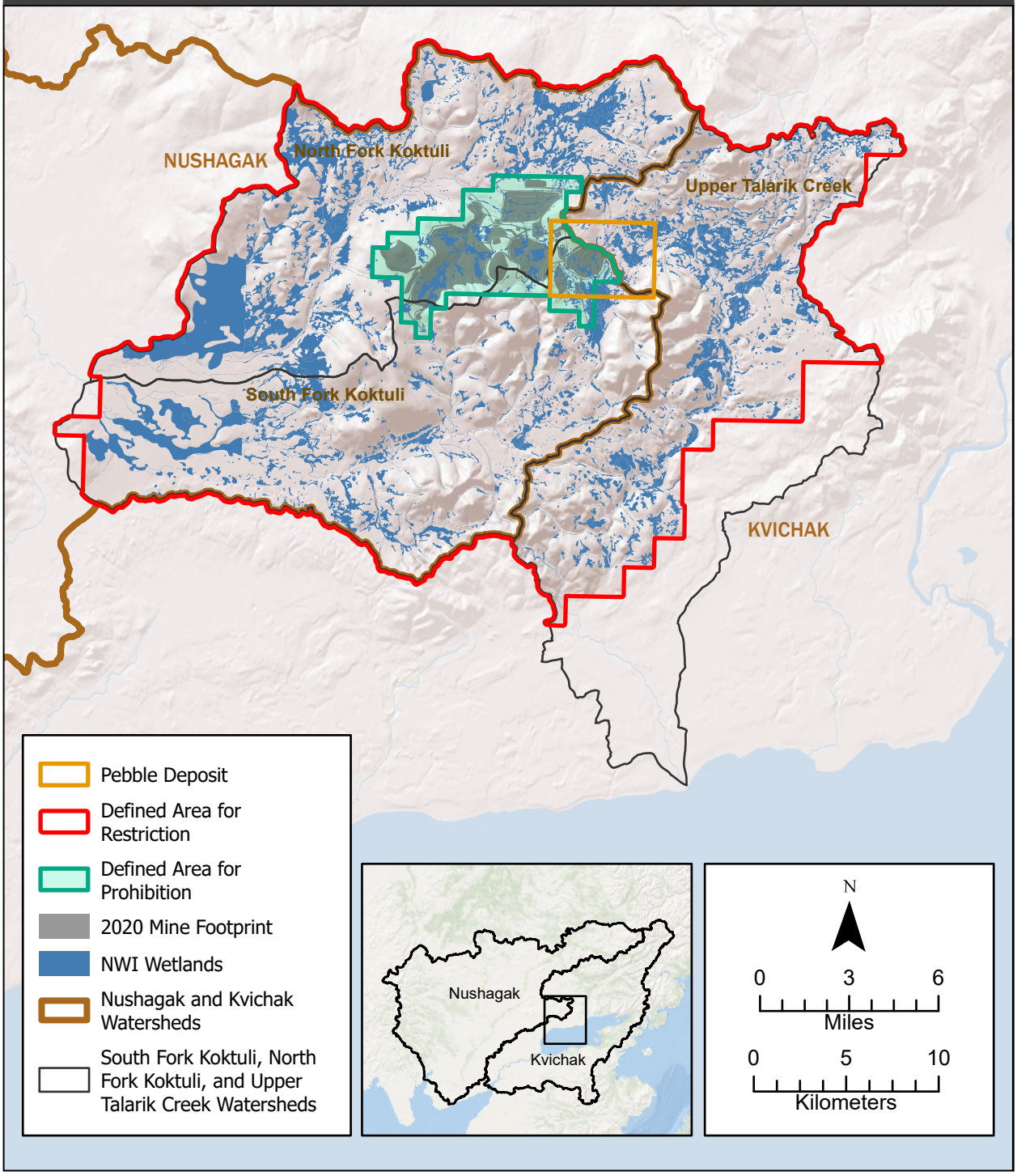
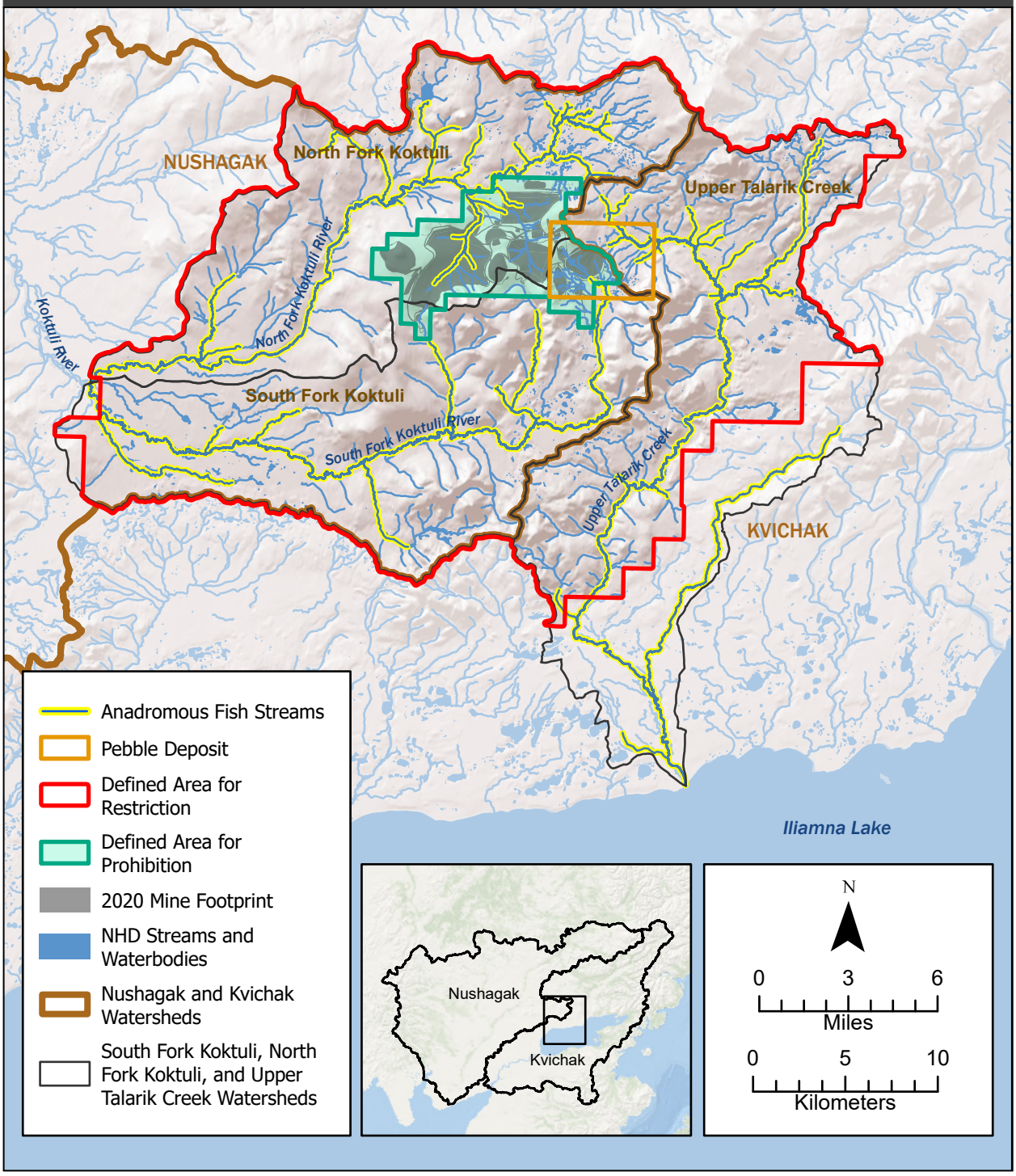


Figure ES-8. The Defined Area for Restriction and the Defined Area for Prohibition overlain on streams and waterbodies from the National Hydrography Dataset (USGS 2021b).



Evaluation of Portions of the CWA Section 404(b)(1) Guidelines

EPA's CWA Section 404(c) regulations provide that consideration should be given to the "relevant portions of the Section 404(b)(1) Guidelines" in evaluating the "unacceptability" of effects (40 CFR 231.2(e)). EPA's consideration of the relevant portions of the CWA Section 404(b)(1) Guidelines further confirm EPA's unacceptable adverse effects determinations.

Specifically, EPA has determined that direct and secondary effects of the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in significant degradation under the CWA Section 404(b)(1) Guidelines. Additionally, EPA has determined that direct and secondary effects of the discharge of dredged or fill material associated with future proposals to construct and operate a mine at the Pebble deposit that would result in adverse effects that are the same, similar or greater than the adverse effects of the 2020 Mine Plan would also result in significant degradation under the CWA Section 404(b)(1) Guidelines. These findings are based on the significantly adverse effects of the discharge of dredged or fill material on special aquatic sites, life stages of anadromous fishes, anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability under the CWA Section 404(b)(1) Guidelines.

EPA evaluated PLP's two compensatory mitigation plans and neither plan adequately mitigates adverse effects described in this final determination to an acceptable level. For informational purposes, EPA also evaluated additional potential compensation measures proposed by PLP and others over the past decade (see Appendix C of this final determination). Available information demonstrates that known compensation measures are unlikely to adequately mitigate effects described in this final determination to an acceptable level. Information regarding evaluation of the CWA Section 404(b)(1) Guidelines can be found in Section 4.3 of this final determination.

Information about Other Adverse Effects of Concern on Aquatic Resources

While not a basis for EPA's final determination, EPA has identified additional potential adverse effects of concern on aquatic resources within the SFK, NFK, and UTC watersheds from discharges of dredged or fill material associated with developing the Pebble deposit.[11] First, adverse effects could result from accidents and failures, such as a tailings dam failure. Uncertainty exists as to whether severe accidents or failures could be prevented over a management horizon of centuries (or in perpetuity), particularly in such a geographically remote area. If such events were to occur, they would have profound ecological ramifications. Second, there are potential adverse impacts associated with the ancillary project components beyond the mine site, such as along the transportation corridor and at the Diamond Point port. Third, there are potential adverse impacts associated with the reasonably foreseeable expansion of

[11] EPA provides an alternative basis for its determination that relies on a broader set of considerations in Section 4.4 of this final determination. To the extent statements in this final determination outside of Section 4.4 conflict with statements within Section 4.4, for purposes of the alternative basis for EPA's determination the text of Section 4.4 governs.

the 2020 Mine Plan evaluated in the FEIS. The FEIS finds that it is reasonably foreseeable that the mine proposed in the 2020 Mine Plan would expand in the future to mine approximately 8.6 billion tons of ore over 78 years. The FEIS estimates that the discharge of dredged or fill material for the construction and operation of this expanded mine would result in the total loss of approximately 430 miles (6921 km) of streams at the expanded mine site, representing approximately 43.5 miles (70 km) of anadromous fish streams and approximately 386 miles (621 km) of additional streams that support anadromous fish streams. Further, the FEIS estimates that discharges of dredged or fill material to construct and operate the expanded mine site would also result in the total loss of more than 10,800 acres (43.7 km^2) of wetlands and other waters that support anadromous fish streams. EPA has already determined that the adverse effects of the discharges evaluated in this final determination are unacceptable and the additional losses that would result from the Expanded Mine Scenario would represent extraordinary and unprecedented levels of anadromous fish habitat loss and degradation, dramatically expanding the scope and scale of unacceptable adverse effects in the SFK, NFK, and UTC watersheds. For example, significant additional anadromous fish habitat losses and degradation in the SFK, NFK, and UTC watersheds caused by future expansion of the mine would threaten genetically distinct Sockeye Salmon populations in both the Koktuli River and UTC.

See Section 6 of this final determination for a discussion of other concerns and considerations.

Authority and Justification for Undertaking a CWA Section 404(c) Review at this Time

Congress enacted CWA Section 404(c) to provide EPA the ultimate authority, if it chooses on a case-by-case basis, to prohibit, withdraw, deny, or restrict the use of any defined area for specification as a disposal site for the discharge of dredged or fill material into waters of the United States "whenever" the Agency makes the required determination under the statute (33 USC 1344(c); 40 CFR 231.1(a), (c); 44 FR 58076; *Mingo Logan Coal Co. v. EPA*, 714 F.3d 618, 612-13 (D.C. Cir. 2013)). EPA may exercise its CWA Section 404(c) authority "at any time," including before a permit application has been submitted, at any point during the permitting process, and after a permit has been issued (*Mingo Logan Coal Co.,* 714 F.3d at 613; 33 U.S.C. 1344(c); 40 CFR 231.1(a), (c); 44 FR 58076).

EPA has reviewed the available information, including the relevant portions of the USACE permitting record, and this information supports EPA's determinations that the discharges of dredged or fill material evaluated in this final determination will have unacceptable adverse effects on anadromous fishery areas within the SFK, NFK, and UTC watersheds.

By acting now, EPA makes clear its assessment of the effects of certain discharges of dredged or fill material associated with developing the Pebble deposit into certain waters of the United States within the SFK, NFK, and UTC watersheds in light of the significant loss of and damage to important anadromous fishery areas. The federal government, the State of Alaska, federally recognized tribal governments, PLP, and many other interested parties have devoted significant resources over many years of study, engagement, and review. Considering the extensive record, it is not efficient or effective

to engage in one or more additional multi-year NEPA and CWA Section 404 processes for future proposals to discharge dredged or fill material associated with developing the Pebble deposit into waters of the United States within the SFK, NFK, or UTC watersheds that will result in adverse effects that EPA has already determined are unacceptable. By acting now, based on an extensive and carefully considered record, EPA promotes regulatory certainty for all interested parties, including USACE and the regulated community; facilitates planning by proponents; and avoids unnecessary expenditure of additional resources by all interested parties (see 44 FR 58077). Ultimately, by acting now, EPA also facilitates "comprehensive rather than piecemeal protection" of important aquatic resources (see *id*.) by ensuring the protection of valuable anadromous fishery areas in the SFK, NFK, and UTC watersheds against unacceptable adverse effects from the discharges evaluated in this final determination.

Conclusion

Discharges of dredged or fill material to construct and operate the 2020 Mine Plan's proposed mine site alone would result in the permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams, 91 miles (147 km) of additional streams that support anadromous fish streams, and approximately 2,108 acres (8.5 km^2) of wetlands and other waters in the SFK and NFK watersheds that support anadromous fish streams. These discharges would also result in streamflow alterations that would adversely affect approximately 29 miles (46.7 km) of additional anadromous fish streams downstream of the mine site due to greater than 20 percent changes in average monthly streamflow. The aquatic resources that would be lost or damaged play an important role in supporting salmon populations in the SFK, NFK, and UTC watersheds.

EPA has determined that the large-scale loss of and damage to headwater streams, wetlands, and other aquatic resources that support salmon populations in the SFK, NFK, and UTC watersheds from the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan will have unacceptable adverse effects on anadromous fishery areas in the SFK, NFK, and UTC watersheds.

To prevent these unacceptable adverse effects, this final determination prohibits the specification of certain waters of the United States in the SFK and NFK watersheds as disposal sites for the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, including future proposals to construct and operate a mine to develop the Pebble deposit with discharges of dredged or fill material into waters of the United States that would result in the same or greater levels of aquatic resource loss or streamflow changes as the 2020 Mine Plan.

This final determination also restricts the use for specification of certain waters of the United States in the SFK, NFK, and UTC watersheds as disposal sites for the discharge of dredged or fill material associated with future proposals to construct and operate a mine to develop the Pebble deposit with discharges of dredged or fill material into waters of the United States that would result in adverse effects

similar or greater in nature and magnitude to the adverse effects of the 2020 Mine Plan (see Section 5 of this final determination).

Proposals to discharge dredged or fill material into waters of the United States associated with developing the Pebble deposit that are not subject to this determination remain subject to all statutory and regulatory authorities and requirements under CWA Section 404.

In light of the immense and unique economic, social, cultural, and ecological value of the aquatic resources in the region, including the fishery areas in the SFK, NFK, and UTC watersheds, and their susceptibility to damage, EPA will carefully evaluate all future proposals to discharge dredged or fill material in the region.

SECTION 1. INTRODUCTION

The Clean Water Act (CWA), 33 U.S. Code (U.S.C.) § 1251 et seq., prohibits the discharge of pollutants, including dredged or fill material, into waters of the United States (including wetlands) except in compliance with, among other provisions, Section 404 of the CWA, 33 U.S.C. § 1344, 33 U.S.C. § 1311. Section 404(a) of the CWA authorizes the Secretary of the Army (Secretary), acting through the Chief of Engineers (U.S. Army Corps of Engineers or USACE), to authorize the discharge of dredged or fill material at specified disposal sites. This authorization is conducted, in part, through the application of environmental guidelines developed by the U.S. Environmental Protection Agency (EPA), in conjunction with the Secretary, under Section 404(b) of the CWA. Section 404(c) of the CWA authorizes EPA to prohibit the specification (including the withdrawal of specification) of any defined area as a disposal site and to restrict or deny the use of any defined area for specification (including the withdrawal of specification) as a disposal site whenever it determines, after notice and opportunity for public hearing, that the discharge of such materials into such area will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas.

The procedures for implementation of CWA Section 404(c) are set forth in Title 40 of the Code of Federal Regulations (CFR) Part 231 and establish a four-step CWA Section 404(c) review process.

- **Step 1: Initial Notification.** If the EPA Regional Administrator has reason to believe, after evaluating the information available to him, that an unacceptable adverse effect could result from the specification or use of a defined area for the disposal of dredged or fill material on one or more of the statutorily listed resources, the Regional Administrator may initiate the CWA Section 404(c) review process by notifying USACE,[12] the owner(s) of record of the site, and the permit applicant (if any), that he intends to issue a public notice of a proposed determination to prohibit or withdraw the specification, or to deny, restrict, or withdraw the use for specification, whichever the case may be, of any defined area as a disposal site.
- **Step 2: Proposed Determination.** If, within 15 days of EPA's initial notification, USACE, the owner(s) of record of the site, and the applicant (if any) have not demonstrated to the satisfaction of the Regional Administrator that no unacceptable adverse effects will occur, or USACE has not notified the Regional Administrator of its intent to take corrective action to prevent an unacceptable adverse effect to his satisfaction, the Regional Administrator shall publish notice of a proposed determination in the *Federal Register*, soliciting public comment on the proposed determination and,

[12] The state would be notified here if the site is covered by an EPA-approved state program (CWA Section 404(g)) to issue permits for discharges of dredged or fill material at specified sites in waters of the United States (40 CFR 231.3(a)(1)).

where the Regional Administrator finds a significant degree of public interest in a proposed determination or that it would be otherwise in the public interest to hold a hearing, offering an opportunity for public hearing.

- **Step 3: Recommended Determination.** Following a public hearing, if one is held, and the close of the comment period, the Regional Administrator must decide whether to withdraw the proposed determination or prepare a recommended determination. If the Regional Administrator prepares a recommended determination, the Regional Administrator must forward the recommended determination and the administrative record to the Assistant Administrator for Water at EPA Headquarters.[13] If the Regional Administrator decides to withdraw the proposed determination, he must notify the Assistant Administrator for Water, who may review the withdrawal at her discretion.[14]
- **Step 4: Final Determination.** If the Regional Administrator prepares and forwards a recommended determination to the Assistant Administrator for Water, the Assistant Administrator for Water will review the recommended determination of the Regional Administrator and the information in the administrative record. The Assistant Administrator for Water will also consult with USACE, the owner(s) of record of the site, and the applicant (if any). Following consultation and consideration of the record, the Assistant Administrator for Water will make the final determination affirming, modifying, or rescinding the recommended determination.

EPA has developed this final determination to prohibit the specification of and restrict the use for specification of certain waters in the Bristol Bay watershed as a disposal site for the discharge of dredged or fill material associated with developing the Pebble deposit, a large ore body in southwest Alaska. The EPA Assistant Administrator for Water is exercising her authority under Section 404(c) of the CWA and its implementing regulations at 40 CFR Part 231 because she has determined that certain discharges of dredged or fill material associated with developing the Pebble deposit will have

[13] In 1984, the EPA Administrator delegated the authority to make final determinations under CWA Section 404(c) to EPA's national CWA Section 404 program manager, who is the Assistant Administrator for Water. That delegation remains in effect. With regard to EPA's CWA Section 404(c) action for the Pebble deposit area, on March 22, 2019, former Administrator Wheeler delegated to the General Counsel the authority to perform all functions and responsibilities retained by the Administrator or previously delegated to the Assistant Administrator for Water related to that action due to the recusals of former Administrator Wheeler and former Assistant Administrator for Water David Ross from participation in matters related to Pebble Mine, which is associated with the Pebble deposit area. The Administrator rescinded the March 22, 2019 one-time delegation on May 17, 2022, because neither the current Administrator nor the current Assistant Administrator for Water have such recusals in place. As a result, the 1984 delegation controls and all functions and responsibilities retained by the Administrator related to the Pebble deposit are delegated to the Assistant Administrator for Water.

[14] If within 10 days of the Regional Administrator notifying the Assistant Administrator for Water of his decision to withdraw the proposed determination, the Assistant Administrator for Water does not notify the Regional Administrator of her intent to review such withdrawal, the Regional Administrator shall give public notice of the withdrawal of the proposed determination. If the Assistant Administrator for Water does decide to review, the Regional Administrator or his designee shall forward the administrative record to the Assistant Administrator for Water for a final determination.

unacceptable adverse effects on anadromous[15] fishery areas in the South Fork Koktuli River (SFK), North Fork Koktuli River (NFK), and Upper Talarik Creek (UTC) watersheds which are located within the Bristol Bay watershed.

This final determination represents Step 4 in the process described previously. In this final determination, the EPA Assistant Administrator for Water (1) prohibits the specification of a defined area as a disposal site, and (2) restricts the use of a defined area for specification as a disposal site because she has determined that certain discharges of dredged or fill material associated with developing the Pebble deposit into these defined areas will have unacceptable adverse effects on anadromous fishery areas.

This final determination is organized as follows.

- Section 2 provides background information on the Pebble deposit, a large, low-grade, porphyry copper deposit that underlies portions of the SFK, NFK, and UTC watersheds; a description of the mine plan developed by the Pebble Limited Partnership (PLP) in support of its CWA Section 404 permit application (the 2020 Mine Plan); a timeline of key events related to the Pebble deposit; and a summary of EPA's actions taken related to CWA Section 404(c) in this case.
- Section 3 provides an overview of the streams, wetlands, and other aquatic resources of the Bristol Bay watershed and discusses their role in supporting important subsistence, commercial, and recreational fisheries. It also describes the streams, wetlands, and other aquatic resources of the SFK, NFK, and UTC watersheds within the Bristol Bay watershed and discusses how they are integral to maintaining the productivity, integrity, and sustainability of both salmon and non-salmon fishery resources. This section also describes how salmon population diversity and dynamics interact to create a portfolio of biological assets resulting in a sustainable fishery.
- Section 4 describes the basis for EPA's determination that the direct and secondary effects of the discharges of dredged or fill material evaluated in this final determination into certain streams, wetlands, and other aquatic resources of the SFK, NFK, and UTC watersheds will have unacceptable adverse effects on anadromous fishery areas in those watersheds. These unacceptable adverse effects include the permanent loss of and damage to streams, wetlands, and other aquatic resources that are important for supporting anadromous fish habitat.
- Section 5 presents the prohibition and the restriction, which are designed to prevent unacceptable adverse effects on anadromous fishery areas in the SFK, NFK, and UTC watersheds that will result from the discharges of dredged or fill material evaluated in this final determination.
- Section 6 identifies other concerns and information that, while not the basis for EPA's final determination, are related to discharges of dredged or fill material evaluated in this final

[15] Anadromous fishes are those that hatch in freshwater habitats, migrate to sea for a period of relatively rapid growth, and then return to freshwater habitats to spawn. For the purposes of this final determination, "anadromous fishes" refers only to Coho or Silver salmon (*Oncorhynchus kisutch*), Chinook or King salmon (*O. tshawytscha*), Sockeye or Red salmon (*O. nerka*), Chum or Dog salmon (*O. keta*), and Pink or Humpback salmon (*O. gorbuscha*).

determination. Such concerns include potential impacts on subsistence resources, environmental justice issues, traditional ecological knowledge, as well as potential spills and failures associated with mine infrastructure at the Pebble deposit. Section 6 also includes other concerns and considerations related to the potential for the discharges of dredged or fill material evaluated in this final determination to result in adverse effects on wildlife, recreation, or public water supplies.

- Section 7 provides the conclusion for the final determination.
- Section 8 lists references cited in the final determination.

SECTION 2. PROJECT DESCRIPTION AND BACKGROUND

2.1 Project Description

2.1.1 Overview of the Pebble Deposit

Several known mineral deposits are located in the Nushagak and Kvichak River watersheds (EPA 2014, USACE 2020a, Kalanchey et al. 2021). The deposit types occurring or likely to occur in the region include porphyry copper, intrusion-related gold, and copper and iron skarn. The potential for mining development within these watersheds appears to be greatest for the Pebble deposit because significant exploration activity has occurred at this deposit for many years and a significant amount of information about this deposit is available.

The Pebble deposit is a large, low-grade deposit containing copper-, gold-, and molybdenum-bearing minerals that underlies portions of the SFK, NFK, and UTC watersheds. The SFK and NFK watersheds are part of the Nushagak River watershed, and the UTC watershed is part of the Kvichak River watershed (Figure ES-2). Extraction at the Pebble deposit would involve the creation of a large open pit and the production of large amounts of waste rock and mine tailings (USACE 2020a).

The Pebble deposit extends over an area of at least 1.9 by 2.8 miles and consists of two contiguous segments, Pebble West and Pebble East (Ghaffari et al. 2011). The approximate center of the deposit is about 9.2 miles north–northeast of Sharp Mountain and 18.7 miles northwest of Iliamna. It covers portions of sections 14 to 16, 20 to 23, and 26 to 29, T. 3 S., R. 35 W., Seward Meridian.[16] The full extent of the Pebble deposit is not yet defined, but Kalanchey et al. (2021) indicate that the Pebble mineral resource may approach 11 billion tons of ore.

PLP holds the largest mine claim block in the Nushagak and Kvichak River watersheds. In 2017, PLP submitted a CWA Section 404 permit application to USACE to develop a mine at the Pebble deposit, which triggered USACE's development of a Final Environmental Impact Statement (FEIS) pursuant to the National Environmental Policy Act (NEPA). As discussed in Section 2.2.1, PLP revised its application during the NEPA and CWA Section 404 review processes, and the final revision (the 2020 Mine Plan) was submitted to USACE in June 2020.

[16] Mine claims may be located by what is known as aliquot part legal description, which is meridian, township, range, section, quarter section, and if applicable quarter-quarter section. These claims are known as MTRSC locations, and they are generally located using global positioning system (GPS) latitude and longitude coordinates. A quarter section location is typically about 160 acres in size, and a quarter-quarter section location is typically 40 acres in size (ADNR 2022a).

2.1.2 Overview of the 2020 Mine Plan

This section describes the 2020 Mine Plan, as presented in PLP's June 8, 2020 CWA Section 404 permit application to USACE (PLP 2020b).[17] The 2020 Mine Plan is evaluated in USACE's FEIS and is identified in the FEIS as Alternative 3 – North Road Only Alternative, Concentrate Pipeline and Return Pipeline Variant.

In the 2020 Mine Plan, PLP proposes to develop the Pebble copper-gold-molybdenum porphyry deposit as a surface mine. The closest communities are the villages of Iliamna, Newhalen, and Nondalton, each of which is approximately 17 miles from the deposit (USACE 2020b). The 2020 Mine Plan would progress through four distinct phases: construction, operations (also referred to as production), closure, and post-closure. The construction period would last approximately 4 years, followed by 20 years of operation. Closure, including physical reclamation of the mine site, is projected to take approximately 20 years. Post-closure activities, including long-term water management and monitoring, is expected to last for centuries (USACE 2020a).

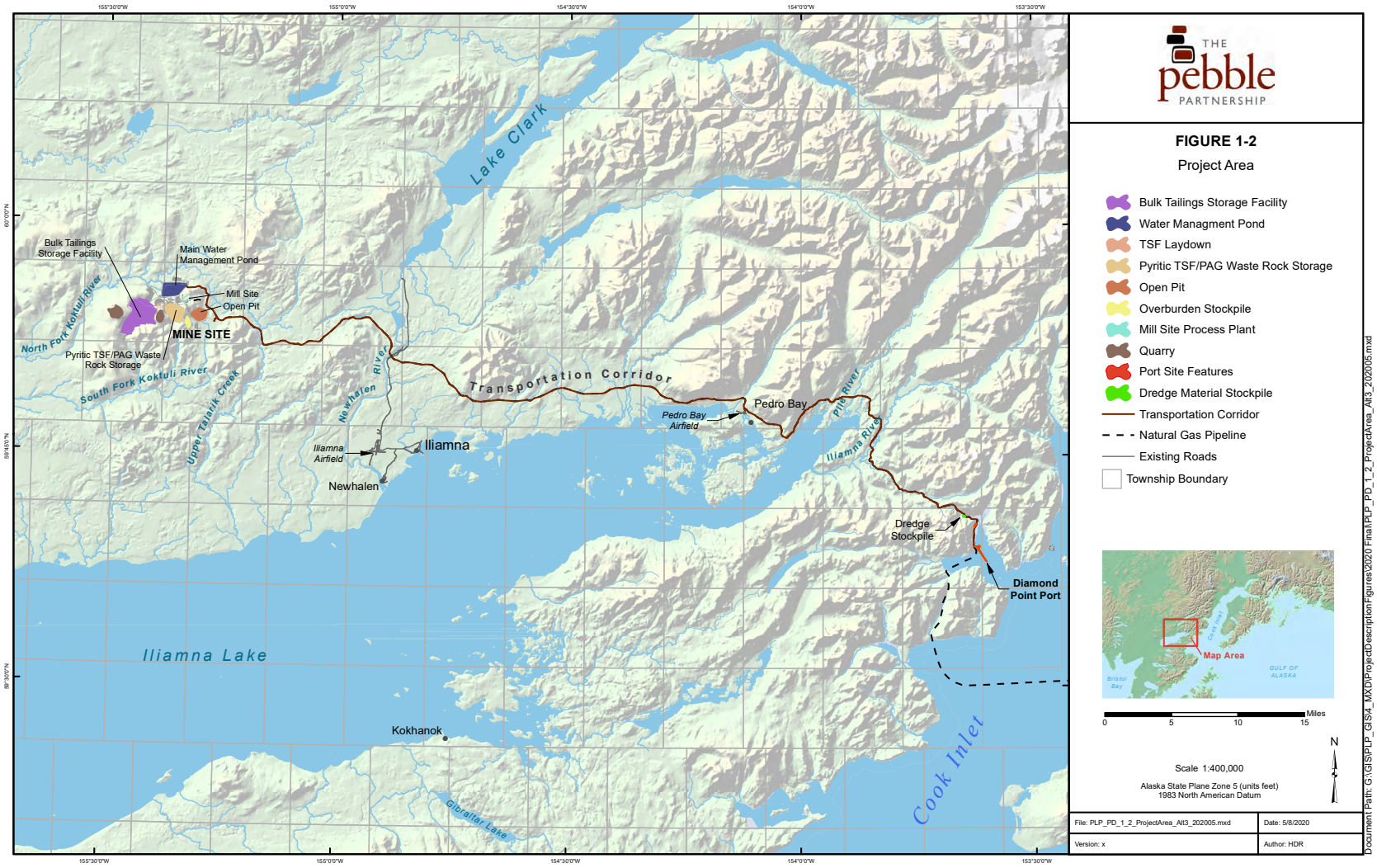
The project consists of four primary elements: the mine site; the Diamond Point port; the transportation corridor, including concentrate and water return pipelines; and the natural gas pipeline and fiber optic cable (Figure 2-1). Between 2018 and 2020, EPA reviewed all four of the primary elements of the 2020 Mine Plan as part of its review of PLP's CWA Section 404 permit application (EPA 2019a), the Draft Environmental Impact Statement (DEIS) (EPA 2019b) and other documents related to the NEPA review, and during the 12-week coordination process with USACE in spring 2020 to evaluate PLP's proposed project for compliance with the CWA Section 404(b)(1) Guidelines. In its Record of Decision (ROD) denying PLP's CWA Section 404 permit application, USACE specifically finds that the discharges of dredged or fill material at the mine site associated with the 2020 Mine Plan would cause significant degradation to the aquatic ecosystem pursuant to the Guidelines (USACE 2020b). Similarly, EPA focused its evaluation during the CWA Section 404(c) process on the adverse effects of the discharges of dredged or fill material proposed at the mine site because, based on the review of the available information, the adverse effects on anadromous fishery areas associated with mine site discharges would be the most significant of the four primary elements of the 2020 Mine Plan.

2.1.2.1 Mine Site

According to USACE, the 2020 Mine Plan is proposed to be a conventional drill, blast, truck, and shovel operation with a mining rate of up to 73 million tons of ore per year. Approximately 1,300 million tons of mineralized rock and 150 million tons of waste rock and overburden would be mined over the project's life. The mineralized material would be crushed and sent to a coarse ore stockpile to feed the process plant. The process plant would include grinding and flotation steps, with a processing rate of up to 66 million tons per year, to produce on average 613,000 tons of copper-gold concentrate and 15,000 tons of molybdenum concentrate annually (USACE 2020b).

[17] Pebble Project Department of the Army Application for Permit POA-2017-00271.

Figure 2-1. Project area map. Figure 1-2 from PLP's June 8, 2020 Clean Water Act Section 404 permit application (PLP 2020b).



The fully developed mine site would include an open pit, bulk tailings storage facility (TSF), pyritic TSF, a 270-megawatt power plant, water management ponds (WMPs), water treatment plants (WTPs), and milling/processing facilities, as well as supporting infrastructure. Non-potentially acid generating and non-metal leaching waste rock would be used in the construction of infrastructure needed to support the mine. In addition to waste rock, three quarries (material sites) would be needed (USACE 2020b) (Figure ES-4).

Bulk tailings would be placed in the bulk TSF, while pyritic tailings would be placed in the lined pyritic TSF. Potentially acid generating (PAG) and metal leaching waste rock would be stored in the lined pyritic TSF until closure, when it would be back-hauled into the open pit. The bulk TSF would have two embankments: the main embankment, constructed using the centerline construction method; and the south embankment, constructed using the downstream construction method to facilitate lining of the upstream face. The pyritic TSF would be fully lined and would have three embankments constructed using the downstream method (USACE 2020b).

Soils and other overburden would be stored in stockpile areas at various locations throughout the site. Stockpiled soils and other overburden would be used for reclamation during mine closure. The proposed mine site is currently undeveloped and is not served by any transportation or utility infrastructure (USACE 2020b).

According to USACE, PLP would manage water flows through the mine area, while providing a water supply for operations. PLP would capture runoff water contacting the facilities at the mine site and water pumped from the open pit, then either reuse the water in the milling process or treat the water before releasing it to surface waters (USACE 2020b).

The open-pit area would be dewatered through groundwater withdrawal from approximately 30 groundwater wells installed around the open-pit perimeter. As the pit is deepened, dewatering would continue via in-pit ditches, in-pit wells, and/or perimeter wells. The water level in the open pit would continue to be managed via pumping of groundwater wells and transfer to the open-pit WMP (USACE 2020b).

As described by USACE, mine facilities would be closed at the end of operations and reclaimed. Reclamation and closure of the project would fall under the jurisdiction of Alaska Department of Natural Resources (ADNR) Division of Mining, Land, and Water and the Alaska Department of Environmental Conservation (ADEC). The Alaska Reclamation Act (Alaska Statute 27.19) is administered by ADNR. It applies to state, federal, municipal, and private land, as well as water subject to mining operations. PLP has prepared a Reclamation and Closure Plan providing guidelines for implementing stabilization and reclamation procedures for various facilities associated with the project (USACE 2020a: Appendix M4.0). USACE indicates that revisions to PLP's Reclamation and Closure Plan may be necessary to address changes during preliminary and detailed design work and state permitting (USACE 2020b). ADNR would be responsible for approving PLP's Reclamation and Closure Plan.

2.1.2.2 Evaluation of Location Options for a Mine Site at the Pebble Deposit

As part of considering alternatives in the Environmental Impact Statement (EIS) and CWA Section 404 processes, USACE evaluated multiple locations throughout the SFK, NFK, and UTC watersheds for siting various components associated with a mine site at the Pebble deposit (USACE 2020a: Section 2 and Appendix B). Siting criteria used to select options varied based on the mine component under consideration but included factors related to potential site capacity, total footprint and catchment area, distance from other mine site components, and ground/substrate conditions. Screening criteria, including overall project purpose, practicability, and environmental impacts, were applied to the range of options and locations identified during the EIS process to narrow the range of alternatives considered in the NEPA and CWA Section 404 analyses.

For example, 26 land options were initially evaluated as potential TSF locations and "detailed information" was provided for each (USACE 2020a: Page B-83). Twenty-three of these options were located at sites within the SFK, NFK, and UTC watersheds (Figure 2-2). The 26 options were compared to the TSF locations put forth in PLP's permit application, and all were rejected. Seven of the options were determined not to be practicable (i.e., not feasible due to inappropriate substrate conditions or inadequate capacity). The remaining options "would all increase the wetlands and stream miles filled when compared to the proposed project" and "would pose risks similar to the proposed project in the event of a tailings dam failure" (USACE 2020a: Page B-84). Similarly, seven alternate locations for the main WMP were evaluated and detailed information was provided for each. All seven options were located within the SFK, NFK, and UTC watersheds (USACE 2020a: Appendix B) (Figure 2-3), and all were rejected because detailed evaluation found them to be "not reasonable or not feasible" (USACE 2020a: Page B-91).

Figure 2-2. Optional locations for siting the Bulk Tailing Storage Facility evaluated within the FEIS. Figure 1.0 from PLP (2018d: RFI 069).

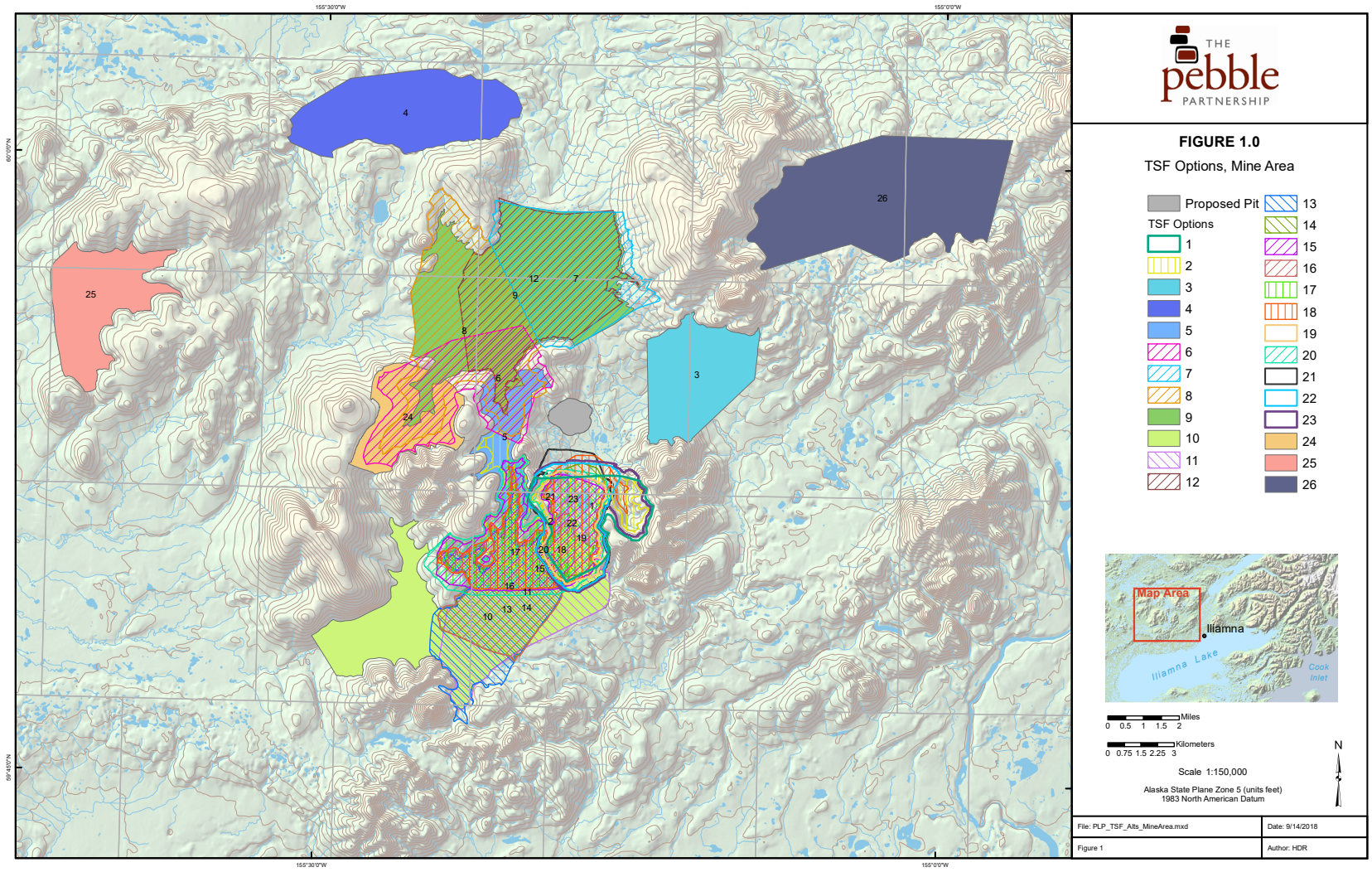
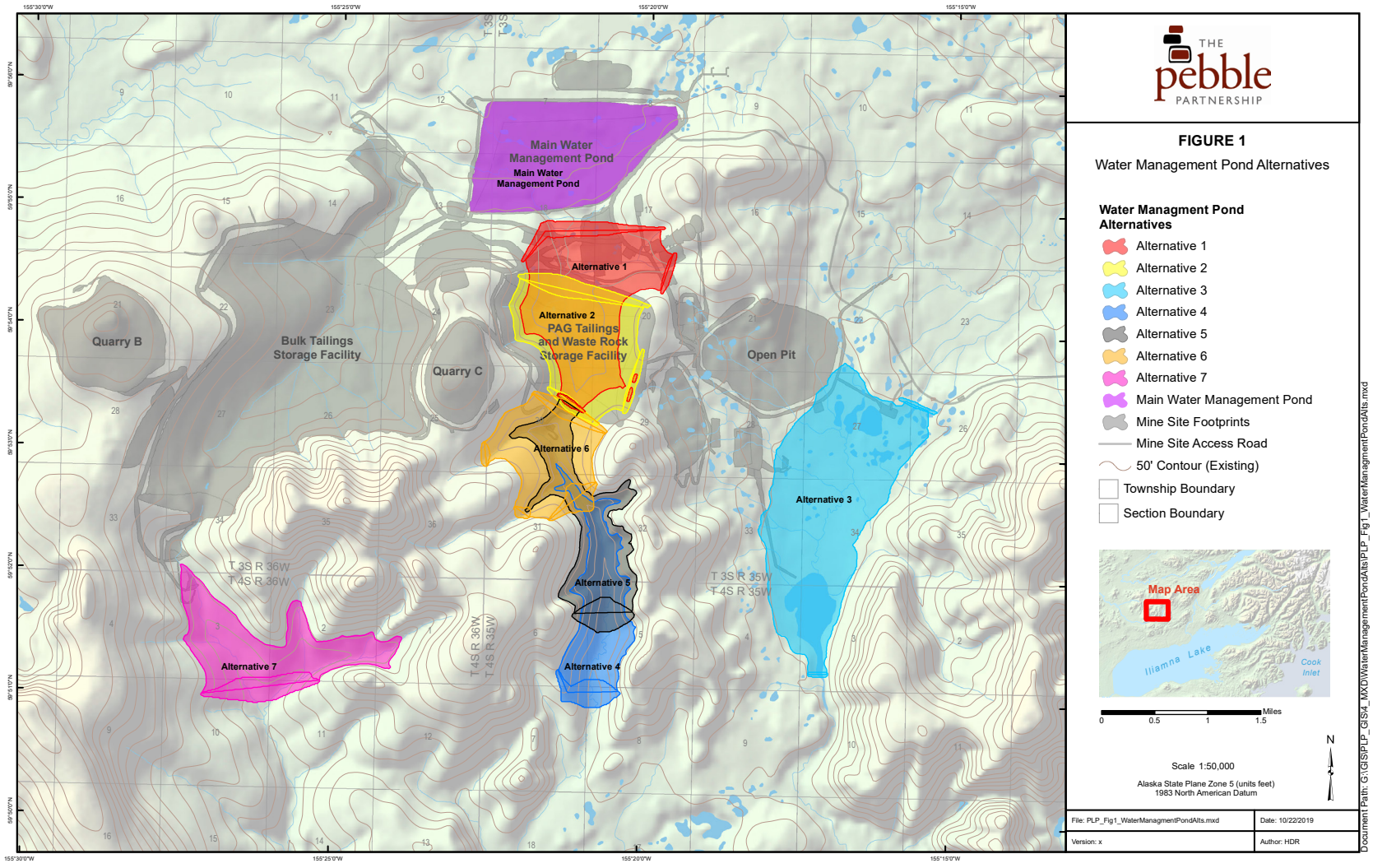


Figure 2-3. Optional locations for siting the Main Water Management Pond evaluated within the FEIS. Figure 1 from PLP (2019d: RFI 150).



2.2 Background

2.2.1 Timeline of Key Events Related to the Pebble Deposit (1984–October 2021)

In 1984, the State of Alaska adopted the *Bristol Bay Area Plan for State Lands* (BBAP). The 1984 BBAP placed fish and wildlife habitat and harvest as a primary use throughout the Bristol Bay study area (ADNR 1984a). To carry out its goals, the 1984 BBAP included Mineral Closing Order (MCO) 393, along with 18 other MCOs, which closed the stream channel plus 100 feet on either side of designated anadromous reaches of 64 streams in the Bristol Bay region to new mineral entry. Implementing MCO 393 was consistent with ADNR's determination that new mineral entry "creates an incompatible surface use conflict with salmon propagation and production, and jeopardizes the economy of the Bristol Bay region and the management of the commercial, sport, and subsistence fisheries in the Bristol Bay area" (ADNR 1984b: Page 2). The BBAP was subsequently amended in 2005 and 2013, but the MCOs established by the initial 1984 BBAP were not affected by these amendments.[18] While the protections associated with MCO 393 apply to portions of the SFK, NFK, and UTC located downstream of the Pebble deposit,[19] the portions of SFK, NFK, and UTC and their tributaries that overlie the Pebble deposit and would be directly affected by the 2020 Mine Plan are not covered by MCO 393.

The Pebble deposit was first explored by Cominco Alaska, a division of Cominco Ltd, now Teck, between 1985 and 1997, with exploratory drilling between 1988 and 1997 (Ghaffari et al. 2011). In November 1987, Teck staked claims in the Pebble prospect and added claims to that area in July 1988. In 2001, Northern Dynasty Minerals Ltd. (NDM) acquired claims related to the Pebble deposit. From 2001 to 2019, NDM, and subsequently PLP,[20] conducted significant mineral exploration at the Pebble deposit, including deposit delineation, and developed environmental, socioeconomic, and engineering studies of the Pebble deposit (Kalanchey et al. 2021).

Beginning in 2004, NDM engaged with USACE in pre-CWA Section 404 permit application meetings. Through these meetings, USACE confirmed that NDM/PLP would need a CWA Section 404 permit to develop a mine at the Pebble deposit and that the permit review process would include a public interest

[18] The 2013 BBAP designates land uses in the footprint of the 2020 Mine Plan. The 2013 BBAP specifies that these lands are to be retained in public ownership and managed for multiple uses—including recreation, timber, minerals, and fish and wildlife—as well as natural scenic, scientific, and historic values (USACE 2020b). This specification does not preclude construction of the mine and related facilities, and the State of Alaska has made no specific determinations whether the 2020 Mine Plan is consistent with the BBAP (USACE 2020b).

[19] Specifically, MCO 393 closed the designated anadromous portions of the South Fork Koktuli River (AWC # 325-30-10100-2202-3080), North Fork Koktuli River (AWC # 325-30-10100-2202-3080-4083), and Upper Talarik Creek (AWC # 324-10-10150-2183), as well as any state-owned lands 100 feet from ordinary high water (on both sides of the stream) to new mineral entry (ADNR 1984b).

[20] PLP was created in 2007 by co-owners NDM and Anglo American PLC to design, permit, construct, and operate a long-life mine at the Pebble deposit (Ghaffari et al. 2011). In 2013, NDM acquired Anglo American's interest in PLP, and NDM now holds a 100 percent interest in PLP (Kalanchey et al. 2021).

review, development of an environmental document in accordance with NEPA, and a review for compliance with the CWA Section 404(b)(1) Guidelines (Lestochi pers. comm.).

Also in 2004, EPA Region 10 met numerous times with NDM to discuss the potential environmental impacts associated with developing a mine at the Pebble deposit, including early environmental baseline study plans and preparation for the review of the mine project pursuant to NEPA and Section 404 of the CWA. Later that year, NDM established and began coordinating a Baseline Environmental Team of federal and state agency technical staff, including EPA Region 10, to continue reviewing the draft environmental baseline study plans. NDM also provided periodic updates on its process to develop a mine, as well as findings from its environmental baseline studies and findings related to cultural resources that could be affected.

In 2006, NDM submitted water rights permit applications to ADNR for water rights to use UTC and the Koktuli River in mining operations (NDM 2006). In total, NDM applied for rights to approximately 35 billion gallons of groundwater and surface water per year (ADNR 2022b).

Between 2007 and 2010, nine state and federal agencies, including Alaska Department of Fish and Game (ADF&G), ADNR, National Marine Fisheries Service (NMFS), National Park Service (NPS), USACE, U.S. Fish and Wildlife Service (USFWS), and EPA Region 10 participated in the Pebble Project Technical Working Group, which was formed by PLP to facilitate coordinated agency review of environmental studies to support future NEPA and subsequent permitting actions (ADNR 2022b).

On May 2, 2010, former EPA Administrator Lisa P. Jackson and former Region 10 Regional Administrator Dennis McLerran received a letter from six federally recognized Bristol Bay tribal governments requesting that EPA initiate a process under Section 404(c) of the CWA to protect waters, wetlands, fishes, wildlife, fisheries, subsistence, and public uses in the Nushagak and Kvichak River watersheds and Bristol Bay from metallic sulfide mining, including a potential Pebble mine. Signatories included Nondalton Tribal Council, New Stuyahok Traditional Council, Levelock Village Council, Ekwok Village Council, Curyung Tribal Council, and Koliganek Village Council. Subsequently, three additional federally recognized Bristol Bay tribal governments signed this letter: Native Village of Ekuk, Village of Clark's Point, and Twin Hills Village Council.

Following the letter from the tribes, EPA and former President Obama received numerous letters from additional partners and stakeholders expressing their interests and concerns regarding potential EPA action to protect Bristol Bay fishery resources. Some requests favored immediate action to comprehensively protect Bristol Bay, including a public process under Section 404(c) of the CWA. Others favored a targeted CWA Section 404(c) action that would restrict only mining associated with the Pebble deposit. In addition to other Bristol Bay tribes, EPA received letters from the Bristol Bay Native Association, the Bristol Bay Native Corporation, other tribal organizations, stakeholder groups dependent on the fishery (i.e., commercial and recreational fishers, seafood processors and marketers, chefs and restaurant and supermarket owners, and sport fishing and hunting lodge owners and guides), sporting goods manufacturers and vendors, a coalition of jewelry companies, conservation organizations, members of the faith community, and elected officials from Alaska and other states.

Other requests received during this time urged EPA to refrain from taking action under CWA Section 404(c). These requests included those that asked for more time to understand potential implications of mine development in the Bristol Bay watershed. Others requested EPA wait until formal mine permit applications had been submitted and an EIS had been developed. These requestors included four federally recognized Bristol Bay tribal governments (Newhalen Tribal Council, South Naknek Tribal Council, King Salmon Traditional Village Council, and Iliamna Village Council), other tribal organizations, former Governor Parnell of Alaska, and attorneys representing PLP.

In response to requests, EPA met with tribal governments and stakeholders, including those that supported and those that opposed a mine at the Pebble deposit, to hear their concerns and receive any information they wished to provide. These meetings occurred in the villages in the Bristol Bay watershed and in Anchorage, Alaska, Seattle, Washington, and Washington, DC.

Former EPA Administrator Jackson and former Region 10 Regional Administrator McLerran visited Alaska in August 2010 to learn about the challenges facing rural Alaska towns and Alaska Native villages. Their itinerary included a meeting with PLP for a briefing on the proposed mining of the Pebble deposit. They also visited Dillingham, where they participated in two listening sessions, one specifically for tribal leaders from Bristol Bay and one meeting open to all local and regional entities.

In February 2011, NDM submitted a preliminary assessment for mining the Pebble deposit to the U.S. Securities and Exchange Commission (SEC) (SEC 2011) entitled *Preliminary Assessment of the Pebble Project, Southwest Alaska* (Ghaffari et al. 2011). The preliminary assessment described three stages of mine development at the Pebble deposit: an initial 2-billion-ton mine consisting of 25 years of open-pit mining, a 3.8-billion-ton mine consisting of 45 years of open-pit mining, and a 6.5-billion-ton mine consisting of 78 years of open-pit mining. The preliminary assessment also indicated that the total Pebble mineral resource might approach 11 billion tons of ore.

Also in February 2011, in response to the competing requests regarding CWA Section 404(c) described previously, former Region 10 Regional Administrator McLerran announced EPA's intent to conduct a scientific assessment to evaluate how future large-scale mining projects might affect water quality and Bristol Bay's salmon fishery. This ecological risk assessment was ultimately entitled *Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska* (Bristol Bay Assessment or BBA).[21] Concurrent with this announcement, EPA Region 10 notified by letter 31 Bristol Bay tribes, ADEC, ADF&G, ADNR, the Bureau of Land Management, NMFS, NPS, USACE, USFWS, and the U.S. Geological Survey (USGS) of its intent to develop the BBA. The same week, EPA Region 10 met with Nuna Resources, which represents several Alaska Native Claims Settlement Act (ANCSA) Village Corporations,[22] and had meetings with other partners and stakeholders. NFMS, USFWS, and USGS

[21] EPA conducted the BBA consistent with its authority under CWA Section 104(a) and (b).

[22] Congress created Regional and Village Corporations (Alaska Native Corporations) to manage the lands, funds, and other assets conveyed to Alaska Natives by ANCSA.

worked closely with EPA on the development of the BBA, including authoring appendices to the BBA (see Table 2-1 for a timeline of BBA development).[23]

In December 2011, PLP provided EPA Region 10 with an advance, embargoed copy of its more than 25,000-page environmental baseline document, which presented the results of baseline studies conducted from 2004 through 2008 (PLP 2011). The environmental baseline document was designed to characterize the existing physical, chemical, biological, and social environments in the SFK, NFK, and UTC watersheds where the Pebble deposit is located, as well as the proposed mine's transportation corridor that would link the mine site to a proposed port site on Cook Inlet. The extensive environmental baseline document developed by PLP (PLP 2011) and NDM's preliminary assessment for mining the Pebble deposit that was submitted to the SEC in February 2011 (Ghaffari et al. 2011) were key resources used in the development of the BBA.

EPA's purpose in conducting the BBA was to characterize the biological and mineral resources of the Bristol Bay watershed; increase understanding of the potential impacts of large-scale mining on the region's fish resources, in terms of both day-to-day operations and potential accidents and failures; and inform future decisions by government agencies and others related to protecting and maintaining the chemical, physical, and biological integrity of the watershed. The BBA represents a review and synthesis of information available at that time to identify and evaluate potential risks of future large-scale mining development on the Bristol Bay watershed's fish habitats and populations and consequent effects on the region's wildlife and Alaska Native communities.

Table 2-1. Bristol Bay Assessment timeline.

2/7/2011	Announced intent to conduct the BBA.
8/2011	Met with Intergovernmental Technical Team to gather information to inform the scope of the BBA.
2/24/2012	Invited the public to nominate qualified experts to be considered for the external peer review panel.
3/2012	Distributed internal review draft of the BBA for Agency technical review.
5/18/2012	Released first external review draft of the BBA for public comment and external peer review.
5/31/2012 and 6/4–7/2012	Held public meetings in Dillingham, Naknek, New Stuyahok, Nondalton, Levelock, Igiugig, Anchorage, and Seattle to communicate the results of the draft BBA and receive public comments.
6/5/2012	Announced the names of the 12 independent peer reviewers to review the draft BBA and released the draft charge questions, providing the public the opportunity to comment on the draft charge questions.
8/7–9/2012	Held external peer review meeting in Anchorage.
11/2012	Released the final peer review report containing the external peer review of the May 2012 draft of the BBA.
4/30/2013	Released second external review draft of the BBA for public comment and follow-on review by external peer reviewers, to evaluate how well the second external review draft responded to peer reviewers' comments on the first external review draft.
1/15/2014	Released the final BBA and EPA Response to Peer Review Comments document.
3/21/2014	Released EPA Response to Public Comments documents.

[23] For more information about EPA's efforts in Bristol Bay or copies of the Bristol Bay Assessment, see http://www.epa.gov/bristolbay.

Meaningful engagement with tribal governments, Alaska Native Corporations, and all stakeholders was essential to ensure that EPA heard and understood the full range of perspectives on both the BBA and potential effects of mining in the region. EPA released two drafts of the BBA for public comment. Approximately 233,000 and 890,000 comments were submitted to the EPA docket during the 60-day public comment periods for the May 2012 and April 2013 drafts, respectively. EPA also held eight public comment meetings in May and June 2012 in Dillingham, Naknek, New Stuyahok, Nondalton, Levelock, Igiugig, Anchorage, and Seattle. Approximately 2,000 people attended these meetings. An overview of these meetings was shared via two webinars in July 2012.

Consistent with Executive Order 13175, entitled *Consultation and Coordination with Indian Tribal Governments,* and EPA Region 10 Tribal Consultation and Coordination Procedures (EPA 2012), EPA Region 10 invited all 31 Bristol Bay tribal governments to participate in consultation and coordination on both drafts of the BBA. Pursuant to Public Law 108-199, 118 Stat. 452, as amended by Public Law 108-447, 118 Stat. 3267, EPA also invited all 26 Alaska Native Corporations in Bristol Bay to participate in engagement on both drafts of the BBA. Throughout the development of the BBA, 20 tribal governments and one tribal consortium participated in the consultation and coordination process, and 17 Alaska Native Corporations participated in the engagement process.

The BBA also underwent external peer review by a panel of 12 independent experts (Table 2-1). The peer review panel reviewed the May 2012 draft and provided EPA with their comments. A 3-day peer review meeting was held in Anchorage on August 7 through 9, 2012, during which peer reviewers heard testimony from approximately 100 members of the public. The peer review panel also reviewed the April 2013 draft and provided EPA with a second round of comments that evaluated whether the April 2013 draft was responsive to their original comments.

In January 2014, EPA released both the final BBA (EPA 2014) and the final Response to Peer Review Comments document. In March 2014, EPA released the final Response to Public Comments documents for both the May 2012 and April 2013 drafts of the BBA.

On February 28, 2014, after careful consideration of available information, including information collected as part of the BBA, other existing scientific and technical information, and extensive information provided by stakeholders, EPA Region 10 notified USACE, the State of Alaska, and PLP that it had decided to proceed under the CWA Section 404(c) regulations, 40 CFR 231, to review potential adverse environmental effects of discharges of dredged or fill material associated with mining the Pebble deposit. EPA Region 10 stated that it was taking this step because it had reason to believe that porphyry copper mining of the scale contemplated at the Pebble deposit could result in unacceptable adverse effects on fishery areas. In accordance with the regulation at 40 CFR 231.3(a)(1), EPA Region 10 provided USACE, the State of Alaska, and PLP an opportunity to submit information for the record, to demonstrate to the satisfaction of the EPA Region 10 Regional Administrator that no unacceptable adverse effects on aquatic resources would result from discharges associated with mining the Pebble deposit, or that USACE intended to take corrective action to prevent unacceptable adverse effects satisfactory to the EPA Region 10 Regional Administrator.

Also on February 28, 2014, EPA Region 10 invited all 31 Bristol Bay tribal governments to participate in tribal consultation, and all 26 Alaska Native Corporations to participate in consultation and engagement on the 2014 Proposed Determination. In total, 17 tribal governments participated in the consultation process, and 6 Alaska Native Corporations participated in the consultation and engagement process.

EPA Region 10 held two meetings on March 25, 2014, one with PLP executives and one with the Alaska Attorney General. On April 29, 2014, PLP and the Alaska Attorney General separately provided information as part of the initial CWA Section 404(c) consultation period. In these submittals, PLP and the Alaska Attorney General raised several legal, policy, scientific, and technical issues, including questions regarding EPA's authority to initiate a CWA Section 404(c) review before PLP had submitted a CWA Section 404 permit application to USACE, the scientific credibility of the BBA, and whether the BBA should be used to inform decision-making under CWA Section 404(c). Most of the scientific and technical issues detailed in these documents had been raised before; EPA had provided responses to these issues in individual correspondence to PLP and the Alaska Attorney General and, most comprehensively, in the 400-page BBA Response to Peer Review Comments document released in January 2014 and the 1,200-page BBA Response to Public Comments documents released in March 2014.

By letter dated March 14, 2014, USACE responded to EPA's February 28, 2014 letter. In its response, USACE did not notify the Regional Administrator of its intent to take corrective action to prevent an unacceptable adverse effect.

After fully considering the April 29, 2014 submittals from PLP and the Alaska Attorney General and the March 14, 2014 letter from USACE, the EPA Region 10 Regional Administrator was not satisfied that no unacceptable adverse effect could occur and USACE did not notify the Regional Administrator of its intent to take corrective action to prevent an unacceptable adverse effect. Thus, EPA Region 10 decided to take the next step in the CWA Section 404(c) process, publication of a proposed determination.

On July 21, 2014, EPA Region 10 published in the *Federal Register* a Notice of Proposed Determination under Section 404(c) of the CWA to restrict the use of certain waters in the SFK, NFK, and UTC watersheds as disposal sites for dredged or fill material associated with mining the Pebble deposit (79 FR 42314, July 21, 2014). The notice started a public comment period that ended on September 19, 2014. EPA Region 10 also held seven hearings during the week of August 11, 2014. These hearings took place in Anchorage, Nondalton, New Stuyahok, Dillingham, Kokhanok, Iliamna, and Igiugig. More than 830 community members participated in the seven hearings, more than 300 of whom provided oral statements. In addition to testimony taken at the hearings, EPA Region 10 received more than 670,000 written comments during the public comment period, more than 99 percent of which supported the 2014 Proposed Determination. The public comments and transcripts from the public hearings can be found in the docket for the 2014 Proposed Determination.[24]

[24] Information regarding the 2014 Proposed Determination can be found in the docket for this effort at www.regulations.gov, docket ID No. EPA-R10-OW-2014-0505.

Before EPA could reach the next step in the CWA Section 404(c) review process—to either withdraw the 2014 Proposed Determination or prepare a recommended determination pursuant to 40 CFR 231.5(a)—PLP filed multiple lawsuits against the Agency. On November 25, 2014, the U.S. District Court for the District of Alaska (District Court) issued a preliminary injunction against EPA in one of those lawsuits, which halted EPA Region 10's CWA Section 404(c) review process until the case was resolved (Order Granting Preliminary Injunction at 1-2, Pebble Limited Partnership v. EPA, No. 3:14-cv-00171 (D. Alaska Nov. 25, 2014)). On May 11, 2017, EPA and PLP settled that lawsuit, as well as PLP's other outstanding lawsuits, and the court subsequently dissolved the injunction and dismissed the case with prejudice.

Under the terms of the settlement, EPA agreed to "initiate a process to propose to withdraw the Proposed Determination" by July 11, 2017. EPA also agreed not to forward a signed recommended determination to EPA Headquarters until May 11, 2021, or until EPA published a notice of USACE's FEIS on PLP's CWA Section 404 permit application for the proposed Pebble mine, whichever came first. To take advantage of this period of forbearance, PLP was required to submit its CWA Section 404 permit application to USACE within 30 months of execution of the settlement agreement.[25]

On July 11, 2017, EPA signed a *Federal Register* notice that initiated the process and proposed to withdraw the 2014 Proposed Determination. Also on July 11, 2017, EPA invited all 31 Bristol Bay tribal governments to participate in consultation and coordination, and all 26 Alaska Native Corporations to participate in consultation on the 2017 proposal to withdraw. In total, 18 tribal governments and 3 Alaska Native Corporations participated in the consultation processes.

On July 19, 2017, in accordance with the terms of the settlement agreement, EPA Region 10 published in the *Federal Register* a notice of its proposal to withdraw the 2014 Proposed Determination (82 FR 33123, July 19, 2017). EPA stated that the Agency was proposing to withdraw the 2014 Proposed Determination because it would (1) provide PLP with additional time to submit a CWA Section 404 permit application to USACE; (2) remove any uncertainty, real or perceived, about PLP's ability to submit a permit application and have that permit application reviewed; and (3) allow the factual record regarding any forthcoming permit application to develop. EPA explained that "[i]n light of the basis upon which EPA is considering withdrawal of the Proposed Determination, EPA is not soliciting comment on the proposed restrictions or on science or technical information underlying the Proposed Determination" (82 FR 33124, July 19, 2017).

The July 19, 2017 notice started a public comment period that ended on October 17, 2017. EPA also held hearings in Dillingham and Iliamna the week of October 9, 2017. EPA received more than one million public comments regarding its proposal to withdraw the 2014 Proposed Determination. Approximately 99 percent of commenters expressed opposition to the withdrawal of the 2014 Proposed Determination. The public comments, transcripts from the public hearings, and summaries of the tribal and Alaska

[25] For a copy of the settlement agreement, *see* https://www.epa.gov/bristolbay/2017-settlement-agreement-between-epa-and-pebble-limited-partnership.

Native Corporation consultations can be found in the docket for the 2017 proposal to withdraw the 2014 Proposed Determination.[26]

On December 22, 2017, PLP submitted to USACE a CWA Section 404 permit application for the discharge of dredged and fill material to waters of the United States to develop a mine at the Pebble deposit, as well as associated infrastructure (e.g., ports, roads, and pipelines). On January 5, 2018, USACE issued a public notice that provided PLP's permit application to the public and stated that an EIS would be required as part of its permit review process, consistent with NEPA. USACE also invited relevant federal, state, and local agencies, as well as tribal governments, to be cooperating agencies on the development of this EIS. EPA, the United States Coast Guard, the Bureau of Safety and Environmental Enforcement, the Advisory Council on Historic Preservation, USFWS, NPS, the Pipeline and Hazardous Materials Safety Administration, the State of Alaska, the Lake and Peninsula Borough, the Curyung Tribal Council, and the Nondalton Tribal Council accepted the USACE invitation and became NEPA cooperating agencies.

On January 26, 2018, EPA Region 10 announced a "suspension" of the proceeding to withdraw the 2014 Proposed Determination. This action was published in the *Federal Register* on February 28, 2018 (83 FR 8668, February 28, 2018).

On March 29, 2018, USACE published in the *Federal Register* a Notice of Intent to prepare an EIS and a Notice of Scoping for the Pebble Project (83 FR 13483, March 29, 2018). The EIS scoping public comment period opened on April 1, 2018 and closed on June 29, 2018. USACE received 174,889 total submissions during the scoping comment period, which are summarized in the FEIS, Appendix A. On June 29, 2018, EPA Region 10 submitted a comment letter to USACE, pursuant to the White House Council on Environmental Quality (CEQ) NEPA regulations and Section 309 of the Clean Air Act (CAA), that contained recommendations for the EIS in response to the scoping process.

On March 1, 2019, USACE released the DEIS for public comment. Also on March 1, 2019, USACE published a public notice soliciting comment on PLP's CWA Section 404 permit application (Public Notice POA-2017-00271). The public comment period for both the DEIS and the CWA Section 404 permit application opened on March 1, 2019 and closed July 1, 2019. USACE also held nine public hearings on the DEIS throughout March and April 2019. USACE received 311,885 public comments on the DEIS, which are summarized in the FEIS, Appendix D. USACE held public hearings on the DEIS in Naknek, Kokhanok, Newhalen, Igiugig, New Stuyahok, Nondalton, Dillingham, Homer, and Anchorage, Alaska.

On July 1, 2019, EPA sent a letter to USACE with its comments and recommendations on the DEIS, pursuant to EPA's review responsibilities under the CEQ NEPA regulations and CAA Section 309 (EPA 2019b). On July 1, 2019, EPA sent a separate letter to USACE with comments on the CWA Section 404 permit public notice (EPA 2019a). These EPA comment letters included more than 160 pages of comments in which EPA identified substantial potential impacts and risks of the proposed project.

[26] Information regarding the proposal to withdraw can be found in the docket for this effort at www.regulations.gov, see docket ID No. EPA-R10-OW-2017-0369.

On August 30, 2019, after conferring with EPA's General Counsel,[27] EPA Region 10 published in the *Federal Register* its decision to withdraw the 2014 Proposed Determination, thereby concluding the withdrawal process that was initiated on July 19, 2017 (84 FR 45749, August 30, 2019). EPA identified that it was withdrawing the 2014 Proposed Determination because (1) new information had been generated since 2014, including information and preliminary conclusions in USACE's DEIS, which EPA would need to consider before any potential future decision-making regarding the matter; (2) the record would continue to develop throughout the permitting process; and (3) EPA could and then had initiated the CWA Section 404(q) Memorandum of Agreement dispute resolution process[28] and it was appropriate to use that process to resolve issues before engaging in any potential future decision-making regarding the matter.

In its August 30, 2019 notice of withdrawal of the 2014 Proposed Determination, EPA stated that "[a]s in EPA's prior notices, EPA is not basing its decision-making on technical consideration or judgments about whether the mine proposal will ultimately be found to meet the requirements of the 404(b)(1) Guidelines or results in 'unacceptable adverse effects' under CWA section 404(c)" (84 FR 45756, August 30, 2019).

In October 2019, twenty tribal, fishing, environmental, and conservation groups challenged EPA's withdrawal of the 2014 Proposed Determination in the District Court. The District Court granted EPA's motion to dismiss the case.

In February 2020, USACE released the preliminary FEIS to the cooperating agencies for comment. EPA Region 10 submitted comments and recommendations to the USACE on the preliminary FEIS on March 26, 2020.

From March 12, 2020 through May 28, 2020, an interagency team of managers and scientific and technical staff from USACE, EPA, and USFWS met weekly to evaluate the proposed project for compliance with the CWA Section 404(b)(1) Guidelines.

Based on its review of the CWA Section 404(b)(1) Guidelines, USACE determined that EIS Alternative 3 (North Road Only with concentrate and return water pipelines) was the least environmentally damaging practicable alternative (LEDPA). In June 2020, PLP submitted to USACE a revised permit application (i.e., the 2020 Mine Plan) to incorporate changes to the project based on USACE's LEDPA determination

[27] See footnote 13 in Section 1.

[28] CWA Section 404(q) directs the Secretary of the Army to enter into agreements with various federal agencies, including EPA "to minimize, to the maximum extent practicable, duplication, needless paperwork, and delays in the issuance of permits under this section" (33 U.S.C. 1344(q)). EPA and USACE have entered into various agreements pursuant to Section 404(q). The operative agreement was entered in 1992. Part IV, paragraph 3 of the 1992 EPA and Army Memorandum of Agreement to implement Section 404(q) (hereinafter referred to as the "404(q) MOA") sets forth the "exclusive procedures" for elevation of individual permits cases (EPA and DA 1992).

(USACE 2020b). USACE determined that the changes to the project described in the revised permit application were not significant enough to warrant development of a Supplemental DEIS.[29]

On July 24, 2020, USACE published a Notice of Availability for the FEIS in the *Federal Register* (USACE 2020a).

On November 20, 2020, USACE issued its ROD denying PLP's CWA Section 404 permit application on the basis that the proposed project would not comply with the CWA Section 404(b)(1) Guidelines and would be contrary to the public interest (USACE 2020b). The USACE permit denial addresses only PLP's specific permit application. By letter dated November 25, 2020, USACE notified PLP that the proposed project failed to comply with the CWA Section 404(b)(1) Guidelines because "the proposed project would cause unavoidable adverse impacts to aquatic resources which would result in Significant Degradation to aquatic resources" (USACE 2020b: Transmittal Letter, Page 1) and that PLP's compensatory mitigation plan submitted to USACE on November 4, 2020, did not alter that finding.

On January 19, 2021, PLP filed a request for an appeal of the USACE permit denial with USACE, pursuant to 33 CFR Part 331. USACE accepted the appeal on February 25, 2021. USACE's review of the appeal is ongoing.

On June 17, 2021, the Ninth Circuit Court of Appeals reversed the District Court's decision to dismiss the tribal, fishing, environmental, and conservation groups' challenge to EPA's withdrawal of the 2014 Proposed Determination. The Ninth Circuit concluded that under EPA's regulations at 40 CFR 231.5(a), EPA is authorized to withdraw a proposed determination "*only* if the discharge of materials would be unlikely to have an unacceptable adverse effect." *Trout Unlimited v. Pirzadeh*, 1 F.4th 738, 757 (9th Cir. 2021) (emphasis in original). The Ninth Circuit remanded the case to the District Court for further proceedings.

On September 28, 2021, EPA filed a motion in the District Court requesting that the court vacate the Agency's 2019 decision to withdraw the 2014 Proposed Determination and remand the action to the Agency for reconsideration. The District Court granted EPA's motion on October 29, 2021.

2.2.2 Re-initiation of Clean Water Act Section 404(c) Review Process (November 2021–Present)

The District Court's vacatur of EPA's 2019 decision to withdraw the 2014 Proposed Determination had the effect of reinstating the 2014 Proposed Determination and reinitiating EPA's CWA Section 404(c) review process. Because the next step in the CWA Section 404(c) review process required the EPA Region 10 Regional Administrator to, within 30 days, decide whether to withdraw the 2014 Proposed Determination or prepare a recommended determination, EPA Region 10 published in the *Federal Register* on November 23, 2021, a notice extending the applicable time requirements through May 31, 2022, to consider available information and determine the appropriate next step in the CWA Section

[29] PLP also submitted an updated permit application to USACE in December 2019 and USACE made a similar finding at that time that a Supplemental DEIS was not warranted.

404(c) review process. In its notice, EPA concluded that it should consider information that has become available since EPA issued the 2014 Proposed Determination.

On January 27, 2022, EPA Region 10 notified USACE, ADNR, PLP, Pebble East Claims Corporation, Pebble West Claims Corporation, and Chuchuna Minerals[30] (the Parties) of EPA's intention to issue a revised proposed determination because, based on EPA Region 10's evaluation to date of available information, it continued to have reason to believe that the discharge of dredged or fill material associated with mining the Pebble deposit could result in unacceptable adverse effects on fishery areas. A copy of EPA Region 10's January 27, 2022 letter can be found in Appendix A.

Also on January 27, 2022, consistent with Executive Order 13175,[31] entitled Consultation and Coordination with Indian Tribal Governments, and EPA Region 10 Tribal Consultation and Coordination Procedures (EPA 2012), EPA Region 10 invited all 31 Bristol Bay tribal governments to participate in consultation. Separately, it also invited consultation with 5 Alaska Native Corporations and offered engagement to 21 Alaska Native Corporations with lands in the Bristol Bay watershed. EPA Region 10 hosted three informational webinars for tribal governments and one informational webinar for Alaska Native Corporations to review the CWA Section 404(c) process and answer questions. In addition, EPA Region 10 engaged in multiple consultations with tribal governments and Alaska Native Corporations from February through October 2022.

Consistent with EPA's CWA Section 404(c) regulations at 40 CFR 231.3(a)(1), EPA Region 10 provided the Parties with the opportunity to submit information for the record to demonstrate to the satisfaction of the EPA Region 10 Regional Administrator that no unacceptable adverse effects on aquatic resources would result from discharges associated with mining the Pebble deposit or that USACE intended to take corrective action to prevent unacceptable adverse effects satisfactory to the EPA Region 10 Regional Administrator. Consistent with EPA's CWA Section 404(c) regulations, EPA requested that the Parties respond by February 11, 2022. On January 29, 2022, PLP requested a total of 45 days—through March 28, 2022—to provide its submission. EPA granted this request and provided the same extension to all Parties.

EPA Region 10 met with Chuchuna Minerals on February 9, 2022, and with PLP on February 18, 2022. On March 28, 2022, ADNR, PLP, and Chuchuna Minerals separately provided information as part of the initial CWA Section 404(c) consultation period. In these submittals, ADNR, PLP, and Chuchuna Minerals raised several legal, policy, scientific, and technical issues, including questions regarding continued reliance on the 2014 Proposed Determination; EPA's authority and justification for undertaking a CWA Section 404(c) review at this time; whether the 2020 Mine Plan's potential impacts on fishery areas warrant review pursuant to CWA Section 404(c); and whether a CWA Section 404(c) action would

[30] EPA Region 10 included Chuchuna Minerals in this notification step because USACE's FEIS for the 2020 Mine Plan indicates that discharges associated with mining the Pebble deposit could expand in the future into portions of areas where Chuchuna Minerals holds mining claims.

[31] On January 26, 2021, President Biden issued the Presidential Memorandum, *Tribal Consultation and Strengthening Nation-to-Nation Relationships*, which charges each federal agency to engage in regular, meaningful, and robust consultation and to implement the policies directed in Executive Order 13175.

violate the rights established in the Alaska Statehood Act (ASA), Cook Inlet Land Exchange Act (CILEA), Alaska National Interest Lands Conservation Act (ANILCA), ANCSA, and the Federal Land Policy and Management Act (FLPMA).

USACE did not request a meeting or provide information as part of this initial CWA Section 404(c) consultation period.

Below is a brief summary of the issues raised in responses to EPA Region 10's January 27, 2022 notification letters and a brief summary of EPA's assessment of the information.

- **Continued reliance on the 2014 Proposed Determination.** PLP referred to the 2014 Proposed Determination as "obsolete," and PLP and ADNR indicated that it would not be appropriate for EPA Region 10 to continue to rely on the document. EPA Region 10 recognized that the scientific and technical record for the development of a mine at the Pebble deposit has evolved since it issued the 2014 Proposed Determination and, as stated in its November 23, 2021 *Federal Register* Notice, agreed that EPA should consider information that had become available since the Agency issued the 2014 Proposed Determination in any CWA Section 404(c) review process for the Pebble deposit area. Accordingly, based on consideration of information that had become available since the issuance of the 2014 Proposed Determination, EPA Region 10 issued the 2022 Proposed Determination.

- **EPA's authority and justification for undertaking a CWA Section 404(c) review at this time.** PLP took the position that EPA's use of CWA Section 404(c) now is unnecessary because EPA could use its CWA Section 404(c) authority later if USACE's permit denial is overturned, or if a new permit application is submitted in the future. ADNR took the position that use of CWA Section 404(c) would be premature because it believes USACE's permit denial inappropriately terminated the permit review process and that "critical information on the effects and measures the agencies would employ to avoid and minimize [project] impacts was not completed or published." EPA has fully considered these issues and provides its rationale for pursuing a CWA Section 404(c) review at this time in Section 2.2.3 of this final determination.

- **Whether the 2020 Mine Plan's potential impacts on fishery areas warrant review pursuant to CWA Section 404(c).** ADNR, PLP, and Chuchuna Minerals questioned the basis for EPA Region 10's concerns that a mine at the Pebble deposit could adversely affect fishery areas. ADNR and PLP provided quotes from the 2020 Mine Plan's FEIS, which suggest that the 2020 Mine Plan's impacts on fishes would not be "measurable." As discussed in detail in Sections 3 and 4, as well as in Appendix B of this final determination, EPA has determined that information in the FEIS and other parts of the record indicates that certain discharges of dredged or fill material associated with construction and routine operation of the 2020 Mine Plan will have unacceptable adverse effects on fishery areas.

- **Whether a CWA Section 404(c) action in this case would violate the rights established in the ASA, CILEA, ANILCA, ANCSA, and FLPMA.** ADNR and PLP took the position that any attempt by EPA to

preclude development within this area would violate the statutory compromises established in the ASA, CILEA, and ANILCA because the State of Alaska selected the lands where the Pebble deposit is located for its potential mining development and because ANILCA requires federal agencies to cooperate with the State to balance the national interest in Alaska's natural resources with recognition of Alaska's interests. For similar reasons, ADNR and PLP also took the position that restricting development of the Pebble deposit would run afoul of ANCSA because Alaska Native Corporations are required to develop and manage their lands to the benefit of their shareholders and a mine at the Pebble deposit would provide economic opportunity in the area. ADNR also argued that EPA's action would violate FLPMA by effectively withdrawing greater than 5,000 acres from mineral development without congressional approval. Nothing in the ASA, CILEA, ANILCA, ANCSA, or FLPMA, nor any other relevant authority, precludes the application of a duly enacted federal law, including Section 404(c) of the CWA, nor does any such law serve as a barrier to EPA's use of Section 404(c) of the CWA to prohibit the specification of or restrict the use for specification of defined areas as disposal sites for discharges of dredged or fill material into waters of the United States.

After fully considering the March 28, 2022 submittals from ADNR, PLP, and Chuchuna Minerals, the EPA Region 10 Regional Administrator was not satisfied that no unacceptable adverse effect could occur and USACE did not notify the Regional Administrator of its intent to take corrective action to prevent an unacceptable adverse effect. Thus, EPA Region 10 decided that the appropriate next step in the CWA Section 404(c) process for the Pebble deposit area was the publication of the 2022 Proposed Determination.

On May 26, 2022, EPA Region 10 published in the *Federal Register* a notice of availability for its 2022 Proposed Determination under Section 404(c) of the CWA to prohibit the specification of and restrict the use for specification of certain waters in the SFK, NFK, and UTC watersheds as disposal sites for the discharge of dredged or fill material associated with developing the Pebble deposit. The notice announced public hearings on the proposed determination (87 FR 32021, May 26, 2022) and started a public comment period that was scheduled to end on July 5, 2022.

On June 16 and 17, 2022, EPA Region 10 held three public hearings (in-person hearings in Dillingham and Iliamna, and one virtual hearing) on the proposed determination. More than 186 people participated in the three hearings, 111 of whom provided oral statements.

EPA Region 10 received several communications regarding an extension of the comment period, including requests to extend the comment period by 60 days and 120 days. EPA Region 10 also received requests not to extend the public comment period. EPA Region 10 considered each of these requests and found good cause existed pursuant to 40 CFR 231.8 to extend the public comment period through September 6, 2022, to provide sufficient time for all parties to meaningfully comment on the proposed determination and supporting documents. On June 30, 2022, a notice announcing extension of the public comment period and public hearing comment period was published in the *Federal Register* (87 FR 39091, June 30, 2022).

On September 6, 2022, EPA Region 10 published in the *Federal Register* a notice to extend the period for the EPA Region 10 Regional Administrator to evaluate public comments. EPA's regulations at 40 CFR 231.5(a) require that, within 30 days after the conclusion of public hearings (but not before the end of the comment period), the Regional Administrator either withdraw the proposed determination or prepare a recommended determination. Because the date of the last public hearing (June 17, 2022) was more than 30 days before the close of the public comment period (September 6, 2022), EPA would not have had time to review any of the public comments before the regulations required it to make its next decision. Accordingly, EPA Region 10 found good cause existed pursuant to 40 CFR 231.8 to extend the time period provided in 40 CFR 231.5(a) to either withdraw the proposed determination or to prepare a recommended determination through no later than December 2, 2022, to help ensure full consideration of the extensive administrative record, including all public comments (87 FR 54498, September 6, 2022).

In addition to the testimony taken at the hearings, EPA Region 10 received more than 582,000 written comments during the public comment period, approximately 99 percent of which expressed support for the proposed determination. The public comments and transcripts from the public hearings can be found in the docket for the proposed determination.[32] For more information regarding these comments and EPA's responses, see *Response to Comments on EPA's Clean Water Act Section 404(c) Determination for the Pebble Deposit Area* (EPA 2023a).

EPA Region 10 reviewed the extensive administrative record, including all public comments received on the proposed determination, and the Regional Administrator decided to prepare a recommended determination. On December 1, 2022, the Regional Administrator transmitted the recommended determination, along with its administrative record to EPA's Assistant Administrator for Water for review and final action.

On December 2, 2022, the Assistant Administrator for Water notified the Parties[33] that she had received EPA Region 10's recommended determination and the administrative record supporting the Regional Administrator's decision. Consistent with EPA's CWA Section 404(c) regulations at 40 CFR 231.6, the Assistant Administrator for Water provided the Parties with the opportunity to notify EPA of their intent to take corrective action to prevent unacceptable adverse effects on anadromous fishery areas from discharges of dredged or fill material associated with developing the Pebble deposit by December 19, 2022. A copy of EPA's December 2. 2022 letter can be found in Appendix A.

On December 12, 2022, ADNR responded to EPA's December 2, 2022 letter. In its December 12, 2022 letter, ADNR, joined by ADEC and ADF&G, expressed concern that EPA Region 10 initiated the CWA Section 404(c) action before ADF&G's Title 16 permitting process had begun, indicating that ADF&G could deny a state permit that would be required under Title 16 "should it determine that development

[32] Information regarding the proposed determination can be found in the docket for this effort at www.regulations.gov, see docket ID No. EPA-R10-OW-2022-0418.

[33] Consistent with EPA's regulations, the USACE representative who received this notification was the Chief of Engineers.

of the Pebble Deposit will result in 'any adverse effect upon fish or wildlife, or their habitat' that cannot be appropriately mitigated."

ADNR also requested an in-person meeting. EPA agreed and on December 20, 2022, the Assistant Administrator for Water and EPA staff met with representatives from ADEC, ADNR, ADF&G, and the Alaska Attorney General's office. During the December 20, 2022 meeting, representatives from the State of Alaska shared a copy of ADEC's public comment letter on the proposed determination and a letter dated December 19, 2022. In its letter dated December 19, 2022, the State reiterated its contention that EPA's CWA Section 404(c) action would violate the ASA and the CILEA and included excerpts from the legislative history of the ASA in support of its assertions. As discussed previously, nothing in the ASA or the CILEA precludes the application of a duly enacted federal law, nor do those laws serve as a barrier to EPA's use of Section 404(c) of the CWA. Federal law, including the CWA, applies to lands and mineral deposits granted to the State just as it does elsewhere.

With respect to the State of Alaska's contentions regarding Title 16, EPA's authority to make CWA Section 404(c) determinations is not contingent upon any action by the State, including independent state permitting authorities. Moreover, EPA considered all of the mitigation measures the State identified during the FEIS process, both compensatory mitigation plans submitted by PLP during the CWA Section 404 permit review process (see Section 4.3.2), as well as all potential compensatory mitigation measures identified over the past decade by PLP and others (see Appendix C) before making its determination that the discharges of dredged or fill material evaluated in the final determination will result in unacceptable adverse effects on anadromous fishery areas in the SFK, NFK, and UTC watersheds. Accordingly, because the State did not identify any mitigation measures not previously considered by EPA, the State did not propose corrective action to prevent unacceptable adverse effects satisfactory to EPA (see 40 CFR 231.6).

During the December 20, 2022 meeting, representatives from the State of Alaska reiterated the same concerns that the State raised throughout the process, including in its public comments and its December 12 and December 19, 2022 letters. EPA considered the concerns raised by the State during the December 20, 2022 meeting before issuing this final determination. For more information about the State's comments and EPA's responses see EPA's Response to Comments (EPA 2023a). On December 19, 2022, PLP responded to EPA's December 2, 2022 letter. PLP's response reiterated comments provided previously to EPA, including its contentions that EPA's action is based on "speculative impacts," that EPA's action is overly broad and vague, that EPA has failed to consider compensatory mitigation, and that "corrective action is unnecessary." PLP did not propose corrective action to prevent unacceptable adverse effects satisfactory to EPA (see 40 CFR 231.6). For more information about PLP's comments and EPA's responses see EPA's Response to Comments (EPA 2023a).

USACE and Chuchuna Minerals responded on December 16, 2022, and December 19, 2022, respectively. Neither identified any corrective actions.

EPA's Office of Water continued the tribal consultation process initiated by EPA Region 10 for this CWA Section 404(c) action. The Assistant Administrator for Water engaged in multiple consultations with

tribal governments and Alaska Native Corporations in January 2023. A summary of EPA's tribal consultation process can be found in the docket for this effort at www.regulations.gov, see docket ID No. EPA-R10-OW-2022-0418.

2.2.3 Authority and Justification for Undertaking a Clean Water Act Section 404(c) Review at this Time

Congress provided EPA with broad authority to decide whether and when to use its CWA Section 404(c) authority. CWA Section 404(c) authorizes EPA to act "whenever" it makes the required determination under the statute. 33 USC 1344(c). EPA has, since at least 1979 when the Agency promulgated its CWA Section 404(c) regulations, construed CWA Section 404(c) to authorize the Agency to prohibit, withdraw, deny, or restrict the use of any defined area for specification as a disposal site for the discharge of dredged or fill material into waters of the United States before a permit application has been submitted, at any point during the permitting process, or after a permit has been issued.[34] 40 CFR 231.1(a), (c); 44 Fed. Reg. 58076 (Oct. 9, 1979). EPA's interpretation of the statute has been upheld by the courts. *See Mingo Logan Coal Co. v. EPA*, 714 F.3d 608, 613 (D.C. Cir. 2013). In *Mingo Logan Coal Co.*, the D.C. Circuit held that CWA Section 404(c) "imposes no temporal limits" on EPA's authority to limit USACE's ability to specify disposal sites "but instead expressly empowers [EPA] to prohibit, restrict or withdraw the specification 'whenever' [it] makes a determination that the statutory "unacceptable adverse effect" will result. *Id.* at 613. Importantly, the court noted that in "[u]sing the expansive conjunction 'whenever,' the Congress made plain its intent to grant [EPA] authority to prohibit/deny/restrict/withdraw a specification *at any time.*") *Id.* (emphasis added). The court further held that the language of CWA Section 404(c) is "unambiguous" and manifests Congress's intent to confer on EPA a broad power to exercise its authority under the subsection beyond the permit process. *Id.*

Similarly, EPA's authority applies broadly to "*any* defined area." 33 USC 1344(c) (emphasis added). The CWA does not define "defined area," nor stipulate a process for identifying a "defined area." Section 404 of the CWA does, however, distinguish between disposal sites that are specified by USACE and defined areas that are identified by EPA under CWA Section 404(c), indicating Congress's intent that "defined areas" identified by EPA under CWA Section 404(c) need not derive from or be limited by the USACE permitting process. [35] *See* 33 USC 1344 (a)-(c). Instead, the phrase "defined area" in CWA Section 404(c) "merely means that a 404(c) action must be directed at a particular or identifiable area rather than

[34] 40 CFR 231.1(a) provides, in relevant part, that "[u]nder section 404(c), [EPA] may exercise a veto over the specification by the U.S. Army Corps of Engineers or by a state of a site for the discharge of dredged or fill material. [EPA] may also prohibit the specification of a site under section 404(c) with regard to any existing or potential disposal site before a permit application has been submitted to or approved by the Corps or a state. [EPA] is authorized to prohibit or otherwise restrict a site whenever [it] determines that the discharge of dredged or fill material is having or will have an 'unacceptable adverse effect' on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas." 40 CFR 231.1(c) provides, in relevant part, that EPA's CWA Section 404(c) regulations "apply to all existing, proposed or potential disposal sites for discharges of dredged or fill material into waters of the United States."

[35] "USACE does not 'define' areas through the permit process; it 'specifies' them." 44 Fed. Reg. 58077 (Oct. 9, 1979).

'wetlands' or some other generic category." 44 Fed. Reg. 58077 (Oct. 9, 1979). In fact, the Ninth Circuit noted that "[b]oth the statute and the first steps in the regulations, 40 CFR 231.3(a), grant the agency unfettered discretion" and that EPA is "free to consider—or not—the suitability of invoking its Section 404(c) authority with respect to any given geographical area." *Trout Unlimited v. Pirzadeh*, 1 F.4th 738, 758 (9th Cir. 2021). It explained that "Congress provided that '[t]he Administrator is authorized' to restrict the specification 'of any defined area . . . as a disposal site, whenever he determines, after notice and opportunity for public hearings, that the discharge of such materials into such area will have an unacceptable adverse effect' on specified resources." *Id.* at 752. "And the number of 'any defined [geographical] area[s]' is limitless, suggesting that the agency retains discretion to choose among areas of infinite variation." *Id.*

Relationship to USACE Permitting Process. CWA Section 404(c) provides EPA with independent authority, separate and apart from the USACE CWA Section 404 permitting process, to review and evaluate potential discharges of dredged or fill material into waters of the United States. While the statutory language in CWA Section 404(b) expressly makes USACE's authority "subject to subsection (c)," there is no comparable text in CWA Section 404(c) that constrains EPA's authority. The statute and EPA's CWA Section 404(c) implementing regulations provide USACE with a consultation role when EPA uses its CWA Section 404(c) authority. Furthermore, EPA's determination of unacceptable adverse effects under CWA Section 404(c) is not coterminous with the requirements that apply to USACE's permitting decisions.

Nothing in the CWA or EPA's CWA Section 404(c) regulations precludes EPA from exercising its authority where USACE has denied a permit. Although EPA's 1979 preamble to the CWA Section 404(c) regulations recognized that EPA may choose not to exercise its authority in instances "where the Regional Administrator also has reason to believe that [the] permitting authority will deny the permit" because "a 404(c) proceeding would be unnecessary," that was a statement of policy affirming EPA's discretion to decide whether or not to initiate a CWA Section 404(c) review process rather than an indication of a limitation on EPA's authority. 44 Fed. Reg. 58079 (Oct. 9, 1979). Moreover, in this instance, PLP filed an administrative appeal of USACE's CWA Section 404 permit denial on January 19, 2021. USACE's review of PLP's appeal is ongoing. Because EPA's use of its CWA Section 404(c) authority is independent from USACE's timing and actions related to a permit denial, by acting now EPA's action facilitates regulatory certainty regardless of the outcome of the permit denial appeal process and any subsequent litigation challenging a USACE final permitting decision. Furthermore, EPA has determined that each of the impacts on aquatic resources identified in Sections 4.2.1 through 4.2.4 independently will have unacceptable adverse effects. EPA's determination is therefore distinguishable from USACE's findings, and ultimately its permit denial, because, among other things, USACE reached its conclusions based on consideration of the impacts on aquatic resources identified in Sections 4.2.1 through 4.2.4 collectively rather than independently.[36]

[36] USACE's denial of PLP's permit application only addresses the 2020 Mine Plan and does not address any other potential proposal to develop the Pebble deposit.

Relationship between CWA Section 404(c) and CWA Section 404(q) Process. EPA's CWA Section 404(c) regulations authorize the Regional Administrator to initiate the CWA Section 404(c) process "after evaluating the information available to him, including any record developed under the section 404 referral process." 40 CFR 231.3(a). EPA's regulations include a comment, which states that "[i]n cases involving a proposed disposal site for which a permit application is pending, it is anticipated that the procedures of the section 404 referral process will normally be exhausted prior to any final decision of whether to initiate a 404(c) proceeding." *See comment* at 40 CFR 231.3(a)(2). EPA has explained that the reference to the "404 referral process" in the regulations is now manifested as the coordination processes EPA and USACE have established under CWA Section 404(q). 84 Fed. Reg. 45749, 45752 (August 30, 2019); *see* EPA and DA 1992.[37]

The stated purpose of the CWA Section 404(q) MOA coordination procedures is to "provide and encourage communication and full consideration of each agencies' views concerning proposed projects within the resource limits of each agency and the time constraints of the regulatory process." (EPA and DA 1992: Part II, Paragraph 1). As an initial matter, the CWA Section 404(q) MOA explicitly recognizes that it does not constrain EPA's statutory authority under CWA Section 404(c): "[t]his agreement does not diminish either Army's authority to decide whether a particular individual permit should be granted, including determining whether the project is in compliance with the Section 404(b)(1) Guidelines, or the Administrator's authority under Section 404(c) of the Clean Water Act." (EPA and DA 1992: Part I, paragraph 5). Nothing in the statute or EPA's regulations restricts EPA to considering information or concerns raised during the CWA Section 404(q) elevation process, if any. All that is required is that EPA consider any information generated during the CWA Section 404(q) MOA interagency coordination process, if applicable. Moreover, as discussed below, EPA coordinated extensively with USACE throughout the permitting process for the proposed 2020 Mine Plan and considered the information raised. Thus, EPA has satisfied the purpose of the CWA Section 404(q) coordination procedures.

EPA Policy and Precedent Regarding Use of Its CWA Section 404(c) Authority. EPA has used its CWA Section 404(c) authority judiciously, including in instances before a permit application has been submitted, at various stages during the permitting process, and after permit issuance. Prior to this final determination, EPA had initiated the process 30 times and only issued 13 final determinations in the 50 years since Congress enacted CWA Section 404(c). Each instance where EPA initiated a CWA Section 404(c) process has involved EPA's case-by-case determination of when and how to exercise its CWA Section 404(c) authority based on the specific facts of each situation consistent with applicable statutory and regulatory requirements. EPA's 1979 preamble to the CWA Section 404(c) regulations includes statements describing EPA's general policy intentions regarding the use of its CWA Section 404(c) authority. It states the following:

> EPA's announcement of intent to start a 404(c) action will ordinarily be preceded by an objection to the permit application, and under § 325.8 such objection serves to halt issuance of the permit until the matter is resolved. . . . The promulgation of regulations under 404(c) will not alter EPA's present obligations to make timely objections to permit applications

[37] See footnote 28 in Section 2.

> where appropriate. It is not the Agency's intention to hold back and then suddenly to spring a veto action at the last minute. The fact that 404(c) may be regarded as a tool of last resort implies that EPA will first employ its tool of 'first resort,' e.g., comment and consultation with the permitting authority at all appropriate stages of the permit process.
>
> 44 Fed. Reg. 58080 (Oct. 9, 1979).

The clear intention behind this policy is that EPA voice any concerns it has throughout the process. EPA has done that here, as summarized below.

EPA's actions throughout the proposed Pebble Mine project history, including during the USACE permitting process, are consistent with the policy articulated in the 1979 preamble. EPA employed its tools of first resort, including comment and coordination with USACE during the permitting process. EPA also initiated the CWA Section 404(q) process by providing USACE a CWA Section 404 "3a" letter on July 1, 2019 out of concern regarding "the extent and magnitude of the substantial proposed impacts to streams, wetlands, and other aquatic resources that may result, particularly in light of the important role these resources play in supporting the region's valuable fishery resources" (EPA 2019a: Page 3). As part of the CWA Section 404(q) MOA dispute resolution process, EPA engaged in 12 weeks of coordination with USACE—from March 2020 through May 2020—to evaluate the 2020 Mine Plan for compliance with the CWA Section 404(b)(1) Guidelines. On May 28, 2020, EPA sent a letter to USACE that had the effect of discontinuing the formal CWA Section 404(q) MOA dispute resolution process. In its May 28, 2020 letter, EPA explained that "[USACE] has demonstrated its commitment to the spirit of the dispute resolution process pursuant to the 1992 Memorandum of Agreement between EPA and the Department of the Army regarding CWA Section 404(q) by the extensive engagement with the EPA over the recent months" and its "recent commitment to continue this coordination into the future, outside of the formal dispute process." EPA's letter recognized that although there was not a need at that time for a formal dispute process, substantive discussions among USACE, EPA, and USFWS regarding compliance with the Guidelines were ongoing and the agencies were continuing to discuss and raise concerns (EPA 2020).

Timing of EPA's Action. As discussed above, Congress enacted CWA Section 404(c) to provide EPA the ultimate authority, if it chooses on a case-by-case basis, to prohibit, withdraw, deny, or restrict the use of any defined area for specification as a disposal site for the discharge of dredged or fill material into waters of the United States "whenever" the Agency makes the required determination under the statute. 33 USC 1344(c); 40 CFR 231.1 (a), (c); 44 Fed. Reg. 58076 (Oct. 9, 1979); *Mingo Logan Coal Co.*, 714 F.3d at 612-13. EPA has reviewed the available information,[38] including the relevant portions of the USACE permitting record, and this information supports EPA's determinations that the discharges of dredged

[38] 40 CFR 231.1(a) provides, in relevant part, that in making its determination that discharges of dredged or fill "[are] having or will have an 'unacceptable adverse effect' on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas," EPA "will take into account all information available to [it], including any written determination of compliance with the section 404(b)(1) Guidelines made in 40 CFR Part 230." The available information includes, among other things, pre-CWA Section 404 permit application and advance NEPA coordination meetings beginning in 2004; NDM's preliminary mine plans submitted to the SEC (Ghaffari et al. 2011, SEC 2011); PLP's initial and supplemental Environmental Baseline Documents (PLP 2011, PLP 2018a); EPA's BBA (EPA 2014); PLP's CWA Section 404 permit application (PLP 2017, PLP 2020b); and USACE's FEIS and ROD regarding PLP's permit application (USACE 2020a, USACE 2020b).

or fill material evaluated in this final determination will have unacceptable adverse effects on anadromous fishery areas in the SFK, NFK, and UTC watersheds.

By acting now, EPA makes clear its assessment of the effects of certain discharges of dredged or fill material associated with developing the Pebble deposit into certain waters of the United States within the SFK, NFK, and UTC watersheds in light of the significant loss of and damage to important anadromous fishery areas. The federal government, the State of Alaska, federally recognized tribal governments, PLP, and many other interested stakeholders have devoted significant resources over many years of study, engagement, and review. Considering the extensive record, it is not efficient or effective to engage in one or more additional multi-year NEPA or CWA Section 404 processes for future proposals to discharge dredged or fill material associated with developing the Pebble deposit into waters of the United States within the SFK, NFK, or UTC watersheds that will result in adverse effects that EPA has already determined are unacceptable. By acting now, based on an extensive and carefully considered record, EPA promotes regulatory certainty for all stakeholders, including USACE and the regulated community; facilitates planning by proponents; and avoids unnecessary expenditure of additional resources by all interested parties. *See* 44 FR 58077.[39] Ultimately, by acting now, EPA also facilitates "comprehensive rather than piecemeal protection" of important aquatic resources, *see id.*, by ensuring the protection of valuable anadromous fishery areas in the SFK, NFK, and UTC watersheds against unacceptable adverse effects from the discharges evaluated in this final determination.

[39] EPA explicitly acknowledged in the preamble to its 1979 CWA Section 404(c) regulations that among other strong reasons to exercise its CWA Section 404(c) authority pre-permit was "eliminating frustrating situations in which a proponent spends time and money developing a project for an inappropriate site . . . ." 44 Fed. Reg. 58077 (Oct. 9, 1979).

SECTION 3. IMPORTANCE OF THE REGION'S ECOLOGICAL RESOURCES

The Bristol Bay watershed represents a largely pristine, intact ecosystem with outstanding ecological resources. It is home to at least 29 fish species, more than 40 terrestrial mammal species, and more than 190 bird species (Woody 2018). This ecological wealth supports a number of sustainable economies that are of vital importance to the region, including subsistence, commercial, and sport fishing; subsistence and sport hunting; and non-consumptive recreation. The undisturbed habitats of the Bristol Bay watershed support one of the last salmon-based cultures in the world (EPA 2014: Appendix D), and the subsistence way of life in this region is irreplaceable. Between 2013 and 2019, the annual economic output generated by Bristol Bay's wild salmon resources was estimated at more than $1 billion (Wink Research and Consulting 2018, McKinley Research Group 2021), with total economic value (including subsistence uses) estimated at more than $2 billion in 2019 (McKinley Research Group 2021).

The following sections consider the Bristol Bay watershed's ecological resources, with particular focus on the region's fish habitats and populations and the watershed characteristics that support these resources. Given the connected and spatially nested structure of watersheds (EPA 2015), the migratory nature of many of the region's fish populations, and the importance of evaluating fish-habitat relationships across spatial scales (Bryant and Woodsmith 2009, Jackson and Fahrig 2015, Hale et al. 2019), these ecological resources are considered at multiple geographic scales.

The Pebble deposit is located in the Bristol Bay watershed, in the headwaters of tributaries to both the Nushagak and Kvichak Rivers. The three tributaries that originate within the Pebble deposit are the SFK, which drains the western part of the Pebble deposit area and converges with the NFK west of the Pebble deposit; the NFK, located immediately west of the Pebble deposit; and UTC, which drains the eastern portion of the Pebble deposit and flows into the Kvichak River via Iliamna Lake.[40] The SFK, NFK, and UTC watersheds are the areas that would be most directly affected by mine development at the Pebble deposit, as well as the watersheds within which the most extensive physical, chemical, and biological data have been collected to date (e.g., PLP 2011, PLP 2018a, USACE 2020a). Streams and wetlands in each of the SFK, NFK, and UTC watersheds provide habitat for five species of Pacific salmon and numerous other fish species. Each of these headwater watersheds also supports fish habitats and populations in larger downstream systems via contributions of water, organisms, organic matter, and other resources.

[40] The SFK comprises two 12-digit hydrologic unit codes (HUCs): the Headwaters Koktuli River (190303021101) and the Upper Koktuli River (109303021102). The NFK comprises two 12-digit HUCs: Groundhog Mountain (190303021103) and one 12-digit HUC located immediately west of the Pebble deposit (190303021104). UTC represents one 10-digit HUC (1903020607).

3.1 Physical Setting

Bristol Bay is a large gulf of the eastern Bering Sea in southwestern Alaska. The land area draining to Bristol Bay consists of six major watersheds—from west to east, the Togiak, Nushagak, Kvichak (including the Alagnak), Naknek, Egegik, and Ugashik River watersheds—and a series of smaller watersheds draining northward along the Alaska Peninsula (Figure ES-1). The Pebble deposit is located in the headwaters of tributaries to both the Nushagak and Kvichak Rivers; together, the watersheds of the Nushagak and Kvichak Rivers account for approximately half of the land area in the Bristol Bay watershed (USACE 2020a: Section 3.24).

Detailed information on the Bristol Bay watershed's physical setting, in terms of physiography, hydrologic landscapes, and seismicity, can be found in Chapter 3 of the BBA (EPA 2014). One component of the watershed's physical setting, however, is particularly important to note: the watersheds draining to Bristol Bay provide intact, connected, and free-flowing habitats from headwaters to ocean. Long, free-flowing rivers are globally rare (Grill et al. 2019). Unlike most other areas supporting Pacific salmon populations in North America, the Bristol Bay watershed is undisturbed by significant human development and impacts. It is located in one of the last remaining virtually roadless areas in the United States (EPA 2014: Chapter 6). Large-scale, human-caused modification of the landscape—a factor contributing to extinction risk for many native salmonid populations (Nehlsen et al. 1991)—is absent, and development in the watershed consists of only a small number of towns, villages, and roads. The Bristol Bay watershed also encompasses Iliamna Lake, the largest lake in Alaska and the largest undeveloped lake in the United States. As a result, the structure and function of aquatic habitats in the Bristol Bay watershed are characteristic of habitats in minimally altered landscapes.

The primary human manipulation of the Bristol Bay ecosystem is the marine harvest of roughly 50 to 70 percent of salmon returning to spawn (Kendall et al. 2009, EPA 2014: Chapter 5). Management of Alaska's salmon fisheries is geared toward maintenance of a sustainable fishery through protection of its wild salmon populations, or stocks (5 AAC 39.200, 5 AAC 39.220, 5 AAC 39.222, 5 AAC 39.223). A key goal of ADF&G's policy for the management of sustainable salmon fisheries is "to ensure conservation of salmon and salmon's required marine and aquatic habitats" (5 AAC 39.222), highlighting the importance of maintaining sustainable salmon-based ecosystems. Fishery management in Bristol Bay is unique in part because no hatchery fishes are reared or released in the watershed, whereas approximately 5 billion hatchery-reared juvenile Pacific salmon are released annually across the North Pacific (Irvine et al. 2012). This lack of hatchery fishes in the Bristol Bay region is notable, given the economic investment that rearing and releasing hatchery fishes requires and the fact that its benefits are highly variable and difficult to quantify (Naish et al. 2008). Hatchery fishes also can have significant adverse effects on wild fish populations (e.g., Levin et al. 2001, Araki et al. 2009, Rand et al. 2012, Evenson et al. 2018, Tillotson et al. 2019).

3.2 Aquatic Habitats

The Bristol Bay region encompasses complex combinations of physiography, climate, geology, and hydrology, which interact to control the amount, distribution, and movement of water through a landscape shaped by processes such as tectonic uplift, glaciation, and fluvial erosion and deposition. Ultimately, these factors result in a landscape marked by abundant, diverse freshwater habitats. These diverse habitats, in conjunction with the enhanced ecosystem productivity associated with anadromous salmon runs, support a high level of biological complexity (biocomplexity) that contributes to the environmental integrity and resilience of the Bristol Bay watershed's ecosystems (Section 3.3.3) (Schindler et al. 2010, Ruff et al. 2011, Lisi et al. 2013, Schindler et al. 2018, Brennan et al. 2019).

This section presents key aspects of the region's aquatic habitats, in terms of characteristics that contribute to their quality and diversity, the quantity and types of streams and wetlands found in the region, and their importance in the larger landscape. Together, these spatially and temporally variable aquatic habitats create the dynamic freshwater ecosystem mosaic (Mushet et al. 2019) critical to maintaining the region's exceptional salmon populations, as well as other fish and wildlife populations. According to the Anadromous Waters Catalog (ADF&G 2022c), fish habitat is "any area on which fish depend, directly or indirectly, during any stage of their life cycle." For salmon, this includes spawning habitats, where adults deposit and fertilize eggs; rearing habitats, where fertilized eggs incubate and juveniles feed, grow, and overwinter as they develop into adults; and migratory habitats, through which juveniles and adults predictably and purposefully move to complete their life cycles (ADF&G 2022c). Habitat needs vary with season and salmon life stage (Bjornn and Reiser 1991), and events occurring during one life stage continue to influence both individuals and populations in later life stages (Marra et al. 2015). As a result, continued productivity of the region's salmon populations depends on diverse, high-quality, and proximally located aquatic habitats that support all freshwater salmon life stages.

3.2.1 Quantity and Diversity of Aquatic Habitats

In general, conditions in the Bristol Bay watershed are highly favorable for Pacific salmon. The region encompasses an abundant and diverse array of aquatic habitats (Section 3.2) that in turn support a diverse salmonid assemblage (Section 3.3). Together, these factors result in high degrees of phenotypic and genotypic diversity across the region's salmon populations. This biocomplexity produces the asynchronous dynamics that stabilize the overall portfolio of salmon returns to the region (Section 3.3.3).

In the Nushagak and Kvichak River watersheds, freshwater habitats range from headwater streams to braided rivers, small ponds to large lakes, and side channels to off-channel alcoves. Overall physical habitat complexity is higher in the Bristol Bay watershed than in many other systems supporting Sockeye Salmon populations. Of 1,509 North Pacific Rim watersheds, the Kvichak, Wood, and Nushagak (exclusive of Wood) Rivers (Figure ES-2) ranked third, fourth, and forty-fourth, respectively, in physical habitat complexity, based on an index including variables such as lake coverage, stream junction density, floodplain elevation and density, and human footprint (Luck et al. 2010, RAP 2011).

Lakes and associated tributary and outlet streams are key spawning and rearing areas for Sockeye Salmon. Lakes cover relatively high percentages of watershed area in the Bristol Bay region, with 7.9 percent lake cover for the Bristol Bay watershed and 13.7 percent lake cover for the Kvichak River watershed within the larger Bristol Bay watershed (RAP 2011). In other North Pacific river systems supporting Sockeye Salmon populations, from northern Russia to western North America, these values tend to be much lower (0.2 to 2.9 percent) (RAP 2011). Relatively low watershed elevations and the absence of artificial barriers to migration (e.g., dams and roads) mean that not only are streams, lakes, and other aquatic habitats abundant in the Bristol Bay region, but they also tend to be accessible to anadromous salmonids (EPA 2014: Appendix A).

Gravel is an essential substrate for salmon spawning and egg incubation (Bjornn and Reiser 1991, Quinn 2018). Specific substrate and hydraulic requirements vary slightly by species (EPA 2014: Appendix A), but stream-spawning salmon generally require relatively clean gravel-sized substrates with interstitial flow, and sufficient bed stability to allow eggs to incubate in place for months prior to fry emergence (Quinn 2018). In the Bristol Bay watershed, gravel substrates are abundant (EPA 2014: Chapter 7). The Pebble deposit area is heavily influenced by past glaciation (PLP 2011: Chapter 3), and unconsolidated glacial deposits cover most of the area's lower elevations (Detterman and Reed 1973). As a result, the SFK, NFK, and UTC stream valleys have extensive glacial sand and gravel deposits (PLP 2011: Chapter 8).

A key aspect of the Bristol Bay watershed's aquatic habitats is the importance of groundwater exchange. Because salmon rely on clean, cold water flowing over and upwelling and downwelling through porous gravel for spawning, egg incubation, and rearing (Bjornn and Reiser 1991), areas of groundwater exchange create high-quality salmon habitat (EPA 2014: Appendix A). For example, densities of beach-spawning Sockeye Salmon in the Wood River watershed (within the larger Nushagak River watershed) were highest at sites with strong groundwater upwelling and zero at sites with no upwelling (Burgner 1991). Significant portions of the Nushagak and Kvichak River watersheds, including the Pebble deposit area, contain coarse-textured glacial drift with abundant, high-permeability gravels and extensive connectivity between surface waters and groundwater (EPA 2014: Chapter 3).

Groundwater is the source of baseflow in most streams draining the Pebble deposit area (Rains 2011, USACE 2020a: Section 3.17). Groundwater contributions to streamflow, along with the influence of run-of-the-river lakes, support flows in the region's streams and rivers that are more stable than those typically observed in many other salmon streams (e.g., in the Pacific Northwest or southeastern Alaska). This results in more moderated streamflow regimes with lower peak flows and higher baseflows, creating a less temporally variable hydraulic environment (EPA 2014: Figure 3-10). Interactions between surface waters and groundwater in the SFK, NFK, and UTC watersheds are complex and depend on factors such as local soil type and land and water table gradients. These watersheds include reaches that gain water from groundwater and reaches that lose water to groundwater, with hyporheic flows occurring at very local scales (USACE 2020a: Section 3.17).

This groundwater–surface water connectivity also has a strong influence on stream thermal regimes in the Nushagak and Kvichak River watersheds, providing a moderating influence against both summer heat and winter cold extremes. Average monthly stream water temperatures in the Pebble deposit area in July or August can range from 6°C to 16°C, and temperatures do not uniformly increase with decreasing elevation (PLP 2011: Appendix 15.1E, Attachment 1). This spatial variability in temperatures in the Pebble deposit area is consistent with streams influenced by a variety of thermal modifiers, including groundwater inputs, upstream lakes, and tributary contributions (Mellina et al. 2002, Armstrong et al. 2010). Longitudinal temperature profiles from August and October indicate that the mainstem SFK and NFK reaches just downstream of the tributaries draining the potential mine area experience significant summer cooling and winter warming compared to adjacent upstream reaches (PLP 2011: Chapter 9), suggesting significant groundwater contributions. Consistent winter observations of ice-free conditions in the area's streams also suggest the presence of upwelling groundwater in strongly gaining reaches of the SFK, NFK, and UTC (PLP 2011: Chapter 7, Woody and Higman 2011). Areas of groundwater downwelling are also important to fish and aquatic species and are documented to occur in the SFK, NFK, and UTC watersheds (USACE 2020a: Section 3.17).

These groundwater–surface water interactions and their influence on water temperature are extremely important for fishes, particularly salmon. Water temperature controls the metabolism and behavior of salmon and, if temperatures are stressful, fishes can be more vulnerable to disease, competition, predation, or death (McCullough et al. 2009). The State of Alaska has maximum temperature limits for salmon migration routes, spawning and rearing areas, and fry incubation areas (ADEC 2020). However, summer is not the only period of temperature sensitivity for salmon (Poole et al. 2004). For example, small temperature changes during salmon egg incubation in gravels can alter the timing of emergence by months (Brannon 1987, Beacham and Murray 1990, Quinn 2018). Groundwater moderates winter temperatures, which strongly control egg development, egg hatching, and emergence timing (Brannon 1987, Hendry et al. 1998). Groundwater contributions that maintain water temperatures above 0^0C are critical for maintaining winter refugia in streams that might otherwise freeze (Power et al. 1999). Thus, winter groundwater connectivity may be critical for fishes in such streams (Cunjak 1996, Huusko et al. 2007, Brown et al. 2011).

Since the timing of migration, spawning, and incubation are closely tied to seasonal water temperatures, groundwater-influenced thermal heterogeneity can also facilitate diversity in run timing and other salmon life-history traits (Hodgson and Quinn 2002, Rogers and Schindler 2011, Ruff et al. 2011). Any thermal regime alterations resulting from changes in groundwater–surface water connectivity could disrupt life-history timing cues and result in mismatches between fishes and their environments that adversely affect survival (Angilletta et al. 2008).

In terms of water quality, streams draining the Pebble deposit area tend to have near-neutral pH, with low conductivity, alkalinity, dissolved solids, suspended solids, and dissolved organic carbon (USACE 2020a: Section 3.18). In these respects, they are characteristic of undisturbed streams. However, as would be expected for a metalliferous site, levels of sulfate and some metals (copper, molybdenum, nickel, and zinc) are elevated, particularly in the SFK. Copper levels in approximately 40 percent of

samples from the SFK exceeded Alaska's chronic water quality standard (USACE 2020a: Section 3.18). However, most exceedances were in or close to the deposit area, and the number and magnitude of exceedances decreased with distance downstream (USACE 2020a: Appendix K3.18).

In summary, the Bristol Bay watershed in general, and the SFK, NFK, and UTC watersheds specifically, provide diverse and productive habitat for salmon and other fishes. Suitable substrates for salmon spawning, egg incubation, and rearing are abundant. Extensive connectivity between groundwater and surface waters creates and maintains a variety of streamflow and thermal regimes across the region, resulting in favorable spawning and rearing habitats for salmonids and helping to support diverse fish assemblages.

3.2.2 Streams

The Nushagak and Kvichak River watersheds contain over 33,000 miles (54,000 km) of streams, approximately 667 miles (1,085 km) of which are in the SFK, NFK, and UTC watersheds. The stream and river habitats of the SFK, NFK, and UTC watersheds can be characterized in terms of attributes that generally represent fundamental aspects of the physical and geomorphic settings in streams. Evaluation of stream and river habitats within the SFK, NFK, and UTC watersheds based on these attributes provides important context for how these streams and rivers contribute to fish habitats (Burnett et al. 2007, Shallin Busch et al. 2013). EPA (2014) describes stream and river valley attributes for each of the 52,277 stream and river reaches in the Nushagak and Kvichak River watersheds documented in the National Hydrography Dataset (NHD) (USGS 2012).[41] Three key attributes were estimated for each reach: mean channel gradient, mean annual streamflow, and percentage of flatland in the contributing watershed lowland (EPA 2014: Chapters 3 and 7). Stream reaches were then categorized according to each attribute to evaluate the relative suitability of these reaches as fish habitat.[42]

Because conditions at salmon spawning sites play a large role in determining the survival of eggs and rearing alevins, the geomorphic and hydrologic conditions at spawning sites are key determinants of population success (Beechie et al. 2008, Gibbins et al. 2008). Results of the stream reach classification show that a high proportion of stream channels in the SFK, NFK, and UTC watersheds possess the broad geomorphic and hydrologic characteristics that create stream and river habitats highly suitable for fishes such as Pacific salmon, Rainbow Trout, and Dolly Varden: low stream gradients, mean annual streamflows greater than or equal to 5.3 ft^3/s (0.15 m^3/s), and at least 5 percent flatland in lowland (an indicator of the potential for floodplain development) (EPA 2014: Chapter 7).

The substrate and hydraulic conditions required by stream-spawning salmon are most often met in stream channels with gradients less than 3 percent (Montgomery et al. 1999). Pool-riffle channels have moderate slopes (<1.5 to 2 percent) and are indicative of quality spawning habitat (Miller et al. 2008,

[41] Analysis is based on the 2012 iteration of the NHD (USGS 2012); total mapped stream length in the SFK, NFK, and UTC watersheds changed by only 1 percent between the 2012 and 2021 iterations of the NHD.

[42] EPA (2014: Chapters 3 and 7) provides a detailed discussion of the importance of each attribute in determining fish habitat and the method used to categorize each attribute.

Buffington et al. 2004). At gradients above 3 percent, the size, stability, and frequency of patches of suitable spawning substrates are substantially reduced (Montgomery and Buffington 1997). In the SFK, NFK, and UTC watersheds, low-gradient (<3 percent) channels account for 87 percent of the stream network, highlighting the availability of quality salmon spawning habitat in this region (Table 3-1).

Table 3-1. Distribution of stream channel length classified by channel size (based on mean annual streamflow), channel gradient, and floodplain potential for streams and rivers in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. See EPA (2014) Chapters 3 and 7 for additional details on the methods used to classify stream channels. [a]

Channel Size	Gradient							
	<1%		≥1% and <3%		≥3% and <8%		≥8%	
	FP [b]	NFP [b]	FP [b]	NFP [b]	FP [b]	NFP [b]	FP [b]	NFP [b]
Small headwater streams [c]	15%	5%	5%	28%	0%	12%	0%	0%
Medium streams [d]	14%	6%	0%	3%	0%	1%	0%	0%
Small rivers [e]	8%	2%	0%	1%	0%	0%	0%	0%
Large rivers [f]	0%	0%	0%	0%	0%	0%	0%	0%

Notes:

[a] Analysis is based on 2012 iteration of the NHD (USGS 2012); total mapped stream length in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds changed by only 1 percent between 2012 and 2021 iterations of the NHD.

[b] FP = high floodplain potential (greater than or equal to 5 percent of flatland in lowland); NFP = no or low floodplain potential (less than 5 percent of flatland in lowland).

[c] 0–5.3 ft^3/s (0–0.15 m^3/s); most tributaries in the mine footprints defined in the BBA (EPA 2014: Chapter 6).

[d] 5.3–100 ft^3/s (0.15–2.8 m^3/s); upper reaches and larger tributaries of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek.

[e] 100–1000 ft^3/s (2.8–28 m^3/s); middle to lower portions of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek, including mainstem Koktuli River.

[f] >1000 ft^3/s (>28 m^3/s); the Mulchatna River below the Koktuli River confluence, the Newhalen River, and other large rivers. Note that there are no large rivers in the SFK, NFK, and UTC watersheds.

Mean annual streamflow is a metric of stream size. Pacific salmon in the Bristol Bay region use a wide range of river and stream sizes for migration, spawning, and/or rearing habitat, but low-gradient streams of medium size (5.3 to 100 ft^3/s [0.15 to 2.8 m^3/s] mean annual streamflow) or greater likely provide high-capacity, high-quality habitats for salmonids (EPA 2014: Chapter 7). Such streams and rivers account for 34 percent of the stream network in the SFK, NFK, and UTC watersheds (Table 3-1). However, salmonid species differ in their propensities for small streams. Dolly Varden have been documented using all stream sizes, including some of the smallest channels. Of the Pacific salmon species, Coho Salmon are most likely to use small streams for spawning and rearing and have been observed in many of the smaller streams near the Pebble deposit (Woody and O'Neal 2010). Larger-bodied Chinook Salmon adults are less likely to access smaller streams for spawning (Quinn 2018), although each year 12 to 21 percent of radio-tagged Chinook Salmon in the Togiak River watershed (located southwest of the Nushagak River watershed) spawned in smaller order tributaries (Sethi and Tanner 2014). Juvenile Chinook Salmon also have been observed in small tributaries where spawning has not been documented (Bradford et al. 2001, Daum and Flannery 2011, Phillis et al. 2018), including in smaller streams near the Pebble deposit. In the SFK, NFK, and UTC watersheds, small streams account for 65 percent of the stream network (Table 3-1).

Streams in the larger valleys of the SFK, NFK, and UTC watersheds tend to have extensive flat floodplains or terraces (Table 3-1). These unconstrained channels generally have higher complexity of channel

habitat types and hydraulic conditions and higher frequencies of off-channel habitats such as side channels, sloughs, and beaver ponds. Such habitat complexity can be beneficial to salmon by providing diverse spawning and rearing habitats throughout the year (Stanford et al. 2005). For Coho and Chinook salmon, as well as river-rearing Sockeye Salmon that may overwinter in streams, such habitats may be particularly valuable by providing unique thermal, foraging, and growth advantages not available to juveniles in the main channel (Bradford et al. 2001, Huntsman and Falke 2019). In addition, smaller, steeper streams in the watersheds provide both seasonal (and some year-round) habitat for other fish species and important nutrient supply to downstream waters (Section 3.2.4).

3.2.3 Wetlands, Lakes, and Ponds

A thorough inventory of wetland, lake, and pond habitats within the Bristol Bay watershed, or even the Nushagak and Kvichak River watersheds, has not been completed. However, the National Wetlands Inventory (NWI) (USFWS 2021) includes data for approximately 96 percent of the area encompassed by the SFK, NFK, and UTC watersheds (Table 3-2). Wetlands comprise roughly 18 percent of the combined area of the three watersheds, with similar wetland types and proportions found in each watershed (Table 3-2; Box 3-1).

Table 3-2. Acreage of wetland habitats in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. Number in parentheses indicates percent of wetland or wetland type relative to total area in the watershed.

Wetland Type	Description	SFK	NFK	UTC	Total [a]
Freshwater emergent wetland	Non-tidal wetlands dominated by erect, rooted herbaceous hydrophytes	3,116 (4)	3,532 (5)	4,580 (5)	11,228 (5)
Freshwater forested/scrub-shrub wetland	Non-tidal wetlands dominated by either trees greater than 20 feet in height (forested) or shrubs and tree saplings less than 20 feet in height (scrub-shrub)	5,693 (8)	12,220 (18) [b]	6,194 (7)	24,107 (11)
Freshwater pond	Non-tidal wetlands and shallow water (less than 6.6 feet deep) habitats that are at least 20 acres in size, have either less than 30 percent vegetative cover or a plant community dominated by species that principally grow on or below water surface, and have at least 25 percent of substrates less than 2.75 inches in size	931 (1)	1,397 (2)	1,090 (1)	3,418 (1)
Lake	Wetlands and deep-water (deeper than 6.6 feet) habitats that are situated in topographic depressions, have less than 30 percent vegetative cover, and are greater than 20 acres in size	611 (1)	427 (1)	698 (1)	1,737 (1)
Riverine	Wetlands and deep-water (deeper than 6.6 feet) habitats in natural or artificial channels that contain flowing water at least periodically	507 (1)	480 (1)	632 (1)	1,619 (1)
TOTAL WETLAND AREA		**10,859 (15)**	**18,056 (26)**	**13,194 (15)**	**42,109 (18)**
TOTAL WATERSHED AREA		**71,492**	**69,612**	**87,547**	**228,651**

Notes:

[a] Approximately 96 percent of the area within these watersheds has National Wetlands Inventory (NWI) coverage; the 4 percent of the area without coverage is located in lower elevation areas of the Upper Talarik Creek watershed. Note that individual percentages may not exactly add to total percentages within and across watersheds due to rounding.

[b] The data presented in NWI for the western portion of the NFK watershed are an "interim scalable map product" (USFWS 2022a) that "is considered preliminary and is a compilation of existing data and limited aerial image interpretation rather than an image-based mapping process" (USFWS 2022b). These preliminary, interim data appear to overestimate the freshwater forested/scrub-shrub wetlands in portions of the NFK watershed compared to the adjacent areas completed using image-based mapping processes.

Source: USFWS 2021.

BOX 3-1. SIMILARITY OF AQUATIC RESOURCES WITHIN THE SOUTH FORK KOKTULI RIVER, NORTH FORK KOKTULI RIVER, AND UPPER TALARIK CREEK WATERSHEDS

Throughout most of Section 3, the SFK, NFK, and UTC watersheds are discussed in combination because of the broad similarity of aquatic resources across the three watersheds. Each watershed is unique, but they share a roughly similar size, a headwater location, and numerous similarities in terms of the types and distribution of aquatic habitats, their physical and chemical characteristics, and their use by fish populations. Specific examples of these similarities are provided below.

Types and distribution of aquatic habitats

- The SFK, NFK, and UTC watersheds have similar lengths of total stream miles (relative to their watershed areas) and similar percentages of total stream miles documented to support anadromous fishes (29–31 percent in each watershed) (Table 3-6).
- Headwaters of all three watersheds contain dense first-order tributary networks that contribute subsidies of flow, energy, and organic matter to downstream reaches (USACE 2020a: Page 3.24-3).
- Each watershed contains multiple lakes, ponds, and wetlands that provide fish habitat and support downstream flows (USACE 2020a: Pages 3.16-8 and 3.24-3); similar amounts and types of wetlands are found in all three watersheds (Table 3-2).
- Floodplain and off-channel habitats, including beaver ponds, are important habitat components in all three watersheds (USACE 2020a: Table 3-24-3).

Physical and chemical characteristics of the watersheds and their aquatic habitats

- Headwaters of the SFK, NFK, and UTC watersheds have similar terrain and elevation (USACE 2020a: Table 3.16-1). All three watersheds transition to lower-gradient streams as one moves from headwaters to downstream areas, and lower stream reaches are similar in terms of gradient and substrate type (USACE 2020a: Table 3.24-2).
- Water temperature and water chemistry parameters are similar across the SFK, NFK, and UTC watersheds (USACE 2020a: Tables K3.18-7–K3.18-9).
- The SFK, NFK, and UTC have similar mean annual streamflows (relative to their watershed areas), as well as similar seasonal discharge patterns, with high streamflows in spring and fall and low streamflows in winter and mid-summer (USACE 2020a: Page 3.16-8, Table K3.16-3).
- Interactions between surface waters and groundwaters are a key component of the aquatic habitats in all three watersheds. Groundwater seeps are common in the headwaters of the three watersheds (USACE 2020a: Figure 3-17.2), and groundwater discharge is an important component of streamflow and fish habitat in all three watersheds (USACE 2020a: Pages 3.16-8 and 3.24-4). Groundwater exchange between the SFK and UTC watersheds has been well documented (USACE 2020a: Page 3.17-4).

Use of aquatic habitats by fishes

- Mainstem reaches of the SFK, NFK, and UTC have all been documented to support important salmon spawning aggregations (USACE 2020a: Table 3.24-8; Figures 3.24-6, 3.24-10, and 3.24-13).
- Aquatic habitats within each of the three watersheds provide fishery areas that support reproductively isolated salmon populations (Section 3.3.3), which in turn contribute to valuable subsistence, commercial, and recreational fisheries.

The similarities detailed above do not mean that aquatic resources across the SFK, NFK, and UTC watersheds are interchangeable. The broad components of these headwater watersheds—in terms of the types and abundance of aquatic habitats, their general physical and chemical characteristics, and the organisms that use those habitats—are similar. Within each watershed, however, these component pieces are put together in unique ways, based on the specific characteristics of individual habitats, how those individual habitats are arranged and connected, and how individual organisms move among them. In each of the three watersheds, similar components combine in different ways to create unique habitat mosaics, which over thousands of years have resulted in local adaptation of populations, especially anadromous fish populations, to site-specific conditions in each watershed. As a result, loss or disruption of aquatic habitats in any of the three watersheds would be expected to result in similar impacts on ecological function.

It is important to note that the characterization of aquatic habitat area is limited by resolution of the available NWI data, which tend to underestimate their extents. For example, multiple sources of high-resolution remote imaging and ground-truthing were used to map streams and wetlands at the mine site (USACE 2020a). This high-resolution mapping identifies approximately 400 percent more stream miles than the NHD and approximately 40 percent more wetland acres than the NWI (USFWS 2021) in this area (see Box 4-3 for additional information on water resources mapping at the mine site). However, this high-resolution mapping of aquatic resources is not available for the entire SFK, NFK, and UTC watersheds. Thus, most of the stream length estimates included in this section are based on the most recent iteration of the NHD (USGS 2021b).

3.2.4 Importance of Headwater Stream and Wetland Habitats to Fish

Headwater streams and wetlands are the small channels and wetland areas located in the upstream source areas of river networks. The branched nature of river networks means that watersheds are dominated by headwater streams, in terms of both stream number and stream length (Hill et al. 2014, Callahan et al. 2015). Small headwater streams make up approximately 65 percent of assessed stream length in the SFK, NFK, and UTC watersheds (Table 3-1).[43] Thus, headwater streams—and their associated headwater wetlands—are key habitat features in this region. These headwater systems provide habitat for numerous fish species, as well as supply water, invertebrates, organic matter, and other resources to larger downstream waters. Because of their large influence on downstream water flow, water chemistry, and biota, the importance of headwater systems reverberates throughout entire watersheds downstream (Freeman et al. 2007, Meyer et al. 2007, Fritz et al. 2018, Schofield et al. 2018, Ferreira et al. 2022).

Headwater streams and spring (headwater) wetland habitats are particularly important in establishing and maintaining fish diversity (Cummins and Wilzbach 2005, Colvin et al. 2019). They support resident fish assemblages, as well as provide key habitats for specific life stages of migratory fishes. For example, headwaters provide spawning and nursery areas for fish species that use larger streams, rivers, and lakes for most of their freshwater life cycles (e.g., Pacific salmon and Rainbow Trout) (Quinn 2018). The use of headwater streams and wetlands by a variety of fish species has been observed in many aquatic ecosystems (see Meyer et al. 2007 for a thorough review). Headwater streams in southeastern Alaska can be an important source area for downstream Dolly Varden populations (Bryant et al. 2004). Foley et al. (2018) examined the distribution of juvenile Coho Salmon in three headwater streams of the Little Susitna River, Alaska; they found that juveniles occurred throughout these headwater streams where stream gradients were less than 4 to 5 percent. In the Nushagak and Kvichak River watersheds, 96 percent of 108 surveyed headwater streams contained fishes, including rearing Coho and Chinook salmon, adult Coho and Sockeye salmon, Rainbow Trout, Dolly Varden, Arctic Grayling, Round Whitefish, Burbot, and Northern Pike (Woody and O'Neal 2010).

[43] Based on the 2012 iteration of the NHD (USGS 2012); total mapped stream length in the SFK, NFK, and UTC watersheds changed by only 1 percent between the 2012 and 2021 iterations of the NHD.

Summer and early fall can provide opportunities for maximum growth for juvenile salmon rearing in headwater systems, as both stream temperatures and food availability increase (Quinn 2018). Although seasonal fish distribution patterns are poorly understood for the region, lower-gradient headwater streams and associated wetlands may also provide important habitat for stream fishes during other seasons. Thermally diverse habitats in off-channel wetlands can provide rearing and foraging conditions that may be unavailable in the mainstream channel, increasing capacity for juvenile salmon rearing (Brown and Hartman 1988, Nickelson et al. 1992, Cunjak 1996, Collen and Gibson 2001, Sommer et al. 2001, Henning et al. 2006, Lang et al. 2006, PLP 2011). Loss of wetlands in more developed regions has been associated with reductions in habitat quality and salmon abundance, particularly for Coho Salmon (Beechie et al. 1994, Pess et al. 2002).

Winter habitat availability for juvenile rearing has been shown to limit salmonid productivity in streams of the Pacific Northwest (Nickelson et al. 1992, Solazzi et al. 2000, Pollock et al. 2004), and may be limiting for fishes in the SFK, NFK, and UTC watersheds given the relatively cold temperatures and long winters in the region (Morrow 1980, Reynolds 1997). Overwintering habitats for stream fishes must provide suitable instream cover, dissolved oxygen, and protection from freezing (Cunjak 1996). Beaver ponds and groundwater upwelling areas in headwater streams and wetlands in the SFK, NFK, and UTC watersheds likely meet these requirements. In winter, beaver ponds typically retain liquid water below the frozen surface, creating important winter refugia for stream fishes (Cunjak 1996). Beaver ponds provide excellent habitat for rearing salmon by trapping organic materials and nutrients and creating structurally complex, large-capacity pool habitats with potentially high macrophyte cover, low streamflow velocity, and/or moderate temperatures (Nickelson et al. 1992, Collen and Gibson 2001, Pollock et al. 2004, Lang et al. 2006). Additionally, beaver dams, including ponds at a variety of successional stages, provide a mosaic of habitats for not just salmon but other fish and wildlife species (e.g., lamprey).

An October 2005 aerial survey of active beaver dams in the Pebble deposit area mapped 113 active beaver colonies (PLP 2011: Chapter 16:16.2-8). As detailed in Section 3.2.2, the SFK, NFK, and UTC watersheds are dominated by low-gradient headwater streams. Beavers preferentially colonize headwater streams—particularly those with gradients less than 6 percent—because of their shallow depths and narrow widths (Collen and Gibson 2001, Pollock et al. 2003). Beaver ponds provide important and abundant habitat within the Pebble deposit area and may be particularly important for overwinter rearing of species such as Coho Salmon and for providing deeper pool habitats for additional species during low streamflow conditions (PLP 2011: Appendix 15.1D, USACE 2020a: Section 3.24).

The lateral expansion of floodplain wetland habitats during flooding greatly influences habitat connectivity by determining whether and for how long fishes can reach newly created or existing habitats (Bunn and Arthington 2002). In the Bristol Bay watershed, field observations have indicated the presence of salmon in stream sites disconnected from surface-water flows (Woody and O'Neal 2010). Annual floods during spring and fall likely reconnect these habitats through a network of ephemeral wetlands and streams. The use of these temporary stream and wetland habitats by fishes is

not well understood in the Bristol Bay watershed, but they appear to be important in establishing habitat connectivity.

Inputs of groundwater-influenced streamflow from headwater tributaries likely benefit fishes by moderating mainstem temperatures and contributing to thermal diversity in downstream waters (Cunjak 1996, Power et al. 1999, Huusko et al. 2007, Armstrong et al. 2010, Brown et al. 2011, Ebersole et al. 2015). Such thermal diversity can be an important attribute of stream systems in the region, providing localized water temperature patches that may offer differing trade-offs for species bioenergetics. For example, salmon may select relatively cold-temperature sites—often associated with groundwater upwelling—for spawning, whereas juvenile salmon rearing in those same streams may take advantage of warm-temperature patches for optimal food assimilation (Armstrong and Schindler 2013). Headwater streams in the SFK and NFK watersheds may provide a temperature-moderating effect and serve as sources of thermal heterogeneity, providing cooler temperatures in summer and warmer temperatures in winter.

It has long been recognized that, in addition to providing habitat for stream fishes, headwater streams and wetlands serve an important role in the stream network by contributing water, nutrients, organic material, macroinvertebrates, algae, and bacteria downstream to higher-order streams in the watershed (Vannote et al. 1980, Meyer et al. 2007, Doretto et al. 2020). This is particularly true in dendritic stream networks like the SFK, NFK, and UTC systems, which have a high density of headwater streams. For example, Koenig et al. (2019) found that small streams with relatively low primary productivity can exert a disproportionate effect on overall gross primary productivity in the river network, due to the large collective surface area of these small channels. Because of their narrow width, headwater streams also receive proportionally greater inputs of organic material from the surrounding terrestrial vegetation than larger stream channels (Vannote et al. 1980, Doretto et al. 2020). This material is either used locally (Tank et al. 2010) or transported downstream to larger streams in the network (Wipfli et al. 2007).

Headwater streams—including streams with only intermittent or ephemeral flow—are important suppliers of invertebrates and detritus to downstream areas that support juvenile salmonids and other fishes (Wipfli and Gregovich 2002, Cummins and Wilzbach 2005, Colvin et al. 2019, Hedden and Giddo 2020). In transporting these materials downstream, headwaters provide an important energy subsidy for juvenile salmonids (Wipfli and Gregovich 2002). For example, Wipfli and Gregovich (2002) found that fishless headwater streams in southeastern Alaska were a year-round source of invertebrate prey for salmonids. They estimated that these streams could provide downstream salmonid-bearing habitat with enough invertebrate prey and detritus to support up to 2,000 juvenile salmonids per kilometer (Wipfli and Gregovich 2002). Recent experimental studies have also shown that disturbance and degradation of small tributaries can affect invertebrate populations in downstream reaches (Chará-Serna and Richardson 2021, González and Elosegi 2021).

The export value of headwater streams can be influenced by the surrounding vegetation. For example, riparian alder (a nitrogen-fixing shrub) was positively related to aquatic invertebrate densities and the

export rates of invertebrates and detritus in southeastern Alaska streams (Piccolo and Wipfli 2002, Wipfli and Musslewhite 2004). Riparian vegetation in the Pebble deposit area is dominated by deciduous shrubs such as willow and alder (USACE 2020a: Section 3.24); thus, these streams are likely to provide abundant, high-quality detrital inputs to downstream reaches.

Headwater streams can also have high instream rates of nutrient processing and storage, thereby influencing downstream water chemistry due to relatively large organic matter inputs, high retention capacity, high primary productivity, bacteria-induced decomposition, and/or extensive hyporheic zone interactions (Richardson et al. 2005, Alexander et al. 2007, Meyer et al. 2007). In examining network-wide patterns in water chemistry of the Kuskokwim River, Alaska, French et al. (2020) found that watershed attributes of headwaters were the best predictor for almost all streamwater constituents (e.g., nitrate, phosphate, dissolved organic carbon) across the entire network. They concluded that headwaters are governing river biogeochemistry in this system (French et al. 2020). Similarly, when the natural flow regimes of headwater streams are altered, adverse effects on downstream water quality often occur (Colvin et al. 2019). Accurate assessment of these physical and chemical connections between headwaters and downstream waters—and perhaps more important, their consequences for the integrity of those downstream waters—should consider aggregate connections over multiple years to decades (Fritz et al. 2018).

In summary, headwater streams and wetlands play a vital role in maintaining diverse, abundant fish populations, both by providing important fish habitat and by supplying the energy and other resources needed to support fishes in connected downstream habitats (Colvin et al. 2019). Headwater streams and wetlands are abundant in the Pebble deposit area and play a crucial role in supporting local and downstream fish populations.

3.3 Fish Resources

Given the abundant, diverse, and high-quality freshwater habitats found in the Nushagak and Kvichak River watersheds, it is not surprising that this region supports world-class fishery resources. This section considers the fish species found in the Nushagak and Kvichak River watersheds, with particular focus on the SFK, NFK, and UTC watersheds; life-history, distribution, and abundance information for these species; the ecological importance of these fish populations, in terms of both maintaining biocomplexity and diversity at local and global scales and providing nutrient subsidies to habitats; and the importance of subsistence, commercial, and recreational fisheries in the region. As this section illustrates, this region supports a robust, diverse fish assemblage of considerable ecological, economic, and cultural value, and loss of these fish resources could have significant repercussions.

3.3.1 Species and Life Histories

The Bristol Bay watershed is home to at least 29 fish species, representing at least nine different families. The 29 species documented to occur in the Nushagak and Kvichak River watersheds, as well as information on their migratory patterns and general abundance, habitat types, and predator-prey

relationships, are listed in Table 3-3. At least 20 of these species are known to inhabit the SFK, NFK, and UTC watersheds (USACE 2020a: Section 3.24). The region is renowned for its fish populations, and it supports world-class fisheries for multiple species of Pacific salmon and other subsistence and game fishes (Dye and Borden 2018, Halas and Neufeld 2018). These resources generate significant benefit for commercial fishers (Section 3.3.5), provide nutritional and cultural sustenance for Alaska Native populations and other residents (Section 3.3.6), and support valued recreational fisheries (Section 3.3.7).

Five species of Pacific salmon spawn and rear in the Bristol Bay watershed's freshwater habitats: Coho or Silver salmon, Chinook or King salmon, Sockeye or Red salmon, Chum or Dog salmon, and Pink or Humpback salmon. Because no hatchery fishes are raised or released in the watershed, the Bristol Bay region supports entirely wild, naturally sustainable fisheries (Section 3.1).

All five salmon species share life-history traits that contribute to their success and significance in the Bristol Bay region. First, they are anadromous: they hatch in freshwater habitats, migrate to sea for a period of relatively rapid growth, and then return to freshwater habitats to spawn. Second, the vast majority of adults undergo extensive homing migrations to return to their natal freshwater habitats to spawn. Salmon imprint on the chemical signatures of their natal sites throughout their early development (Dittman and Quinn 1996, Ueda 2019), then use olfactory and other cues to migrate back to these locations as adults. This homing behavior fosters reproductive isolation, creating distinct, localized populations that are uniquely adapted to the specific environmental conditions of their natal habitats (Blair et al. 1993, Dittman and Quinn 1996, Ramstad et al. 2010, Eliason et al. 2011, Zwollo 2018, Smith and Zwollo 2020) (Section 3.3.3). Finally, each species is semelparous: adults return to their natal streams to spawn once and then inevitably die. Because adults only have one opportunity to reproduce, spawning site selection is a critical determinant of their reproductive fitness. Upon their death, adult salmon release the nutrients incorporated in their bodies into their spawning habitats; this slow release of marine-derived nutrients provides critical resources for their offspring and many other organisms (Section 3.3.4).

The seasonality of spawning and incubation is roughly the same for all five Pacific salmon species, although the timing can vary somewhat by species, population, and region. For example, Coho Salmon tend to spawn later in the season and have shorter incubation periods (Spence 1995), whereas Sockeye and Chinook salmon tend to return and spawn earlier in the season. In general, salmon spawn from summer through fall, and fry emerge from spawning gravels the following spring to summer. Freshwater habitats used for spawning and rearing vary across and within species, and include headwater streams, larger mainstem rivers, side- and off-channel wetlands, spring-fed ponds, and lakes (Table 3-4; Section 3.3.3). Use of lakes is common among salmonids (Arostegui and Quinn 2019a). Sockeye Salmon are unique among the Pacific salmon species in that most populations rely on lakes as the primary freshwater rearing habitat ("lake-type" Sockeye Salmon) (Table 3-4), although there are populations in the Bristol Bay watershed that rear in small streams and rivers ("river-type" Sockeye Salmon) (Section 3.3.3).

Table 3-3. Fish species reported in the Nushagak and Kvichak River watersheds. Species in bold have been documented to occur in aquatic habitats within the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. (H) indicates species considered to be harvested—that is, they are well-distributed across the Nushagak and Kvichak River watersheds and are or have been targeted by subsistence, commercial, or recreational fisheries. This list does not include primarily marine species that periodically venture into the lower reaches of coastal streams.

Family	Species	Migratory Pattern(s) [a]	Relative Abundance	Predator–Prey Relationships [b]
Salmonids (Salmonidae)	Bering Cisco *(Coregonus laurettae)*	N and A	Very few specific reports	-
	Humpback Whitefish (H) *(C. pidschian)*	N and A	Common in large lakes; locally and seasonally common in large rivers	Feed primarily on aquatic invertebrates (mollusks, insect larvae), also salmon eggs and small fry Eaten by other fishes (Northern Pike, Lake Trout); eggs eaten by Round Whitefish, Arctic Grayling)
	Least Cisco *(C. sardinella)*	N and A	Locally common in some lakes (e.g., Lake Clark, morainal lakes near Iliamna Lake); less common in Iliamna Lake and large slow-moving rivers, such as the Chulitna, Kvichak, and lower Alagnak	Feed on aquatic invertebrates (insect larvae, copepods) Eaten by other fishes (Lake Trout, Northern Pike, Burbot) and fish-eating birds
	Pygmy Whitefish *(Prosopium coulterii)*	N	Locally common in a few lakes or adjacent streams	Feed on aquatic invertebrates (insect larvae, zooplankton, mollusks) and whitefish eggs Eaten by other fish (Lake Trout, Arctic Char, Dolly Varden) and fish-eating birds
	Round Whitefish *(P. cylindraceum)*	N	Abundant/widespread throughout larger streams in upland drainages; not found in headwaters or coastal plain areas	Feed on aquatic invertebrates (insect larvae, snails) and salmon and whitefish eggs Eaten by other fishes (Burbot, Lake Trout, Northern Pike)
	Coho Salmon (H) *(Oncorhynchus kisutch)*	A	Juveniles abundant/widespread in flowing waters of Nushagak River watershed and in some Kvichak River tributaries downstream of Iliamna Lake; present in some Iliamna Lake tributaries; not recorded in the Lake Clark watershed	Juveniles feed primarily on aquatic invertebrates (insect larvae) and salmon eggs and carcasses
	Chinook Salmon (H) *(O. tshawytscha)*	A	Juveniles abundant and widespread in upland flowing waters of Nushagak River watershed and in Alagnak River; infrequent upstream of Iliamna Lake	Juveniles feed primarily on aquatic invertebrates (insect larvae)
	Sockeye Salmon (H) *(O. nerka)*	A	Abundant	Juveniles feed primarily on zooplankton
	Chum Salmon (H) *(O. keta)*	A	Abundant in upland flowing waters of Nushagak River watershed and in some Kvichak River tributaries downstream of Iliamna Lake; rare upstream of Iliamna Lake	-

Family	Species	Migratory Pattern(s) [a]	Relative Abundance	Predator–Prey Relationships [b]
	Pink Salmon (H) *(O. gorbuscha)*	A	Abundant (in even years), with restricted distribution, in the Nushagak River watershed and in some Kvichak River tributaries downstream of Iliamna Lake; rare upstream of Iliamna Lake	-
	Rainbow Trout (H) *(O. mykiss)*	N [c]	Frequent/common; in summer, closely associated with spawning salmon	Feed on aquatic invertebrates (insect larvae), terrestrial invertebrates, sockeye salmon eggs, and salmon carcasses Eaten by other fishes; eggs eaten by Slimy Sculpin
	Arctic Char (H) *(Salvelinus alpinus)*	N	Locally common in upland lakes	Feed on aquatic invertebrates (insect larvae, snails, mollusks) and fishes (Threespine Stickleback, sculpin) Eaten by other fishes (Lake Trout, larger Arctic Char)
	Dolly Varden (H) *(S. malma)*	N and A	Abundant in upland headwaters and selected lakes	Feed on aquatic invertebrates (insect larvae, zooplankton), terrestrial invertebrates, juvenile salmon, and salmon eggs Eaten by larger Dolly Varden, Lake Trout, and terrestrial predators (River Otters, fish-eating birds)
	Lake Trout (H) *(S. namaycush)*	N	Common in larger upland lakes and seasonally present in lake outlets; absent from the Wood River lakes	Feed on aquatic invertebrates when small and fishes (Least Cisco, salmon, Arctic Grayling, many others) when large Eaten by other fishes (Burbot, large Lake Trout); eggs eaten by other fish (Slimy Sculpin, Round Whitefish, other Lake Trout)
	Arctic Grayling (H) *(Thymallus arcticus)*	N	Abundant/widespread	Feed on aquatic and terrestrial invertebrates and salmon eggs Eaten by Lake Trout and Dolly Varden
Lampreys (Petromyzontidae)	**Arctic Lamprey** [d] *(Lethenteron camtschaticum)*	A	Juveniles common/widespread in sluggish flows where fine sediments accumulate	Feed on detritus and salmon carcasses Eaten by rainbow trout, other fish, birds, and mammals
	Alaskan Brook Lamprey [d] *(L. alaskense)*	N		
	Pacific Lamprey *(Entosphenus tridentatus)*	A	Rare	
Suckers (Catostomidae)	Longnose Sucker *(Catostomus catostomus)*	N	Common in slower flows of larger streams	Feed on aquatic invertebrates and plants Eaten by other fish (Lake Trout, Northern Pike, Burbot) and River Otters
Pikes (Esocidae)	**Northern Pike** (H) *(Esox lucius)*	N	Common/widespread in still or sluggish waters	Feed on aquatic invertebrates when small (insect larvae, zooplankton) and fishes when large (salmon, Arctic Char, Lake Trout, many others)

Family	Species	Migratory Pattern(s) [a]	Relative Abundance	Predator–Prey Relationships [b]
Mudminnows (Umbridae)	Alaska Blackfish *(Dallia pectoralis)*	N	Locally common/abundant in still or sluggish waters in flat terrain	Feed on aquatic invertebrates (copepods, cladocerans, insect larvae, snails) and algae Eaten by Northern Pike and larger Alaska Blackfish
Smelts (Osmeridae)	**Rainbow Smelt** *(Osmerus mordax)*	A	Seasonally abundant in streams near the coast	Feed on aquatic invertebrates and fishes (Slimy Sculpin) Eaten by fish-eating birds, Rainbow Trout, and River Otters
	Pond Smelt *(Hypomesus olidus)*	N	Locally common in coastal lakes and rivers, Iliamna Lake, inlet spawning streams, and the upper Kvichak River; abundance varies widely interannually	Feed primarily on zooplankton Eaten by other fishes (Arctic Char, Lake Trout)
	Eulachon *(Thaleichthys pacificus)*	A	No or few specific reports; if present, distribution appears limited and abundance low	-
Cods (Gadidae)	**Burbot** *(Lota lota)*	N	Infrequent to common in deep, sluggish, or still waters	Feed on aquatic invertebrates when small (insect larvae) and fishes when large (Least Cisco, Lake Trout, sculpin, Round Whitefish) Eaten by other fishes (larger Burbot)
Sticklebacks (Gasterosteidae)	**Threespine Stickleback** *(Gasterosteus aculeatus)*	N and A	Locally abundant in still or sluggish waters; abundant in Iliamna Lake	Feed on aquatic invertebrates (cladocerans, copepods, amphipods) Eaten by other fishes (Arctic Char, Northern Pike, Rainbow Trout, others), fish-eating birds, and large aquatic invertebrates (predatory insect larvae)
	Ninespine Stickleback *(Pungitius pungitius)*	N	Abundant/widespread in still or sluggish waters	
Sculpins (Cottidae)	Coastrange Sculpin *(Cottus aleuticus)*	N	Abundant/widespread [e]	Feed on aquatic invertebrates (insect larvae) and salmon eggs, alevins, and fry Eaten by other fishes (salmon fry, Burbot, Humpback Whitefish, Northern Pike, others)
	Slimy Sculpin *(C. cognatus)*	N		

Notes:

[a] A = anadromous (fishes that spawn in freshwaters and migrate to marine waters to feed); N = non-anadromous (fishes that spend their entire life in fresh waters, with possible migrations between habitats within a watershed). N and A indicates fishes in which some individuals have non-anadromous and some have anadromous migratory patterns.

[b] For anadromous species, only predator-prey relationships in freshwater habitats are presented. Dash (-) indicates either that the species is rare and detailed information is not available for the region, or that the species spends limited time in fresh water (i.e., for Pink and Chum salmon).

[c] In the Bristol Bay watershed, anadromous individuals (Steelhead) are known to spawn and rear only in the North Alaska Peninsula watershed.

[d] Juveniles of these two species, which are the most commonly encountered life stages in these watersheds, are indistinguishable. Both species are present in the watershed, but it is possible that all documented occurrences are for one of these species.

[e] These species are combined here, because they are not reliably distinguished in field conditions, although Slimy Sculpin is thought to be more abundant and widely distributed.

Source: EPA 2014, USACE 2020a: Table 3.24-11; see Appendix B, Table 1 in EPA (2014) for references and additional information on the abundance and life history of each species.

Table 3-4. Life history, habitat characteristics, and total documented stream length occupied for Bristol Bay's five Pacific salmon species in the Nushagak and Kvichak River watersheds.

Salmon Species	Freshwater Rearing Period (years)	Freshwater Rearing Habitat	Ocean-Feeding Period (years)	Spawning Habitat	Documented Stream Length Occupied (miles)
Coho	1–3	Headwater streams to moderate-sized rivers, headwater springs, beaver ponds, side channels, sloughs	1+	Headwater streams to moderate sized rivers	4,470
Sockeye	0–3	Lakes, rivers	2–3	Beaches of lakes, streams connected to lakes, larger braided rivers	3,174
Chinook	1+	Headwater streams to large-sized mainstem rivers	2–4	Moderate-sized streams to large rivers	3,108
Chum	0	Limited	2–4	Moderate-sized streams and rivers	2,170
Pink	0	Limited	1+	Moderate-sized streams and rivers	1,334

Source: EPA 2014: Appendix A (life history and habitat characteristics), the Anadromous Waters Catalog (Giefer and Graziano 2022) (stream lengths).

With some exceptions, preferred spawning habitat consists of gravel-bedded stream reaches of moderate water depth (12 to 24 in [30 to 60 cm]) and current (12 to 40 in/s [30 to 100 cm/s]) (Quinn 2018). In Alaska, studies have also found groundwater exchange to be of key importance for spawning salmon site selection (MacLean 2003, Curran et al. 2011, Mouw et al. 2014, McCracken 2021).

Both Chum and Pink salmon migrate to the ocean soon after fry emergence (Heard 1991, Salo 1991). Because Coho, Chinook, and Sockeye salmon spend a year or more rearing in the Bristol Bay watershed's streams, rivers, and lakes before their ocean migration (Table 3-4), these species depend more on upstream freshwater resources than do Chum and Pink salmon.

In addition to the five Pacific salmon species, the Bristol Bay region is home to at least 24 resident fish species, most of which typically (but not always) remain within the watershed's freshwater habitats throughout their life cycles. The region contains highly productive waters for such subsistence and sport fish species as Rainbow Trout,[44] Dolly Varden, Arctic Char, Arctic Grayling, Humpback Whitefish, Northern Pike, and Lake Trout, as well as numerous other species that are not typically harvested (Table 3-3). These fish species occupy a variety of habitats throughout the watershed, including headwater streams, rivers, off-channel habitats, wetlands, and lakes.

Given the importance of Rainbow Trout, Dolly Varden, and Northern Pike that rely on salmon populations to both subsistence and sport fisheries (Sections 3.3.6 and 3.3.7), it is worth considering key life-history and habitat-use traits of these species. The spawning habitat and behavior of Rainbow Trout are generally similar to those of the Pacific salmon species, with a few key exceptions. First, Rainbow Trout are iteroparous, meaning that they can spawn repeatedly. Second, spawning occurs in spring,

[44] The species *O. mykiss* includes both a non-anadromous or resident form (commonly referred to as Rainbow Trout) and an anadromous form (commonly referred to as Steelhead). In the Bristol Bay watershed, Steelhead generally are restricted to a few spawning streams near Port Moller, on the Alaska Peninsula.

versus summer and early fall for salmon. Juveniles emerge from spawning gravels in summer (Johnson et al. 1994, ADF&G 2022a), and immature fishes may remain in their natal streams for several years before migrating to other freshwater habitats (Russell 1977).

Rainbow Trout in the Bristol Bay watershed exhibit complex migratory patterns, moving between spawning, rearing, feeding, and overwintering habitats. For example, many adults in the region spawn in inlet or outlet streams of large lakes, then migrate shortly after spawning to feeding areas within those lakes. Some mature fishes may seasonally move distances of 120 miles (200 km) or more (Russell 1977, Burger and Gwartney 1986, Minard et al. 1992, Meka et al. 2003). Often, these migratory patterns ensure that Rainbow Trout are in close proximity to the eggs and carcasses of spawning salmon, which provide an abundant, high-quality food resource (Meka et al. 2003). The variety of habitat types used by Rainbow Trout is reflected by different life-history types identified in the region, including lake, lake-river, and river residents (Meka et al. 2003).

Dolly Varden is a highly plastic fish species, with multiple genetically, morphologically, and ecologically distinct forms that can co-exist in the same waterbodies (Ostberg et al. 2009). Both anadromous and non-anadromous Dolly Varden are found in the Bristol Bay watershed, and both life-history forms can exhibit complex and extensive migratory behavior (Armstrong and Morrow 1980, Reynolds 2000, Scanlon 2000, Denton et al. 2009, Hart et al. 2015, Chin et al. 2022). Anadromous individuals usually undertake three to five ocean migrations before reaching sexual maturity (DeCicco 1992, Lisac and Nelle 2000, Crane et al. 2003). During these migrations, Dolly Varden frequently leave one drainage, travel through marine waters, and enter a different, distant drainage (DeCicco 1992, DeCicco 1997, Lisac 2009). Non-anadromous individuals also may move extensively between different habitats (Scanlon 2000).

Dolly Varden spawning occurs in fall, upstream of overwintering habitats (DeCicco 1992). Northern-form anadromous Dolly Varden (the geographic form of Dolly Varden found north of the Alaska Peninsula) overwinter primarily in lakes and in lower mainstem rivers where sufficient groundwater provides suitable volumes of free-flowing water (DeCicco 1997, Lisac 2009). Within the Nushagak and Kvichak River watersheds, juveniles typically rear in low-order, high-gradient stream channels (ADF&G 2022a). Because Dolly Varden occur in headwater lakes and high-gradient headwater streams (ADF&G 2022a)—farther upstream than many other fish species and above migratory barriers to anadromous salmon populations—they may be especially vulnerable to habitat degradation in these headwater areas. Like Rainbow Trout, Dolly Varden rely on salmon-derived food resources such as salmon eggs and carcasses, as well as invertebrates feeding on those carcasses (Denton et al. 2009, Denton et al. 2010, Jaecks and Quinn 2014).

Northern Pike primarily spawn in sections of lakes, wetlands, or very low-gradient streams that provide shallow (<3 feet [1 m]), slow, or still waters with aquatic vegetation and soft substrates (EPA 2014: Appendix B). Their summer habitat is typically deeper but still relatively warm water with dense aquatic vegetation. Northern Pike overwinter in lakes, spring-fed rivers, and larger deep rivers where water and oxygen are sufficient for survival until spring (EPA 2014: Appendix B). In spring, mature Northern Pike ascend tributaries, beneath the ice, to reach spawning areas, then move to deeper waters to feed. Fry

remain near or downstream of spawning areas. Many mature Northern Pike do not travel far, but some river-system individuals make extensive seasonal migrations—sometimes as far as 180 miles (290 km) per year—between spawning, feeding, and overwintering areas (EPA 2014: Appendix B).

Table 3-3 provides summary information on the other 21 fish species that have been documented in the Nushagak and Kvichak River watersheds. It is important to note that none of these species exists in isolation—rather, they together make up diverse fish assemblages that interact with each other in numerous ways. For example, sculpins, Dolly Varden, and Rainbow Trout consume salmon eggs and emergent fry (including lamprey ammocoetes), and Northern Pike can be effective predators of juvenile salmon and other fish species (Sepulveda et al. 2013, Schoen et al. 2022). Insectivorous and planktivorous fishes may compete with juvenile salmonids for food (e.g., Hartman and Burgner 1972). These types of prevalent interactions among species mean that impacts on any one fish species could affect the entire assemblage.

3.3.2 Distribution and Abundance

As Section 3.3.1 illustrates, the Nushagak and Kvichak River watersheds in general—and the SFK, NFK, and UTC watersheds in particular—support a robust assemblage of fishes, including several species that support valuable subsistence, commercial, and recreational fisheries (Sections 3.3.5 through 3.3.7). These fishes use a diversity of freshwater habitats throughout their life cycles. Fish populations across the Bristol Bay watershed have not been sampled comprehensively, so estimates of total distribution and abundance across the region are not available. All fish distribution maps included here represent the currently documented distributions for each species, based on the AWC (Giefer and Graziano 2022) and the AFFI (ADF&G 2022a). Note that species absence cannot be inferred from these maps, as areas without documented occurrence of a species may not have been sampled; however, available data[45] provide at least minimum estimates of where key species are found and how many individuals of those species have been caught.[46] More information on the distribution and abundance of key fish species can be found in Section 3.24 of USACE (2020a) and Appendices A and B of the BBA (EPA 2014).

3.3.2.1 Nushagak and Kvichak River Watersheds

Most (72 percent) of the smaller watersheds within the Nushagak and Kvichak River watersheds are documented to contain at least one species of spawning or rearing salmon within their boundaries; 19 percent are documented to contain all five species (Figure 3-1). Reported distributions for the five salmon species in the Nushagak and Kvichak River watersheds are shown in Figure 3-2.

[45] Notable sources of data include the AWC (Giefer and Graziano 2022), AFFI (ADF&G 2022a), and fish escapement and harvest data. The AWC is the State of Alaska's official record of anadromous fish distributions and, if available, the life stages present (categorized as spawning, rearing, or present but life stage unspecified). The AFFI includes all fish species found at specific sampling points; some observers also documented life stage (adult or juvenile).

[46] See Appendix B of this document for additional information on the interpretation of available fish distribution data.

Coho Salmon spawn and rear in many stream reaches throughout the Nushagak and Kvichak River watersheds. Juveniles distribute widely into headwater streams, where they are often the only salmon species present (Woody and O'Neal 2010, King et al. 2012). Because Coho Salmon spend 1 to 3 years in fresh water, rearing habitat in headwater streams can be an especially important factor influencing their productivity (Nickelson et al. 1992, Solazzi et al. 2000).

Chinook Salmon spawn and rear throughout the Nushagak River watershed and in several tributaries of the Kvichak River. Although Chinook Salmon is the least common salmon species across the Bristol Bay region, the Nushagak River watershed supports a large Chinook Salmon fishery: on average, more than 75 percent of Bristol Bay's commercial Chinook Salmon catch comes from the Nushagak fishing district (Section 3.3.5). Chinook Salmon returns to the Nushagak River are consistently greater than 100,000 fish per year and have exceeded 200,000 fish per year in 11 years between 1966 and 2010, which places the Nushagak River at or near the size of the world's largest Chinook Salmon runs (EPA 2014: Chapter 5). In recent years, Nushagak River Chinook Salmon have failed to meet their established escapement goal (i.e., the number of adult salmon that "escape" harvest and return to freshwaters to spawn). In October 2022, ADF&G recommended that Nushagak River Chinook Salmon be designated as a stock of management concern (ADF&G 2022f), highlighting the importance of the species in this region.

Sockeye Salmon is by far the most abundant salmon species in the Bristol Bay watershed (Tiernan et al. 2021).[47] Between 2010 and 2019, the average annual inshore run of Sockeye Salmon was 17.9 million fish in the Naknek-Kvichak district and 12.9 million fish in the Nushagak district (Tiernan et al. 2021). Tributaries to Iliamna Lake, Lake Clark, and, in the Nushagak River watershed, the Wood-Tikchik Lakes are major Sockeye Salmon spawning areas, and juveniles rear in each of these lakes. Iliamna Lake provides the majority of Sockeye Salmon rearing habitat in the Kvichak River watershed and historically has produced more Sockeye Salmon than any other lake in the Bristol Bay region (Fair et al. 2012). Riverine Sockeye Salmon populations spawn and rear throughout the Nushagak River watershed.

Chum Salmon is the second most abundant salmon species in the Nushagak and Kvichak River watersheds. Both Chum and Pink salmon spawn throughout the Nushagak and Kvichak River watersheds, but do not have extended freshwater rearing stages.

Extensive sampling for Rainbow Trout, Dolly Varden, Arctic Grayling, Northern Pike, and other fishes has not been conducted throughout the Bristol Bay region, so total distributions and abundances are unknown. Reported occurrences of a subset of these resident fishes, which provide a minimum estimate of their extents throughout the Nushagak and Kvichak River watersheds, are shown in Figures 3-3 and 3-4: Rainbow Trout, Dolly Varden, and Arctic Grayling (Figure 3-3) and Northern Pike, stickleback, and sculpin (Figure 3-4).

[47] Bristol Bay is home to the largest Sockeye Salmon fishery in the world, with 46 percent of the average global abundance of wild Sockeye Salmon between 1956 and 2005 (Ruggerone et al. 2010, EPA 2014: Figure 5-9A). Between 2010 and 2019, the average annual inshore run of Sockeye Salmon in Bristol Bay was approximately 45.5 million fish (ranging from a low of 24.4 million in 2013 to a high of 63.0 million in 2018) (Tiernan et al. 2021).

Figure 3-1. Diversity of Pacific salmon species production in the Nushagak and Kvichak River watersheds. Counts of salmon species (Coho, Chinook, Sockeye, Chum, and Pink) spawning and rearing, based on the Anadromous Waters Catalog (Giefer and Graziano 2022), are summed by 12-digit hydrologic unit codes.

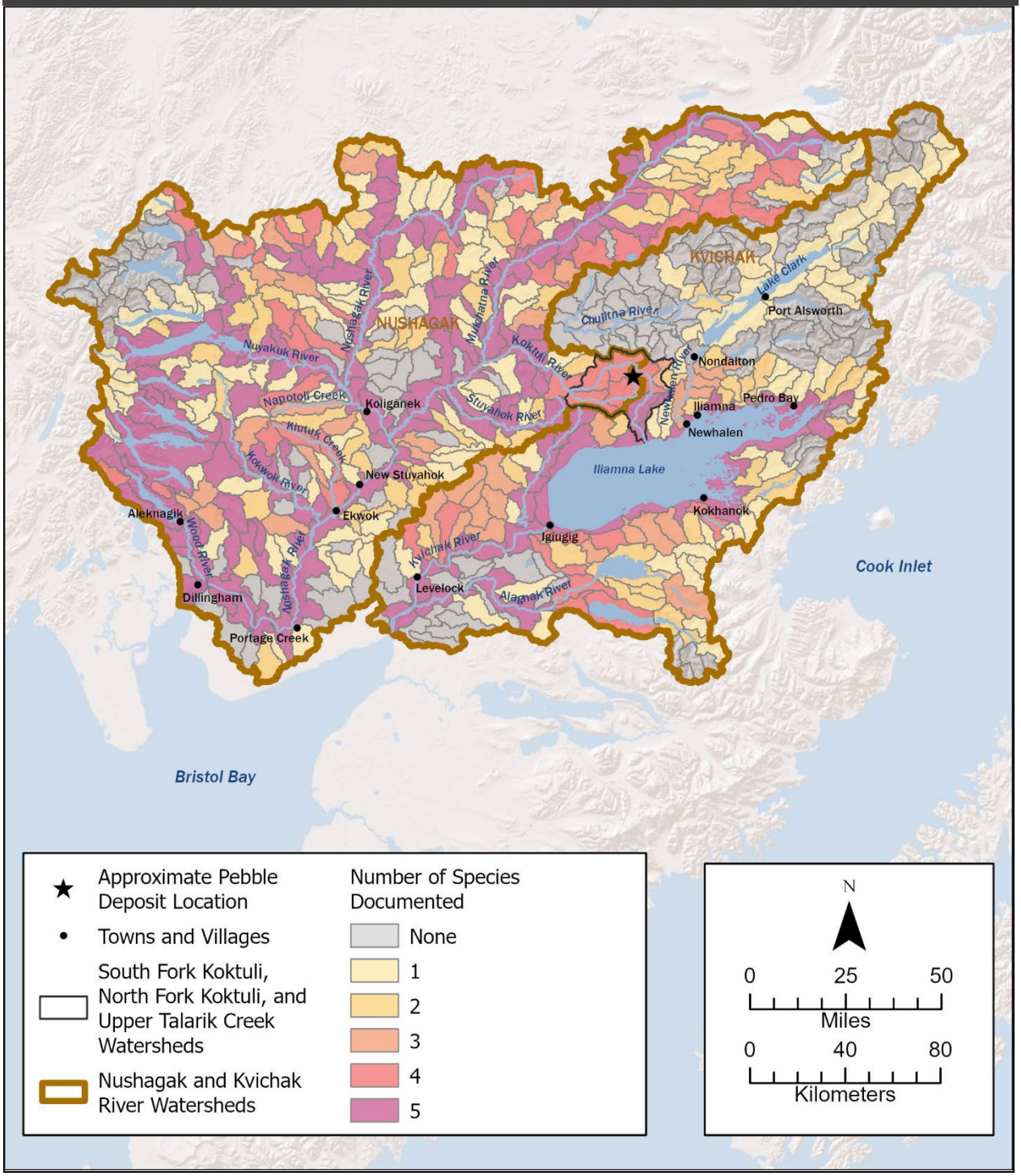


Figure 3-2. Anadromous fish distribution in the Nushagak and Kvichak River watersheds. Documented salmon use indicates that at least one Pacific salmon species (Coho, Chinook, Sockeye, Chum, or Pink) has been documented at the most upstream point in the channel, based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

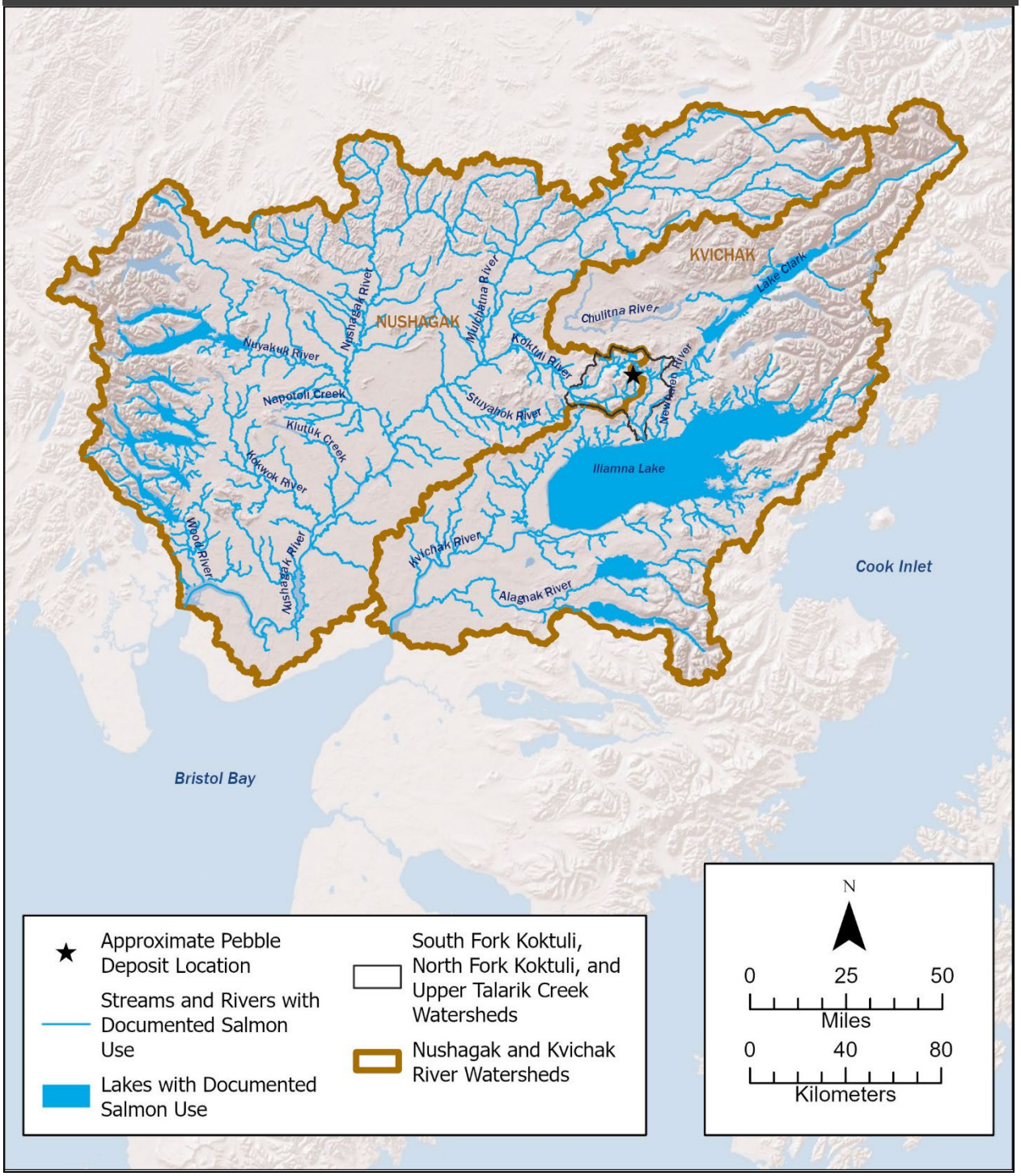


Figure 3-3. Rainbow Trout, Dolly Varden, and Arctic Grayling occurrence in the Nushagak and Kvichak River watersheds. Designation of species presence is based on the Alaska Freshwater Fish Inventory (ADF&G 2022a). Note that points shown on land actually occur in smaller streams not shown on this map.

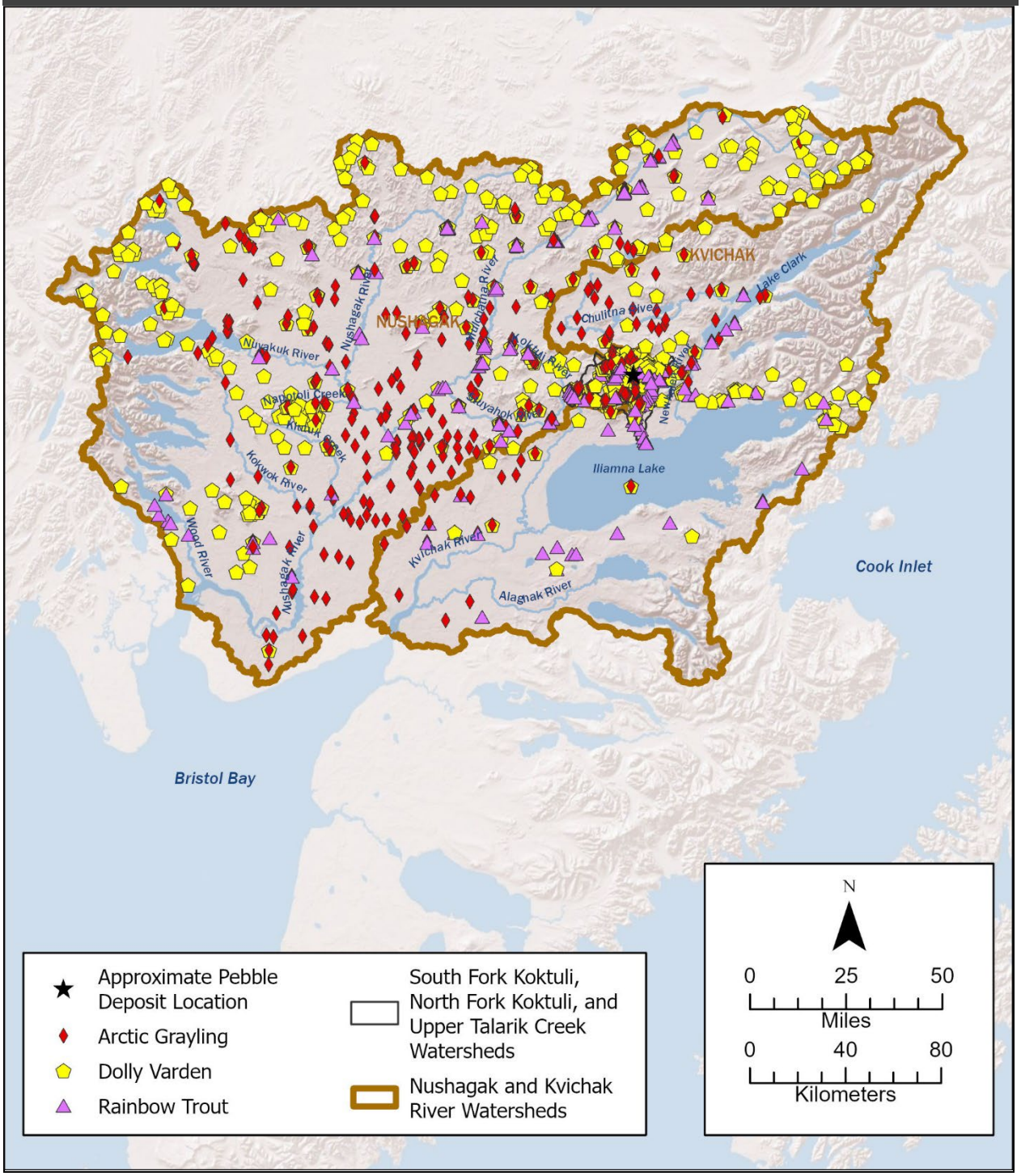
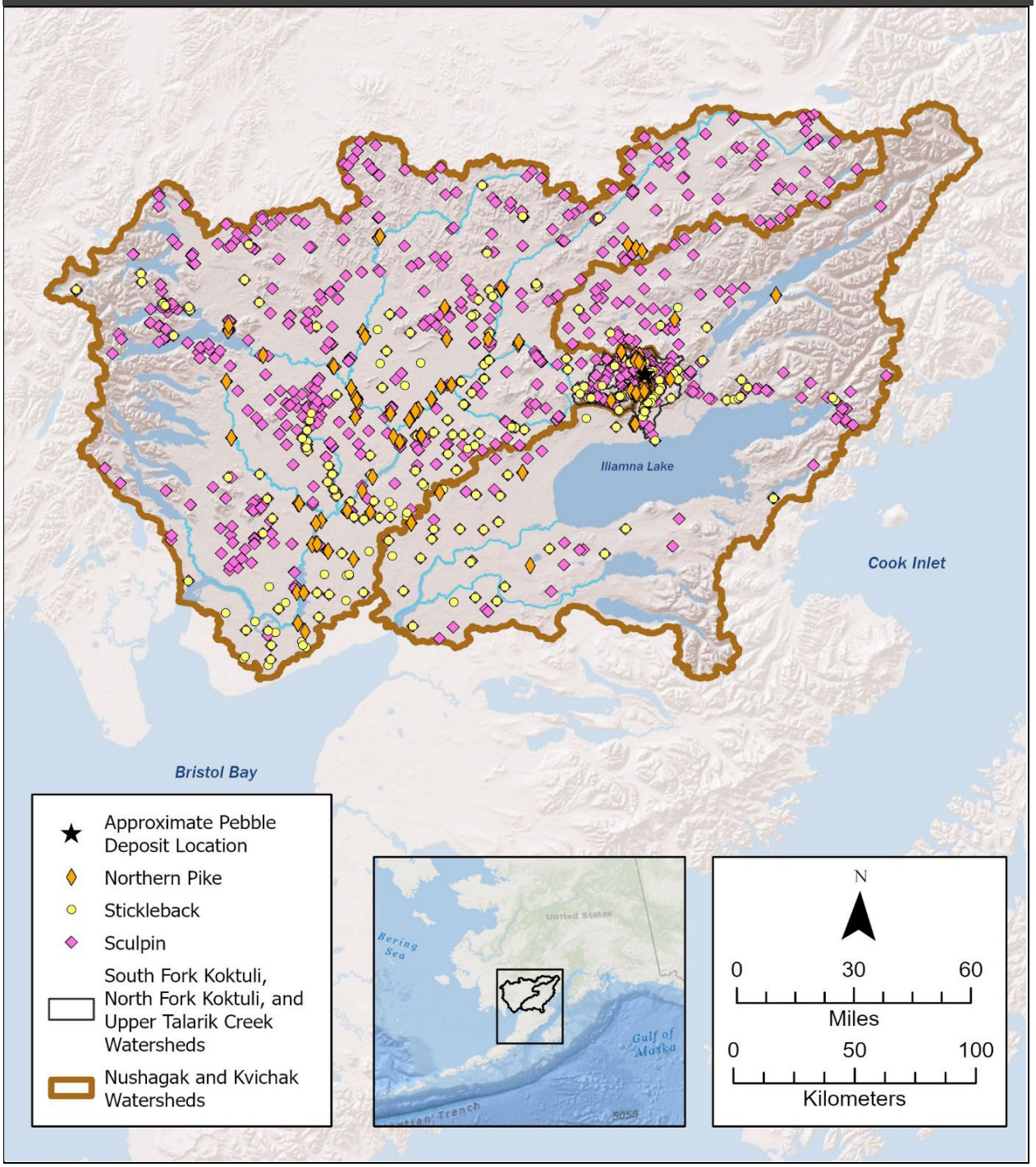


Figure 3-4. Northern Pike, stickleback, and sculpin occurrence in the Nushagak and Kvichak River watersheds. Designation of species presence is based on the Alaska Freshwater Fish Inventory (ADF&G 2022a). Note that points shown on land actually occur in smaller streams not shown on this map.



3.3.2.2 South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek Watersheds

This section highlights the abundance and diversity of fish resources in the SFK, NFK, and UTC watersheds, particularly in terms of Pacific salmon. The important relationship between the region's aquatic habitats and its fish populations—and the resulting ecological value of this relationship—is discussed in greater detail in Section 3.3.3.

Summer fish distributions in the SFK, NFK, and UTC watersheds have been sampled over several years (PLP 2011: Chapter 15, PLP 2018a: Chapter 15). The catalogued distributions of the five Pacific salmon species (Coho, Chinook, Sockeye, Chum, and Pink), resident Rainbow Trout, Dolly Varden (both anadromous and non-anadromous forms are present), and Arctic Grayling in these watersheds are shown in Figures 3-5 through 3-10. In addition, Arctic-Alaskan Brook Lamprey, Northern Pike, Humpback Whitefish, Least Cisco, Round Whitefish, Burbot, Threespine Stickleback, Ninespine Stickleback, and Slimy Sculpin occur in these watersheds (Table 3-5) (ADF&G 2022a). Summary information about these species is provided in Table 3-3; more detailed information on distributions, abundances, habitats, life cycles, predator-prey relationships, and harvests is provided in Appendix B of EPA (2014) and Section 3.6 of USACE (2020a).

Table 3-5. Documented fish species occurrence in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds.

Species [a]	Number of Unique Sites [b]
Humpback Whitefish	2
Least Cisco	3
Round Whitefish	3
Coho Salmon	525
Chinook Salmon	183
Sockeye Salmon	102
Chum Salmon	7
Rainbow Trout	110
Dolly Varden [c]	682
Arctic Grayling	199
Arctic-Alaskan Brook Lamprey [c]	4
Northern Pike	74
Burbot	2
Threespine Stickleback	32
Ninespine Stickleback	67
Unspecified stickleback species	27
Slimy Sculpin	533
Unspecified sculpin species	226

Notes:

[a] This is not a complete list of species found in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, because it is based only on the Alaska Freshwater Fish Inventory (ADF&G 2022a); for example, Pink Salmon are only listed in the Anadromous Waters Catalog (Giefer and Graziano 2022).

[b] Number of unique sample sites for each species (i.e., number of sample sites where at least one life stage of the species was found).

[c] Juveniles of these two species, which are the most commonly encountered life stage in these watersheds, are indistinguishable. Both species are present in the watersheds, but it is possible that all documented occurrences are for one of these species.

Source: Alaska Freshwater Fish Inventory (ADF&G 2022a).

Of the 667 stream miles (1,073 km) that have been mapped in the SFK, NFK, and UTC watersheds, 201 miles (323 km) or 30 percent have been documented to contain anadromous fishes (Table 3-6; see Appendix B for discussion of why this likely represents a significant underestimation of actual anadromous waters). Coho Salmon have the most widespread distribution of the five salmon species in the three watersheds and make extensive use of mainstem and tributary habitats, including headwater streams (Figure 3-5). Chinook and Sockeye salmon have been documented throughout mainstem reaches of the three watersheds, as well as several tributaries (Figures 3-6 and 3-7). The distributions of Chum and Pink salmon are generally restricted to mainstem reaches where spawning and migration have been documented. Chum Salmon have been found in all three watersheds, whereas Pink Salmon, at very low numbers, have been reported only in the lowest section of UTC and in the Koktuli River below the confluence of the SFK and NFK (Figures 3-8 and 3-9). Rainbow Trout have been collected at many mainstem and several tributary locations, especially in UTC (Figure 3-10). Dolly Varden are found throughout the three watersheds, with fish surveys indicating that they are commonly found in the smallest streams (i.e., first-order tributaries) (Figure 3-10). Arctic Grayling are also found throughout the three watersheds, particularly in the SFK headwaters (Figure 3-10).

Table 3-6. Total documented anadromous fish stream length and stream length documented to contain different salmonid species in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds.

	South Fork Koktuli River (miles)	North Fork Koktuli River (miles)	Upper Talarik Creek (miles)	Total (miles)
Total mapped streams [a]	194	209	264	667
Total anadromous fish streams [b]	60	65	76	201
By species				
Chinook Salmon	38	43	39	120
Chum Salmon	23	20	28	71
Coho Salmon	59	64	76	199
Pink Salmon	0	0	4	4
Sockeye Salmon	40	29	49	119

Notes:

[a] From the National Hydrography Dataset (USGS 2021b).

[b] From the Anadromous Waters Catalog (Giefer and Graziano 2022).

Figure 3-5. Reported Coho Salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. "Present" indicates the species was present but life-stage use was not determined; "spawning" indicates spawning adults were observed; and "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

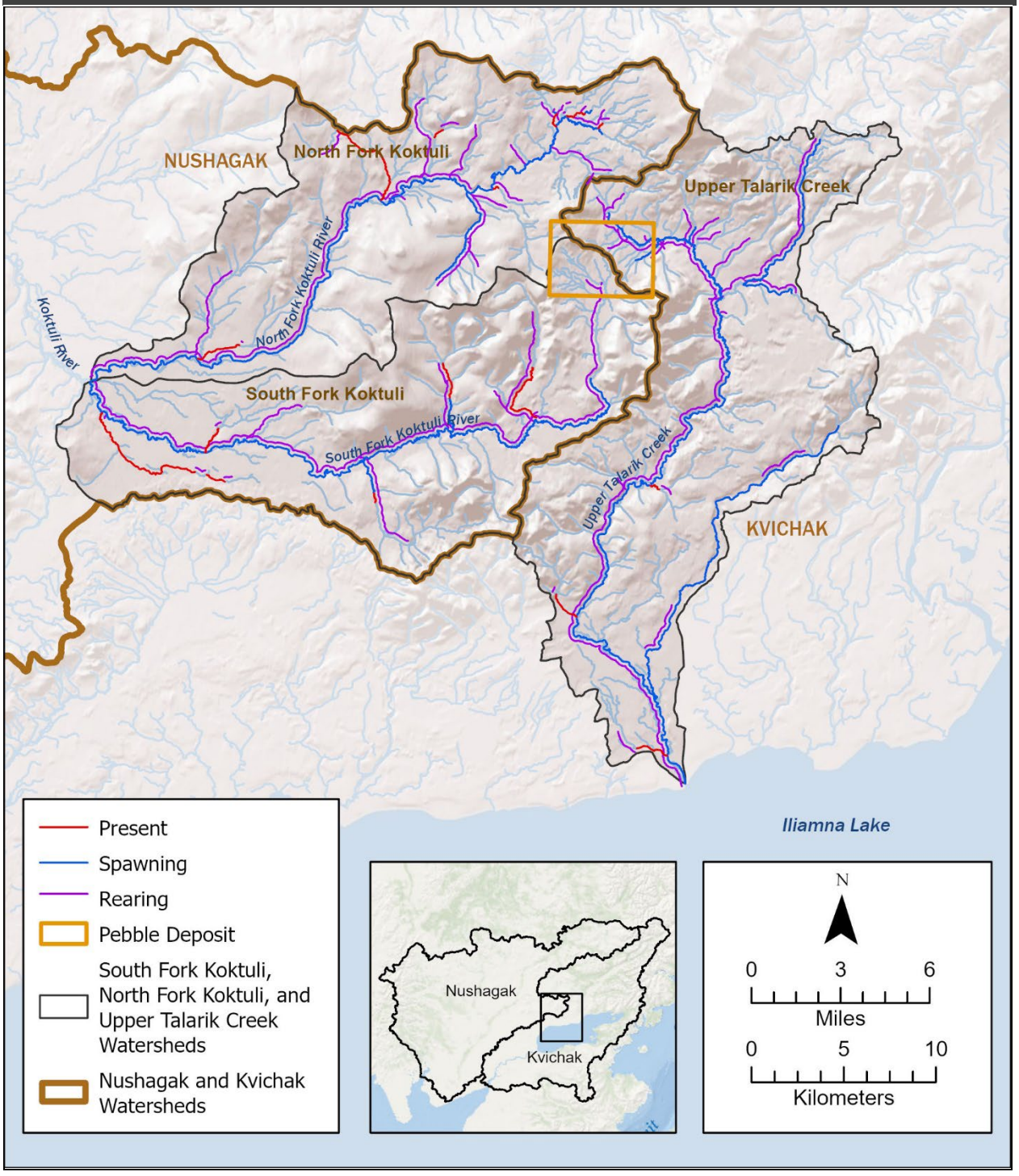


Figure 3-6. Reported Chinook Salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. "Present" indicates the species was present but life-stage use was not determined; "spawning" indicates spawning adults were observed; and "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

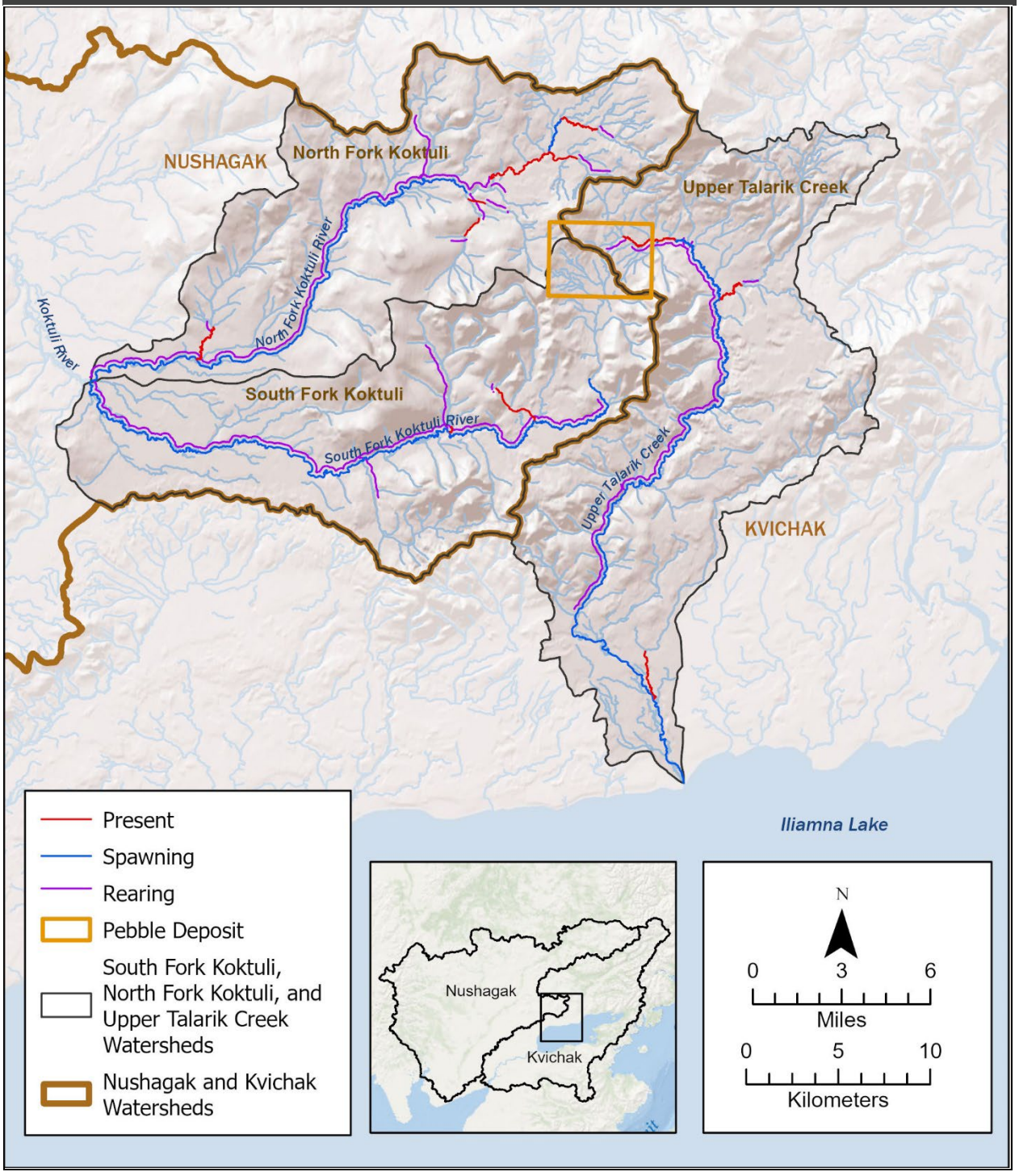


Figure 3-7. Reported Sockeye Salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. "Present" indicates the species was present but life-stage use was not determined; "spawning" indicates spawning adults were observed; and "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

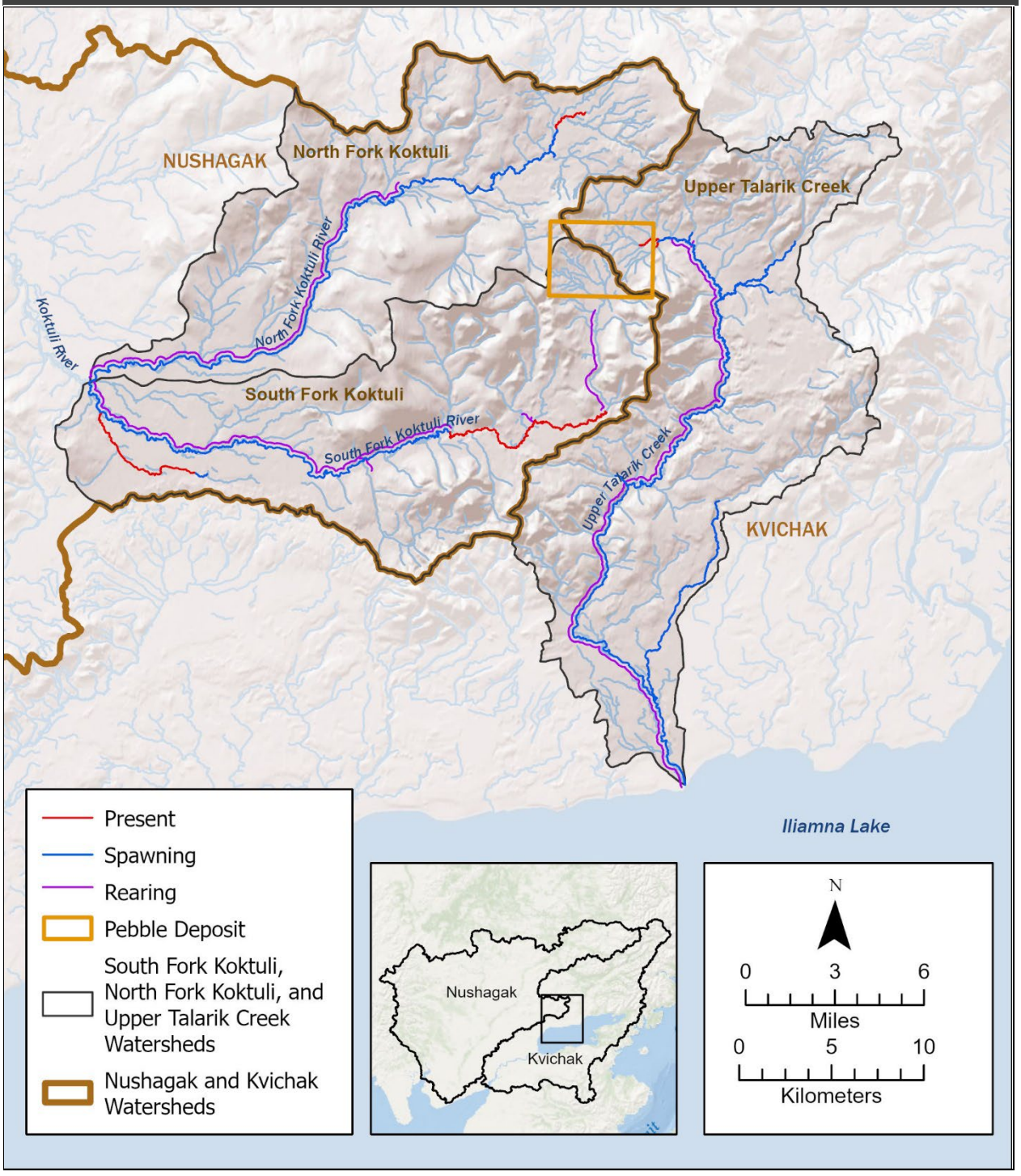


Figure 3-8. Reported Chum Salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. "Present" indicates the species was present but life-stage use was not determined; "spawning" indicates spawning adults were observed; and "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

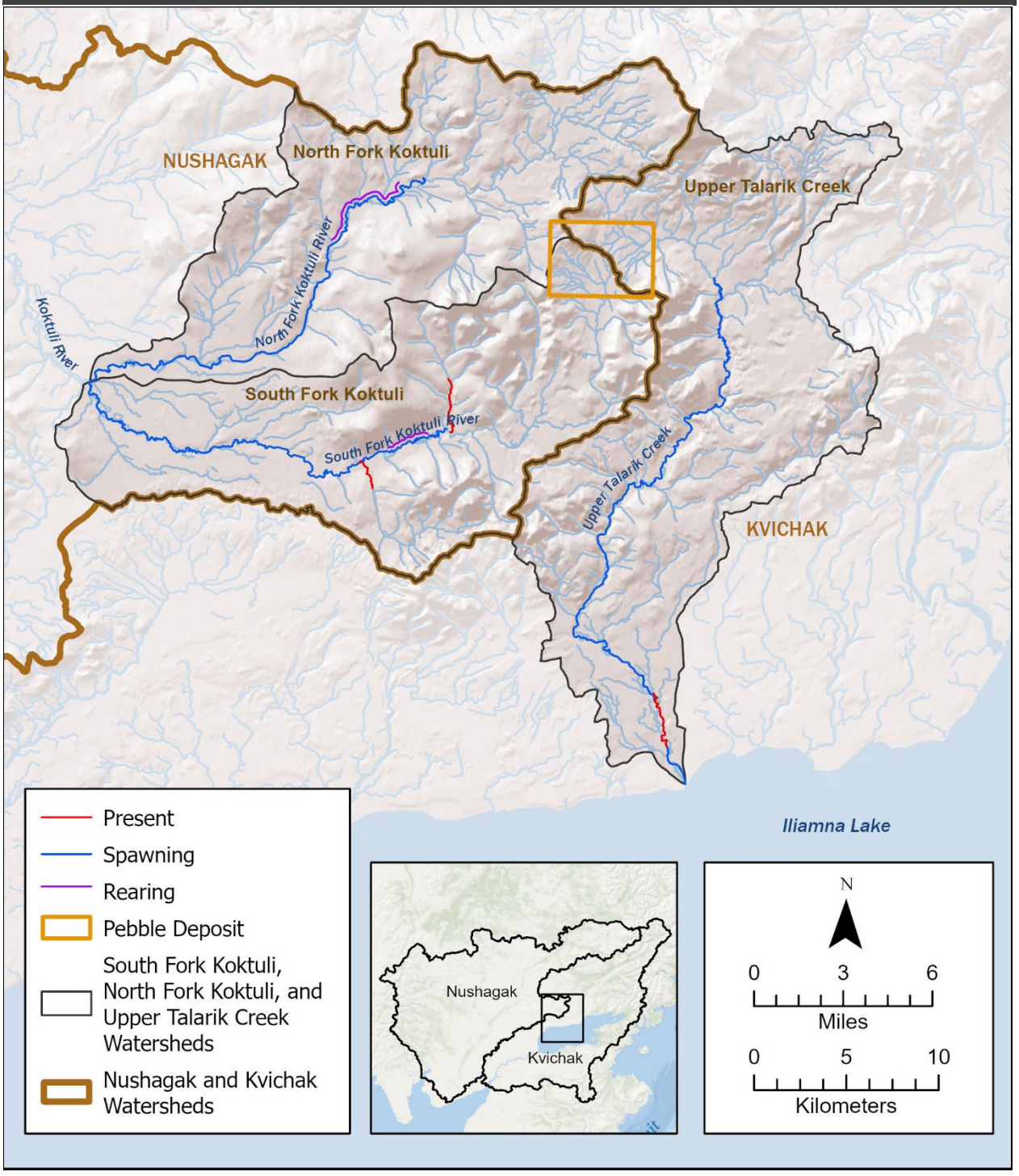


Figure 3-9. Reported Pink Salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. "Present" indicates the species was present but life-stage use was not determined; "spawning" indicates spawning adults were observed; and "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

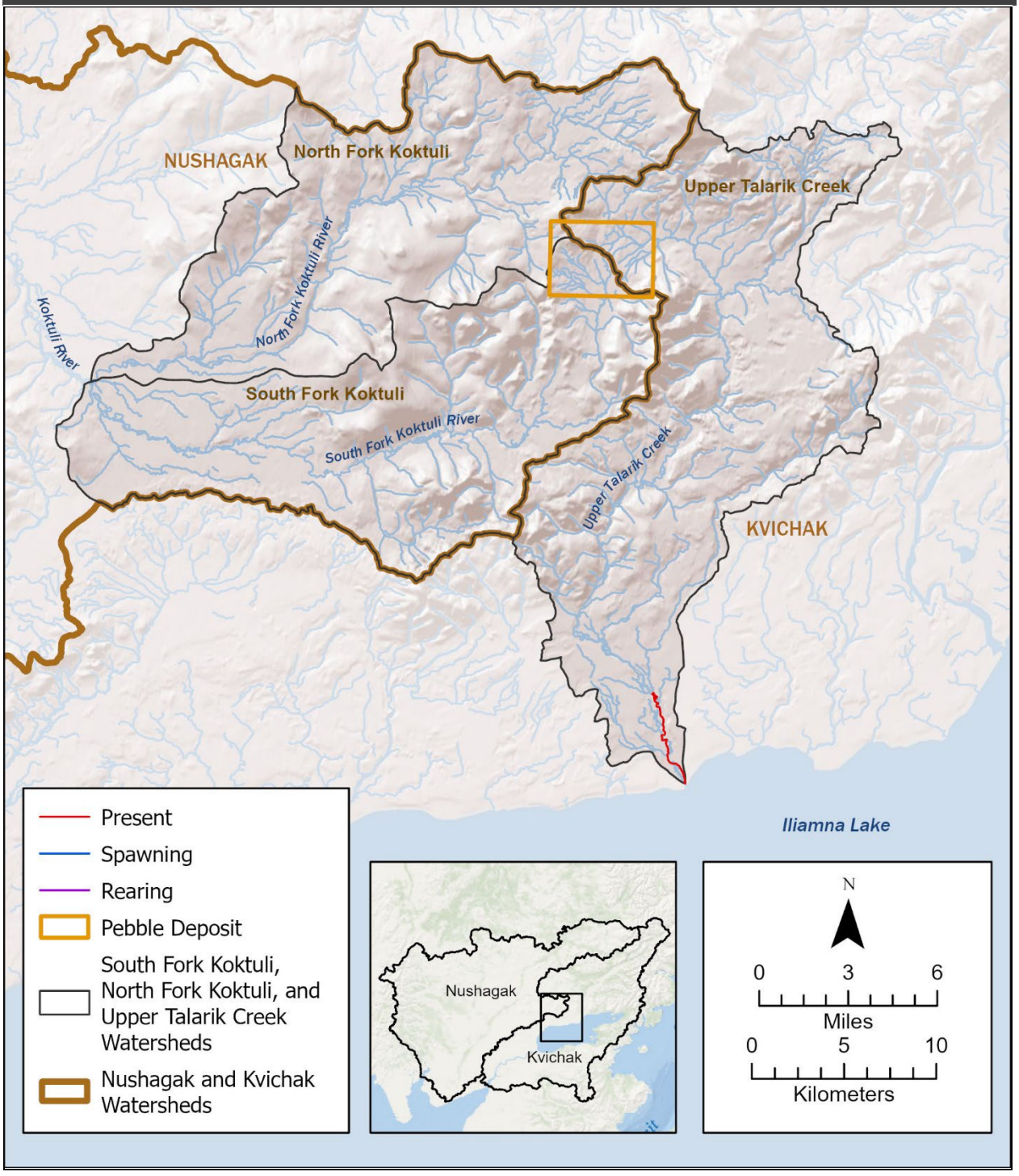
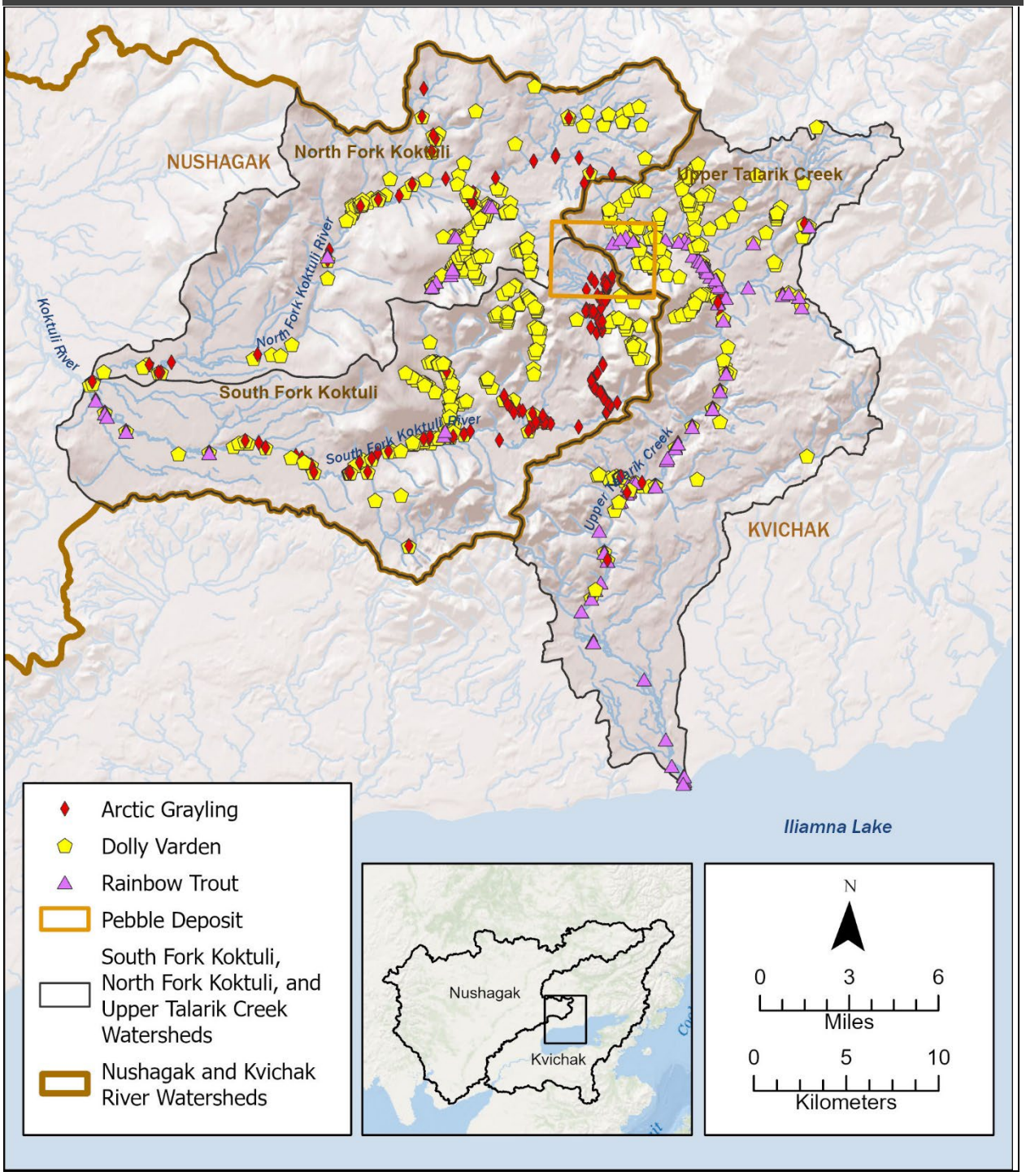


Figure 3-10. Rainbow Trout, Dolly Varden, and Arctic Grayling occurrence in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. Designation of species presence is based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).



Index estimates of relative spawning salmon abundance in the SFK, NFK, and UTC watersheds are available for Sockeye, Coho, Chinook, and Chum salmon. Both ADF&G and PLP have conducted aerial index counts of spawning salmon at different points in time. This type of survey is used primarily to track variation in run size over time. Survey values tend to underestimate true abundance: for example, USACE (2020a: Section 3.24) states that aerial surveys capture only an average of 18 percent of total abundance. This underestimation occurs for several reasons. An observer in an aircraft is not able to count all fishes in dense aggregations or those concealed under overhanging vegetation or undercut banks, and only a fraction of the fishes that spawn at a given site are present at any one time (Bue et al. 1998, Jones et al. 2007). Weather, water clarity, and other factors that influence fish visibility can also contribute to underestimates. In addition, surveys intended to capture peak abundance may not always do so. For example, aerial surveys counted, on average, only 44 percent of the Pink Salmon counted by surveyors walking the same Prince William Sound spawning streams (Bue et al. 1998). Peak aerial counts of Pink Salmon in southeastern Alaska are routinely multiplied by 2.5 to represent more accurately the number of fishes present at the survey time (Jones et al. 2007). Helicopter surveys of Chinook Salmon on the Kenai Peninsula's Anchor River over 5 years counted only 5 to 10 percent of the fishes documented by a concurrent sonar/weir counting station (Szarzi et al. 2007).

ADF&G conducts aerial index counts that target peak Sockeye Salmon spawning periods on UTC and peak Chinook Salmon spawning periods on the Koktuli River system. Sockeye Salmon counts have been conducted in most years since 1955 (Morstad 2003), and Chinook Salmon counts in most years since 1967 (Dye and Schwanke 2009). Between 1955 and 2011, Sockeye Salmon counts in UTC ranged from 0 to 70,600, with an average of 7,021 over 49 count periods (Morstad pers. comm.). Between 1967 and 2009, Chinook Salmon counts in the Koktuli River system ranged from 240 to 10,620, with an average of 3,828 over 29 count periods (Dye and Schwanke 2009). The mean aerial count of Chinook Salmon in the Koktuli River represents nearly one-quarter of the mean total for the entire Nushagak-Mulchatna watershed (Dye and Schwanke 2009). Thus, the Nushagak River is the largest producer of Chinook Salmon in the Bristol Bay watershed, and the Koktuli River is the largest producer of Chinook Salmon in the Nushagak River watershed.

PLP (2018a) provides aerial index counts for Chinook, Chum, Coho, and Sockeye salmon adults in the SFK, NFK, and UTC mainstem segments and select tributaries from 2004 to 2008. Surveys on the SFK and NFK began at their confluence and extended upward to the intermittent reach or Frying Pan Lake on the SFK and upward to Big Wiggly Lake or river kilometer 56 on the NFK. Surveys on UTC ran from the mouth and extended upstream to Tributary 1.350 (just east of Koktuli Mountain) or to the headwaters. Multiple counts were usually made for each stream and species in a given year.

Table 3-7 reports the minimum and maximum values for highest index spawner count in the SFK, NFK, and UTC mainstems, from 2004 through 2008 (SFK and NFK) or 2009 (UTC) (PLP 2018a: Chapter 15, Tables 15-14 through 15-17). Peak index counts capture only a portion of total spawning run abundance, because only a portion of the spawning population is present on the spawning grounds on any given day. Individual spawners are visible on their spawning grounds for days to weeks (e.g., Bue et al. 1998), but the spawning season can extend for weeks to months in the SFK, NFK, and UTC watersheds

(PLP 2018a). The highest peak index counts for Coho and Sockeye salmon were in UTC, whereas the highest counts for Chinook and Chum salmon were in the SFK and NFK (Table 3-7). The overall highest count was for Sockeye Salmon in UTC in 2008, when approximately 50,317 fish were estimated (Table 3-7).

Table 3-7. Highest reported index spawner counts in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek, based on mainstem aerial surveys.

Watershed	Years Surveyed	Salmon Species	Number of Surveys Counted Per Year (Min-Max)	Highest Index Spawner Count (Year of Count) [a]	
				Minimum Value	Maximum Value
South Fork Koktuli River	2004–2008	Chinook	3–9	327 (2006)	2,780 (2004)
		Chum [b]	4–11	189 (2007)	917 (2008)
		Coho	2–21	270 (2004)	1,955 (2008)
		Sockeye	3–14	1,730 (2004)	6,133 (2008)
North Fork Koktuli River	2004–2008	Chinook	3–8	434 (2008)	2,889 (2005)
		Chum	1–9	350 (2005)	1,432 (2008)
		Coho	1–17	114 (2007)	1,704 (2008)
		Sockeye	2–11	563 (2004)	2,188 (2007)
Upper Talarik Creek	2004–2009	Chinook	2–9	80 (2009)	272 (2004)
		Chum [b]	1–8	3 (2005)	44 (2008)
		Coho	2–21	1,041 (2005)	7,542 (2009)
		Sockeye	2–20	10,557 (2007)	50,317 (2008)

Notes:

[a] Values likely underestimate true spawner abundance (see Appendix B of this document for additional information).

[b] Chum were not counted in the North Fork Koktuli or Upper Talarik Creek in 2004.

Source: PLP 2018a: Chapter 15, Tables 15-14 through 15-17.

Aerial counts of adult salmon were also conducted in tributaries of the SFK, NFK, and UTC between 2004 and 2009 (Table 3-8). Adult Coho and Chum salmon were counted in SFK tributaries; adult Coho and Sockeye salmon were counted in NFK tributaries; and adult Coho, Chinook, Chum, and Sockeye salmon were counted in UTC tributaries. The highest number of adults reported in tributaries of each watershed were 50 Coho Salmon (SFK 1.190), 111 Sockeye Salmon (NFK 1.240), and 31,922 Sockeye Salmon (UTC 1.160) (Table 3-8).

Table 3-8. Highest reported number of adult salmon in tributaries of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek, based on aerial surveys.

Watershed	Tributary	Years Surveyed	Total Number of Surveys (Min-Max Number of Surveys Per Year) [a]	Salmon Species [b]	Highest Reported Number in an Individual Survey
South Fork Koktuli River	SFK 1.130	2004–2008	26 (0–24)	Chum	6
				Coho	48
	SFK 1.190	2004–2008	42 (0–24)	Chum	28
				Coho	50
	SFK 1.240	2004–2008	26 (0–14)	Coho	5
North Fork Koktuli River	NFK 1.190 [c]	2004–2008	39 (0–21)	Coho	27
	NFK 1.240 [c]	2004–2008	26 (1–17)	Coho	12
				Sockeye	111
	NFK 1.260	2004–2008	11 (0–10)	Coho	4
	NFK 1.270	2004–2008	6 (0–5)	Coho	23
	NFK 1.280	2006–2008	2 (0–1)	Coho	2
Upper Talarik Creek	UTC 1.160	2008–2009	42 (18–24)	Coho	1,079
				Sockeye	31,922
	UTC 1.190	2004–2009	53 (0–22)	Sockeye	49
	UTC 1.350 [c]	2004–2009	52 (1–25)	Chum	3
				Coho	571
				Sockeye	57
	UTC 1.390 [c]	2007–2009	(1–27)	Coho	29
				Sockeye	115
	UTC 1.410	2004–2009	34 (0–19)	Chinook	2
				Chum	21
				Coho	43
				Sockeye	30
	UTC 1.460	2004–2005	3 (1–2)	Coho	7

Notes:

[a] In all but one case, the maximum number of surveys occurred in 2008.

[b] Only tributaries and salmon species with at least one survey count greater than one are listed.

[c] NFK 1.190 also includes NFK 1.190.10; NFK 1.240 also includes NFK 1.240P1, 1.240P1 Big Wiggly Lake, and 1.240.20.P1; UTC 1.350 also includes 1.350.20, 1.350.20P1, 1.350.20P2, and 1.350.20P3; UTC 1.390 also includes 1.390.20P2.

Source: PLP 2018a: Chapter 15, Appendix 15B2.

Mainstem and off-channel habitats of the SFK, NFK, and UTC also provide abundant habitat for juvenile salmonids. Table 3-9 presents maximum estimated densities and total numbers observed for juvenile Pacific salmon species in mainstem SFK, NFK, and UTC reaches (PLP 2018a: Chapter 15, USACE 2020a). Reported fish densities summarized over the 5-year period vary widely by stream and reach, which is typical for fishes in heterogeneous stream environments. The highest maximum estimated density for juvenile salmon was approximately 124 juvenile Coho Salmon in UTC Reach F (Table 3-9). Habitat-specific densities were much higher, however: for example, a density of approximately 1,600 Coho Salmon (of which roughly 90 percent were juveniles) per 100 m^2 of pool habitat was estimated in UTC Reach D (PLP 2011: Figure 15.1-82).

Table 3-9. Maximum estimated densities and total observed number of juvenile Pacific salmon in mainstem habitats of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek.

Watershed/Reach (River Kilometers)	Maximum Estimated Density (# per 100 m²) [a]			Total Number Observed at Mainstem Index Sites [b]		
	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye
South Fork Koktuli River						
SFK-A (0.0–24.9)	24.86	37.40	1.77	1,246	762	29
SFK-B (24.9–34.3)	0.21	20.21	0.57	4	292	8
SFK-C (34.3–51.7)	0.12	19.77	0.35	4	101	-
SFK-D (51.7–54.7)	1.39	2.52	0.00	-	-	-
SFK-E (54.7–64.2)	0.00	1.18	0.00	-	1	-
North Fork Koktuli River						
NFK-A (0.0–13.7)	18.84	17.67	0.15	802	415	7
NFK-B (13.7–21.1)	30.68	34.52	1.18	95	190	-
NFK-C (21.1–36.6)	8.24	28.07	1.89	213	624	42
NFK-D (36.6–48.4)	0.38	2.73	0.12	-	23	1
NFK-E (48.4–52.5)	0.00	0.00	0.00	-	-	-
Upper Talarik Creek						
UTC-A (0.0–5.9)	0.38	1.25	0.00	10	33	-
UTC-B (5.9–16.8)	17.62	46.24	0.14	61	931	-
UTC-C (16.8–24.8)	11.31	67.24	2.28	101	422	1
UTC-D (24.8–36.3)	4.64	48.99	0.29	6	868	-
UTC-E (36.3–45.1)	4.77	115.42	4.12	5	1,240	5
UTC-F (45.1–59.1)	1.53	123.78	0.67	-	992	1
UTC-G (59.1–62.4)	0.00	21.53	0.00	-	2	-

Notes:

[a] Maximum estimated juvenile density across values reported for 2004–2007, 2008, and 2009.

[b] Total number of juveniles observed across index sites within given reach in 2009, surveyed by beach seine and snorkel methods. South Fork Koktuli River sites were sampled 7/24 to 8/28; North Fork Koktuli River sites were sampled 7/25 to 8/21; Upper Talarik Creek sites were sampled 7/26 to 8/28. Dash (-) indicates that no counts for the given species were reported within that reach.

Source: USACE 2020a: Table 3.24-9, PLP 2018a: Chapter 15, Table 15-11.

Abundant and diverse off-channel habitats are also found in the SFK, NFK, and UTC watersheds (Section 3.2.2). Aerial imagery shows that roughly 70 percent of the mainstem SFK and UTC and roughly 90 percent of the mainstem NFK are bordered by some form of off-channel habitat (USACE 2020a: Section 3.24), most commonly beaver complexes (Section 3.2.2) (USACE 2020a: Section 3.24). Off-channel habitats provide important rearing habitat for many fish species but may be especially important as rearing and overwintering habitats for juvenile salmonids (Huntsman and Falke 2019, USACE 2020a: Section 3.24). Table 3-10 highlights the diversity of both off-channel habitats and the fish species that rely on them in the SFK, NFK, and UTC watersheds. Relative abundance in these habitats was highest for Coho Salmon, with an estimate of more than 1,300 fish per 100 meters.

Table 3-10. Relative abundance of salmonids in off-channel habitats of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek.

Watershed	Off Channel Habitats		Number of Fish Per 100 Meters					
	Type	No. of Sites	Chinook Salmon	Coho Salmon	Sockeye Salmon	Arctic Grayling	Dolly Varden	Rainbow Trout
South Fork Koktuli River [a]	Alcove	-	-	-	-	-	-	-
	Beaver pond	36	2.94	30.38	10.84	7.37	4.29	0
	Beaver pond outlet channel	-	-	-	-	-	-	-
	Isolated pool	2	0	8.22	2.35	0	0	0
	Percolation channel	2	0	11.43	0	0	0	0
	Side channel	3	10.34	66.41	5.17	0.52	0	0.52
North Fork Koktuli River [b]	Alcove	1	2.06	1,334.02	24.74	0	12.37	0
	Beaver pond	9	0.18	78.19	0.53	0	1.07	0
	Beaver pond outlet channel	1	0	0	0	0	0	0
	Isolated pool	2	0	0	0	0	0	0
	Percolation channel	16	2.49	51.60	0.62	0	8.70	0
	Side channel	8	0	568.13	0	0	69.21	0
Upper Talarik Creek [c]	Alcove	1	0	87.10	0	0	0	0
	Beaver pond	24	1.38	317.41	0.42	0.26	1.38	0.42
	Beaver pond outlet channel	3	0	42.38	0	0	1.32	1.32
	Isolated pool	4	0	15.09	0	0	0	0
	Percolation channel	10	0.63	144.38	3.92	12.54	0.16	0.78
	Side channel	3	0.75	270.33	1.51	0	0.75	0

Notes:

[a] Off-channel sites in the South Fork Koktuli River were sampled in September 2005, June and August 2006, and July 2007; it is not clear if or how data from sampling dates were combined to arrive at table values.

[b] Off-channel sites in the North Fork Koktuli River were sampled between late July to mid-August 2008; it is not clear if or how data from sampling dates were combined to arrive at table values.

[c] Off-channel sites in Upper Talarik Creek were sampled in July and October 2007; it is not clear if or how data from these sampling dates were combined to arrive at table values.

Source: PLP 2011: Chapter 15, Appendix 15.1D, Table 6.

As Table 3-3 illustrates, the SFK, NFK, and UTC watersheds are home to several fish species in addition to Pacific salmon. Maximum estimated densities for a subset of these other fishes in the SFK, NFK, and UTC mainstem reaches are shown in Table 3-11. Estimated densities were highest for Artic Grayling, particularly in upstream reaches of all three watersheds.

Table 3-11. Maximum estimated densities of resident fishes in mainstem habitats of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek.

Watershed/Reach (River Kilometers)	Maximum Estimated Density (# per 100 m²) [a]					
	Rainbow Trout	Dolly Varden	Arctic Grayling	Northern Pike	Sculpin spp.	Stickleback spp.
South Fork Koktuli River						
SFK-A (0.0–24.9)	0.03	3.44	0.67	0.00	2.52	0.00
SFK-B (24.9–34.3)	0.29	0.64	2.47	0.00	1.29	0.00
SFK-C (34.3–51.7)	0.00	0.82	35.31	0.47	4.94	0.21
SFK-D (51.7–54.7)	0.00	5.55	45.02	1.26	19.78	0.00
SFK-E (54.7–64.2)	0.00	0.00	15.90	2.36	9.29	0.15
North Fork Koktuli River						
NFK-A (0.0–13.7)	0.23	0.74	2.44	0.00	1.52	0.00
NFK-B (13.7–21.1)	0.00	0.24	0.21	0.00	2.01	0.00
NFK-C (21.1–36.6)	0.00	1.76	6.68	0.00	1.76	0.00
NFK-D (36.6–48.4) [b]	0.00	1.05	6.01	0.10	6.77	0.19
NFK-E (48.4–52.5) [b]	0.00	0.00	0.00	0.00	10.00	0.00
Upper Talarik Creek						
UTC-A (0.0–5.9) [b]	0.11	0.00	0.04	0.00	0.66	14.55
UTC-B (5.9–16.8) [b]	10.64	0.20	0.61	0.00	1.96	0.00
UTC-C (16.8–24.8)	11.03	0.47	32.10	0.00	13.31	0.54
UTC-D (24.8–36.3)	0.45	1.22	1.19	0.00	3.70	0.44
UTC-E (36.3–45.1)	0.32	0.44	0.70	0.00	7.53	0.04
UTC-F (45.1–59.1)	0.87	3.35	0.43	0.00	28.65	0.17
UTC-G (59.1–62.4)	0.00	7.46	0.00	0.00	16.58	0.00

Notes:

[a] Maximum estimated adult and juvenile density across values reported for 2004–2007, 2008, and 2009.

[b] Reach was not sampled from 2004–2007.

Source: USACE 2020a: Table 3.24-9.

3.3.3 Habitat Complexity, Biocomplexity, and the Portfolio Effect

The world-class salmon fisheries in Bristol Bay result from numerous, interrelated factors. Closely tied to the Bristol Bay region's physical habitat complexity (Section 3.2) is its biocomplexity, which greatly increases the region's ecological productivity and stability. This biocomplexity operates at multiple scales and across multiple species, but it is especially evident in the watershed's Pacific salmon populations (Shedd et al. 2016). As a result, the loss of even a small, discrete population within the Bristol Bay watershed's overall salmon populations may have more significant effects than expected, due to associated decreases in biocomplexity.

3.3.3.1 The Relationship between Habitat Complexity and Biocomplexity

The five Pacific salmon species found in the Bristol Bay watershed vary in life-history characteristics (Table 3-4). Even within a single species, life histories can vary significantly. For example, Sockeye Salmon may spend anywhere from 0 to 3 years rearing in freshwater habitats, then 2 to 3 years feeding at sea, before returning to the Bristol Bay watershed anytime within a 4-month window (Table 3-4). Coho Salmon similarly may spend anywhere from 1 to 3 years rearing in freshwater habitats

(Table 3-4). This staggered and overlapping age structure reduces variation in recruitment because it reduces the probability that all individuals in a cohort of siblings will encounter unfavorable environmental conditions over the course of their life cycles.

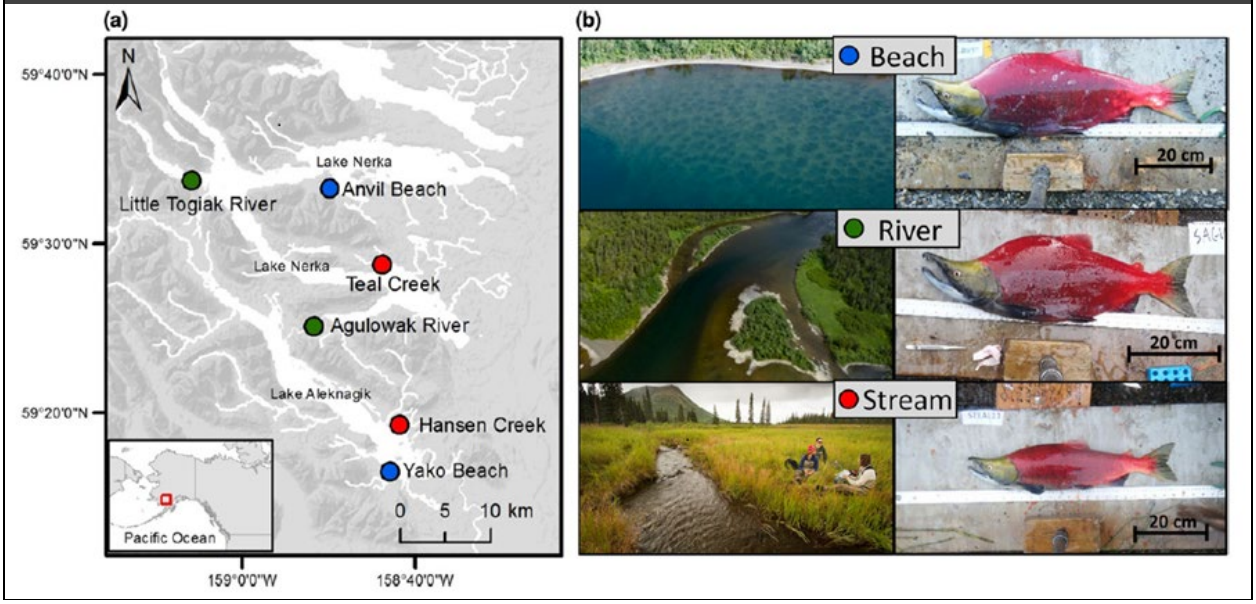
Pacific salmon exhibit homing behavior, meaning that they return to their natal streams to spawn. This homing behavior reduces gene flow between breeding groups and allows natural selection and genetic drift to produce discrete populations within each species that are adapted to their own specific spawning and rearing habitats and that are distinguishable using various genetic tools (Hilborn et al. 2003, Ramstad et al. 2010, Schindler et al. 2010, Larson et al. 2019). As research tools have improved, it is increasingly clear that population differentiation can occur at very fine spatial scales (Quinn et al. 2012), enabled by the remarkable homing abilities of Pacific salmon species (Quinn et al. 2006) and driven by differences in environmental characteristics such as thermal regime and water chemistry (Ruff et al. 2011, Keefer and Caudill 2014).

Both geography and ecology influence this genetic divergence within salmon species (Gomez-Uchida et al. 2011). Spawning populations return at different times and to different locations, creating and maintaining a degree of reproductive isolation due to reduced genetic exchange and allowing development of genetically distinct populations (Varnavskaya et al. 1994, Hilborn et al. 2003, McGlauflin et al. 2011). Within discrete spawning areas, natural selection may favor traits differently based on the unique environmental characteristics of spawning or rearing areas. For example, phenotypic variation in Sockeye Salmon body size and shape in the Bristol Bay region has been related to gravel size and spawning habitat (Quinn et al. 1995, Quinn et al. 2001, Larson et al. 2017, Schindler et al. 2018), illustrating the apparent adaptive significance of this variation.

These life history characteristics allow Pacific salmon species to fully exploit the range of habitats available throughout the Bristol Bay watershed, where many populations of each of these species are arrayed across a diverse landscape. Hydrologically diverse riverine and wetland landscapes across the region provide a variety of large river, small stream, floodplain, pond, and lake habitats for salmon spawning and rearing. Environmental conditions can differ among habitats in close proximity, and variations in temperature and streamflow associated with seasonality and groundwater–surface water interactions create a habitat mosaic that supports a range of spawning times across the watersheds (Lisi et al. 2013, Schindler et al. 2018).

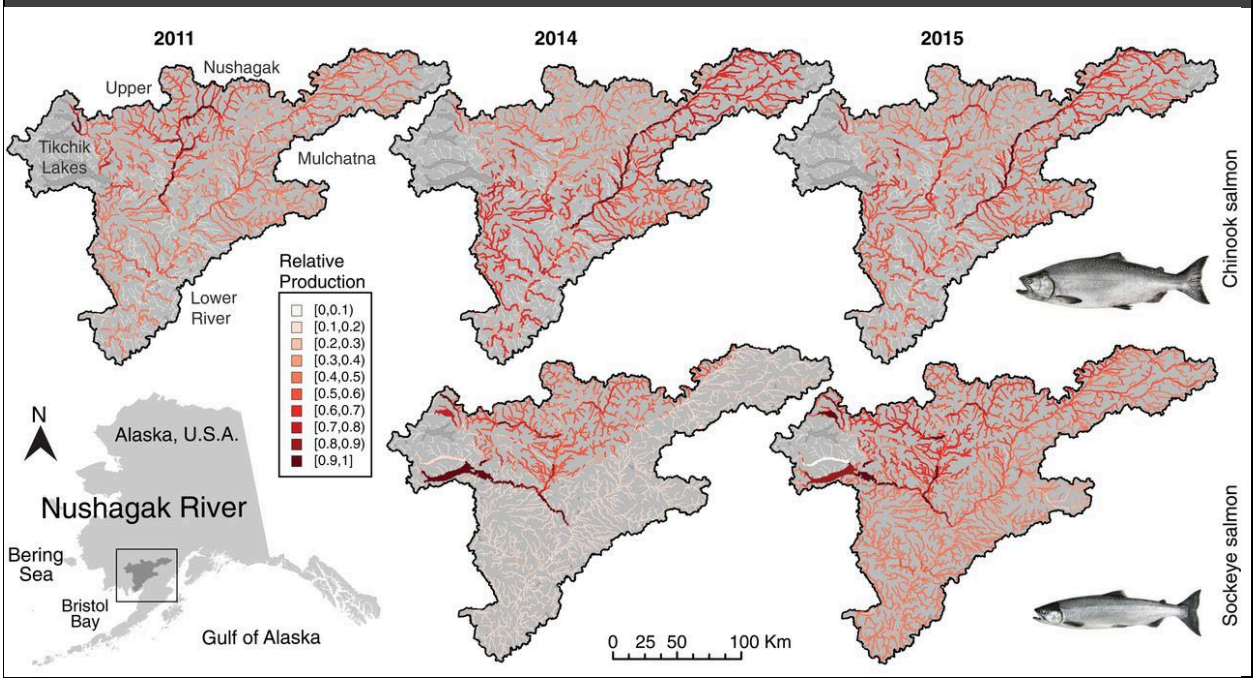
Bristol Bay is home to the largest Sockeye Salmon fishery in the world (Section 3.3.5). Sockeye Salmon from Bristol Bay produce relatively consistent returns due to the high degree of population diversity found within both the species and the region (Hilborn et al. 2003, Wood et al. 2008, Schindler et al. 2010, Schindler et al. 2015, Moore et al. 2021). A major component of this population diversity is associated with the diversity of habitats used for spawning, which has resulted in the formation of distinct spawning ecotypes (Figure 3-11) (Quinn et al. 1995, Lin et al. 2008a, Dann et al. 2012, Larson et al. 2017, Schindler et al. 2018).

Figure 3-11. Bristol Bay salmon genetic lines of divergence linked to ecotypes. Genotypic and phenotypic diversity are linked in Sockeye Salmon from the Wood River system in Bristol Bay, providing an example of phenotypic variation due to selective adaptive pressures from the diversity of habitats (beaches, rivers, and streams) across the landscape. From Larson et al. (2017); reprinted with permission.



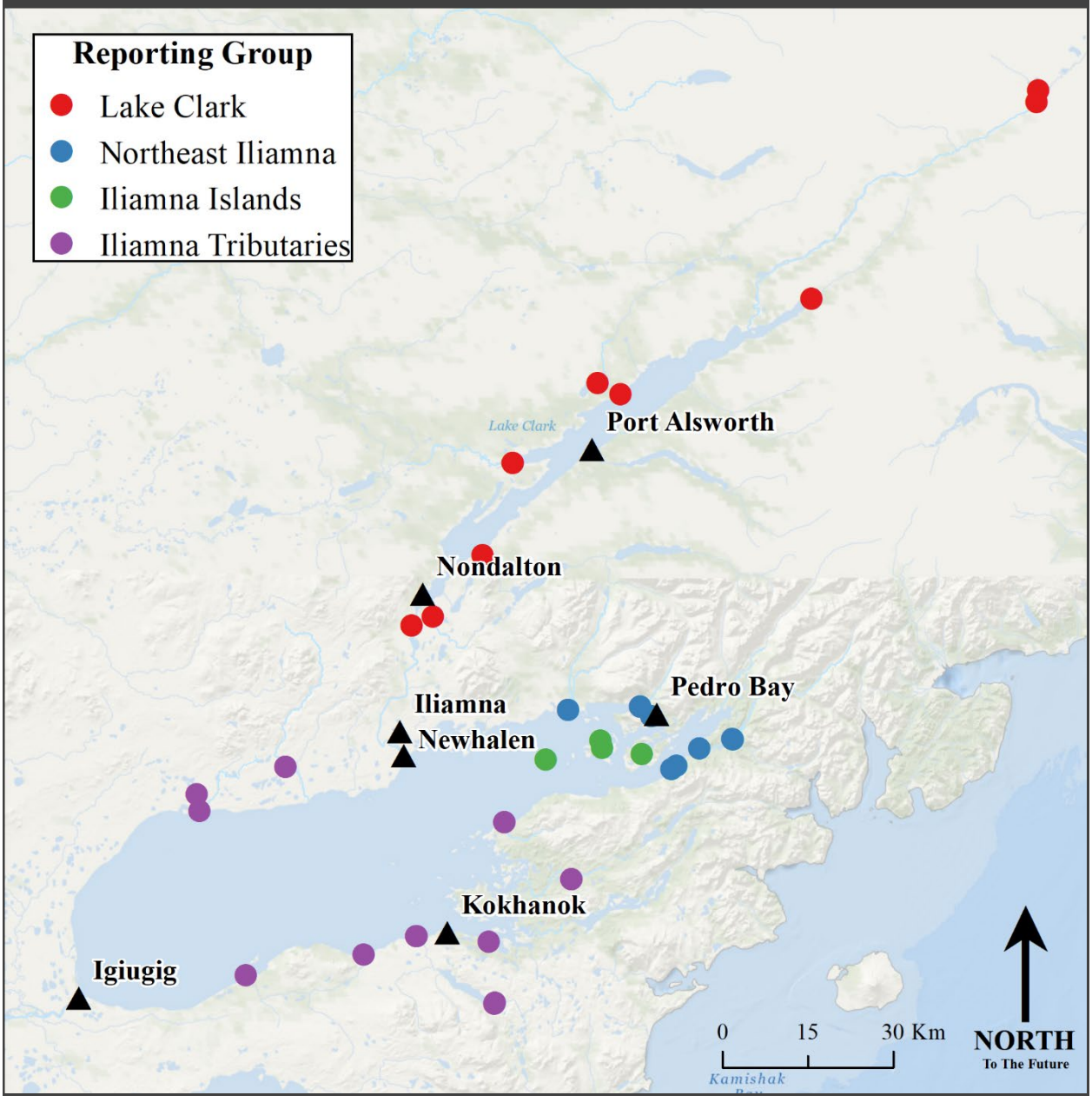
For both Chinook and Sockeye salmon, biocomplexity—operating across a continuum of integrated, nested spatial and temporal scales—stabilizes salmon production and fisheries in the Nushagak River watershed (Brennan et al. 2019). Productivity of Sockeye and Chinook salmon shifts within the Nushagak River watershed from year to year (Figure 3-12). Because the productivity of individual habitats and sub-watersheds in the Nushagak River watershed varies with environmental conditions, maintaining habitat diversity across the landscape is critical for maintaining the sustainability and productivity of the watershed's salmon populations. The phenotypic, genotypic, and behavioral diversity of these salmon populations depends on the diversity of aquatic habitats in space and time (Davis et al. 2017, Schindler et al. 2018, Brennan et al. 2019).

Figure 3-12. Productive habitats for Chinook and Sockeye salmon across the Nushagak River watershed shift over time. From Brennan et al. (2019); reprinted with permission.



Although this genetic differentiation and associated phenotypic differences tend to increase with distance between the populations, even populations in relatively close proximity can exhibit high degrees of differentiation (May et al. 2020). As a result, these discrete populations can occur at localized spatial scales. For example, Sockeye Salmon that use spring-fed ponds and streams approximately 0.6 mile (1 km) apart exhibit differences in spawn timing, productivity, and other traits that are consistent with discrete populations (Quinn et al. 2012). Multiple beach-spawning populations of Sockeye Salmon are found in Iliamna Lake (Figures 3-11 and 3-13) (Stewart et al. 2003, Larson et al. 2017). Genetically distinct river-type and lake-type populations can co-occur within watersheds (Dann et al. 2013, Shedd et al. 2016, Larson et al. 2017), and inlet and outlet spawners with distinct migration patterns can occur within the same lake (Burger et al. 1997). Iliamna Lake supports genetically unique populations within tributary, island, and lake shoreline ecotones, with UTC identified as the location of one of the 22 populations (Figure 3-13). Genetic diversity of Sockeye Salmon in Bristol Bay has been found to be distributed hierarchically between ecotypes, among drainages within ecotypes, and among populations within drainages (Figure 3-11) (Dann et al. 2013, Larson et al. 2017, Schindler et al. 2018, Larson et al. 2019).

Figure 3-13. Kvichak River Sockeye Salmon populations. 22 populations of Sockeye Salmon (color-coded by reporting group) have been identified in the Kvichak River. From Dann et al. (2018); reprinted with permission.



Sockeye Salmon that spawn in small streams tend to be smaller than beach or river spawners, as shallow stream depths and size-selective predation by bears favor survival of smaller spawning adults (Figure 3-11) (Quinn et al. 2001, Larson et al. 2017). These different spawning environments also vary in other characteristics, such as temperature, gravel size, and spawning density, resulting in differences in egg size (Quinn et al. 1995, Hendry et al. 2000), timing of spawning (Schindler et al. 2010) and pathogen susceptibility (hypothesized in Larson et al. 2014). Local adaptation to these diverse habitats is key to creating and preserving salmon genetic diversity.

The river-type form of Sockeye Salmon, with juveniles that rear in rivers and tributaries for one or more years before migrating to the ocean, is relatively rare in Bristol Bay; the lake-type form, with juveniles that rear in lakes for one or more years before migrating, is more common (Wood et al. 2008). However, river-type Sockeye Salmon are found in the Nushagak River watershed, including in the Koktuli River (Dann et al. 2012). River-type Sockeye Salmon represent an important form of genetic diversity, as these populations typically exhibit greater diversity within and less diversity among populations than the more abundant lake-type sockeye salmon (Larson et al. 2019). It has been hypothesized that river-type Sockeye Salmon have a greater tendency than lake-type Sockeye Salmon to stray from natal areas and, thus, may be the colonizers of the species (Wood 1995, Wood et al. 2008). In this manner, life history and genetic diversity can help "seed" new freshwater habitats that become available (e.g., as glaciers recede due to climate change [Pitman et al. 2020]).

3.3.3.2 The Portfolio Effect

The life-history complexity of Bristol Bay's Pacific salmon species is superimposed on localized adaptations, resulting in a high degree of biocomplexity organized into discrete, locally distinct fish populations. For example, the Bristol Bay watershed includes a complex of different Sockeye Salmon populations—that is, a combination of hundreds of genetically distinct, wild populations, each adapted to specific, localized environmental conditions (Hilborn et al. 2003, Schindler et al. 2010, Schindler et al. 2018). As genetic tools and techniques develop, the science continues to advance our understanding of the prevalence and importance of individual populations.

Management of Alaska's salmon fisheries is geared toward protection of these wild salmon populations, or stocks (5 AAC 39.222, 5 AAC 39.220, 5 AAC 39.223, 5 AAC 39.200). The ADF&G Genetic Policy provides the fundamental document for guiding decisions made to protect the genetic integrity of significant and unique wild stocks (Evenson et al. 2018), and the mission of the ADF&G Gene Conservation Laboratory includes the protection of these genetic resources. The foundational premise behind the Genetic Policy guidelines is that salmonid populations have adapted to their native habitats over long periods of time and, thus, have maximized their fitness. These adaptations among populations provide increased resilience to variation in environmental conditions (Figge 2004, Schindler et al. 2010); disruption of these adaptations reduces the long-term fitness of populations.

This complex structure of genetically distinct populations can be likened to a financial portfolio in which assets are divided among diverse investments to increase financial stability. Essentially, it creates a biological portfolio effect (Lindley et al. 2009, Schindler et al. 2010, Schindler et al. 2015): under any

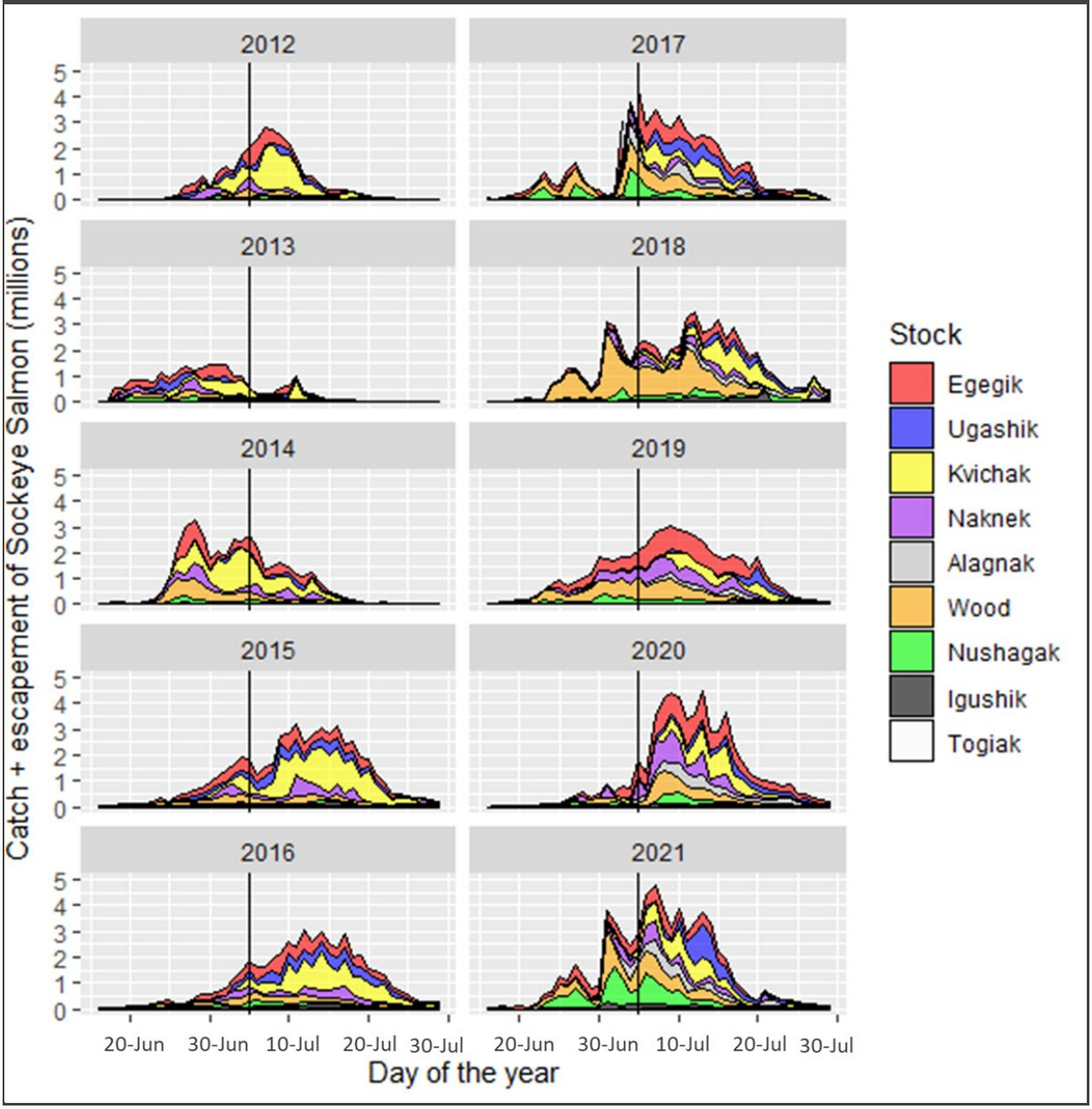
given set of conditions, some assets (e.g., discrete Sockeye Salmon populations) will perform well while others perform less well, but maintenance of the diversified portfolio stabilizes returns over time because fluctuations of these discrete populations are asynchronous.

The portfolio concept is based on three key principles: (1) diversity provides stabilization; (2) habitat diversity creates genetic and phenotypic diversity in space and time; and (3) genetic and phenotypic diversity dampen ecological risk through asynchrony of population dynamics (i.e., spawning, rearing, migration) across the landscape (Schindler et al. 2010). Across the entire watershed, overall salmon productivity is stabilized as the relative contributions of Sockeye Salmon that differ in genetic structure and life-history characteristics and that inhabit different regions of the Bristol Bay watershed change over time, in response to changing environmental conditions (Hilborn et al. 2003).

Asynchrony in the productivity of different populations within the complex has been demonstrated at both local and regional scales—that is, across individual tributaries and across the Bristol Bay watershed's major river systems (Rogers and Schindler 2008, Schindler et al. 2010, Griffiths et al. 2014, Raborn and Link 2022). This asynchrony among populations is an important characteristic of stable ecosystems (Rogers and Schindler 2008, Quinn et al. 2012). At the local scale, for example, salmon populations that spawn in small streams may be negatively affected by low-streamflow conditions, whereas populations that spawn in lakes may not be affected (Hilborn et al. 2003). At the regional scale, the relative productivity of Bristol Bay's major rivers has changed over time during different climatic regimes (Hilborn et al. 2003, Raborn and Link 2022). For example, small Sockeye Salmon runs in the Egegik River were offset by large runs in the Kvichak River prior to 1977, whereas declining runs in the Kvichak River were offset by large runs in the Egegik River in the 2000s (EPA 2014: Appendix A, Figure 9). Figure 3-14 illustrates how the proportion of Sockeye Salmon catch from each of Bristol Bay's major rivers varies both within and across years.

Asynchrony of population dynamics across a diverse set of habitats has enabled the Bristol Bay salmon fishery to be less variable and more reliable and sustainable than would otherwise be the case (Davis and Schindler 2021). The high level of system-wide biocomplexity inherent in the overall population complex structure reduces year-to-year variability in salmon run sizes. Without the portfolio effect, annual variability in the size of Bristol Bay's Sockeye Salmon runs would be expected to more than double, and fishery closures would be expected to become more frequent due to a weakening of the portfolio (Schindler et al. 2010, Griffiths et al. 2014). Simulations have shown that loss of headwater salmon populations can reverberate throughout the river network, resulting in reduced catch stability and increased fishery variability at the most downstream locations (Moore 2015). In other watersheds with previously robust salmon fisheries, such as the Sacramento River's Chinook Salmon fishery, losses of biocomplexity have contributed to overall salmon population declines (Lindley et al. 2009). Loss of accessible floodplain and headwater habitats also can be a significant driver of these declines, as illustrated in Canada's Lower Fraser River (Finn et al. 2021).

Figure 3-14. Seasonal catch plus escapement of Sockeye Salmon for each genetically distinct stock in Bristol Bay, Alaska, 2012–2021. Escapement refers to the number of adult salmon that "escape" harvest and return to freshwaters to spawn. Black vertical lines denote July 4, to facilitate run timing comparison across years. From Raborn and Link (2022); reprinted with permission.

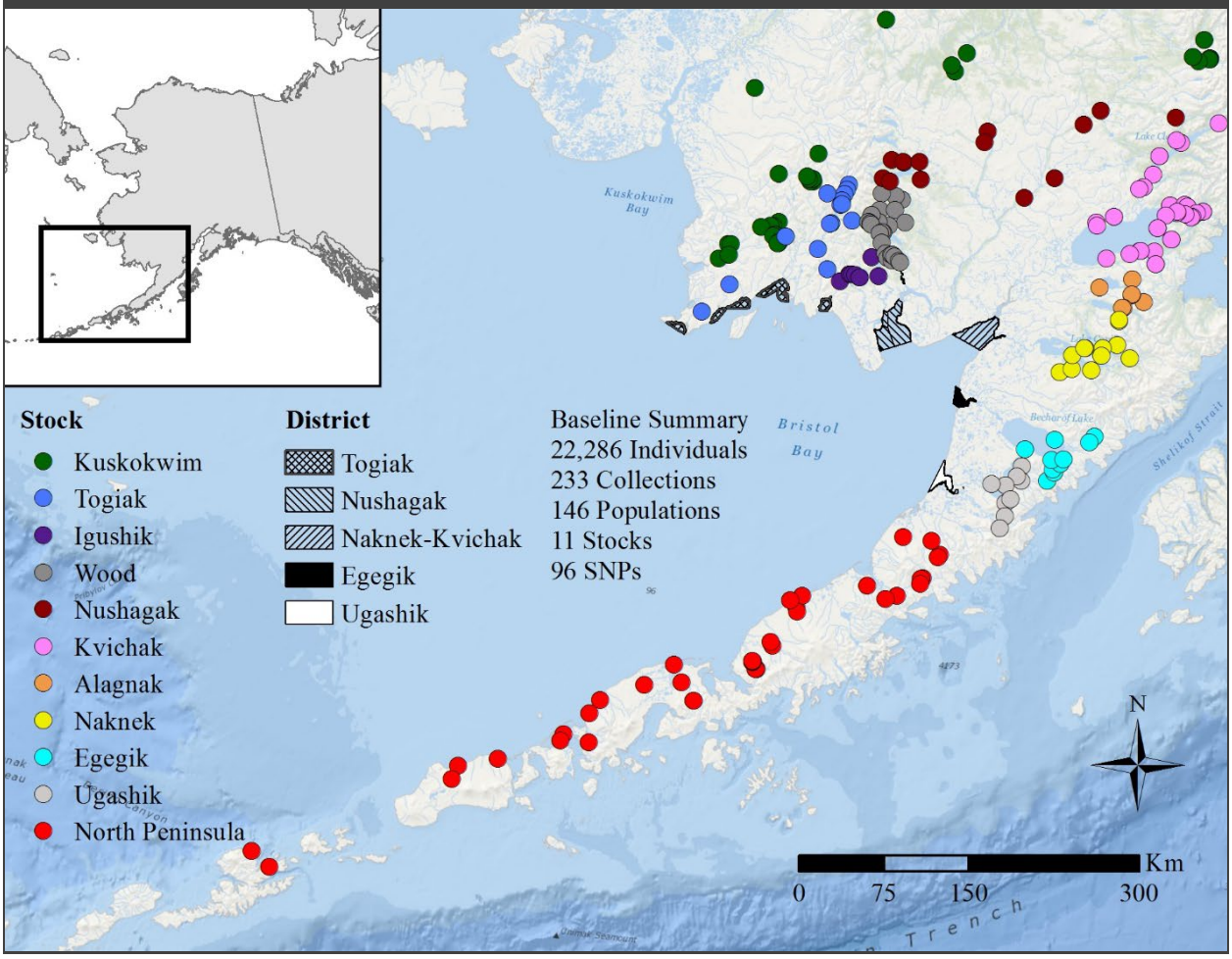


ADF&G has identified 11 genetic reporting groups (stocks), corresponding to nine major watersheds of Bristol Bay[48] and the two flanking regions (North Peninsula to the south and Kuskokwim to the north) (Figure 3-15). In Bristol Bay, a "stock" has been defined as a composite of all populations of a given species within each of those 11 watersheds (Dann et al. 2009). Each river stock contains tens to hundreds of wild, locally adapted populations distributed among tributaries and lake habitats. In Bristol Bay, the ADF&G Sockeye Salmon genetic baseline, which is assembled by sampling spawning populations contributing to the commercial fishery (Section 3.3.5), has recently increased from 96 to 146 distinct populations that range from the Kuskokwim River (to the north) to the Aleutian Islands (to the south) (Dann et al. 2013). Even this higher value likely underestimates the actual number of distinct breeding groups. Prior to the development of genetic tools and the current genetic baseline, Demory et al. (1964) catalogued Sockeye Salmon spawning sites of the Kvichak River system, including UTC. This catalog represents historical recognition of nearly 100 distinct stream and beach Sockeye Salmon spawning groups in the Kvichak River system alone. Given technological advances in genetic methods and the fact that this region has remained largely undeveloped and undisturbed since this initial estimate, it seems likely that additional genetic diversity will continue to be identified as further sampling of spawning groups and analysis of genetic structuring occur.

The genetic population structure of Bristol Bay Sockeye Salmon indicates that upper Mulchatna River fish are distinct from lower Mulchatna River fish, and that both of these populations are genetically distinct from the upper Nushagak River fish. Sockeye Salmon spawning in the Koktuli River are part of the Lower Mulchatna River and have recently been determined to be genetically distinct (Dann et al. 2012, Shedd et al. 2016). This incredible local diversity of Sockeye Salmon—which translates to the robustness of the region's Sockeye Salmon portfolio—reflects the species' ability to exploit a wide range of habitat conditions, the reproductive isolation of populations created by precise homing to natal spawning sites and, thus, the species' capacity for microevolution.

[48] Figure ES-1 shows six major watersheds draining to Bristol Bay, whereas Dann et al. (2009) refer to nine major watersheds. This difference results from consideration of the Igushik and Wood River watersheds as distinct from the Nushagak River watershed and the Alagnak River watershed as distinct from the Kvichak River watershed in Dann et al. (2009).

Figure 3-15. Reporting group affiliation for 146 Sockeye Salmon populations in Bristol Bay. These populations are used to estimate stock composition of catch samples from the Port Moller Test Fishery and district harvests. SNP = single nucleotide polymorphism, a common type of genetic marker. From Dann et al. 2013; reprinted with permission.



The close management of mixed-stock fisheries allows for the capitalization of genotypic and phenotypic diversity of Bristol Bay Sockeye Salmon while spreading the risk to any one stock across the stock portfolio (Veale and Russello 2017). The buffering effect of the salmon portfolio is reflected in the 2022 Bristol Bay Sockeye Salmon Forecast (ADF&G 2021a), which reports that individual river forecasts have greater uncertainty compared to the Bristol Bay-wide forecast. ADF&G (2021a) notes that since 2001, the forecast has, on average, underestimated returns to the Alagnak (-33 percent), Togiak (-14 percent), Kvichak (-21 percent), Wood (-20 percent), Nushagak (-25 percent), Ugashik (-5 percent), and Naknek (-15 percent) Rivers, and overestimated returns to the Igushik (11 percent) and Egegik Rivers (13 percent). Over-forecasting returns to some rivers while under-forecasting returns to other rivers means that the overall Bristol Bay forecast is often more accurate than the forecast to any individual river. This illustrates the power of a diverse stock portfolio to provide sustained resiliency for Bristol Bay's Sockeye Salmon fishery, by buffering risk to any one stock temporally and spatially across multiple

stocks: certain rivers may have lower than expected returns in a given year due to environmental conditions and other factors, but these losses can be offset by higher than expected returns in other rivers (Figure 3-14).

Baseline genetic research suggests that other Bristol Bay fisheries, in addition to Sockeye Salmon, may also be stabilized by the portfolio effect; in fact, the basic biology of these species makes such stabilization virtually inevitable. However, other Pacific salmon species have been less intensively studied in general, and their genetic baselines are not currently as advanced as they are for Sockeye Salmon. Coho Salmon in western Alaska tend to occur in smaller, more isolated populations (Olsen et al. 2003). Thus, Coho Salmon may have higher rates of genetic differentiation than nearby populations of other salmon species (e.g., Chum Salmon) in this region, and the loss of Coho Salmon populations may be more likely to translate to loss of significant amounts of overall genetic variability (Olsen et al. 2003, Schindler et al. 2018).

Chinook Salmon populations also tend to be relatively small (Healey 1991) and exhibit diverse life history traits (e.g., variations in size and age at migration, duration of freshwater and estuarine residency, time of ocean entry) (Lindley et al. 2009). Chinook populations in the Togiak River differ in spawning habitats (mainstem versus tributary) and migration timing, which translates to a clear stock structure (Sethi and Tanner 2014, Clark et al. 2015). The Chinook Salmon population in the Nushagak River watershed (i.e., the Nushagak watershed genetic reporting group) is represented by several spawning aggregations: the Koktuli River near the confluence of the SFK and NFK, the Chilikadrotna River, the Mulchatna River, the Stuyahok River, Klutuspak Creek and the Iowithla River. Based on variations in allele frequencies, these six spawning aggregations are considered six genetically differentiated populations that cannot be pooled into a single baseline population (Howard et al. 2019). The Koktuli River aggregation is a large component of the overall Nushagak watershed genetic reporting group (Templin et al. 2011). The current Chinook Salmon baseline update includes tissue samples from adults collected on spawning grounds in the lower Koktuli River mainstem and the SFK. Spawning populations of Chinook Salmon are also found in portions of the NFK and the UTC, but these populations are not currently well represented in the genetic baseline for Chinook Salmon.

Pacific salmon are not the only fish species that display genetic differentiation in this region. Radio telemetry, tagging, phenotypic variation, and genetic studies also indicate that multiple Rainbow Trout populations are found in the Bristol Bay watershed (Burger and Gwartney 1986, Minard et al. 1992, Krueger et al. 1999, Meka et al. 2003, Dye and Borden 2018, Arostegui and Quinn 2019b, Arostegui et al. 2019).

The potential for fine-scale population structuring of salmon fisheries, particularly in terms of Sockeye and Coho salmon, exists throughout the entire Bristol Bay watershed. Finer-scale habitats can sustain unique, genetically distinct populations, each of which helps to maintain the integrity of overall salmon stocks across the Bristol Bay watershed and contributes to the overall resilience of these stocks to perturbation. For example, Sockeye Salmon populations in proximity to each other show phenotypic differences related to differences in spawning habitats (Lin et al. 2008b, Ramstad et al. 2010), and

Sockeye Salmon that use spring-fed ponds and streams as close as approximately 0.6 mile (1 km) apart exhibit differences in traits (e.g., spawn timing and productivity) that suggest they may comprise discrete populations (Quinn et al. 2012). Genetic population structure also occurs at a fine geographic scale for Coho Salmon, with many populations found in small first- and second-order headwater streams (Olsen et al. 2003). The ability of Bristol Bay to sustain diverse salmon populations therefore depends on sustaining the viability of the vast network of unique habitats at small spatial scales across the landscape. This suggests that even the loss of a small population within the Bristol Bay watershed's overall salmon populations may have more significant effects than expected, due to the associated loss of genetic and phenotypic diversity of a discrete population (Schindler et al. 2010, Moore et al. 2014, Waples and Lindley 2018).

In summary, a substantial body of research supports the conclusion that a diversity of habitats is necessary for maintaining locally adapted populations that create a stock portfolio of individual species. The multiple, genetically distinct populations of Sockeye Salmon that have been documented in the SFK, NFK, and UTC watersheds contribute to the region's wild salmon portfolio. It is clear from the evolving understanding of the stabilizing effects of the salmon portfolio that the conservation of habitat diversity and connectivity, which leads to locally adapted population diversity across the landscape, is critical to achieve and maintain the sustainability of Bristol Bay's salmon populations.

3.3.4 Salmon and Marine-Derived Nutrients

Salmon play a crucial role in maintaining and supporting the overall productivity of the Bristol Bay watershed. Salmon are a cornerstone species in the Bristol Bay region in that they comprise a significant portion of the resource base upon which both aquatic and terrestrial ecosystems in the region depend (Willson et al. 1998). Approximately 95 to 99 percent of the carbon, nitrogen, and phosphorus in an adult salmon's body is derived from the marine environment during their ocean feeding period (Larkin and Slaney 1997, Schindler et al. 2005). Adult salmon returning to their natal freshwater habitats to spawn import these marine-derived nutrients (MDN) back into these freshwater habitats, spatially and temporally across the watershed (Cederholm et al. 1999, Gende et al. 2002). MDN from salmon account for a significant portion of nutrient budgets in the Bristol Bay watershed (Kline et al. 1993). For example, Sockeye Salmon were estimated to import approximately 14 tons (12.7 metric tons) of phosphorus and 11 tons (10.1 metric tons) of nitrogen into the Wood River system, and 55 tons (50.2 metric tons) of phosphorus and 438 tons (397 metric tons) of nitrogen into the Kvichak River system, annually (Moore and Schindler 2004). These nutrients provide the foundation for aquatic and terrestrial foodwebs via two main pathways: direct consumption of salmon in any of its forms (spawning adults, eggs, carcasses, and/or juveniles) and nutrient recycling (Gende et al. 2002).

Given that aquatic systems in the Bristol Bay watershed tend to be nutrient-poor, MDN contributions play a significant role in the Bristol Bay region's productivity. However, the distribution and relative importance of the trophic subsidies provided by MDN within salmon-bearing watersheds are not expected to be spatially or temporally uniform (Janetski et al. 2009). MDN concentrations will be highest in areas of high spawning density and where carcasses accumulate. Adult salmon are found in

headwater streams of the SFK, NFK, and UTC watersheds, sometimes in extremely high numbers (Table 3-8); thus, MDN are likely contributing to the biological productivity of these headwaters and downstream habitats.

Where salmon are abundant, productivity of the Bristol Bay region's fish and wildlife species is highly dependent on this influx of MDN into the region's freshwater habitats (EPA 2014: Box 5-3). When and where available, salmon-derived resources—in the form of eggs, carcasses, and invertebrates that feed upon carcasses—are important dietary components for many fishes (e.g., juvenile Pacific salmon, Rainbow Trout, Dolly Varden, Arctic Grayling). Numerous studies have shown that the availability of MDN benefits stream-dwelling fishes via enhanced growth rate (Bilby et al. 1996, Wipfli et al. 2003, Giannico and Hinch 2007), body condition (Bilby et al. 1998), energy storage (Heintz et al. 2004), and ultimately increased chance of survival to reproductive age and adulthood (Gardiner and Geddes 1980, Wipfli et al. 2003, Heintz et al. 2004).

Eggs from spawning salmon are a major food source for Bristol Bay Rainbow Trout and are likely responsible for much of the growth attained by these fish and the abundance of trophy-sized Rainbow Trout in the Bristol Bay system. Scheuerell et al. (2007) reported that upon arrival of spawning salmon in the Wood River basin, Rainbow Trout shifted from consuming aquatic insects to primarily consuming salmon eggs, resulting in a five-fold increase in ration and energy intake. With this rate of intake, a bioenergetics model predicted a 3.5-ounce (100-g) trout would gain 2.9 ounces (83 g) in 76 days; without the salmon-derived subsidy, the same fish was predicted to lose 0.2 ounce (5 g) (Scheuerell et al. 2007). Rainbow Trout in Lower Talarik Creek, a stream immediately west of UTC, were significantly fatter (i.e., had a higher condition factor) in years with high salmon spawner abundance than in years with low abundance (Russell 1977).

Rainbow Trout are not the only fish species to benefit from these MDN subsidies. Research in Iliamna Lake suggests that between 29 percent and 71 percent of the nitrogen in juvenile Sockeye Salmon, and even higher proportions in other aquatic taxa, comes from MDN, and that the degree of MDN influence increases with escapement (Kline et al. 1993). In the Kvichak River, Dolly Varden move into ponds where Sockeye Salmon are spawning and experience three-fold higher growth rates when salmon eggs are available as a food source (Denton et al. 2009); Dolly Varden in the Iliamna River similarly rely heavily on MDN subsidies in the form of salmon eggs, carcasses, and associated invertebrates (Jaecks and Quinn 2014).

By dying in the habitats in which they spawn, adult salmon add their nutrients to the ecosystem that will feed their young and, thus, subsidize the next generation. In lakes and streams, MDN help to fuel the production of algae, bacteria, fungi, and other microorganisms that make up aquatic biofilms. These biofilms, in turn, provide food for aquatic invertebrates. MDN inputs are associated with increased standing stocks of macroinvertebrates (Claeson et al. 2006, Lessard and Merritt 2006, Walter et al. 2006), a primary food resource for juvenile salmon and other stream-dwelling fishes.

The importance of MDN to fish populations is perhaps most clearly demonstrated in cases where MDN supplies are disrupted by depletion of salmon populations. For example, prolonged depression of

salmon stocks in the Columbia River basin in Oregon has resulted in a chronic nutrient deficiency that hinders the recovery of endangered and threatened Pacific salmon stocks (Gresh et al. 2000, Petrosky et al. 2001, Achord et al. 2003, Peery et al. 2003, Scheuerell et al. 2005, Zabel et al. 2006) and diminishes the potential of expensive habitat improvement projects (Gresh et al. 2000). Density-dependent mortality has been documented among juvenile Chinook Salmon, despite the fact that populations have been reduced to a fraction of historical levels, suggesting that nutrient deficits have reduced the carrying capacity of spawning streams in the Columbia River basin (Achord et al. 2003, Scheuerell et al. 2005). Thus, diminished salmon runs can create a negative feedback loop, in which the decline in spawner abundance reduces the capacity of streams to produce new spawners (Levy 1997).

It is not just aquatic systems that benefit from these salmon-based MDN subsidies. Terrestrial mammals (e.g., Brown Bears, wolves, foxes, minks) and birds (e.g., Bald Eagles, waterfowl) also benefit from these subsidies (Brna and Verbrugge 2013, EPA 2014: Chapter 5; Armstrong et al. 2016). Alaskan Brown Bears aggregate and exhibit fidelity in their foraging of salmon in small streams in the Bristol Bay watershed (Wirsing et al. 2018). Availability and consumption of salmon-derived resources can have significant benefits for these species, including increased growth rate, energy storage, litter size, nesting success, and population density (Brna and Verbrugge 2013). In response to temporally shifting distributions of spawning Sockeye Salmon, species such as Brown Bears and gulls change their spatial distributions within the Bristol Bay watershed over the course of the summer (Schindler et al. 2013). Bears, wolves, and other wildlife also transport carcasses and excrete wastes throughout their ranges (Darimont et al. 2003, Helfield and Naiman 2006), thereby providing food and nutrients for other terrestrial species.

3.3.5 Commercial Fisheries

All five species of Pacific salmon are commercially harvested in Bristol Bay, across five fishing districts identified by specific rivers draining to the bay (Table 3-12). Sockeye Salmon dominate the region's salmon runs and harvest by a large margin (Table 3-12). Management of the Sockeye Salmon fishery in Bristol Bay is focused on discrete stocks (Section 3.3.3.2) (Tiernan et al. 2021), and the fishery's success depends on the conservation of biodiversity and sound, conservative management based on sustainable yields (ADF&G 2022d). Bristol Bay is home to the largest Sockeye Salmon fishery in the world, with 46 percent of the average global abundance of wild Sockeye Salmon between 1956 and 2005 (Ruggerone et al. 2010); between 2015 and 2019, Bristol Bay contributed 53 percent of global Sockeye Salmon production (McKinley Research Group 2021). Annual commercial harvest of Sockeye Salmon averaged 31.5 million fish between 2010 and 2019 (Table 3-12) (Tiernan et al. 2021). The 2021 commercial harvest of 40.4 million Sockeye Salmon was 44 percent higher than the recent 20-year average of 28.0 million for all districts (ADF&G 2021b). In 2021, 66.1 million Sockeye Salmon returned to Bristol Bay (ADF&G 2021b); this number increased by almost 20 percent in 2022, to 79.0 million—the largest inshore Sockeye Salmon run ever recorded in the region (ADF&G 2022e). More than half of the Bristol Bay watershed's Sockeye Salmon harvest comes from the Nushagak and Kvichak River watersheds (Table 3-12) (EPA 2014: Figure 5-9B).

Table 3-12. Mean annual commercial catch (number of fish) by Pacific salmon species and Bristol Bay fishing district, 2010–2019. Number in parentheses indicates percentage of total found in each district.

Salmon Species	Bristol Bay Fishing District					
	Naknek-Kvichak [a]	Egegik	Ugashik	Nushagak [a]	Togiak	TOTAL
Sockeye	10,737,106 (34)	7,595,433 (24)	3,439,233 (11)	9,059,705 (29)	636,660 (2)	31,468,532
Chinook	2,168 (7)	930 (3)	753 (2)	25,111 (76)	3,983 (12)	32,945
Coho	2,316 (2)	8,012 (6)	630 (2)	91,263 (72)	25,215 (18)	127,436
Chum	233,281 (22)	72,472 (7)	50,366 (5)	540,280 (51)	163,062 (15)	1,059,464
Pink [b]	12,362 (1)	1,972 (<1)	539 (<1)	802,849 (88)	94,282 (10)	912,004

Notes:

[a] Naknek-Kvichak district includes the Alagnak River; Nushagak district includes the Wood and Igushik Rivers.

[b] Pink Salmon data are from even-numbered years only; harvest is negligible during odd-year runs.

Source: Tiernan et al. 2021.

The Nushagak River watershed supported 72 percent of commercial Coho Salmon catch in the region between 2010 and 2019 (Table 3-12). Although Chinook Salmon is the least common salmon species across the Bristol Bay region, the Nushagak River watershed also supports a large Chinook Salmon fishery, and its commercial harvests are greater than those of all other Bristol Bay river systems combined (Table 3-12). Between 2010 and 2019, on average 76 percent of Bristol Bay's commercial Chinook Salmon catch came from the Nushagak fishing district (Table 3-12). Chinook Salmon returns to the Nushagak River are consistently greater than 100,000 fish per year and have exceeded 200,000 fish per year in 11 years between 1966 and 2010. This frequently places the Nushagak River at or near the size of the world's largest Chinook Salmon runs, which is notable given the Nushagak River's small watershed area compared to other Chinook-producing rivers (EPA 2014: Chapter 5).

Given the productivity of Pacific salmon, the commercial salmon fishery currently provides the Bristol Bay region's greatest source of economic activity, creating thousands of jobs and generating $1 billion or more in economic output value through commercial fishing, processing, and support activities (Knapp et al. 2013, Wink Research and Consulting 2018, USACE 2020a, McKinley Research Group 2021). The McKinley Research Group (2021) estimates that in 2019, Bristol Bay's commercial fishery and related activities resulted in 15,000 jobs and an economic impact of $2.0 billion, $990 million of which was in Alaska. From 2000 through 2019, annual commercial salmon harvest in Bristol Bay averaged more than 27 million fishes across all five species (Tiernan et al. 2021). The annual ex-vessel commercial value[49] of this catch averaged $147.9 million, $146.4 million of which resulted from the Sockeye Salmon fishery (Table 3-13). In 2019, approximately 23 percent of Bristol Bay salmon permit holders were residents of the Bristol Bay watershed, and an additional 29 percent were residents of other areas in Alaska (McKinley Research Group 2021). This ex-vessel value translates to even higher wholesale values: for example, the 2010 Bristol Bay Sockeye Salmon harvest was worth $165 million in direct harvest value and $390 million in first wholesale value after processing (Knapp et al. 2013).

[49] Ex-vessel commercial value is the value paid to the fisher or permit holder upon delivery.

Table 3-13. Estimated ex-vessel value of Bristol Bay's commercial salmon catch by species, 2000–2019. Values are in thousands of dollars; number in parentheses indicates year that minimum or maximum value was obtained.

Salmon Species	Mean Value	Minimum Value (Year)	Maximum Value (Year)
Sockeye	146,372	31,962 (2002)	344,253 (2018)
Chinook	420	135 (2001)	1,240 (2006)
Coho	409	18 (2002)	1,990 (2014)
Chum	1,392	228 (2000)	2,891 (2018)
Pink [a]	436	0 (2002)	1,567 (2010)
TOTAL	147,874	32,544 (2002)	348,579 (2018)

Notes:
[a] Pink Salmon data are from even-numbered years only; harvest is negligible during odd-year runs.
Source: Tiernan et al. 2021: Appendix A24.

3.3.6 Subsistence Fisheries

In the Bristol Bay region, the subsistence way of life is irreplaceable. Subsistence resources provide high-quality foods, foster a healthy lifestyle, and form the basis for social relations. Alaska Natives are the majority population in the Bristol Bay region, and salmon has been central to their health, welfare, and culture for thousands of years. In fact, Alaska Native cultures in the region represent one of the last intact salmon-based cultures in the world (EPA 2014: Appendix D). Much of the region's population—including both Alaska Natives and non-Alaska Natives—practices subsistence, with salmon making up a large proportion of subsistence diets. Thus, residents in this region are particularly vulnerable to potential changes in salmon resources (see Section 6.3 for discussion of tribal considerations, including environmental justice concerns).

There are 31 Alaska Native villages in the wider Bristol Bay region, 25 of which are located in the Bristol Bay watershed. Fourteen of these communities are within the Nushagak and Kvichak River watersheds, with a total population of 4,197 in 2020 (U.S. Census Bureau 2022). Dillingham (population 2,249) is the largest community; other communities range in size from four (year-round) residents (Portage Creek) to 512 residents (New Stuyahok). In some communities, the population increases during the subsistence fishing season. Thirteen of these 14 villages—all but Port Alsworth—have federally recognized tribal governments and had an Alaska Native population majority in 2020. No towns, villages, or roads are currently located in the SFK, NFK, and UTC watersheds. However, this area has been noted as important to the health and abundance of subsistence resources by traditional knowledge experts from communities in the area.

The following sub-sections discuss the use of subsistence fisheries in the region and its nutritional, cultural, and spiritual importance. Subsistence related to foods other than fish is discussed in Section 6.3.1.

3.3.6.1 Use of Subsistence Fisheries

Alaska Native populations of the Bristol Bay watershed, as well as non-Alaska Native residents, have continual access to a range of subsistence foods. As described by Fall et al. (2009), these subsistence resources are the most consistent and reliable component of local economies in the Bristol Bay

watershed, even given the world-renowned commercial fisheries and other recreational opportunities the region supports.

Virtually every household in the Nushagak and Kvichak River watersheds uses subsistence resources (EPA 2014: Appendix D, Table 12). No watershed-wide data are available for the proportion of residents' diets made up of subsistence foods, as most studies focus on harvest data and are not dietary surveys. However, data from 2014 indicate that the overall composition of wild food harvest in the Bristol Bay area is composed of 58 percent salmon, 20 percent land mammals (mostly moose and caribou), 9 percent other fishes, and 13 percent other sources (marine mammals, birds, eggs, marine invertebrates and wild plants) (Halas and Neufeld 2018). In 2004 and 2005, annual subsistence consumption rates in the Nushagak and Kvichak River watersheds were over 300 pounds per person in many villages and reached as high as 900 pounds per person (EPA 2014: Appendix D, Table 12).[50]

Subsistence use varies throughout the Bristol Bay watershed, as villages differ in the per capita amount of subsistence harvest and the variety of subsistence resources used (Table 3-14). Salmon and other fishes are harvested throughout the Nushagak and Kvichak River watersheds (Figure 3-16) and provide the largest portion of subsistence harvests of Bristol Bay communities. On average, about 50 percent of the subsistence harvest by local community residents (measured in pounds usable weight) is Pacific salmon, and about 10 percent is other fishes (Fall et al. 2009). The percentage of salmon harvest in relation to all subsistence resources ranges from 29 percent to 82 percent in the villages (EPA 2014: Appendix D, Table 11); see Section 6.3.1 for further discussion of non-fish subsistence resources.

[50] For comparison, an average American consumes roughly 2,000 pounds of food per year.

Table 3-14. Harvest of subsistence fisheries resources in selected communities of the Bristol Bay watershed.

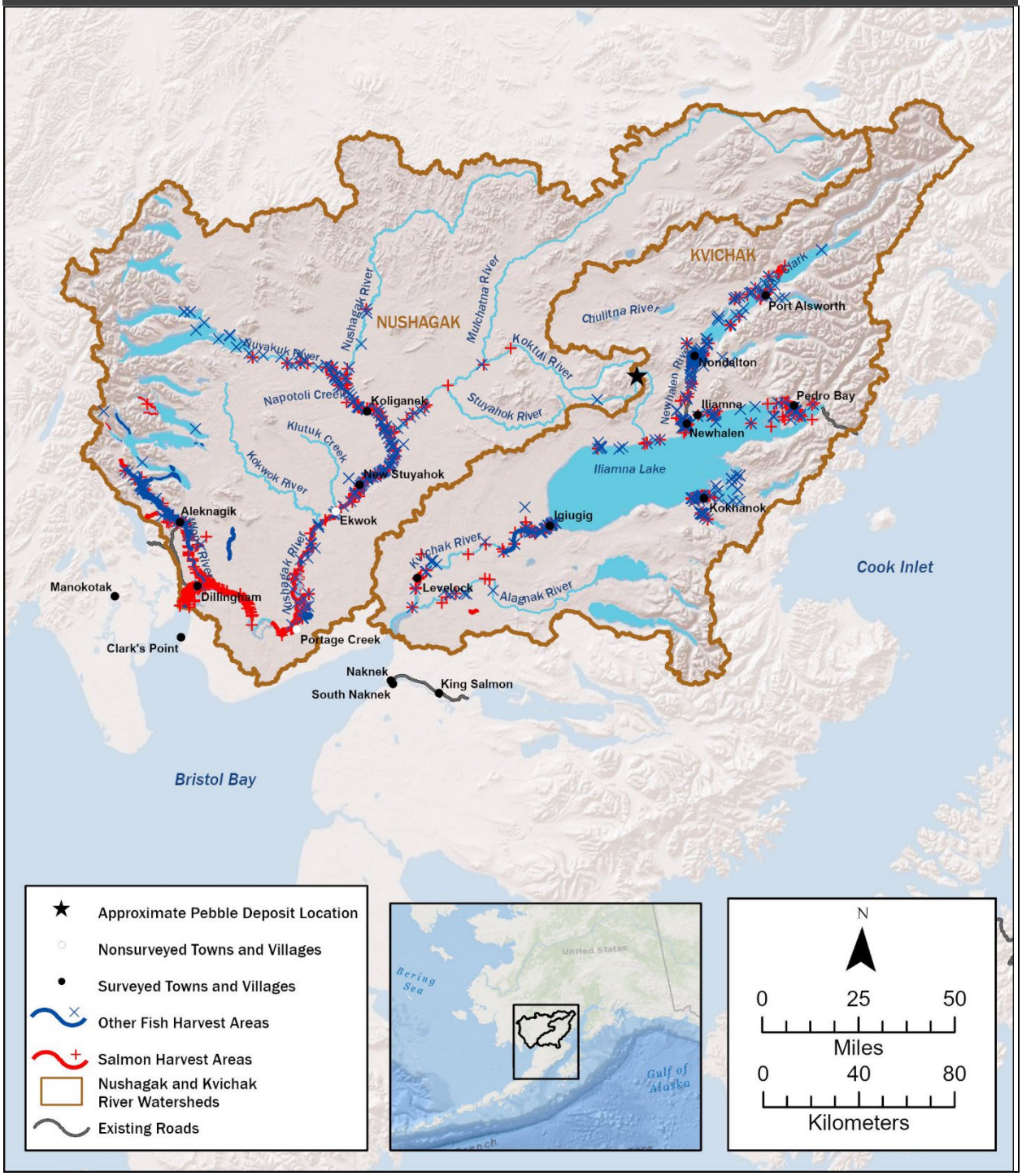
Community	Year	Total Harvest (pounds) [a]	Estimated Per Capita Harvest (pounds)				Households Using Salmon (%)		
			All Salmon	Sockeye Salmon	Chinook Salmon	Non-Salmon Fishes	Used	Gave	Received
Aleknagik	2008	51,738	143	40	72	26	100	59	59
Dillingham	2010	486,533	131	46	55	7	91	57	56
Ekwok	1987	77,268	456	160	180	68	93	48	52
Igiugig	2005	22,310	205	168	5	59	100	83	83
Iliamna	2004	34,160	370	370	0	34	100	31	39
Kokhanok	2005	107,644	513	480	3	36	97	63	60
Koliganek	2005	134,779	565	688	194	90	100	61	54
Levelock	2005	17,871	152	86	43	40	93	36	79
New Stuyahok	2005	163,927	188	36	113	28	90	55	63
Newhalen	2004	86,607	502	488	10	32	100	64	32
Nondalton	2004	58,686	219	219	0	34	92	55	63
Pedro Bay	2004	21,026	250	250	0	15	100	72	78
Port Alsworth	2004	14,489	89	88	1	12	100	46	55

Notes:

[a] Total harvest values represent usable weight and include fishes, land mammals, freshwater seals, beluga, other marine mammals, plant-based foods, birds or eggs, and marine invertebrates. See Section 6.3.1 for additional information on non-fish subsistence resources.

Source: Schichnes and Chythlook 1991 (Ekwok), Fall et al. 2006 (Iliamna, Newhalen, Nondalton, Pedro Bay, and Port Alsworth); Krieg et al. 2009 (Igiugig, Kokhanok, Koliganek, Levelock, New Stuyahok); Holen et al. 2012 (Aleknagik); Evans et al. 2013 (Dillingham).

Figure 3-16. Subsistence harvest and harvest-effort areas for salmon and other fishes in the Nushagak and Kvichak River watersheds. Other fishes are those classified as Arctic Char, Dolly Varden, Humpback Whitefish, Lake Trout, Least Cisco, Rainbow Trout, Round Whitefish, Steelhead (anadromous Rainbow Trout), trout, and whitefish in relevant subsistence use reports (Fall et al. 2006, Krieg et al. 2009, Holen and Lemons 2010, Holen et al. 2011, Holen et al. 2012).



Between 2008 and 2017, average annual subsistence salmon harvest in the Nushagak district was 49,024 fishes and in the Naknek-Kvichak district was 66,174 fishes (Halas and Neufeld 2018). There are differences in the relative importance of different subsistence fisheries between the two watersheds, however. Sockeye Salmon comprised 97 percent of this harvest in the Naknek-Kvichak district but only 53 percent in the Nushagak district, where Chinook Salmon (25 percent) and Coho Salmon (11 percent) were larger subsistence resources (Halas and Neufeld 2018). Villages along the Nushagak River (e.g., Ekwok, New Stuyahok) are particularly dependent on Chinook Salmon as a subsistence resource (Table 3-14), in part because Chinook Salmon are the first spawners to return each spring (EPA 2014: Appendix D). Between 2008 and 2017, average annual subsistence harvest of Sockeye Salmon ranged from 740 fish in Levelock to 27,755 fish in Dillingham (Table 3-15).

Table 3-15. Estimated subsistence salmon harvest in communities of the Bristol Bay watershed, 2008–2017. Values represent numbers of fish.

Community	Average Annual Subsistence Harvest of Salmon [a]	Minimum Annual Subsistence Harvest of Sockeye Salmon (Year)	Maximum Annual Subsistence Harvest of Sockeye Salmon (Year)
Aleknagik	2,623	1,570 (2010)	3,560 (2014)
Dillingham	27,755	22,037 (2012)	33,220 (2016)
Ekwok	1,849	1,253 (2012)	2,700 (2014)
Igiugig	1,346	345 (2013)	2,901 (2010)
Iliamna/Newhalen	10,564	6,403 (2017)	15,433 (2011)
Kokhanok	11,136	5,430 (2017)	16,530 (2012)
Koliganek	3,573	2,085 (2015)	7,290 (2013)
Levelock	740	30 (2008)	1,265 (2016)
New Stuyahok	6,727	5,062 (2012)	11,104 (2013)
Nondalton	7,215	2,320 (2016)	10,550 (2013)
Pedro Bay	3,742	1,678 (2017)	7,802 (2009)
Port Alsworth	4,024	3,155 (2009)	6,588 (2015)

Notes:

[a] For communities in the Kvichak River watershed, number represents Sockeye Salmon harvest; for communities in the Nushagak River watershed, number represents all salmon species.

Source: Halas and Neufeld 2018.

All communities in the Nushagak and Kvichak River watersheds also rely on non-salmon fishes, including Northern Pike, various whitefish species, Dolly Varden, Arctic Char, and Arctic Grayling, but to a lesser extent than salmon. These fishes are taken throughout the year by a variety of harvest methods and fill an important seasonal component of subsistence cycles (Halas and Neufeld 2018). Non-salmon fishes are particularly important subsistence resources in spring and fall, when salmon and other resources are less available (Hazell et al. 2015). For example, in the mid-2000s, annual subsistence harvests for 10 communities in the Nushagak and Kvichak River watersheds were estimated at 3,450 Dolly Varden/Arctic Char (Alaska's fisheries statistics do not distinguish between the two species); 4,385 Northern Pike; and 7,790 Arctic Grayling (Fall et al. 2006, Krieg et al. 2009). Northern Pike were the most important non-salmon fishes in four of those villages during that time (Fall et al. 2006, Krieg et al. 2009). From the mid-1970s to the mid-2000s, Dolly Varden/Arctic Char, Northern Pike, and Arctic Grayling were estimated to represent roughly 16 to 27 percent, 10 to 14 percent, and 7

to 10 percent of the total weight of the Kvichak River watershed's non-salmon freshwater fish subsistence harvest, respectively (Krieg et al. 2005).

Although subsistence is a non-market economic activity that is not officially measured, the effort put into subsistence activities is estimated to be the same as or greater than full-time equivalent jobs in the cash sector (EPA 2014: Appendix E). There is a strong and complex relationship between subsistence and the market economy (largely commercial fishing and recreation) in the area (Wolfe and Walker 1987, Krieg et al. 2007). For example, income from the market economy funds household purchases of goods and services that are then used for subsistence activities (e.g., boats, rifles, nets, snowmobiles, and fuel). When Alaskan households spend money on subsistence-related supplies, the subsistence harvest of fishes generates regional economic benefits. In total, individuals in Bristol Bay communities harvest about 2.6 million pounds of subsistence foods per year (EPA 2014: Chapter 5). In 2010, the U.S. Census Bureau reported an estimated 1,873 Alaska Native and 666 non-Alaska Native households in the Bristol Bay region. Goldsmith et al. (1998) estimated that Alaska Native households spend an average of $3,054 on subsistence harvest supplies, whereas non-Alaska Native households spend an estimated $796 on supplies (values updated to 2009 price levels). Based on these estimates, subsistence harvest activities resulted in expenditures of approximately $6.3 million (EPA 2014: Table 5-4).

The estimates above reflect only the annual economic activity generated by subsistence activities and not the value of the subsistence resources harvested. A study by the McKinley Research Group (2021) estimated that the replacement value of the 2017 Bristol Bay subsistence salmon harvest—that is, the cost of replacing subsistence salmon protein with store-bought substitutes—was between $5 million and $10 million (Table 3-16).

Table 3-16. Estimated replacement value of 2017 Bristol Bay subsistence salmon harvest.

Variable	Chinook	Chum	Coho	Pink	Sockeye	TOTAL
Number of fish	12,985	4,907	8,154	553	89,704	116,303
Pounds of usable fish	98,199	22,907	39,776	1,441	341,567	503,890
Species-specific % of total usable fish	19	5	8	0	68	100
Replacement value at $10 per pound	$981,992	$229,066	$397,762	$14,411	$3,415,673	$5,038,904
Replacement value at $20 per pound	$1,963,980	$458,140	$795,524	$28,820	$6,831,346	$10,077,800

Source: McKinley Research Group 2021.

3.3.6.2 Importance of Subsistence Fisheries

The salmon-dependent diet of Alaska Natives benefits their physical and mental well-being in multiple ways, in addition to encouraging high levels of fitness based on subsistence activities. Salmon and other traditional wild foods make up a large part of people's daily diets throughout their lives, beginning as soon as they are old enough to eat solid food (EPA 2014: Appendix D). Disproportionately high amounts of total diet protein and some nutrients come from subsistence foods. For example, a 2009 study of two rural Alaska regions found that 46 percent of protein, 83 percent of vitamin D, 37 percent of iron, 35 percent of zinc, 34 percent of polyunsaturated fat, 90 percent of eicosapentaenoic acid, and 93 percent of docosahexaenoic acid came from subsistence foods consumed by Alaska Natives (Johnson

et al. 2009). These foods have demonstrated nutritional benefits, including lower cumulative risk of nutritionally mediated health problems such as diabetes, obesity, high blood pressure, and heart disease (Murphy et al. 1995, Dewailly et al. 2001, Dewailly et al. 2002, Din et al. 2004, Hall et al. 2005, Chan et al. 2006, Ebbesson et al. 2007) and provision of essential micronutrients and omega-3 fatty acids (Murphy et al. 1995, Nobmann et al. 2005, Bersamin et al. 2007, Ebbesson et al. 2007). In addition, the cost of replacing subsistence salmon in diets, even with lower-quality protein sources, is likely to be significant (Table 3-16).

However, for Alaska Natives, subsistence is much more than the harvesting, processing, sharing, and trading of foods. Subsistence holistically subsumes the cultural, social, and spiritual values that are the essence of Alaska Native cultures (USACE 2020a: Section 3.9). Traditional and more modern spiritual practices place salmon in a position of respect and importance, as exemplified by the First Salmon Ceremony and the Great Blessing of the Waters (EPA 2014: Appendix D). The salmon harvest provides a basis for many important cultural and social practices and values, including the sharing of resources, fish camp, gender and age roles, and the perception of wealth. Tribal Elders and culture bearers continue to instruct young people, particularly at fish camps where cultural values, as well as fishing and fish processing techniques, are shared. The social system that forms the backbone of the culture, by nurturing the young, supporting the producers, and caring for the tribal Elders, is based on the virtue of sharing wild foods harvested from the land and waters.

The importance of salmon as a subsistence food source is inseparable from it being the basis for Alaska Native cultures. The characteristics of the subsistence-based salmon cultures in the Bristol Bay region have been widely documented (EPA 2014: Appendix D). The cultures have a strong connection to the landscape and its resources, and in the Bristol Bay watershed this connection has been maintained for centuries by the uniquely pristine condition of the region's landscape and resources. In turn, the respect and importance given salmon and other wildlife, along with Alaska Natives' traditional knowledge of the environment, have produced a sustainable, subsistence-based economy (EPA 2014: Appendix D). This subsistence-based way of life is a key element of Alaska Native identity and serves a wide range of economic, social, and cultural functions (USACE 2020a: Section 3.9).

3.3.7 Recreational Fisheries

In addition to commercial and subsistence fisheries, the Bristol Bay region also supports world-class recreational or sport fisheries. The Bristol Bay watershed (as reflected by the Bristol Bay Sport Fish Management Area, or BBMA) has been acclaimed for its sport fisheries, for fishes such as Pacific salmon, Rainbow Trout, Arctic Grayling, Arctic Char, and Dolly Varden, since the 1930s (Dye and Borden 2018). The uncrowded, pristine wilderness setting of the Bristol Bay watershed attracts recreational fishers, and aesthetic qualities are rated by Bristol Bay anglers as most important in selecting fishing locations (Duffield et al. 2007).

The importance of recreational fisheries can be estimated in several ways, including their economic value, the effort expended by recreational fishers, the number of fishes harvested, and the number of fishes caught (i.e., those harvested in addition to those caught and released).

Sport fishing in the Bristol Bay watershed accounts for approximately $66.58 million in expenditures, expressed in 2020 dollars (USACE 2020a: Section 3.6). In 2009, approximately 29,000 sport-fishing trips were taken to the Bristol Bay region (12,000 trips by people living outside of Alaska, 4,000 trips by Alaskans living outside the Bristol Bay area, and 13,000 trips by Bristol Bay residents). These sport-fishing activities directly employ over 800 full- and part-time workers. In 2010, 72 businesses and 319 guides were operating in the Nushagak and Kvichak River watersheds alone, down from a peak of 92 businesses and 426 guides in 2008 (Rinella et al. 2018).

Between 2007 and 2017, angler-days of effort within the BBMA ranged from 74,560 to 102,844 annually, with total annual sport harvest for the same period ranging from 42,082 to 58,658 fishes (Dye and Borden 2018). Guided sport-fishing effort between 2007 and 2016 averaged 32,821 angler-days across the BBMA, of which approximately 7,059 and 1,704 angler-days were spent in the Nushagak River and Kvichak River watersheds, respectively (Dye and Borden 2018).

The majority of sport fishes harvested in the BBMA are Sockeye, Chinook, and Coho salmon, although Rainbow Trout, Dolly Varden, Arctic Char, and other species are also harvested throughout the BBMA (Table 3-17) (Dye and Borden 2018). The Nushagak and Kvichak River watersheds support several popular recreational fisheries, particularly for Sockeye and Chinook salmon (Figure 3-17), as well as Rainbow Trout. The Nushagak River watershed accounted for more than 50 percent of the annual average sport harvest (2004–2017) of Chinook Salmon in the BBMA, with an estimated harvest of 6,467 out of a total estimated harvest of 10,937 fish (Dye and Borden 2018); estimated recreational Chinook Salmon catches are much higher (Table 3-18). In the Kvichak River, recreational harvests are dominated by Sockeye Salmon, whereas recreational catches are dominated by Rainbow Trout.

Table 3-17. Estimated sport harvest by species in the Bristol Bay Sport Fish Management Area. Values are mean annual sport harvests from 2004 to 2017, and ranges observed during that same period. The years that the low and high values of each range were recorded are noted in brackets.

Fish	Mean Annual BBMA Sport Harvest [a]	Range
Sockeye Salmon	15,876	11,925 [2005]–23,842 [2017]
Chinook Salmon	10,836	6,224 [2010]–13,821 [2007]
Coho Salmon	15,682	12,380 [2013]–20,699 [2014]
Chum Salmon	1,627	501 [2007]–2,946 [2013]
Pink Salmon	805	47 [2009]–3,138 [2004]
Rainbow Trout	1,117	323 [2013]–2,411 [2007]
Dolly Varden/Arctic Char	2,498	1,040 [2013]–6,365 [2004]
Arctic Grayling	1,179	361 [2016]–3,010 [2004]
Lake Trout	759	188 [2012]–1,370 [2011]
Northern Pike	931	216 [2016]–1,751 [2004]

Notes:

[a] BBMA = Bristol Bay Sport Fish Management Area.

Source: Dye and Borden 2018.

Figure 3-17. Popular areas for recreational fishing in the Nushagak and Kvichak River watersheds. Areas were digitized from previously published maps (Dye et al. 2006). Areas for recreational Rainbow Trout fishing are also distributed throughout the watersheds.

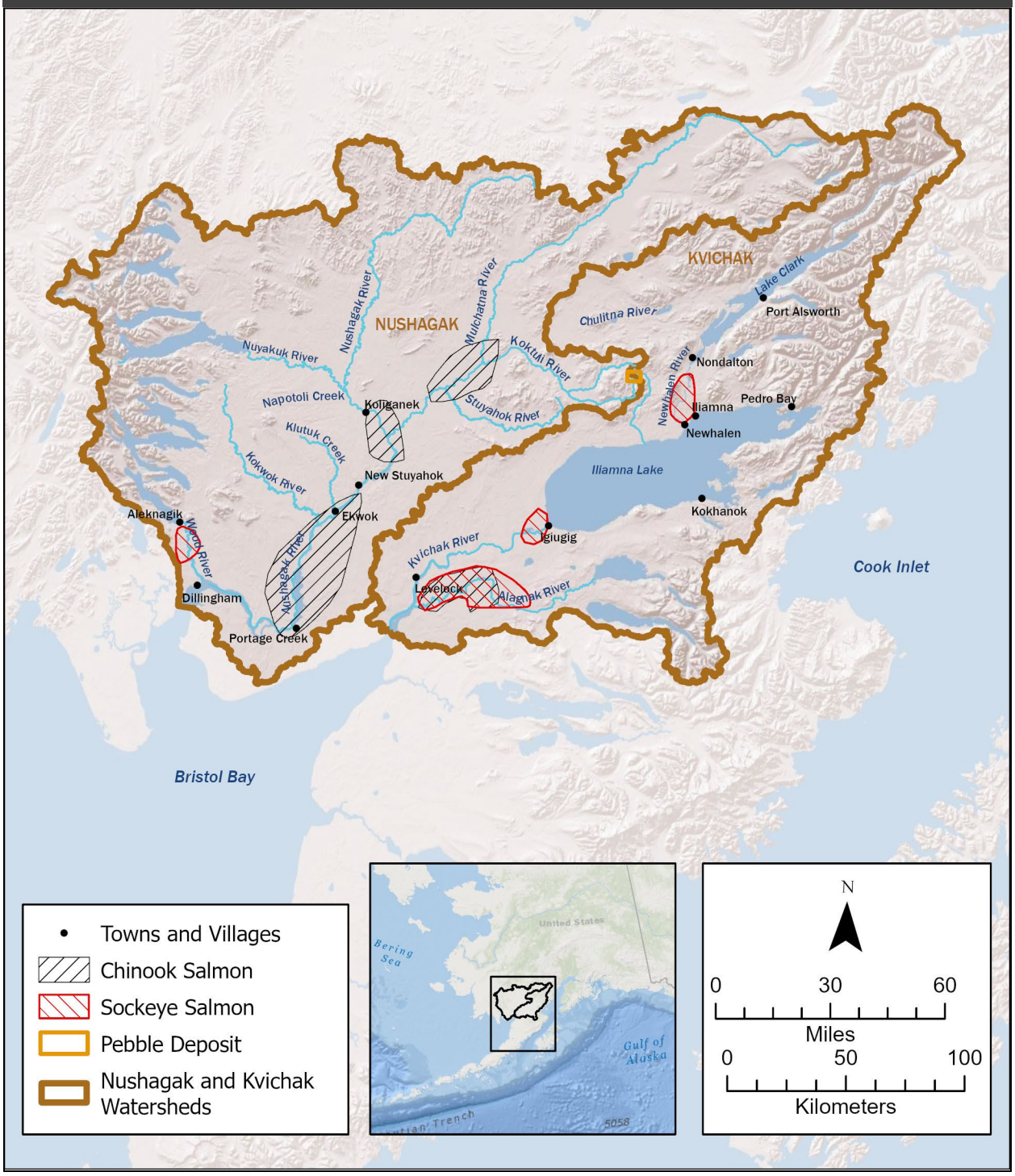


Table 3-18. Estimated annual sport harvest and catch of fishes in the Kvichak River watershed and the Nushagak, Wood, and Togiak River watersheds, 2008–2017. Estimated annual sport harvest is presented as the range between the minimum and maximum estimated annual harvest over the 2008–2017 period; estimated sport catch is shown for 2017.

Watershed	Fish	Estimated Annual Sport Harvest (Range, 2000–2010)	Estimated 2017 Sport Catch
Kvichak River	Pacific salmon [a]	7,199–14,731	56,492
	Sockeye	5,383–13,025	30,349
	Chinook	206–1,427	4,424
	Coho	342–676	9,138
	Chum	26–898	11,950
	Pink	10–625	631
	Rainbow Trout	48–996	114,431
	Dolly Varden/Arctic Char	46–605	16,239
	Arctic Grayling	84–757	18,695
	Lake Trout	124–856	2,224
	Northern Pike	11–547	1,938
	Whitefish	0–449	179
Nushagak, Wood, and Togiak River	Pacific salmon [a]	10,252–15,435	85,719
	Sockeye	1,598–5,504	12,514
	Chinook	4,514–9,283	31,631
	Coho	839–1,924	30,034
	Chum	561–2,560	9,216
	Pink	0–664	2,324
	Rainbow Trout	52–450	30,282
	Dolly Varden/Arctic Char	740–2,051	25,222
	Arctic Grayling	54–725	20,833
	Lake Trout	10–206	1,196
	Northern Pike	78–1,064	1,654
	Whitefish	0–514	602

Notes:

[a] Total for all five Pacific salmon species (Coho, Chinook, Sockeye, Chum, Pink).

Source: Romberg et al. 2021.

3.3.8 Region's Fisheries in the Global Context

The Bristol Bay region is a unique environment supporting world-class fisheries, particularly in terms of Pacific salmon populations. Recent Sockeye Salmon returns to Bristol Bay highlight the region's productivity relative to other watersheds in the United States: the number of Sockeye Salmon that returned to Bristol Bay in 2022 (79.0 million)—more than 60 percent of which returned to the Nushagak and Naknek-Kvichak River watersheds—is roughly 20 million more than the number of individuals of all Pacific salmon species that historically returned annually to Washington, Oregon, and California before rivers in these states were dammed (Gresh et al. 2000, ADF&G 2022e). The region takes on even greater significance when one considers the status and condition of Pacific salmon populations throughout their native geographic distributions. These declines are discussed briefly below; for additional information on threatened and endangered salmon stocks, see Appendix A of the BBA (EPA 2014).

Although it is difficult to quantify the true number of extinct Pacific salmon populations around the North Pacific, estimates for the western United States (California, Oregon, Washington, and Idaho) range from 106 to 406 populations (Nehlsen et al. 1991, Augerot 2005, Gustafson et al. 2007). Pacific salmon are no longer found in 40 percent of their historical breeding ranges in the western United States, and populations tend to be significantly reduced or dominated by hatchery fishes where they do remain (NRC 1996). In contrast, Bristol Bay's salmon fisheries are robust and entirely wild, with no contribution from hatchery fishes in the watershed (Section 3.1).

For example, 214 salmon and Steelhead (anadromous Rainbow Trout) stocks were identified as facing risk of extinction in the western United States; 76 of those stocks were from the Columbia River basin alone (Nehlsen et al. 1991). In general, these losses have resulted from cumulative effects of habitat loss, water quality degradation, climate change, overfishing, dams, and other factors (NRC 1996, Schindler et al. 2010). Many watersheds that have historically supported large salmon runs, such as the Fraser River in Canada, are affected by multiple types of urban and industrial development, resulting in habitat loss and degradation and declines in salmon runs (O'Neal and Woody 2011, EPA 2014: Box 8-4). Species with extended freshwater rearing periods (e.g., Coho, Chinook, and Sockeye salmon) are more likely to be extinct, endangered, or threatened than species that spend less time in freshwater habitats (NRC 1996, Gustafson et al. 2007). No Pacific salmon populations from Alaska are known to have gone extinct, although many show signs of population declines.

The status of Pacific salmon throughout the United States highlights the value of the Bristol Bay watershed as a salmon sanctuary or refuge (Rahr et al. 1998, Pinsky et al. 2009). This value is likely to increase under changing climate conditions, which pose a key challenge for Pacific salmon conservation (Shanley and Albert 2014, Ebersole et al. 2020). Climate-associated changes in water temperature and streamflow, resulting changes in spawning and rearing habitats, responses of salmon populations, and the inherent uncertainties involved in predicting these relationships highlight the increasing importance of maintaining and protecting areas currently supporting diverse and robust salmon habitats and populations (Schindler et al. 2008, Anderson et al. 2015, Ebersole et al. 2020, Vynne et al. 2021).

The Bristol Bay watershed contains intact, connected, and heterogeneous habitats that extend from headwaters to ocean with minimal influence of human development. These characteristics, combined with the region's high Pacific salmon abundance and life-history diversity, make the Bristol Bay watershed a significant resource of global conservation value (Pinsky et al. 2009).

3.4 Summary

Because of its climate, geology, hydrology, largely undeveloped environment, and other characteristics, the Bristol Bay watershed is home to abundant, diverse, high-quality aquatic habitats. These streams, rivers, wetlands, lakes, and ponds support world-class subsistence, commercial, and recreational fisheries for multiple species of Pacific salmon, as well as numerous other fish species valued as subsistence and recreational resources. Because the region's salmon resources have supported Alaska Native cultures in the region for thousands of years and continue to support one of the last intact wild

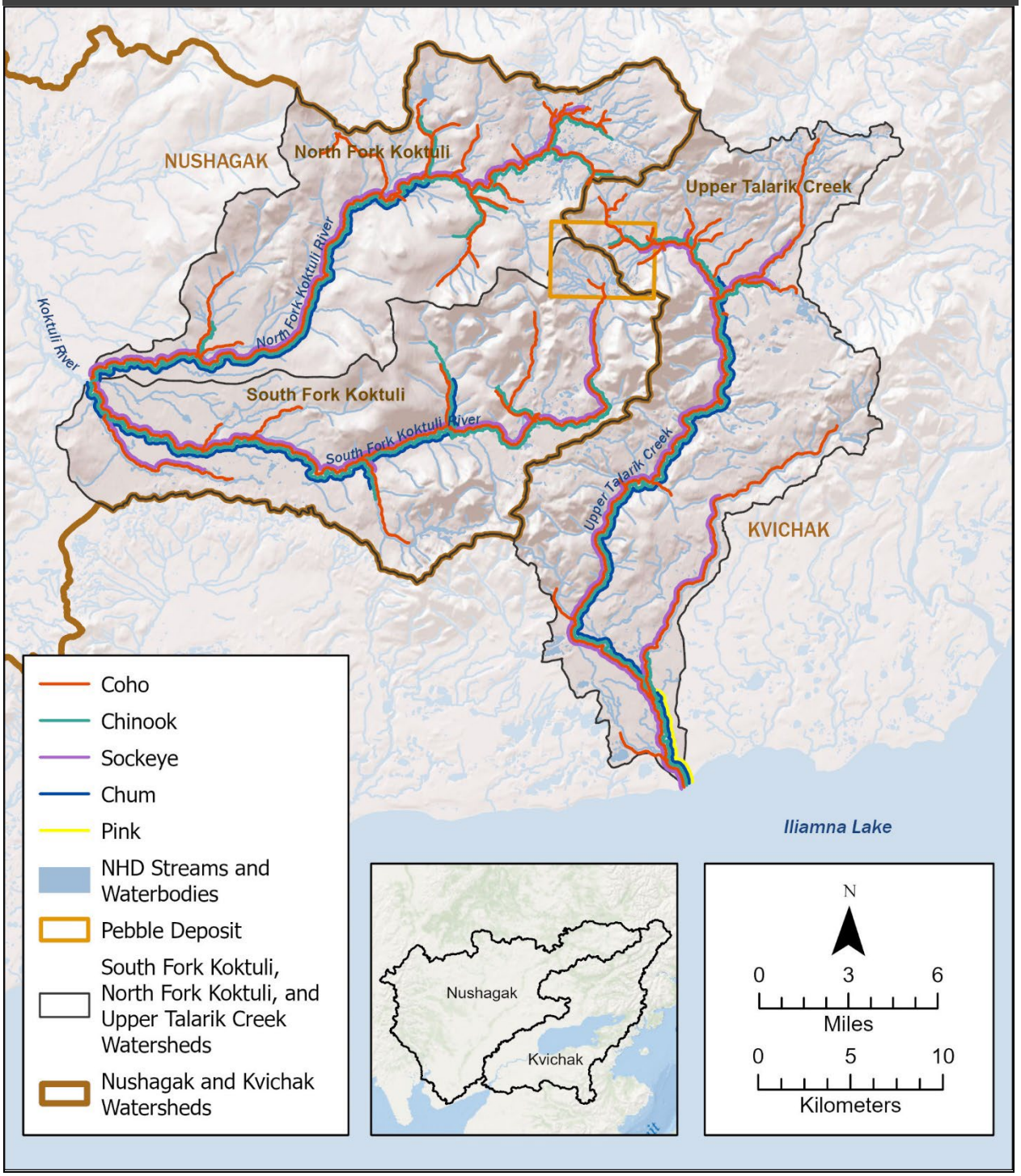
salmon-based cultures in the world (EPA 2014: Appendix D, Nesbitt and Moore 2016, USACE 2020a: Section 3.7), the watershed also has global cultural significance.

The productivity and diversity of the watershed's aquatic habitats are closely tied to the productivity and diversity of its wild fisheries, and waters of the SFK, NFK, and UTC watersheds are critical for maintaining the integrity, productivity, and sustainability of the region's salmon and non-salmon fishery resources. Aquatic habitats in the three watersheds are ideal for maintaining high levels of fish production with clean, cold water, gravel substrates, and abundant areas of groundwater exchange (upwelling and downwelling). These conditions create preferred salmon spawning habitat and provide favorable conditions for egg incubation and survival and juvenile rearing, and Pacific salmon species and life stages have been documented to occur, often in high numbers, throughout the three watersheds (Figure 3-18). They also provide high-quality habitat for other fishes, such as Rainbow Trout, Dolly Varden, Arctic Grayling, and Northern Pike. Wetlands and other off-channel areas provide essential habitats that protect young Coho Salmon and other resident and anadromous fish species, as well as provide spawning areas for Northern Pike. All of these species move throughout the region's freshwater habitats during their life cycles, and all are fished—commercially, for subsistence use, and recreationally—in downstream waters. Thus, the intact headwater-to-larger river systems found in the SFK, NFK, and UTC watersheds, with their associated wetlands, lakes, and ponds, help sustain the overall productivity of these fishery areas.

Not only do the aquatic habitats of the SFK, NFK, and UTC watersheds directly provide habitat for salmon and other fishes, they also provide critical support for downstream habitats. By contributing water, organic matter, macroinvertebrates, and other materials to downstream systems, these headwater areas help maintain downstream habitats and fuel their fish productivity. Together, these functions—direct provision of high-quality habitat and indirect provision of other resources to downstream habitats—help support the valuable fisheries of the Bristol Bay watershed.

This support is particularly important in terms of Coho, Chinook, and Sockeye salmon fisheries. Chinook Salmon are the rarest of the North American Pacific salmon species and are a critical subsistence resource, particularly along the Nushagak River. The SFK, NFK, and UTC watersheds are known to support small, discrete populations of Sockeye Salmon that are genetically programmed to return to specific, localized reaches or habitats to spawn. The current state of understanding surrounding Pacific salmon genetic baselines in the region indicates that the watersheds also support small, discrete populations of Coho Salmon and Chinook Salmon. These portfolios of multiple small populations, which exist as a result of the region's habitat complexity, are essential for maintaining the genetic diversity, and thus the stability and productivity, of the region's overall wild salmon stocks.

Figure 3-18. Streams, rivers, lakes, and documented salmon use in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds near the Pebble deposit. Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).



SECTION 4. BASIS FOR FINAL DETERMINATION

Starting with an analysis of the 2020 Mine Plan, this section provides EPA's evaluation regarding how certain discharges of dredged or fill material into certain waters of the United States associated with developing a mine at the Pebble deposit will have unacceptable adverse effects on anadromous fishery areas (including spawning and breeding areas).

Section 4.1 presents a brief review of the CWA Section 404(c) Standards. Section 4.2 provides the unacceptability findings that support the prohibition and restriction described in Section 5. Section 4.3 provides an overview of EPA's evaluation of the effects of discharges associated with developing a mine at the Pebble deposit, such as the 2020 Mine Plan, under the relevant portions of the CWA Section 404(b)(1) Guidelines (40 CFR Part 230). Section 4.4 provides an alternative basis for EPA's determination, which includes additional considerations such as EPA's consideration of costs as described below.

4.1 CWA Section 404(c) Standards

The purpose of the CWA is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. 1251(a)). The CWA sets several goals, including attainment and preservation of "water quality which provides for the protection and propagation of fish, shellfish and wildlife" (33 U.S.C. 1251(a)(2)).

To this end, CWA Section 404(c) specifically authorizes EPA to exercise its discretion to act "whenever" it determines that the discharge of dredged or fill material will have an unacceptable adverse effect on specific aquatic resources. CWA Section 404(c) provides the following:

> The Administrator is authorized to prohibit the specification (including the withdrawal of specification) of any defined area as a disposal site, and he is authorized to deny or restrict the use of any defined area for specification (including the withdrawal of specification) as a disposal site, whenever he determines, after notice and opportunity for public hearings, **that the discharge of such materials into such area will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas**. Before making such determination, the Administrator shall consult with the Secretary. The Administrator shall set forth in writing and make public his findings and his reasons for making any determination under this subsection. [33 USC 1344(c)] [emphasis added]

Importantly, CWA Section 404(c) specifically directs EPA to consider adverse effects from the discharge of dredged or fill material to fishery areas, including spawning and breeding areas. As a scientific matter, evaluating adverse effects to fishery areas (e.g., fish habitat) involves consideration of numerous factors, including adverse effects that discharges of dredged or fill material can directly have on aquatic areas where fish occurrence has been documented, as well as the adverse effects such discharges can have on

aquatic areas that provide ecosystem functions and values that support fishery areas. Therefore, this section includes discussion of these considerations.

CWA Section 404(c) does not define the term "unacceptable adverse effect." EPA's regulations at 40 CFR 231.2(e) define "unacceptable adverse effect" as:

> [I]mpact on an aquatic or wetland ecosystem which is likely to result in significant degradation of municipal water supplies (including surface or ground water) or significant loss of or damage to fisheries, shellfishing, or wildlife habitat or recreation areas. In evaluating the unacceptability of such impacts, consideration should be given to the relevant portions of the Section 404(b)(1) Guidelines (40 CFR Part 230).[51]

The preamble to EPA's final rule promulgating 40 CFR Part 231 further explained that "[t]he term 'unacceptable' in EPA's view refers to the significance of the adverse effect – "e.g., is it a large impact and is it one that the aquatic ecosystem cannot afford." (44 FR 58076, 58078).

EPA's determination of an "unacceptable adverse effect" necessarily involves a case-by-case determination based on many factors, including the unique characteristics of the aquatic resource that would be affected by discharges of dredged or fill material. EPA defines "unacceptable adverse effect" to mean an "impact on an aquatic or wetland ecosystem *which is likely to result in* … significant loss of or damage to fisheries, shellfishing, or wildlife habitat" 40 CFR 231.2(e) (emphasis added). EPA's preamble to the CWA Section 404(c) regulations explained that "[b]ecause 404(c) determinations are by their nature based on predictions of future impacts, what is required is a reasonable likelihood that unacceptable adverse effects will occur – not absolute certainty but more than mere guesswork" (44 FR 58078).[52]

Finally, EPA's consideration of "unacceptable adverse effects" on the enumerated statutory resources (e.g., fishery areas) may include adverse effects on those resources within the defined area or adverse effects on such resources in areas downstream of the defined area. *See Mingo Logan Coal Co. v. U.S. EPA*, 70 F. Supp. 3d 151, 177-180 (D.D.C., 2014) (holding that "EPA may consider downstream effects when conducting its section 404(c) unacceptable adverse effects analysis."); *aff'd Mingo Logan Coal. Co. v. U.S. EPA,* 829 F.3d 710, 725-26 (D.C. Cir 2016) (concluding "that, as part of EPA's overall authority, section 404(c) authorizes it to assess the effects of the fill beyond the fill's footprint").

The EPA Assistant Administrator for Water has prepared this final determination because she has determined that certain discharges of dredged or fill material into certain waters of the United States

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[51] The language referring to "municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas" in Section 404(c) of the CWA is synonymous with the references in 40 CFR 231.2 to "municipal water supplies (including surface or ground water)" and "fisheries, shellfishing, or wildlife habitat or recreation areas."

[52] In fact, EPA's 404(c) regulations include different standards throughout the process to reflect that EPA's certainty regarding its unacceptable adverse effect determination builds as the record develops (i.e., from unacceptable adverse effect "could result" at the early proposed determination stage to using ""would" at the later stages). The preamble to the final CWA Section 404(c) regulations explained "[w]hile EPA has used the word 'would' for the later stages in the proceedings, to reflect the statutory language, it is important to note that absolute certainty is not required." 44 FR 58078.

associated with developing the Pebble deposit will have unacceptable adverse effects on anadromous fishery areas. These effects are described in detail in Section 4.2.

4.2 Effects on Fishery Areas from Discharges of Dredged or Fill Material from Developing the Pebble Deposit

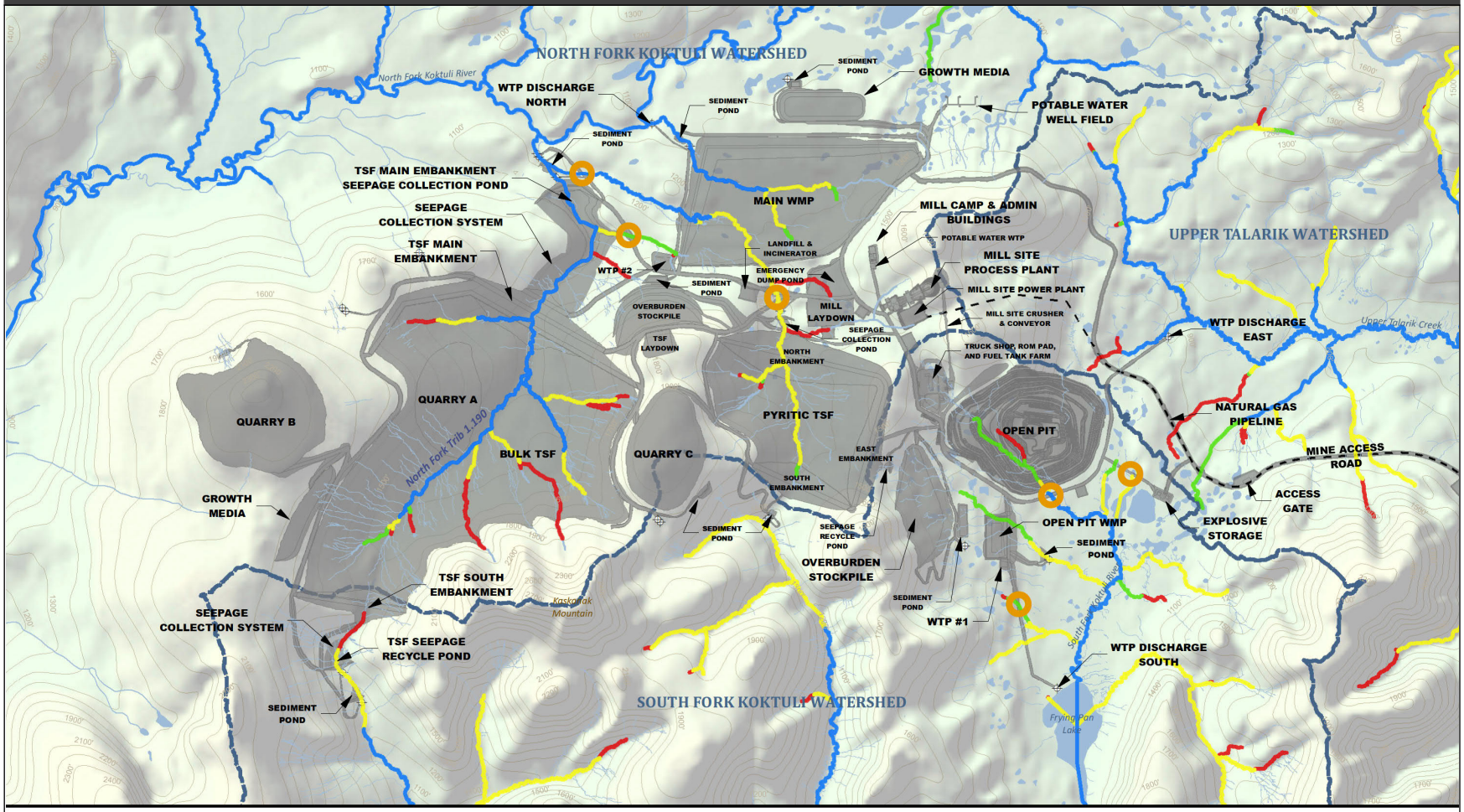
Development of a mine at the Pebble deposit is expected to require the discharge of dredged or fill material into waters of the United States due to current mining technology and the high density of water resources around the Pebble deposit. For example, development of the 2020 Mine Plan would require the discharge of dredged or fill material into waters of the United States at the mine site (PLP 2020b, USACE 2020a, USACE 2020b).

According to the FEIS for the 2020 Mine Plan, "no other wild salmon fishery in the world exists in conjunction with an active mine of this size" (USACE 2020a: Page 4.6-9). As discussed in Section 3, the Bristol Bay watershed is an outstanding global resource, providing pristine, intact, connected aquatic habitats from headwaters to ocean. These aquatic habitats provide extensive spawning and rearing areas for and support genetically diverse populations of wild salmon. Like the larger Bristol Bay watershed, the SFK, NFK, and UTC watersheds also contain pristine, intact aquatic habitats that provide extensive spawning and rearing areas for and support genetically diverse populations of wild salmon.

EPA also recognizes the 2020 Mine Plan represents only one configuration of a potential mine at the Pebble deposit, and any relocation of mine site components to other areas would result in discharges of dredged or fill material to water resources within and beyond the mine site area delineated in the 2020 Mine Plan (Figure 4-1).

EPA has evaluated the adverse effects of discharges of dredged or fill material associated with development of the Pebble deposit on anadromous fishery areas in the SFK, NFK, and UTC watersheds. EPA has evaluated these adverse effects at the scale of the SFK, NFK, and UTC watersheds because these watersheds are the areas that would be most directly affected by discharges of dredged or fill material associated with the development of a mine at the Pebble deposit and because the most extensive physical, chemical, and biological data currently available have been collected in these watersheds (e.g., PLP 2011, PLP 2018a, USACE 2020a). Evaluating the effects of discharges of dredged or fill material for the construction and routine operation of a mine at the Pebble deposit at the scale of the SFK, NFK, and UTC watersheds also enables EPA to draw conclusions at the spatial and temporal scales that are most biologically relevant to the species (salmon) and life stages (eggs, juveniles, adults) of concern—that is, the spatial and temporal scales that ultimately determine the reproductive success and long-term persistence of these species and their genetically distinct populations.

Figure 4-1. Mine site area fish distribution. Figure 4.24-1 from the FEIS (USACE 2020a: Section 4.24).



Sources:PLP 2019-RFI153; USGS;
ADF&G AWC & AFFI; PLP (R2 et al. 2011)

US Army Corps of Engineers

0.5 0 0.5 1
Miles

Fish Distribution
- Anadromous Salmonids
- Resident (non-anadromous) Salmonids
- Non-Salmonid Fish Only
- No Fish Observed
- Stream Crossing

Alternative 1a
- Monitoring Wells
- Natural Gas Pipeline
- Mine Site Footprint

Other Features
- Perennial/Intermittent Streams
- Lake/Pond
- Watershed
- 100' Contour (Existing)

MINE SITE AREA FISH DISTRIBUTION

PEBBLE PROJECT EIS **FIGURE 4.24-1**

This section considers both the direct and secondary effects of such discharges on anadromous fishery areas. Direct effects are impacts on aquatic resources associated with the discharge (actual placement) of dredged or fill material into waters of the United States. Direct adverse effects of the 2020 Mine Plan would include elimination of streams and other aquatic resources within the footprints of the mine site components (e.g., TSFs, WMPs, stockpiles, and the open pit).

Secondary effects are associated with the discharge of dredged or fill material, but do not result from actual placement of this material [40 CFR 230.11(h)(1)]. Secondary effects "are an important consideration in evaluating the acceptability of a discharge site" under the CWA Section 404(b)(1) Guidelines (45 FR 85343).

Direct and secondary (indirect) effects evaluated in the FEIS include the following (USACE 2020a: Section 4.22.3):

- Direct effects from:
    - Clearing and removal of vegetation
    - Excavation or removal of soil and vegetation
    - Placement of fill materials
    - Dredging and discharges of dredged materials
    - Alteration and removal of stream channels
- Secondary effects from:
    - Fragmentation of aquatic resources
    - Fugitive dust
    - Downstream habitat degradation
    - Dewatering

The direct and secondary adverse effects of the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan include both the permanent loss of certain aquatic resources and the degradation of and, thus, damage to additional aquatic resources. For the purposes of this final determination, aquatic resource losses result from elimination, dewatering, and fragmentation (Box 4-1 and Box 4-2).

BOX 4-1. SECONDARY EFFECTS AND AQUATIC RESOURCE LOSSES

Secondary effects are associated with the discharge of dredged or fill material, but do not result from actual placement of this material (40 CFR 230.11(h)(1)). Severity of these secondary effects depends on factors such as the type of aquatic resource being impacted, the type of impact, and the duration of the impact. When sufficiently severe, these secondary effects of the discharge of dredged or fill material can result in the loss of aquatic resources. For example, in certain circumstances, secondary effects such as habitat fragmentation and dewatering can result in aquatic resource losses.

Fragmentation of streams, wetlands, and other waters results when development divides a formerly continuous aquatic resource into smaller, more isolated remnants. Effects of fragmentation on streams, wetlands, and other waters are wide-ranging and depend on several factors, including the nature of the development; the size, shape, and complexity of the remnants; the hydrogeomorphology and community composition of the affected habitat; and the needs and mobility of fish and wildlife species that depend on the affected habitats. Decreased connectivity of aquatic ecosystems could preclude the completion of aquatic organisms' life cycles; for example, fragmentation could prevent anadromous fishes from reaching spawning grounds or accessing off-channel habitat (USACE 2020a: Section 4.22). For anadromous fishes, the most severe form of fragmentation occurs when discontinuities are created that either (1) separate an aquatic habitat (stream, wetland, lake, pond) or complex of aquatic habitats from the tributary network in such a way that precludes use (e.g., spawning, rearing, feeding, migration, overwintering) by anadromous fish species and life stages documented to occur in the habitat, or (2) eliminate the movement of water or dissolved or suspended materials to downstream anadromous fish streams. This type of fragmentation represents a loss for anadromous fishes when it persists for 5 or more years, because such a time period reflects the typical life cycle of anadromous fishes (Brazil and West 2016) that are discussed in this final determination.

Dewatering of streams, wetlands, and other aquatic resources causes the alteration or loss of hydrology and may result in the conversion of habitat to more mesic types. Under the 2020 Mine Plan, groundwater drawdown can extend beyond half of a mile in some areas, but is expected primarily around the open pit from dewatering activities, as well as around quarries, TSFs, and WMPs from diversions and drainage/underdrain systems. Altered saturated surface flows and shallow interflows resulting from a depression of the groundwater table are expected to permanently affect area wetlands, surface waters, and vegetation. The severity of impact will depend on a number of factors, including aquatic resource type, hydrogeomorphology, and community composition (USACE 2020a: Section 4.22). For anadromous fishes, the most severe effects of dewatering for each aquatic resource type are as follows:

- For documented anadromous waters, removing sufficient flow to eliminate access to or use of habitat for the species and life stages documented to occur in the reach in question;
- For additional streams, removing sufficient flow to eliminate the downstream movement of water or dissolved or suspended materials;
- For ponds or lakes, reducing the spatial extent of the pond or lake; and
- For wetlands, changing the hydrologic regime such that the wetland no longer exhibits wetland hydrology, as defined in the *Corps of Engineers Wetland Delineation Manual* (USACE 1987).

These effects of dewatering represent a loss for anadromous fishes when they persist for 5 or more years, because such a time period reflects the typical life cycle of anadromous fishes (Brazil and West 2016) that are discussed in this final determination.

BOX 4-2. KEY DEFINITIONS

The following definitions are provided to clarify key terms in this final determination.

Anadromous fishes hatch in freshwater habitats, migrate to sea for a period of relatively rapid growth, and then return to freshwater habitats to spawn. For the purposes of this final determination, "anadromous fishes" refers to Coho or Silver salmon (*Oncorhynchus kisutch*), Chinook or King salmon (*O. tshawytscha*), Sockeye or Red salmon (*O. nerka*), Chum or Dog salmon (*O. keta*), and Pink or Humpback salmon (*O. gorbuscha*). For these five species of Pacific salmon, the majority of surviving adults return to their natal freshwater habitats to spawn. This homing behavior fosters reproductive isolation, thereby enabling populations to adapt to the specific environmental conditions of their natal habitats (Section 3.3.3). Each of these species is semelparous: adults die after spawning a single time (representing a single opportunity to pass on their genes), thereby depositing the nutrients incorporated in their body mass into their spawning and rearing habitats (Section 3.3.4).

Documented anadromous fish occurrence means any use by Coho, Chinook, Sockeye, Chum, or Pink salmon. As a general matter, EPA has relied on the Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes (Giefer and Blossom 2021, ADF&G 2022b, Giefer and Graziano 2022) and its associated Atlas to describe use by the five salmon species. The catalog and atlas identify the streams, rivers, and lakes specified by the Alaska Department of Fish and Game as important for the spawning, rearing, or migration of anadromous fish pursuant to AS 16.05.871.

Additional streams that support anadromous fish streams refers to streams that do not have documented anadromous fish occurrence but that support downstream anadromous fish streams. Although such streams may also be used by anadromous fishes (see also Section 4.2.2 and Appendix B), the potential for such use is not a basis for this final determination. These aquatic resources are identified as *stream habitat* in the FEIS.

Loss, as in loss of streams, wetlands, or other waters, can result either directly from the discharge of dredged or fill material for the construction and routine operation of a mine to develop the Pebble deposit or indirectly from the secondary effects of such discharges. A loss would result in the following effects for 5 years or more:

- Elimination of streams, wetlands, or other waters within the footprints of mine site components (e.g., TSFs, WMPs, stockpiles, roads, and the open pit);
- Dewatering (see definition below); or
- Fragmentation, meaning creation of discontinuities that separate an aquatic habitat (stream, wetland, lake, pond) or complex of aquatic habitats from the tributary network in such a way that either precludes use (e.g., spawning, rearing, feeding, migration, overwintering) by anadromous fish species and life stages documented to occur in the habitat or eliminates the downstream movement of water or dissolved or suspended materials.

Dewatering includes:

- For documented anadromous waters, removing sufficient flow to eliminate access to or use of habitat for the anadromous fish species and life stages documented to occur in the reach in question;
- For additional streams, removing sufficient flow to eliminate the downstream movement of water or dissolved or suspended materials;
- For ponds or lakes, reducing the spatial extent of the pond or lake; and
- For wetlands, changing the hydrologic regime such that the wetland no longer exhibits wetland hydrology, as defined in the *Corps of Engineers Wetland Delineation Manual* (USACE 1987).

Section 4.2 considers the following impacts from the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan:

- The loss of approximately 8.5 miles (13.7 km) of documented anadromous fish streams[53] (Section 4.2.1).
- The loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams (Section 4.2.2).[54]
- The loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters that support anadromous fish streams (Section 4.2.3).[55]
- Adverse impacts on approximately 29 additional miles (46.7 km) of documented anadromous fish streams resulting from greater than 20 percent changes in average monthly streamflow (Section 4.2.4).

Sections 4.2.1 through 4.2.4 describe the basis for EPA's determination that each of these losses or streamflow changes independently will have unacceptable adverse effects on anadromous fishery areas (including spawning and breeding areas) in the SFK and NFK watersheds. Because the 2020 Mine Plan represents only one configuration of a potential mine to develop the Pebble deposit,[56] Sections 4.2.1 through 4.2.4 also evaluate the adverse effects of these levels of loss and streamflow changes resulting from discharges of dredged or fill material associated with developing the Pebble deposit, if they occur elsewhere in the mine site area (Figure 4-1) within the SFK and NFK watersheds or anywhere in the SFK, NFK, and UTC watersheds.

As discussed in Sections 4.2.1 through 4.2.4, EPA has also determined that discharges of dredged or fill material associated with developing the Pebble deposit anywhere in the mine site area that would result in the same or greater levels of loss or streamflow changes as the 2020 Mine Plan will have unacceptable adverse effects on anadromous fishery areas because such discharges would involve the same aquatic resources characterized in the evaluation of the 2020 Mine Plan.

Furthermore, the SFK, NFK, and UTC watersheds share several similarities in characteristics and aquatic resources, including similarities in the types and abundance of aquatic habitats, their general physical and chemical characteristics, and the organisms that use those habitats (Box 3-1). As discussed in Sections 4.2.1 through 4.2.4, these similarities provide support for EPA's determination that, if the levels of loss and streamflow changes identified for the 2020 Mine Plan occurred anywhere in the SFK, NFK,

[53] For the purposes of this final determination, anadromous fishery areas include anadromous fish streams.

[54] This value has been rounded in this final determination to address differences in rounding of stream length information in different parts of the FEIS (USACE 2020a).

[55] This value changed from the proposed determination to reflect only losses of wetlands and other waters in the SFK and NFK watersheds, which are a particular focus of Section 4.2.3.

[56] Given current mining technology and the high density of water resources in the area, the discharge of dredged or fill material into waters of the United States is expected to be necessary to develop the Pebble deposit.

and UTC watersheds, those losses and streamflow changes also will have unacceptable adverse effects on anadromous fishery areas in these watersheds.

In making its unacceptable adverse effects determinations, EPA considered adverse effects on anadromous fishery areas within the defined areas and downstream of the defined areas. In Sections 4.2.1 through 4.2.4, EPA explains its basis for concluding that the impacts of the discharges evaluated in this final determination on the aquatic or wetland ecosystems are likely to result in significant loss of or damage to fisheries (i.e., fishery areas, including breeding or spawning grounds) and that the significance of the adverse effects are unacceptable (i.e., why EPA considers the impacts "large" and ones "that the aquatic and wetland ecosystem cannot afford") (44 FR 58078).

4.2.1 Adverse Effects of Loss of Anadromous Fish Streams

EPA has determined that the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, resulting in the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in the NFK watershed. As discussed in Section 4.2.1, this conclusion is based on the permanent loss of anadromous fish streams.[57] The permanent loss of 8.5 miles (13.7 km) of anadromous fish streams in the NFK watershed represents a significant loss of anadromous fishery areas and the permanent loss of ecological subsidies these anadromous fish streams provide to downstream anadromous fish streams represents significant damage to these downstream anadromous fishery areas.

4.2.1.1 Extent of Anadromous Fish Streams That Would Be Permanently Lost at the Mine Site

Streams in the mine site area for the 2020 Mine Plan were evaluated in detail and several were found to provide habitat for anadromous fishes (Figure 4-1). Discharges of dredged or fill material associated with the 2020 Mine Plan would result in the permanent loss of approximately 8.5 miles (13.7 km) of streams with documented anadromous fish occurrence, specifically occurrence of Coho and Chinook salmon (Table 4-1, Figure 4-2) (PLP 2020b, USACE 2020a: Section 4.24, Giefer and Graziano 2022). The loss of all 8.5 miles (13.7 km) would be confined to the NFK watershed, specifically to Tributary NFK 1.190, Tributary NFK 1.200, and their sub-tributaries (Figure 4-2). The loss of 8.5 miles (13.7 km) of anadromous fish streams represents approximately 13 percent of the anadromous fish streams in the NFK watershed (USACE 2020a: Section 4.24, Giefer and Graziano 2022).

[57] These permanent losses are the result of streams filled or otherwise eliminated for the construction of various mine components and from streams that would no longer be accessible to fishes due to mine site infrastructure (i.e., fragmentation).

Figure 4-2. Streams, rivers, and lakes with documented salmon use overlain with the Pebble 2020 Mine Plan. Anadromous streams lost are the streams identified as lost in the FEIS and are listed in Table 4-1 (USACE 2022). Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

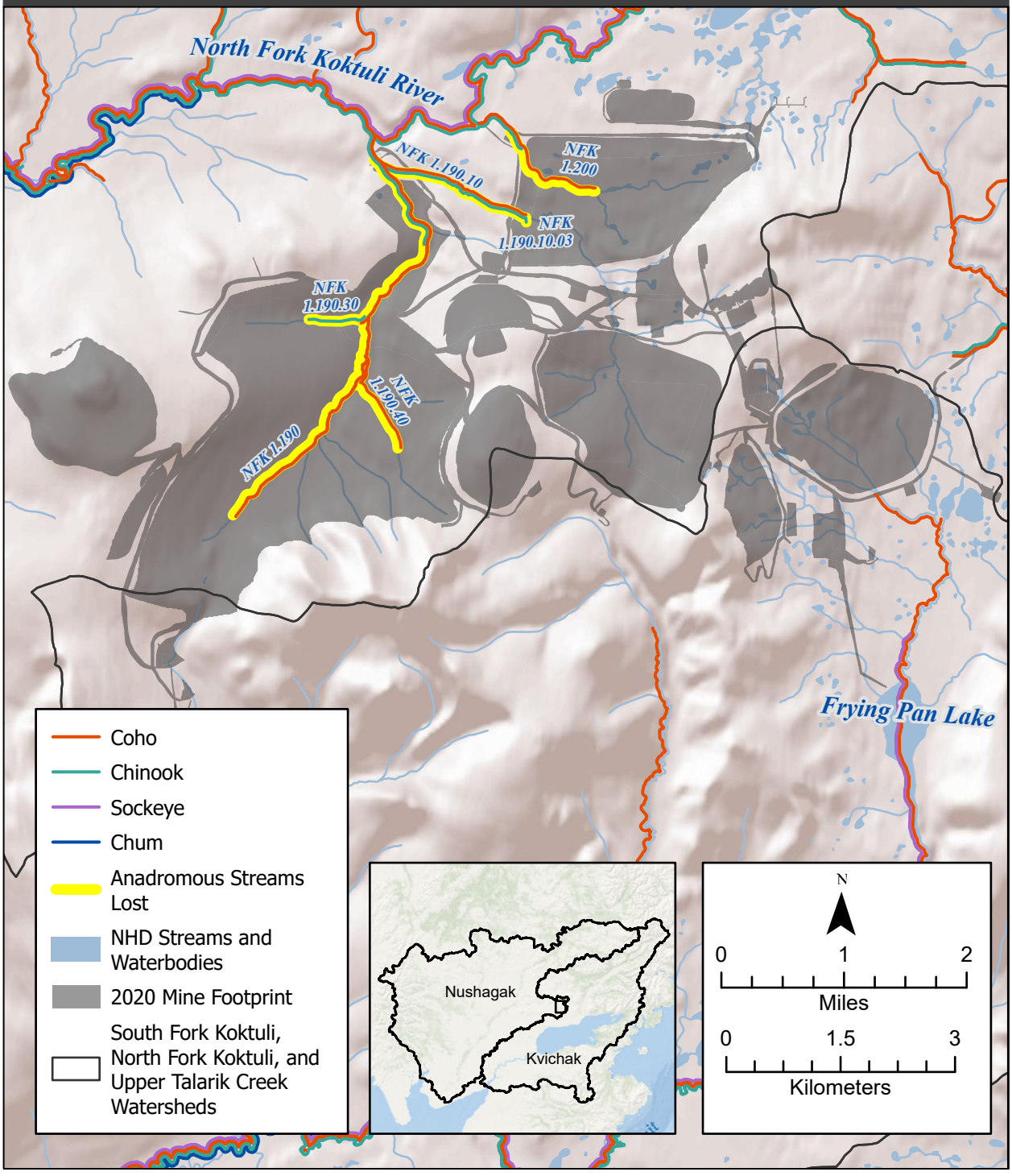


Table 4-1. Length of anadromous fish streams permanently lost in tributaries to the North Fork Koktuli River associated with the 2020 Mine Plan.

Tributary	AWC Code [a]	Length of Anadromous Habitat (miles) [b]
NFK 1.190	325-30-10100-2202-3080-4083-5215	4.2
NFK 1.190.10	325-30-10100-2202-3080-4083-5215-6001	1.7
NFK 1.190.10.03	325-30-10100-2202-3080-4083-5215-6001-7012	0.05
NFK 1.190.30	325-30-10100-2202-3080-4083-5215-6006	0.5
NFK 1.190.40	325-30-10100-2202-3080-4083-5215-6007	0.9
NFK 1.200	325-30-10100-2202-3080-4083-5217	1.1
TOTAL		8.5

Notes:

[a] Source = Giefer and Graziano 2022.

[b] Source = USACE 2022.

The discharge of dredged or fill material from the 2020 Mine Plan would result in the permanent loss of at least 7.1 miles (11.4 km) of Coho Salmon habitat and at least 3.7 miles (6.0 km) of Chinook Salmon habitat (Table 4-2) (Giefer and Graziano 2022).[58] Most of these losses would occur where the bulk TSF would be built (Figure 4-1) (USACE 2020a: Section 4.24). Construction of the bulk TSF alone would permanently eliminate 5.6 miles (9.1 km) of anadromous fish streams in Tributaries NFK 1.190, NFK 1.190.30, and NFK 1.190.40 (USACE 2022). These three anadromous fish streams provide at least 4.8 miles (7.7 km) of rearing habitat and 3.7 miles (6.0 km) of spawning habitat for Coho Salmon and at least 1.4 miles (3.4 km) of rearing habitat and 0.8 mile (1.3 km) of migrating habitat for Chinook Salmon (Giefer and Graziano 2022). Construction of other mine site components, including the main WMP (Figure 4-1), would result in the remaining documented anadromous fish stream losses in Tributaries NFK 1.190.10, NFK 1.190.10.03, and NFK 1.200 (Figure 4-2).

Table 4-2. Coho and Chinook salmon stream habitat permanently lost in the North Fork Koktuli River watershed associated with the 2020 Mine Plan. From Giefer and Graziano (2022).

Species	Length of Anadromous Habitat (miles)			
	Rearing	Spawning	Present	TOTAL [a]
Coho Salmon	7.1	3.7	-	7.1
Chinook Salmon	2.3	-	1.4	3.7

Notes:

[a] Coho and Chinook salmon habitat overlap, and rearing and spawning habitat overlap, so individual values cannot be added together. The totals represent the total extent of habitat lost for each species of Coho and Chinook salmon.

Tributary NFK 1.190 and its sub-tributaries have been documented to provide Coho Salmon spawning habitat, and rearing juvenile salmon have been observed in Tributaries NFK 1.190 and NFK 1.200 (USACE 2020a: Section 4.24). Rearing juvenile Chinook Salmon have been documented to occur in Tributary NFK 1.200 (USACE 2020a: Section 4.24). Chinook Salmon rear in the third-order

[58] Coho Salmon are documented to occur in 7.1 miles (11.4 km) of the 8.5 miles (13.7 km) of anadromous fish streams that would be lost, and Chinook Salmon are documented to occur in 3.7 miles (6.0 km) of the 8.5 miles (13.7 km) of anadromous fish streams that would be lost (Table 4.2).

beaver-modified stream that the bulk TSF would eliminate (i.e., Tributary NFK 1.190), along with 0.5 mile (0.8 km) of Tributary NFK 1.190.30 (Figure 4-2) (Giefer and Graziano 2022).[59]

Other anadromous fish streams in the mine site area (Figure 4-1) are part of the same hydrologically connected network of headwater streams as the 8.5 miles (13.7 km) of anadromous fish streams that would be lost as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8).

4.2.1.2 Adverse Effects from Permanent Loss of Anadromous Fish Streams at the Mine Site

The 8.5 miles (13.7 km) of permanent anadromous fish stream losses would result in fish displacement, injury, and mortality. In addition to the permanent removal of streamflow and subsequent effects on fish migration, "fisheries, invertebrate, and riparian habitat and productivity would be permanently removed" from lost streams (USACE 2020a: Pages 4.24-3 and 4.24-4). The permanent loss of 8.5 miles (13.7 km) of anadromous fish streams from a single project represents a large impact—one that is unprecedented in the context of the CWA Section 404 regulatory program in Alaska—and as discussed, would result in long-term adverse effects on salmon populations in the NFK watershed.

All 8.5 miles (13.7 km) of anadromous fish streams would be completely eliminated and, thus, would permanently lose the ability to support salmon. Coho Salmon would lose at least 7.1 miles (11.4 km) of habitat as a direct result of discharges of dredged or fill material associated with the 2020 Mine Plan, which amounts to more than 11 percent of documented Coho Salmon habitat in the NFK watershed (Table 3-6). Habitat losses for Chinook Salmon would be 8.7 percent of documented habitat in the NFK watershed.

The anadromous fish streams that would be permanently lost as a result of the discharge of dredged or fill material associated with the 2020 Mine Plan are ecologically valuable, particularly for juvenile salmon (Section 3.2.4). Tributary NFK 1.190 is connected with ponds and seasonally to permanently inundated wetlands that result from beaver activity (USFWS 2021).[60] These features provide excellent rearing habitat and important overwintering and flow velocity refugia for salmonids (Section 3.2.4) (Nickelson et al. 1992, Cunjak 1996, Collen and Gibson 2001, Lang et al. 2006). The permanent loss of anadromous fish streams resulting from the discharges of dredged or fill material associated with the 2020 Mine Plan would also result in the loss of salmon spawning habitat, which would, in turn, result in the loss of marine-derived nutrients those fishes would have contributed upon death. Given the naturally low nutrient concentrations in these streams, the inputs of marine-derived nutrients may be

[59] Fish surveys have documented juvenile Coho Salmon in a short (260-foot) reach at the downstream end of this tributary, NFK 1.190.30 (Giefer and Graziano 2022).

[60] Connection to such floodplain wetland and pond habitats can greatly enhance the carrying capacity and productive potential of anadromous fish streams (Section 3).

especially important in supporting primary and secondary production and, thus, food for juvenile salmonids in these and downstream habitats (Section 3.3.4). These streams also support biological production via inputs of leaf litter from deciduous shrubs and grasses in riparian areas (Meyer et al. 2007, Dekar et al. 2012), which help fuel the production of macroinvertebrates, a key food for salmonids (Table 3-3). Thus, the anadromous fish streams that would be lost as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan, as well as similar habitats in the SFK, NFK, and UTC watersheds, play an essential role in the successful completion of the life cycle of salmon.

These anadromous fish stream losses alone would be unacceptable, but the effects of these losses would be compounded by the fact that such losses would affect Coho and Chinook salmon populations that are uniquely adapted to the physical and chemical conditions of their natal streams (i.e., their streams of birth, see Section 3.3.1). Adaptation to local environmental conditions results in discrete, genetically distinct salmonid populations. This biocomplexity—operating across a continuum of integrated, nested spatial and temporal scales—depends on the abundance and diversity of aquatic habitats in the area and acts to stabilize overall salmon production and fishery resources (Section 3.3.3) (Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019). As discussed below, the substantial spatial and temporal extent of anadromous fish stream losses resulting from the discharge of dredged or fill material associated with the 2020 Mine Plan suggests that these losses would reduce the overall reproductive capacity and productivity of Coho and Chinook salmon in the entire NFK watershed.

Pacific salmon exhibit high fidelity to their natal spawning and rearing environments, which results in genetic variation among discrete populations (Quinn 2018). The existence of discrete, genetically distinct salmon populations has been well-documented in the Bristol Bay watershed (Olsen et al. 2003, Ramstad et al. 2010, Quinn et al. 2012, Dann et al. 2012, Shedd et al. 2016, Brennan et al. 2019, Raborn and Link 2022). Both the Koktuli River (including the SFK and NFK) and UTC are known to support genetically distinct populations of Sockeye Salmon (Dann et al. 2012, Shedd et al. 2016, Dann et al. 2018). Research has shown that these distinct populations can occur at very fine geographic scales (Section 3.3.3). For example, Sockeye Salmon populations in close proximity to each other show phenotypic variations related to differences in spawning habitats (ecotypes) (Ramstad et al. 2010), and Sockeye Salmon that use spring-fed ponds and streams as close as approximately 0.6 mile (1 km) apart exhibit differences in traits (e.g., spawn timing and productivity) that suggest they may comprise discrete populations (Quinn et al. 2012).

Genetic baselines for salmonid species in Alaska are being updated or are under development, with some species being further along than others. Research on the presence of genetically distinct populations of Coho and Chinook salmon in Alaska is ongoing, and additional genetically distinct populations have been identified in recent years (Section 3.3.3.2). Existing evidence suggests that local adaptation and fine-scale population structure likely exist for these species as well (Olsen et al. 2003,

Sethi and Tanner 2014, Clark et al. 2015).[61] Similar patterns of genetic variation among species emphasize the vital importance that landscape heterogeneity (i.e., habitat complexity across the intact ecosystem) plays in determining genetic structure (Ackerman et al. 2013).

Coho and Chinook salmon are the two rarest of North America's five species of Pacific salmon (Healey 1991, Woody 2018) and are particularly vulnerable to losses of small, discrete populations. As a result, these species may be more likely to be adversely affected by habitat losses that would occur as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan. Coho and Chinook salmon have the greatest number of population extinctions among the five species of Pacific salmon (Nehlsen et al. 1991, Augerot 2005). Many of the patterns of population extinction relate to longer periods of their life history spent rearing in freshwater, making them more vulnerable to freshwater habitat loss and degradation. For example, Chinook Salmon populations that rear for 1 or more years in freshwater—the dominant type in the Bristol Bay watershed (Healey 1991)—have a higher rate of extinction than populations that migrate to sea within their first year of life (Gustafson et al. 2007). The Nushagak River is the largest producer of Chinook Salmon in the Bristol Bay watershed. In October 2022, ADF&G recommended that Nushagak River Chinook Salmon be designated as a stock of management concern based on the inability of the stock to meet inriver run management goals during 5 of the past 6 years (ADF&G 2022f). This potential designation highlights the importance of the species in this region. During the upcoming March 2023 Board of Fish meeting, a decision on the development and implementation of an ADF&G management action plan to prevent further decline of the Nushagak River Chinook Salmon stock will be discussed. These conservation concerns surrounding the Nushagak River Chinook Salmon provide support for avoiding unacceptable adverse effects to this valuable species.

Alaska Coho Salmon populations are generally small, isolated, and likely exhibit local adaptation to different spawning and freshwater rearing habitats (Olsen et al. 2003). They occupy a wide array of freshwater habitat types, with many populations occupying small first- and second-order headwater streams with limited spawning and juvenile rearing habitat (Sandercock 1991, McCracken 2021). Small, genetically diverse populations of Coho Salmon represent reproductively isolated populations that are innately adapted to their spawning and rearing habitats (Dittman and Quinn 1996, Olsen et al. 2003, Peterson et al. 2014, Bett and Hinch 2016, McCracken 2021). The loss of these habitats would threaten the long-term fitness of these locally adapted populations (Olsen et al. 2003, Mobley et al. 2019). ADF&G has developed a genetic baseline for Coho Salmon for Cook Inlet, but genetic baselines have not been completed elsewhere in Alaska due to a lack of representative samples. In the Cook Inlet watersheds, the most genetically divergent populations are generally those farthest upstream and those from the most southern portion of Cook Inlet (Barclay and Habicht 2019).

[61] Advances in genomics and other techniques are allowing detection of genetic structure at increasingly fine scales; as methods to evaluate these genetic differences improve, researchers are uncovering more fine-scaled population structure in many salmon species (Meek et al. 2020).

Olsen et al. (2003) summarize the implications of Coho Salmon population structuring at fine geographic scales for conservation of the species:

> Fishery management and conservation actions affecting coho salmon in Alaska must recognize that the genetic population structure of coho salmon occurs on a fine geographic scale. Activities or conditions that cause declines in population abundance are more likely to have strong negative impacts for coho than for species in which genetic variation is distributed over a broader geographic scale (e.g., chum salmon). Coho salmon are probably more susceptible to extirpation, less likely to be augmented or "rescued" by other populations through straying (gene flow), **and the loss of populations means loss of significant amounts of overall genetic variability. These risks underscore the importance of single populations to the long term viability of coho salmon in Alaska and justify managing and conserving coho salmon at a fine geographic scale**. (Page 568) [emphasis added]

Chinook Salmon populations also tend to be relatively small (Healey 1991) and exhibit a diversity of life history traits (e.g., variations in size and age at migration, duration of freshwater and estuarine residency, time of ocean entry) (Lindley et al. 2009). Chinook Salmon populations in the Togiak River exhibit differences in spawning habitats (mainstem versus tributary) and migration timing, which translate to a clear stock structure (Sethi and Tanner 2014, Clark et al. 2015). Patterns of genetic differentiation between upstream and downstream populations along the same river network have also been found for other salmonids (Olsen et al. 2011, Ackerman et al. 2013, Barclay and Habicht 2019, Miettinen et al. 2021). Chinook Salmon populations in western Alaska similarly show fine-scale population differences across the four major regions (Norton Sound, the Yukon River, the Kuskokwim River, and Bristol Bay). This finding supports the contention that discrete Chinook Salmon populations likely exist in this region, which includes the Koktuli River (Larson et al. 2014, McKinney et al. 2020). Brennan et al. (2019) provide further support for this contention, demonstrating that the relative productivity of different portions of the Nushagak River varies over relatively short (1- to 4-year) time frames for both Chinook and Sockeye salmon.

Because Sockeye, Coho, and Chinook salmon spend a year or more rearing in freshwater streams, the survival and reproductive success of these species are highly reliant on high-quality freshwater habitats and habitat complexity. Loss of these habitats would affect multiple age classes of these species (e.g., potentially eggs, age-1 fish, and age-2 fish), with detrimental effects on adult returns of those age classes. Thus, reliance on freshwater habitats for longer periods of time increases the vulnerability of small, discrete populations of these species to losses of freshwater habitats, such as those resulting from the discharge of dredged or fill material associated with the 2020 Mine Plan. The importance of maintaining the diversity among populations (e.g., in terms of migration timing, other life history traits, and genetic composition) for long-term population persistence and sustainability has been well-documented (Moore et al. 2014 , Schindler et al. 2010, Brennan et al. 2019, Davis and Schindler 2021). Loss of any genetically distinct populations in the SFK, NFK, or UTC watersheds would constitute a measurable adverse effect, in addition to any effects these losses may have at the scale of the entire Bristol Bay watershed via the portfolio effect (Section 3.3.3).

Thus, the permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams represents a significant loss of anadromous fish habitat and would also reduce both habitat complexity and biocomplexity in the NFK watershed In addition, biocomplexity at relatively localized geographic scales contributes to the resilience and persistence of downstream populations. Biocomplexity, operating across a continuum of nested spatial and temporal scales, acts to buffer salmon populations from sudden and extreme changes in abundance, thereby maintaining overall salmon productivity (Section 3.3.3). Brennan et al. (2019: Page 785) underscore the critical role that streams and other aquatic habitats across the entire Nushagak River watershed, including those that would be adversely affected by the 2020 Mine Plan, play in stabilizing the Nushagak River's productive Sockeye and Chinook salmon fisheries, concluding that "[u]ltimately, entire landscapes are involved in stabilizing biological production."

4.2.1.1.3 Adverse Effects from Permanent Loss of Ecological Subsidies to Anadromous Fish Streams Downstream of the Mine Site

The permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams would also adversely affect downstream anadromous fish habitat (i.e., downstream anadromous fishery areas, including spawning and breeding areas). The following downstream secondary effects would result from the loss of these anadromous fish streams: reduced primary production, reduced nutrient cycling, reduced or lost gravel recruitment, reduced terrestrial inputs, and altered water chemistry (USACE 2020a: Section 4.24). These impacts "would be certain to occur if the project is permitted and constructed" (USACE 2020a: Page 4.24-9).

Coho, Chinook, and Sockeye salmon spawn and Coho and Chinook salmon rear in stream reaches immediately downstream of the 8.5 miles (13.7 km) of anadromous fish streams that would be permanently lost as a result of the discharge of dredged or fill material associated with the 2020 Mine Plan (Figures 3-5 through 3-7and Figures 4-3 and 4-4). These downstream spawning and rearing areas would be damaged by the loss of the ecological subsidies provided by the 8.5 miles (13.7 km) of anadromous fish streams that would be destroyed.

Because of their crucial influence on downstream water flow, chemistry, and biota, impacts on headwaters reverberate throughout entire watersheds (Freeman et al. 2007, Meyer et al. 2007, Colvin et al. 2019, Koenig et al. 2019, French et al. 2020). As described in Section 3.2.4, headwater streams such as the 8.5 miles (13.7 km) of anadromous fish streams that would be permanently lost are important sources of water, nutrients, organic material, macroinvertebrates, and algae for habitats lower in the watersheds, and thereby provide important year-round subsidies for juvenile salmonids in those lower watershed habitats (Vannote et al. 1980, Wipfli and Gregovich 2002, Meyer et al. 2007, Wipfli et al. 2007, Colvin et al. 2019). For example, Alexander et al. (2007) found that perennial headwaters have a significant influence on downstream water quality and quantity, contributing roughly 55 percent of mean annual water volume and 40 percent of nitrogen flux in fourth and higher-order streams and rivers. This example highlights the critical role that headwaters play in determining the structure and function of larger downstream areas (Section 3.2.4). Where they provide salmon spawning areas, the anadromous fish streams that would be permanently lost are also a source of marine-derived nutrients for downstream waters (Section 3.3.4). Thus, elimination of these spawning areas would reduce the

downstream transport of these marine-derived energy subsidies resulting in damage to downstream anadromous fishery areas.

Permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams due to discharges of dredged or fill material associated with the 2020 Mine Plan would also fundamentally alter surface water and groundwater hydrology and, in turn, the flow regimes of receiving—or formerly receiving—streams. Such alterations would reduce the extent and frequency of stream connectivity to off-channel habitats, as well as reduce groundwater inputs and their modifying influence on the thermal regimes of downstream habitats, including spawning, rearing, and overwintering areas (Section 4.2.4). Lost streams also would no longer support or export macroinvertebrates, which are a critical food source for juvenile salmon, resident salmonids, and other biota, resulting in further damage to downstream anadromous fishery areas.

This damage to downstream anadromous fishery areas in the NFK watershed and the resulting effects on salmon populations that rely on those habitats would erode habitat complexity and biocomplexity within these watersheds, which are critical for buffering salmon populations from sudden and extreme changes in abundance and ultimately maintaining the stability and productivity of these populations. (Section 4.2.1.2).

4.2.1.4 Impacts on Other Fish Species

Although this final determination is based solely on adverse effects on anadromous fishery areas, EPA notes that the 8.5 miles (13.7 km) of anadromous fish streams that would be lost under the 2020 Mine Plan also provide habitat for non-anadromous fish species. The assemblage of non-anadromous fishes found in and supported by these anadromous fish streams is an important component of these habitats and further underscores the biological integrity and ecological value of these pristine, intact headwater networks.

Based on currently available fish survey data (ADF&G 2022a), the anadromous fish streams that would be permanently eliminated support three non-anadromous salmonid species (Rainbow Trout, Dolly Varden, and Arctic Grayling) and one other resident fish species (Slimy Sculpin) (Figures 4-4 through 4-7). Rainbow Trout, Dolly Varden, and Arctic Grayling are targets of downstream subsistence and recreational fisheries. Slimy Sculpin support those fisheries as forage fish (Section 3.3.1). The three non-anadromous salmonid species likely migrate substantial distances (120 miles [200 km] to 200 miles [320 km]) within their freshwater habitats (Section 3.3.1), suggesting that individuals move between headwaters and downstream areas. Most of the individuals observed in fish surveys in the 2020 Mine Plan footprint area were juveniles or sub-adults (ADF&G 2022a), further supporting that fishes rearing in headwater tributaries may contribute to downstream harvests.

Figure 4-3. Streams, rivers, and lakes with documented salmon use in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan. Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

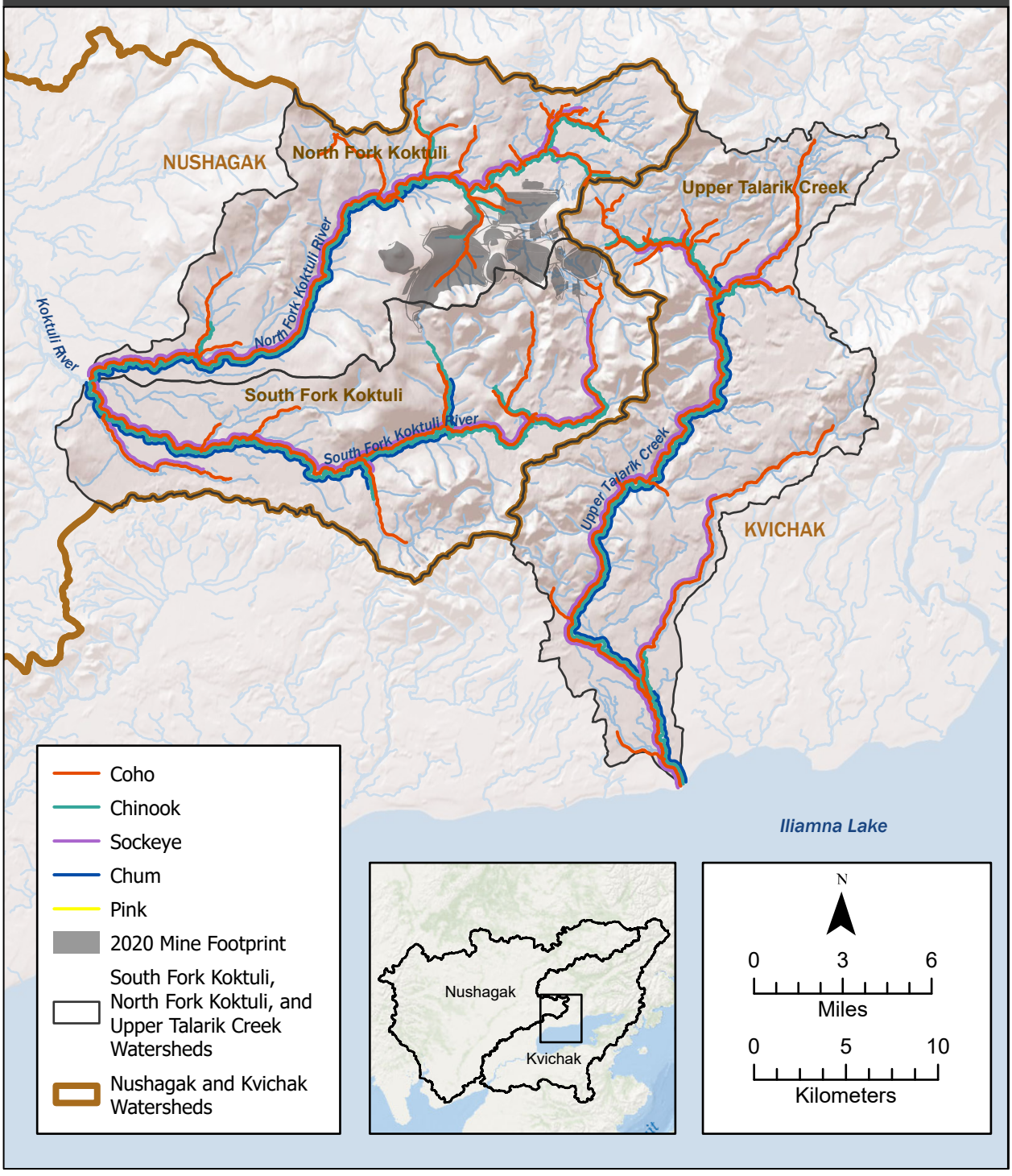


Figure 4-4. Reported occurrence of Arctic Grayling, Rainbow Trout, and Dolly Varden in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).

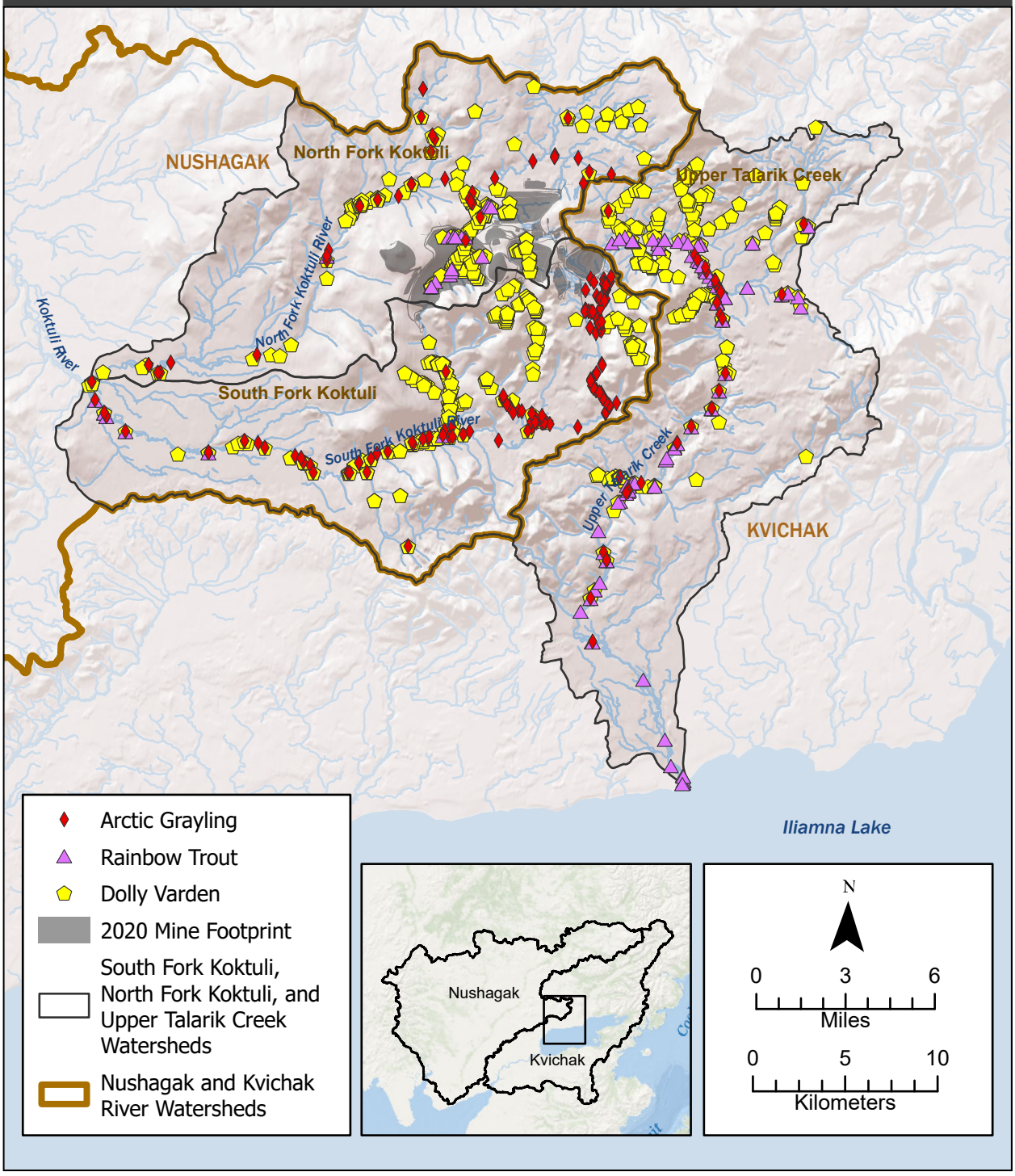


Figure 4-5. Reported occurrence of other resident fish species in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).

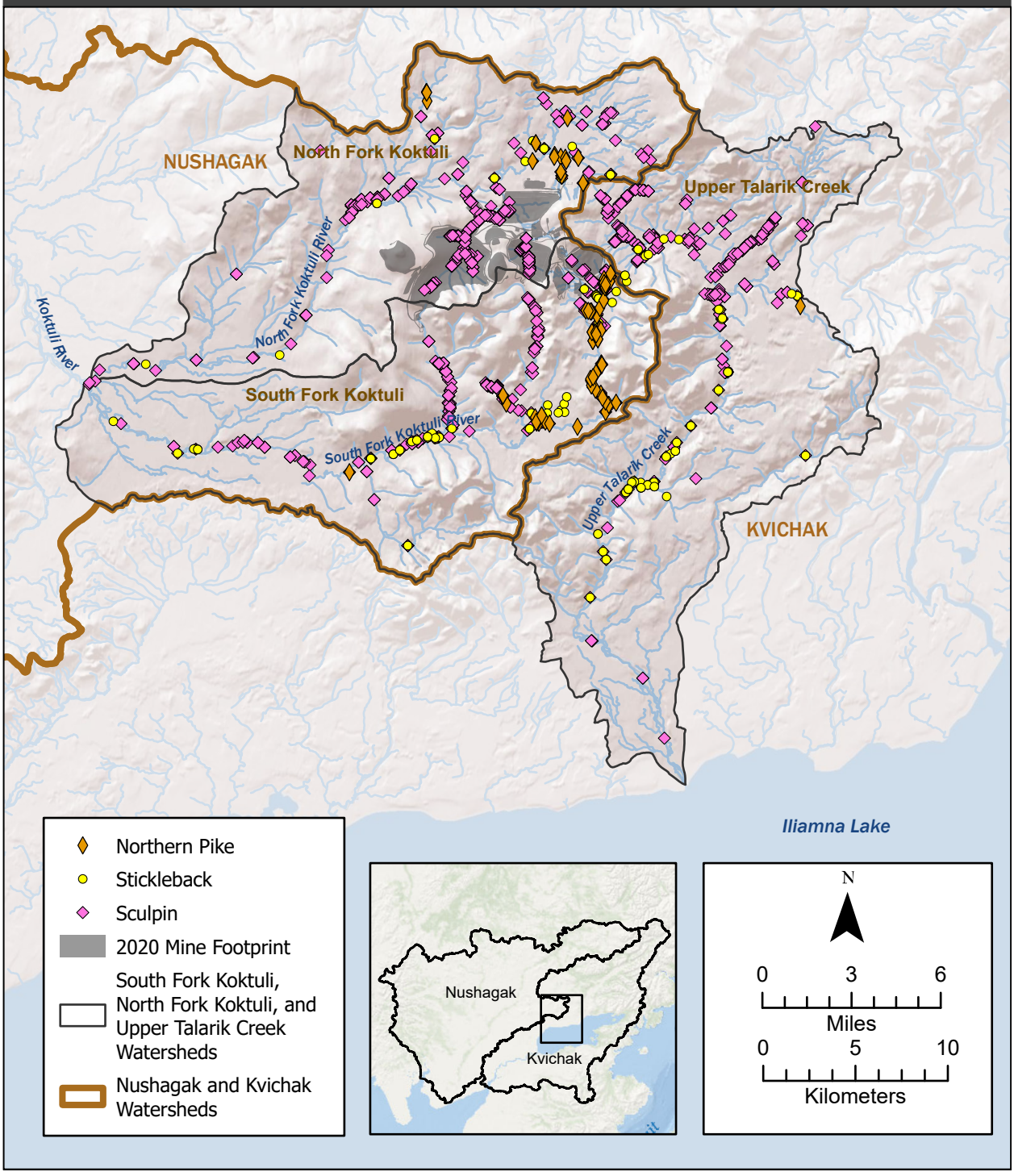


Figure 4-6. Reported occurrence of Arctic Grayling, Rainbow Trout, and Dolly Varden overlain with the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).

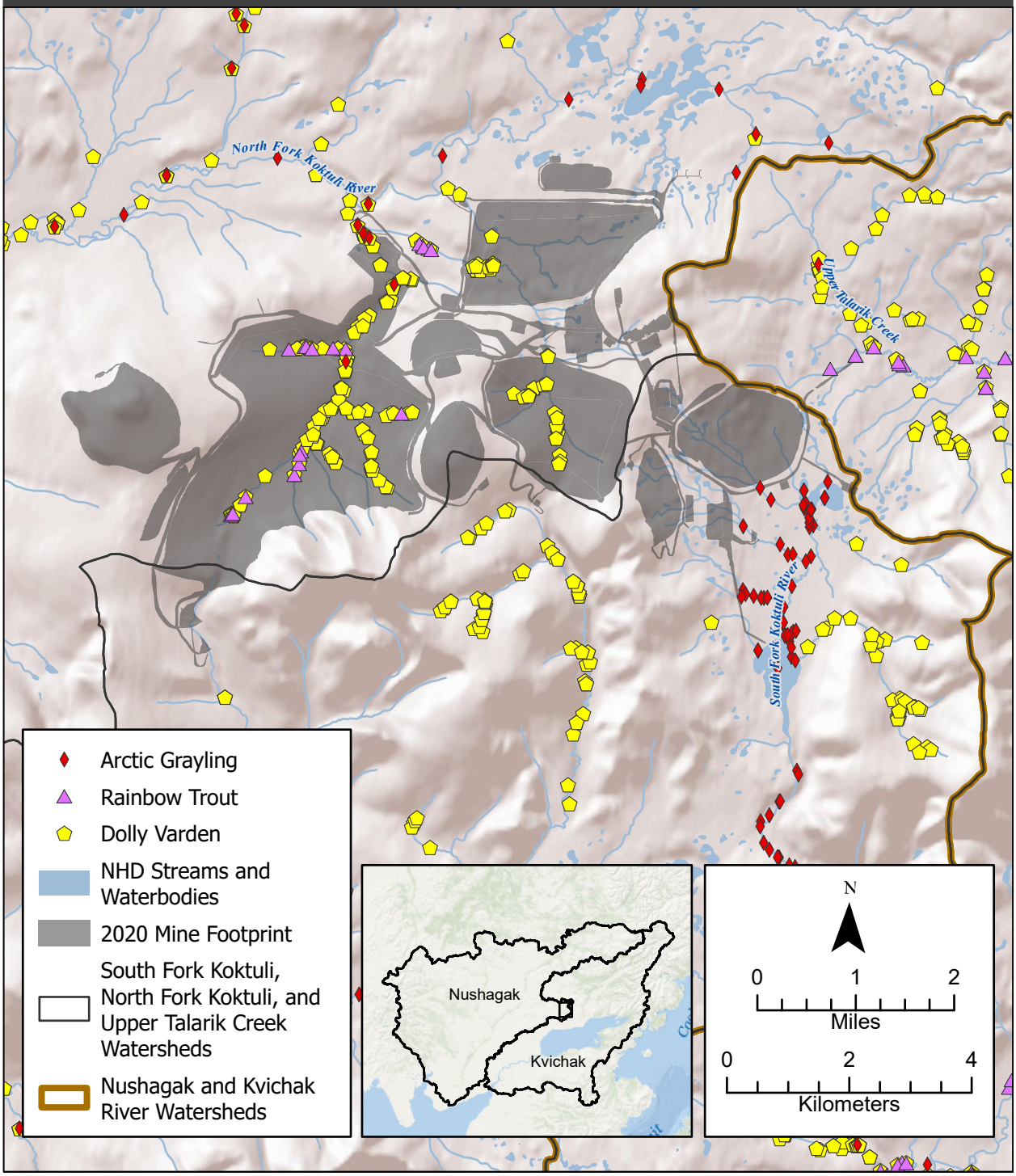
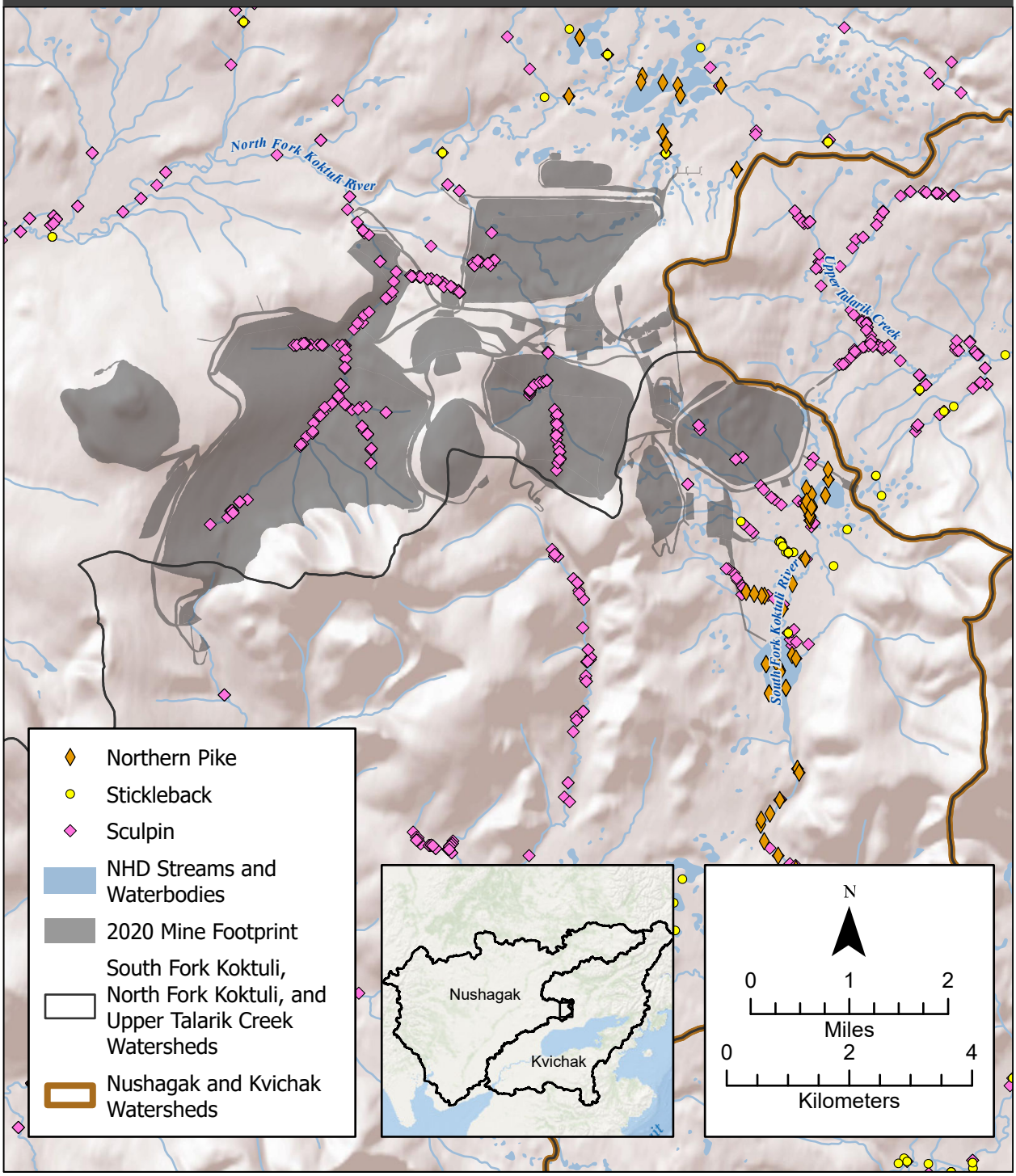


Figure 4-7. Reported occurrence of other resident fish species overlain with the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).



4.2.1.5 Conclusions

EPA has considered and evaluated the information available regarding how the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit would affect anadromous fishery areas in the SFK, NFK, and UTC watersheds. As described below, the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams from such discharges will have unacceptable adverse effects on anadromous fishery areas if the losses are located in the mine site area (Figure 4-1) within the SFK and NFK watersheds or elsewhere in the SFK, NFK, and UTC watersheds. The following conclusions and rationale directly support the prohibition described in Section 5.1 and the restriction described in Section 5.2.

4.2.1.5.1 Adverse Effects of Loss of Anadromous Fish Streams at the Mine Site

EPA has determined that the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, resulting in the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in the NFK watershed. This conclusion is based on the following factors described in detail in Sections 4.2.1.1 through 4.2.1.3: the large amount of permanent loss of anadromous fish habitat (including spawning and breeding areas); the particular importance of the permanently lost habitat for juvenile Coho and Chinook salmon; the degradation of and thus damage to additional downstream spawning and rearing habitat for Coho, Chinook, and Sockeye salmon due to the loss of ecological subsidies provided by the eliminated anadromous fish streams; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the NFK watershed, both of which are key to the abundance and stability of salmon populations within this watershed.

Other anadromous fish streams in the mine site area (Figure 4-1) are part of the same hydrologically connected network of headwater streams as the 8.5 miles of anadromous fish streams that would be eliminated by discharges of dredged or fill material associated with the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8). Thus, the same or greater levels of loss of these anadromous fish streams from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds also will have unacceptable adverse effects on anadromous fishery areas in these watersheds. These conclusions support the prohibition described in Section 5.1.

4.2.1.5.2 Adverse Effects of Loss of Anadromous Fish Streams Elsewhere in the SFK, NFK, and UTC Watersheds

Over the past decade, EPA has reviewed the large body of available information about the SFK, NFK and UTC watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a), including the role that aquatic resources in these watersheds play in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (e.g., Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019, Raborn and Link 2022). Furthermore, EPA recognizes that the 2020 Mine Plan

represents only one configuration of a potential mine at the Pebble deposit and any relocation of mine site components to other locations in the SFK, NFK, and UTC watersheds would result in discharges of dredged or fill material to water resources beyond the mine site area delineated in the 2020 Mine Plan.[62]

Thus, this final determination considers the effects of relocating the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams to other areas of the SFK, NFK, and UTC watersheds, in addition to the specific mine placement included in the 2020 Mine Plan. To determine whether unacceptable adverse effects would result from discharges within this larger area, EPA evaluated the aquatic resource components of the SFK, NFK, and UTC watersheds, including the types and abundance of aquatic habitats (e.g., streams, wetlands, and other waters), their physical and chemical characteristics, and the organisms that use those habitats (Section 3), based on the data available for sites throughout these three watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a).

Based on its evaluation, EPA determined that the diverse, highly connected, and ecologically valuable aquatic habitats in the SFK, NFK, and UTC watersheds provide the foundation for productive fishery areas in these watersheds. All three watersheds comprise largely undeveloped landscapes with intact, high-quality, connected, and free-flowing aquatic habitats from their headwaters to their downstream extents. There are significant similarities in the structure and function of rivers, streams, wetlands, and other waters throughout the three watersheds. The productivity of the SFK, NFK, and UTC watersheds, for anadromous fishes, as well as other biota, depends on the characteristics of these individual habitats and how they are arranged and connected, all of which vary in space and time to create unique and dynamic habitat mosaics throughout these three watersheds. As a result, similar habitats across the three watersheds are not interchangeable, but represent distinct resources that play a crucial role in supporting and stabilizing productive salmon populations in these watersheds. Thus, they are an integral component in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (Box 3-1).

The SFK, NFK, and UTC watersheds all have a similar stream network structure, with numerous headwater tributaries contributing to downstream mainstem reaches (Figure ES-8). Similar stream extents have been mapped in each watershed (194–264 miles) (Table 3-6). Most of these stream miles consist of small channels: small headwater streams (≤5.3 cubic feet per second [ft^3/s] or ≤0.15 cubic meters per second [m^3/s] mean annual streamflow) comprise 65 percent of stream channel length in the SFK, NFK, and UTC watersheds, and small or medium streams (≤100 ft^3/s [≤2.8 m^3/s] mean annual streamflow) comprise 89 percent of stream channel length (Table 3-1). Wetlands (primarily freshwater emergent and freshwater forested scrub/shrub wetlands) cover at least 15 percent of the total area in each watershed (Figure ES-7), and each watershed contains multiple lakes and ponds. Floodplain and off-channel habitats are important habitat components in all three watersheds (USACE 2020a: Table 3-

[62] The FEIS considers the environmental impacts of discharges of dredged or fill material to construct components associated with developing the Pebble deposit (e.g., TSFs) at other locations in these three watersheds (Section 2.1.2.2) (USACE 2020a: Section 2 and Appendix B).

24-3). For example, aerial imagery shows that roughly 70 percent of the mainstem SFK and UTC and roughly 90 percent of the mainstem NFK are bordered by some form of off-channel habitat (USACE 2020a: Section 3.24), most commonly beaver complexes (Section 3.2.2) (USACE 2020a: Section 3.24).

This network of headwater streams and wetlands provides critical support for downstream anadromous fish streams. Existing data show that streams and rivers in the SFK, NFK, and UTC watersheds provide similar levels of high-capacity, high-quality habitats for salmonids. These habitats provide ideal conditions for adult salmon spawning, egg incubation, and juvenile rearing, such as clean, cold water; extensive unembedded gravel substrates; abundant areas of groundwater exchange (upwelling and downwelling); and highly suitable stream gradients and sizes. For example, low-gradient streams of medium size (5.3 to 100 ft^3/s [0.15 to 2.8 m^3/s] mean annual streamflow) or greater likely provide high-capacity, high-quality habitats for salmonids (EPA 2014: Chapter 7), and such streams comprise 34 percent of the stream network in the SFK, NFK, and UTC watersheds (Table 3-1).

In fact, multiple Pacific salmon species and life stages have been documented to occur in high numbers and across diverse habitats (Tables 3-7 through 3-10) throughout the three watersheds (Figure 3-18). The SFK, NFK, and UTC watersheds contain similar extents of documented anadromous fish streams (60–76 miles) (Table 3-6). At least 30 percent of streams within the three watersheds are documented anadromous fish streams (Table 3-6), although this value likely represents a significant underestimate (Appendix B). Anadromous fish streams in the SFK, NFK, and UTC watersheds directly support critical life history stages of multiple anadromous fish species. Coho, Sockeye, Chinook, and Chum salmon rely on and are adapted to aquatic habitats in the SFK, NFK, and UTC watersheds for completion of their life cycles: eggs incubate and hatch in spawning gravels, juveniles overwinter and grow in streams and off-channel habitats, smolts migrate downstream through the stream network, and adults migrate upstream to spawn (Section 3.3.1). Timing of life history events (e.g., spawning and emergence) varies by species and by population, and is dictated by the unique conditions of habitats, their positions in the watershed, and their connectivity in space and time, resulting in asynchrony of salmon availability across the landscape (Section 3.3.3.2). Aquatic resource components in each of these three watersheds combine in different ways to create unique habitat mosaics, which over thousands of years have resulted in local adaptation of anadromous fish populations to site-specific conditions in each watershed.

All three watersheds contain documented spawning and rearing habitat for Coho, Chinook, and Sockeye salmon (Figures 3-5 through 3-7) and documented spawning habitat for Chum Salmon (Figure 3-8). Coho Salmon are the most widely distributed salmon species in the three watersheds (Figure 3-5) and have been documented to occur in at least 59 stream miles within each watershed (Table 3-6). Coho Salmon make extensive use of mainstem and tributary habitats, including headwater streams (Figure 3-5). Chinook Salmon have been documented to occur in at least 38 stream miles in each watershed (Table 3-6). Coho and Chinook salmon—the salmon species most reliant on habitats in the SFK, NFK, and UTC watersheds—are the two rarest of North America's five species of Pacific salmon (Healey 1991, Woody 2018) and are particularly vulnerable to losses of small, discrete populations.

Discharges of dredged or fill material associated with the 2020 Mine Plan would result in the permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams.[63] The permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit in any part of the SFK, NFK, and UTC watersheds would result in adverse effects on anadromous fishery areas that are similar to those identified for the 2020 Mine Plan, specifically due to the elimination of salmon spawning and rearing habitat and downstream ecological subsidies and the resulting erosion of habitat complexity and biocomplexity. Permanent loss of these fishery areas would result in the permanent loss of their functional and productive capacity to support anadromous fishes, as well as resident fishes and other aquatic biota. Although salmon may attempt to occupy nearby habitats when displaced from their natal streams, this displacement can reduce their reproductive fitness (e.g., via reduced habitat quality, delayed occupancy of spawning habitats, and competition with fishes adapted to those nearby habitats). The functional and productive capacity of remaining downstream fishery areas also would be damaged, due to the loss of ecological subsidies to downstream anadromous fish habitats. Ultimately, these large losses of anadromous fish habitat, including habitats comprising unique combinations of habitat components to which anadromous fish populations have adapted can reduce the productivity and resilience of the salmon populations they support.

Given the significant similarities in the structure and function of aquatic resources across the SFK, NFK, and UTC watersheds and the adverse effects that would result from the discharges of dredged or fill material associated with developing the Pebble deposit if mine components were relocated to other locations in these watersheds, EPA has determined that the discharge of dredged or fill material associated with developing the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds, resulting in the loss of approximately 8.5 miles (13.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in these watersheds. As explained in detail above, this conclusion is based on the same record and analysis used to evaluate the effects of the 2020 Mine Plan, as well as the following factors: the presence of anadromous fish streams throughout the SFK, NFK, and UTC watersheds, which directly support critical life history stages (e.g., spawning, rearing, migration) of at least one anadromous fish species (Section 3.3); that these three watersheds have similar amounts of total anadromous fish streams, as well as similar amounts of anadromous fish streams for each of the five Pacific salmon species (Table 3-6, Figure 3-18); that the anadromous fish streams throughout these watersheds are currently among the least developed and least disturbed (i.e., closest to pristine) habitats of this type in North America (Section 3.1); that anadromous fish streams across these three watersheds function similarly to support multiple species and life stages of anadromous fishes that are adapted to the unique set of environmental conditions each stream provides (Section 3.3); the large amount of permanent loss of anadromous fish habitat that approximately 8.5 miles (13.7 km) would represent; the degradation of and thus damage to additional downstream anadromous fish habitat due

[63] The FEIS concluded that placement of a bulk TSF at other locations in the SFK, NFK, or UTC watersheds would result in similar or greater losses of documented anadromous fish streams than the bulk TSF location proposed in the 2020 Mine Plan (PLP 2018e: RFI 098).

to the loss of ecological subsidies provided by the anadromous fish streams that would be lost; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds. This conclusion supports the restriction described in Section 5.2.

4.2.2 Adverse Effects of Loss of Additional Streams that Support Anadromous Fish Streams

In addition to the permanent loss of approximately 8.5 miles (13.7 km) of documented anadromous fish streams, discharges of dredged or fill material at the mine site for the 2020 Mine Plan would result in the permanent loss of approximately 91 miles (147 km)[64] of additional streams that support anadromous fish streams[65] in the SFK and NFK watersheds (USACE 2020a: Section 4.24) (Figure 4-8, Box 4-3). EPA has determined that the permanent loss of these additional streams will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. As discussed in this section, this conclusion is based on the extensive permanent loss of additional streams that support anadromous fish streams and the permanent loss of the ecological subsidies these additional streams provide to downstream anadromous fish streams, which represent significant damage to these downstream anadromous fishery areas.

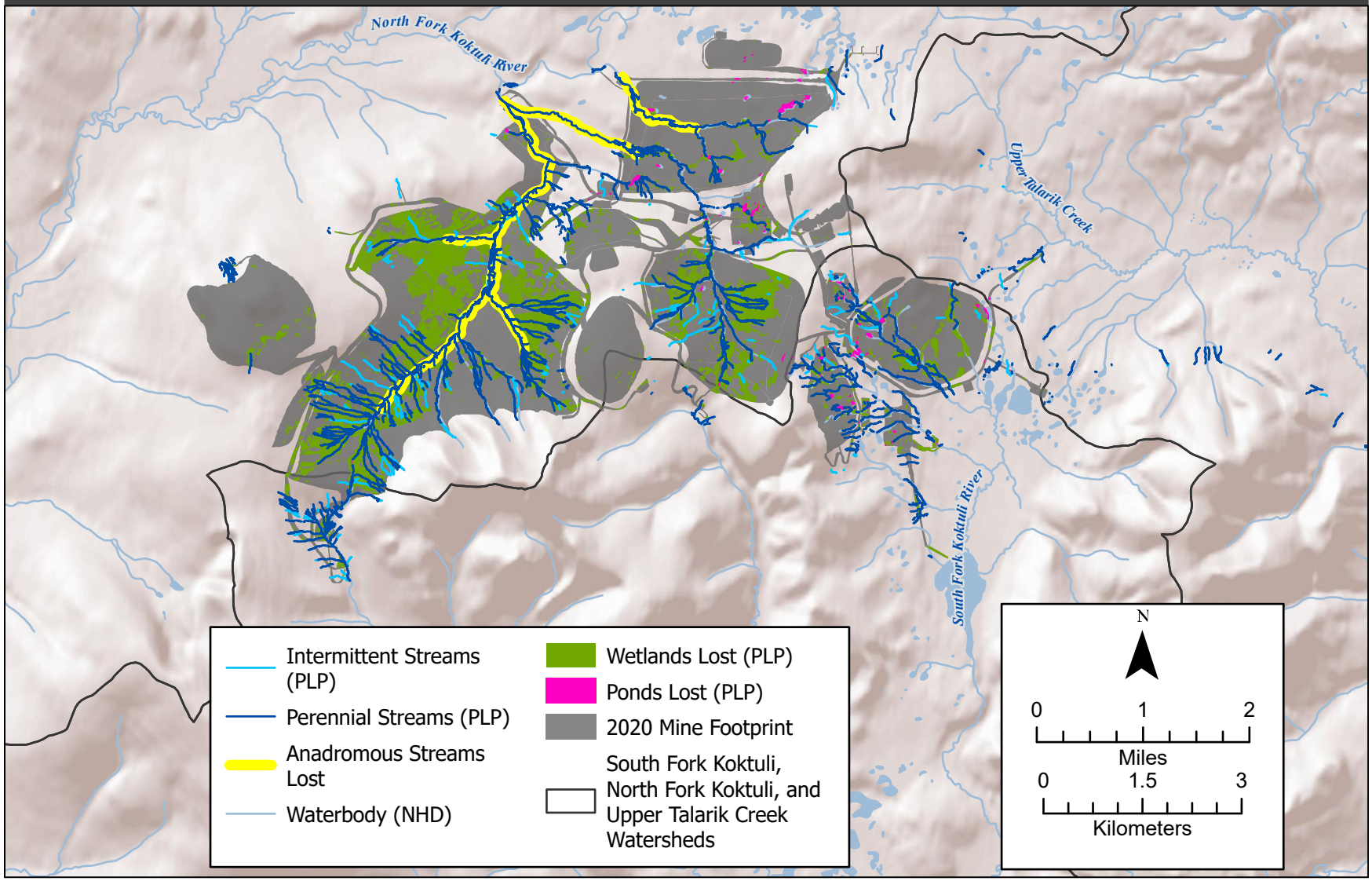
4.2.2.1 Extent of Additional Streams that Support Anadromous Fish Streams that Would Be Permanently Lost

Streams in the mine site area (Figures ES-5 and 4-8) were analyzed in detail to identify "all aquatic habitats potentially directly or indirectly affected by permitted mine site activities" (USACE 2020a: Page 4.24-1). The FEIS identifies 99.7 miles of streambed habitat at the mine site that would be lost as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan. This loss includes the 8.5 miles of anadromous fish stream losses discussed in Section 4.2.1 (USACE 2020a: Section 4.24). Most of these losses would be located in the NFK watershed, where 72.4 miles (116.5 km) of additional streams would be permanently lost (in addition to the 8.5 miles [13.7 km] of anadromous fish stream losses). Permanent losses of additional streams in the SFK and UTC watersheds would be 18.8 miles (30.3 km) and 0.02 mile (0.02 km), respectively (PLP 2020b). The FEIS indicates the combined 99.7 miles (160.5 km) of anadromous fish stream and additional stream losses would represent "about

[64] According to the FEIS, "[a] total of 80 miles of stream habitat would be eliminated in the NFK drainage, including 8.5 miles of anadromous Pacific salmon habitat" and "a total of 19 miles of stream habitat would be eliminated in the SFK drainage" (USACE 2020a: Page 4.24-9). According to PLP's June 8, 2020 CWA Section 404 permit application, additional stream losses in the UTC would be less than 0.02 mile (PLP 2020b).

[65] *Additional streams that support anadromous fish streams* refers to streams that do not currently have documented anadromous fish occurrence. As explained in this section, such streams support downstream anadromous fish streams. Although there is not currently documented anadromous fish occurrence in these streams, they may nonetheless be used by anadromous fish; however, the potential for such use is not a basis for this final determination (see Box 4-2 and Appendix B).

Figure 4-8. Streams, wetlands, and ponds lost under the Pebble 2020 Mine Plan. Streams, wetlands, and ponds at the mine site are based on PLP's June 2020 Permit Application (PLP 2020b).



BOX 4-3. WATER RESOURCES MAPPING AT THE MINE SITE

As shown in Figure 4-8, PLP completed field-verified mapping of wetlands and other waters at the mine site. This type of higher resolution stream and wetland mapping would be necessary to accurately predict impacts on water resources from the discharge of dredged or fill material for the purposes of any final determination in this case. Project-specific map layers provide more detail and include more water courses than publicly available stream and wetland databases. A brief review of these databases is provided to demonstrate how the water resource impacts described in the FEIS and this final determination differ from the typical stream and wetland mapping available for the rest of the SFK, NFK, and UTC watersheds.

National stream and wetland databases are readily accessible for these watersheds, but these data come with limitations. The U.S. Geological Survey provides a nationwide database of streams, waterbodies, and watersheds as part of the National Hydrography Dataset (NHD). The NHD is a feature-based database that identifies stream segments or reaches that make up the nation's surface water drainage system. These data are mapped at 1:63,360 scale or larger in Alaska (USGS 2022). Similarly, the U.S. Fish and Wildlife Service maintains the National Wetlands Inventory (NWI) to provide information on the status, extent, characteristics, and functions of the nation's wetlands, riparian, and deepwater habitats (USFWS 2022a). The NWI mapping available for the SFK, NFK, and UTC watersheds is derived from 1:65,000 scale aerial photography (USFWS 2021). While NWI is not available nationwide, it is currently available for approximately 96 percent of the SFK, NFK, and UTC watersheds.

The stream and wetland mapping generated by PLP was developed using more site-specific information than is typically used in the development of the NHD or the NWI. For approximately 44 percent of the SFK, NFK, and UTC watershed areas, PLP developed high resolution vegetation and stream mapping layers using a combination of field data collection and aerial photography interpretation. Wetland boundaries were digitized on aerial photography at a scale between 1:1,200 and 1:1,500. Waterbodies were digitized based on aerial photography scaled at 1:400 using an average minimum mapping unit of 0.05 acre (USACE 2020a: Section 3.22). This mapping addressed some data gaps that otherwise exist when using non-project–specific stream and wetland mapping layers like the NHD or the NWI.

A comparison of these stream and wetland mapping sources helps demonstrate how impacts on water resources can appear to vary due solely to changes in map resolution. EPA understands the area under the 2020 Mine Plan footprint was subject to more review by USACE during the CWA Section 404 permit review process. Therefore, this area is assumed to provide the most accurate comparison area of national datasets to higher resolution water resources maps. While the NHD only shows approximately 25.8 miles (41.5 km) of streams under the 2020 Mine Plan footprint (USGS 2021b), PLP identified 99.7 miles (160.5 km) of stream habitat that would be impacted in this same area, including the 8.5 miles (13.7 km) of streams documented to contain anadromous fishes (USACE 2020a: Section 4.24). These values indicate there may be almost four times as many streams in these headwater areas than are mapped in the NHD. As indicated in the FEIS, PLP's identification of additional small-scale watercourses resulted in an increase in stream miles expected to receive direct and indirect impacts in the mine site analysis areas than had been disclosed in the DEIS (USACE 2020a: Section 4.22).

Similarly, while PLP's CWA Section 404 application identified 2,113 acres (8.6 km^2) of wetlands and other waters that would be permanently lost due to the discharge of dredged or fill material at the mine site, the NWI identified only 1,492 acres (6.0 km^2) of wetlands and deepwater habitats in this same area. These values indicate that there may be over 40 percent more wetlands and other deepwater habitats in the vicinity of the Pebble deposit than are included in the NWI.

20 percent of available [stream] habitat in the Headwaters Koktuli River [watershed]" (i.e., the SFK, NFK, and Middle Koktuli River HUC-12 watersheds) and "12 percent of available [stream] habitat in the larger Koktuli River [watershed]" (USACE 2020a: Page 4.24-8).[66]

[66] EPA acknowledges that water resources have not been consistently mapped across these watersheds (USACE 2020a: Page 4.24-8). Nonetheless, the 2020 Mine Plan would result in the permanent loss of at least approximately 100 miles of headwater streams, which is the focus of Sections 4.2.1 and 4.2.2.

4.2.2.2 Adverse Effects from Permanent Loss of Additional Streams that Support Anadromous Fish Streams

The permanent loss of approximately 91 miles (147 km) of additional streams from discharges of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in reduced stream productivity in downstream anadromous fishery areas of the SFK and NFK due to the loss of physical and biological inputs that would no longer be provided to downstream fishery areas that support Coho, Chinook, Sockeye, and Chum salmon. These reductions in productivity would be permanent and certain to occur (USACE 2020a: Section 4.24).

The majority of the additional streams that would be permanently lost are small headwater streams. An extensive body of scientific evidence demonstrates that headwater streams are important aquatic habitats and play a critical role in the structure and function of downstream reaches (Section 3.2.4). The small size and large collective surface area of headwater streams result in a disproportionate effect on larger downstream habitats (Vannote et al. 1980, Alexander et al. 2007, Koenig et al. 2019, Colvin et al. 2019). Thus, loss of these headwater streams and their important ecological subsidies (e.g., food resources, nutrients, surface water flows, groundwater exchange) can have larger than expected impacts on downstream reaches. Headwater streams that the 2020 Mine Plan would eliminate contribute spawning gravels, invertebrate drift, organic matter, nutrients, surface water flows, groundwater flows, and woody debris to downstream channels (USACE 2020a: Section 4.24). The loss of temperature moderation via groundwater-influenced flows to downstream anadromous fish streams would exacerbate the potentially substantial changes in stream temperature caused by WTP discharges (USACE 2020a: Section 4.24). Headwater streams also can serve as refugia for fishes that may seasonally or periodically use these habitats (USACE 2020a: Section 3.24). For example, headwater streams can provide refuge from predators (Sepulveda et al. 2013), floods (Brown and Hartman 1988), or otherwise temporarily inhospitable conditions in downstream waters. Indeed, the capacity and tendency of juvenile salmonids (e.g., Coho Salmon) to move extensively within the stream system, including upstream movements of kilometers, is becoming increasingly apparent (e.g., Kahler et al. 2001, Anderson et al. 2013, Armstrong and Schindler 2013, reviewed by Shrimpton et al. 2014).

The 91 miles (147 km) of additional streams that would be permanently lost in the SFK and NFK watersheds as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan provide important provisioning functions (via ecological subsidies) and habitat functions (via refugia) that are beneficial for downstream anadromous fishery areas. As a result, headwater streams such as those that would be permanently lost in the mine site area play a vital role in maintaining diverse, abundant anadromous fish populations (Section 3.2.4). Losses of this magnitude would result in significant damage to downstream anadromous fishery areas that provide spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds (Figures 3-5 through 3-8, Figures 4-2 and 4-3). These losses would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK), as well as Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1).

As explained for the loss of 8.5 miles (13.7 km) of anadromous fish streams, the loss of and damage to downstream anadromous fishery areas in the SFK and NFK watersheds that would result from elimination of 91 miles (147 km) of additional streams would further erode habitat complexity and biocomplexity within these watersheds. This diversity of salmon habitats and associated salmon population diversity help buffer salmon populations from sudden and extreme changes in abundance and ultimately maintain the stability and productivity of these populations. By itself, without contemplation of any other certain losses, the permanent destruction of approximately 91 miles (147 km) of additional streams from a single project would be unprecedented for the CWA Section 404 regulatory program in the Bristol Bay watershed. Such losses are unprecedented for good reason: the effects of these additional stream losses would degrade downstream habitats and adversely affect species such as Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds, all of which support important subsistence, commercial, and recreational fisheries.

Other streams in the mine site area are part of the same hydrologically connected network of headwater streams as the 91 miles of additional streams that would be eliminated as a result of the discharges of dredged or fil material associated with the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8).

4.2.2.3 Impacts on Other Fish Species

Although this final determination is based solely on adverse effects on anadromous fishery areas, EPA notes that the 91 miles (147 km) of additional streams that support anadromous fishery areas in the SFK and NFK watersheds and would be lost under the 2020 Mine Plan also provide habitat for non-anadromous fish species. The assemblage of non-anadromous fishes found in and supported by these additional streams is an important component of these habitats and further underscores the biological integrity and ecological value of these pristine, intact headwater networks.

The permanent loss of approximately 91 miles (147 km) of additional streams from the discharge of dredged or fill material under the 2020 Mine Plan would adversely affect non-anadromous fish species and assemblages. Available data indicate that approximately 14.1 miles (22.7 km) of these 91 miles (147 km) of additional streams support non-anadromous fish species such as Rainbow Trout, Dolly Varden, Arctic Grayling, Ninespine Stickleback, and Slimy Sculpin (Figures 4-6 and 4-7). Approximately 1.4 miles (2.3 km) of streams in the SFK watershed that would be lost to the mine footprint (Figure 4-8; USACE 2020a: Section 4.24) provide habitat for Arctic Grayling, Northern Pike, Slimy Sculpin, and Ninespine Stickleback. The remaining 12.7 miles (20.4 km) that would be permanently lost are located in the NFK watershed (USACE 2020a: Section 4.24) and provide habitat for Dolly Varden, Rainbow Trout, and Slimy Sculpin (ADF&G 2022a). As described in Section 4.2.1, Rainbow Trout, Dolly Varden, and Arctic Grayling are targets of downstream subsistence and recreational fisheries. Stickleback and Slimy Sculpin support those fisheries as forage fishes (Table 3-3).

As discussed previously in this section, waters downstream of the mine site would be degraded as a result of the elimination of 91 miles (147 km) of additional streams at the mine site. In addition to the four Pacific salmon species already discussed, these waters support Rainbow Trout, Dolly Varden, Arctic Grayling, Northern Pike, Ninespine Stickleback, and Slimly Sculpin. Thus, the ecological value of the approximately 91 miles (147 km) of additional streams that would be eliminated is further highlighted by the fact that they provide both habitat and habitat support functions for six non-anadromous fish species important to subsistence and recreational fisheries and aquatic food webs (Section 3.3.1).

4.2.2.4 Conclusions

EPA has considered and evaluated the information available regarding how the loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit would affect downstream anadromous fishery areas in the SFK, NFK, and UTC watersheds. As described below, the loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams from such discharges will have unacceptable adverse effects on anadromous fishery areas if the losses are located in the mine site area (Figure 4-1) within the SFK and NFK watersheds or elsewhere in the SFK, NFK, and UTC watersheds. The following conclusions and rationale directly support the prohibition described in Section 5.1 and the restriction described in Section 5.2.

4.2.2.4.1 Adverse Effects of Loss of Additional Streams at the Mine Site that Support Anadromous Fish Streams

EPA has determined that the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, resulting in the loss of approximately 91 miles (147 km) of additional streams, will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. This conclusion is based on the following factors described in detail in Sections 4.2.2.1 and 4.2.2.2: the large amount of permanent loss of additional streams and the crucial role that these headwater streams play in providing ecological subsidies to downstream anadromous fish streams; the degradation of and thus damage to downstream anadromous fish streams, including spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon, due to the loss of ecological subsidies provided by the eliminated headwater streams; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK and NFK watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds.

Other streams in the mine site area are part of the same hydrologically connected network of headwater streams as the 91 miles of additional streams that would be eliminated by the discharges of dredged or fill material associated with the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8). Thus, the same or greater levels of loss of these additional streams from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK

watersheds also will have unacceptable adverse effects on anadromous fishery areas in these watersheds. These conclusions support the prohibition described in Section 5.1.

4.2.2.4.2 Adverse Effects of Loss of Additional Streams Elsewhere in the SFK, NFK, and UTC Watersheds that Support Anadromous Fish Streams

Over the past decade, EPA has reviewed the large body of available information about the SFK, NFK and UTC watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a), including the role that aquatic resources in these watersheds play in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (e.g., Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019, Raborn and Link 2022). Furthermore, EPA recognizes that the 2020 Mine Plan represents only one configuration of a potential mine at the Pebble deposit and any relocation of mine site components to other locations in the SFK, NFK, and UTC watersheds would result in discharges of dredged or fill material to water resources beyond the mine site area delineated in the 2020 Mine Plan.[67]

Thus, this final determination considers the effects of relocating the loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams to other areas of the SFK, NFK, and UTC watersheds, in addition to the specific mine placement included in the 2020 Mine Plan. To determine whether unacceptable adverse effects would result from discharges within this larger area, EPA evaluated the aquatic resource components of the SFK, NFK, and UTC watersheds, including the types and abundance of aquatic habitats (e.g., streams, wetlands, and other waters), their physical and chemical characteristics, and the organisms that use those habitats (Section 3), based on the data available for sites throughout these three watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a).

Based on its evaluation, EPA determined that the diverse, highly connected, and ecologically valuable aquatic habitats in the SFK, NFK, and UTC watersheds provide the foundation for productive fishery areas in these watersheds. All three watersheds comprise largely undeveloped landscapes with intact, high-quality, connected, and free-flowing aquatic habitats from their headwaters to their downstream extents. There are significant similarities in the structure and function of rivers, streams, wetlands, and other waters throughout the three watersheds. The productivity of the SFK, NFK, and UTC watersheds, for anadromous fishes, as well as other biota, depends on the characteristics of these individual habitats and how they are arranged and connected, all of which vary in space and time to create unique and dynamic habitat mosaics throughout these three watersheds. As a result, similar habitats across the three watersheds are not interchangeable, but represent distinct resources that play a crucial role in supporting and stabilizing productive salmon populations in these watersheds. Thus, they are an integral component in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (Box 3-1).

[67] The FEIS considers the environmental impacts of discharges of dredged or fill material to construct components associated with developing the Pebble deposit (e.g., TSFs) at other locations in these three watersheds (Section 2.1.2.2) (USACE 2020a: Section 2 and Appendix B).

The SFK, NFK, and UTC watersheds all have a similar stream network structure, with numerous headwater tributaries contributing to downstream mainstem reaches (Figure ES-8). Similar stream extents have been mapped in each watershed (194–264 miles) (Table 3-6). Most of these stream miles consist of small channels: small headwater streams (≤5.3 ft^3/s [≤0.15 m^3/s] mean annual streamflow) comprise 65 percent of stream channel length in the SFK, NFK, and UTC watersheds, and small or medium streams (≤100 ft^3/s [≤2.8 m^3/s] mean annual streamflow) comprise 89 percent of stream channel length (Table 3-1). Wetlands (primarily freshwater emergent and freshwater forested scrub/shrub wetlands) cover at least 15 percent of the total area in each watershed (Figure ES-7), and each watershed contains multiple lakes and ponds. Floodplain and off-channel habitats are important habitat components in all three watersheds (USACE 2020a: Table 3-24-3). For example, aerial imagery shows that roughly 70 percent of the mainstem SFK and UTC and roughly 90 percent of the mainstem NFK are bordered by some form of off-channel habitat (USACE 2020a: Section 3.24), most commonly beaver complexes (Section 3.2.2) (USACE 2020a: Section 3.24).

This network of headwater streams and wetlands provides critical support for downstream anadromous fish streams. Existing data show that streams and rivers in the SFK, NFK, and UTC watersheds provide similar levels of high-capacity, high-quality habitats for salmonids. These habitats provide ideal conditions for adult salmon spawning, egg incubation and juvenile rearing, such as clean, cold water; extensive unembedded gravel substrates; abundant areas of groundwater exchange (upwelling and downwelling); and highly suitable stream gradients and sizes. For example, low-gradient streams of medium size (5.3 to 100 ft^3/s [0.15 to 2.8 m^3/s] mean annual streamflow) or greater likely provide high-capacity, high-quality habitats for salmonids (EPA 2014: Chapter 7), and such streams comprise 34 percent of the stream network in the SFK, NFK, and UTC watersheds (Table 3-1).

In fact, multiple Pacific salmon species and life stages have been documented to occur in high numbers and across diverse habitats (Tables 3-7 through 3-10) throughout the three watersheds (Figure 3-18). The SFK, NFK, and UTC watersheds contain similar extents of documented anadromous fish streams (60–76 miles) (Table 3-6). At least 30 percent of streams within the three watersheds are documented anadromous fish streams (Table 3-6), although this value likely represents a significant underestimate (Appendix B). Anadromous fish streams in the SFK, NFK, and UTC watersheds directly support critical life history stages of multiple anadromous fish species. Coho, Sockeye, Chinook, and Chum salmon rely on and are adapted to aquatic habitats in the SFK, NFK, and UTC watersheds for completion of their life cycles: eggs incubate and hatch in spawning gravels, juveniles overwinter and grow in streams and off-channel habitats, smolts migrate downstream through the stream network, and adults migrate upstream to spawn (Section 3.3.1). Timing of life history events (e.g., spawning and emergence) varies by species and by population, and is dictated by the unique conditions of habitats, their positions in the watershed, and their connectivity in space and time, resulting in asynchrony of salmon availability across the landscape (Section 3.3.3.2). Aquatic resource components in each of these three watersheds combine in different ways to create unique habitat mosaics, which over thousands of years have resulted in local adaptation of anadromous fish populations to site-specific conditions in each watershed.

All three watersheds contain documented spawning and rearing habitat for Coho, Chinook, and Sockeye salmon (Figures 3-5 through 3-7) and documented spawning habitat for Chum Salmon (Figure 3-8). Coho Salmon are the most widely distributed salmon species in the three watersheds (Figure 3-5) and have been documented to occur in at least 59 stream miles within each watershed (Table 3-6). Coho Salmon make extensive use of mainstem and tributary habitats, including headwater streams (Figure 3-5). Chinook Salmon have been documented to occur in at least 38 stream miles in each watershed (Table 3-6). Coho and Chinook salmon—the salmon species most reliant on habitats in the SFK, NFK, and UTC watersheds—are the two rarest of North America's five species of Pacific salmon (Healey 1991, Woody 2018) and are particularly vulnerable to losses of small, discrete populations.

An extensive body of scientific evidence demonstrates that headwater streams play a critical role in the structure and function of downstream reaches, by providing important fish habitat and supplying the energy and other resources needed to support fishes in connected downstream habitats (Section 3.2.4). Headwater streams transport invertebrates and detritus to downstream areas, where these resources support juvenile salmonids and other fishes (Wipfli and Gregovich 2002, Cummins and Wilzbach 2005, Colvin et al. 2019, Hedden and Giddo 2020). Headwater streams also influence downstream water chemistry (Richardson et al. 2005, Alexander et al. 2007, Meyer et al. 2007). Together, the small size and large collective surface area of headwater streams result in a disproportionate effect on larger downstream habitats (Vannote et al. 1980, Alexander et al. 2007, Koenig et al. 2019, Colvin et al. 2019). Because of their large influence on downstream water flow, water chemistry, and biota, the importance of headwater systems reverberates throughout entire watersheds downstream (Freeman et al. 2007, Meyer et al. 2007, Fritz et al. 2018, Schofield et al. 2018, Ferreira et al. 2022).

Discharges of dredged or fill material associated with the 2020 Mine Plan would result in the permanent loss of approximately 91 miles (147 km) of additional headwater streams at the mine site that support anadromous fish streams. The permanent loss of approximately 91 miles (147 km) of additional headwater streams that support anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit, in any part of the SFK, NFK, and UTC watersheds, would result in adverse effects on anadromous fishery areas that are similar to those identified for the 2020 Mine Plan, specifically due to the elimination of downstream ecological subsidies and the resulting erosion of habitat complexity and biocomplexity. Losses of this magnitude would eliminate substantial downstream ecological subsidies of surface water flows, energy, substrate, nutrients, organic matter, macroinvertebrates, and other materials, resulting in significant damage to downstream anadromous fishery habitats, including downstream salmon spawning and rearing habitats, leading to erosion of habitat complexity and biocomplexity. Ultimately, these significant permanent losses of additional streams that support anadromous fish streams would therefore reduce the functional and productive capacity of these downstream anadromous fishery areas to support anadromous fishes, as well as resident fishes and other aquatic biota.

Given the significant similarities in the structure and function of aquatic resources across the SFK, NFK, and UTC watersheds and the adverse effects that would result from the discharges of dredged or fill material associated with developing the Pebble deposit if mine components were relocated to other

locations in these watersheds, EPA has determined that the discharge of dredged or fill material associated with developing the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds, resulting in the loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in these watersheds. As explained in detail above, this conclusion is based on the same record and analysis used to evaluate the effects of the 2020 Mine Plan, as well as the following factors: headwater streams throughout the SFK, NFK, and UTC watersheds are among the least developed and least disturbed (i.e., closest to pristine) habitats of this type in North America (Section 3.1) and play a critical role in supporting productive and diverse Pacific salmon populations (Section 3.2); headwater streams across these three watersheds function similarly to support productive fishery areas for anadromous fishes (Section 3.3); the large amount of outright loss of stream habitat and the crucial role that these headwater streams play in providing ecological subsidies to downstream anadromous fish streams; the degradation of and thus damage to downstream anadromous fish streams from the loss of ecological subsidies provided by the lost headwater streams; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds. This conclusion supports the restriction described in Section 5.2.

4.2.3 Adverse Effects of Loss of Wetlands and Other Waters that Support Anadromous Fish Streams

In addition to the losses of anadromous fish streams and additional streams that support anadromous fish streams, the discharge of dredged or fill material at the mine site for the construction and routine operation of the 2020 Mine Plan would also result in the permanent loss of approximately 2,113 acres (8.6 km^2) of wetlands and other waters in the SFK, NFK, and UTC watersheds; approximately 2,108 acres (8.5 km^2) of these losses would occur in the SFK and NFK watersheds (Figure 4-8, Table 4-3, see also Box 4-3) (USACE 2020a, USACE 2020b). EPA has determined that these permanent losses of wetlands and other waters will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. As discussed in this section, this conclusion is based on the extensive permanent loss of wetlands and other waters and the corresponding permanent loss of ecological subsidies these wetlands provide to downstream anadromous fish streams, which represent significant damage to these downstream anadromous fishery areas.

Table 4-3. Area of wetlands and other waters lost under the Pebble 2020 Mine Plan.

Hydrogeomorphic/National Wetland Inventory (NWI) Group			Headwaters Koktuli River [a]	Upper Talarik Creek [b]	Combined Watershed Area (acres)
SLOPE	Wetlands	Total Wetlands	1,909	4	1,913
		Herbaceous	547	1	547
		Deciduous Shrubs	1,352	3	1,355
		Evergreen Shrubs	11	—	11
	Other Waters	Total Other Waters	16		16
		Aquatic Bed	2	—	2
		Ponds	13	—	13
		TOTAL SLOPE	1,925	4	1,929
DEPRESSIONAL	Wetlands	Total Wetlands	12	<1	12
		Herbaceous	5	<1	5
		Deciduous Shrubs	7	—	7
	Other Waters	Total Other Waters	38	<1	39
		Ponds	38	<1	39
		TOTAL DEPRESSIONAL	50	<1	50
FLAT	Wetlands	Total Wetlands	8		8
		Herbaceous	3	—	3
		Deciduous Shrubs	6	—	6
		TOTAL FLAT	8		8
LACUSTRINE FRINGE	Wetlands	Total Wetlands	<1		<1
		Herbaceous	<1	—	<1
		TOTAL LACUSTRINE FRINGE	<1		<1
RIVERINE	Wetlands	Total Wetlands	118		118
		Herbaceous	42	—	42
		Deciduous Shrubs	76	—	76
	Other Waters	Total Other Waters	7		7
		Ponds	7	—	7
		TOTAL RIVERINE	125		125
Total Impacts to Wetlands (acres)			**2,047**	**4**	**2,051**
Total Impacts to Other Waters (acres)			**61 [c]**	**<1**	**61 [c]**
Total Impacts to Wetlands and Other Waters (acres)			**2,108 [c]**	**4**	**2,113 [c]**
Total Area of NWI Wetlands and Other Waters (acres)			**36,458**	**13,193**	**49,651**
Percent Total of NWI Wetlands and Other Waters			**6**	**<1**	**4**

Notes:

[a] 100 percent of the Headwaters Koktuli River watershed has been mapped in NWI.

[b] 91 percent of the Upper Talarik Creek watershed has been mapped in NWI.

[c] To be consistent with the USACE's ROD (USACE 2020b), stream area was removed from values presented in FEIS Table 4.22-3 such that the Other Waters acreage values only include the following NWI group types: aquatic bed and ponds (USACE 2022).

Source: Adapted from FEIS Table 4.22-3 (USACE 2020a).

4.2.3.1 Extent of Wetlands and Other Waters that Support Anadromous Fish Streams that Would Be Permanently Lost

The FEIS states that the permanent "loss of wetlands from development of the mine site represent about 6 percent of mapped wetlands in the Headwaters Koktuli River watershed" (USACE 2020a: Page 4.22-

13)[68] (i.e., the SFK, NFK, and Middle Koktuli River HUC-12 watersheds) and 4 percent of mapped wetlands in the Headwaters Koktuli River and UTC watersheds (Table 4-3, Box 4-3) (USACE 2020a: Section 4.22).

4.2.3.2 Adverse Effects from Permanent Loss of Wetlands and Other Waters that Support Anadromous Fish Streams

The FEIS evaluates the "potential direct and indirect impacts from construction and operations" of the 2020 Mine Plan on wetlands and other waters across the mine site area (Figure ES-5) (USACE 2020a: Page 4.22-1). Wetlands and other waters that would be permanently lost as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan play a critically important role in the life cycles of anadromous fishes in the SFK and NFK watersheds (Section 3.2.3) (PLP 2011: Appendix 15.1.D). "[A]ll wetlands are important to the greater function and value of ecosystems and subsistence cultures they support" (USACE 2020a: Page 3.22-8). In addition, the wetlands and other waters that would be lost or damaged by the discharges of dredged or fill material associated with the 2020 Mine Plan "possess unique ecological characteristics of productivity, habitat, wildlife protection, and other important and easily disrupted values" (USACE 2020a: Page 3.22-1). The specific wetlands and other waters that would be permanently lost are also relatively free from human-induced alteration and provide extensive and heterogeneous habitats (Table 4-3) (USACE 2020a: Section 3.22). These wetlands and other waters are a key component of the diverse portfolio of pristine aquatic habitats that is crucial to supporting the productivity and stability of salmon populations in these watersheds (Section 3.3.3).

The permanent loss of wetlands and other waters would destroy habitat, result in mortality of aquatic organisms, and reduce the collective functional capacity and value of wetlands and other waters across multiple watersheds (USACE 2020a: Section 4.22). The permanent loss of wetlands and other waters also would cause the displacement, injury, and/or mortality of species that rely on these aquatic environments for all or part of their life cycles (USACE 2020a: Section 4.22). Under these circumstances, sedentary aquatic species (e.g., mollusks, fixed crustaceans, and benthic organisms) are likely to suffer mortality from sedimentation or smothering by fill; mobile species (e.g., fishes, free-swimming crustaceans, amphibians, and macroinvertebrates) may attempt to relocate (USACE 2020a: Section 4.22). Highly mobile salmon may attempt to occupy nearby habitats when displaced from their natal aquatic habitats, but this displacement can reduce their reproductive fitness (e.g., via reduced habitat quality, delayed occupancy of spawning habitats, and competition with fishes adapted to those nearby habitats).

The discharge of dredged or fill material into wetlands and other waters for the construction and routine operation of the 2020 Mine Plan would eliminate the biological productivity of wetland ecosystems buried by fill and alter the periodicity of water movement (USACE 2020a: Section 4.22). The elimination of productivity and alteration of water current patterns and velocities would eliminate or

[68] In its comments on the proposed determination, PLP indicated that following publication of the FEIS it provided information to USACE that this value is 4.8 percent based on updated mapping results. This clarification does not change EPA's analysis since the absolute amount of loss has not changed.

reduce the cycling of nutrients and other materials. The disruption of wetland hydrology would interfere with the filtration, aquifer recharge, and storm and floodwater modification functions that wetlands provide (USACE 2020a: Section 4.22). Many of the affected wetlands in the mine site area (e.g., slope wetlands) are considered headwater wetlands from a watershed perspective, meaning they are the primary source of intermittent and upper perennial streams. Impacts to these wetlands would alter groundwater discharges that maintain hydrology and water quality and buffer water temperatures in these streams; this alteration of hydrologic function is likely to extend to wetlands and other waters immediately downgradient from the affected wetlands (USACE 2020a: Section 4.22). All of these changes will significantly degrade these wetlands and other waters as habitat for anadromous fish and the ability of these wetlands and other waters to provide ecological subsides to downstream anadromous fishery areas.

Changes in flow in the SFK, NFK, and UTC due to modification of upgradient wetlands and mine operations have the potential to change the hydrologic connectivity of off-channel habitats and associated wetlands (USACE 2020a: Section 4.22). Off-channel habitats, including fringing riparian wetlands, provide cover important to juvenile salmon rearing (Section 3.2) (USACE 2020a: Section 4.22). Changes to flow and loss of connectivity between wetlands and other waters and stream channels also would adversely affect nutrient availability, degrade the transport of invertebrates downstream, and reduce available habitat for benthic macroinvertebrate production, thereby adversely affecting overall productivity of downstream anadromous fish streams and other additional streams that support anadromous fish streams (USACE 2020a: Section 4.22).

As described in Section 4.2.1, the wetlands and other waters that would be permanently lost due to discharges of dredged or fill material associated with the 2020 Mine Plan include beaver ponds and wetlands inundated as a result of beaver activity (USFWS 2021). Coho and Chinook salmon rear in many of the beaver-modified waters or the streams they abut (Table 3-10). Beaver-modified waters provide excellent rearing habitat and important overwintering and flow-velocity refugia for anadromous fishes (Section 3.2.4) and may be especially important in maintaining salmon productivity (Nickelson et al. 1992, Solazzi et al. 2000, Pollock et al. 2004).

Wetlands in the SFK, NFK, and UTC watersheds that are contiguous with and adjacent to anadromous fish streams likely provide additional anadromous fish habitat. Such areas often provide habitat to juveniles of species such as Coho Salmon (Henning et al. 2006, EPA 2014: Appendix B). The lower gradient of lakes, ponds, and inundated wetlands connected to anadromous fish streams also can provide beneficial rearing and foraging conditions that may be unavailable in the mainstream channel (Sommer et al. 2001, Henning et al. 2006), thereby increasing capacity for juvenile salmon growth and rearing (Nickelson et al. 1992, Sommer et al. 2001).

Wetlands in the SFK, NFK, and UTC watersheds also indirectly support anadromous fish streams by providing cover; moderating stream temperatures and flows; maintaining baseflows; serving as groundwater recharge zones; and supplying nutrients, organic material, macroinvertebrates, algae, and other materials to abutting streams and streams lower in the watershed. These inputs serve as

important subsidies for juvenile salmonids (Vannote et al. 1980, Wipfli and Gregovich 2002, Meyer et al. 2007, Dekar et al. 2012, Doretto et al. 2020). Abundant wetlands and small ponds, for example, have been documented to contribute disproportionately to groundwater recharge in this region (Rains 2011). Given the importance of groundwater–surface water exchange in the SFK, NFK, and UTC watersheds, groundwater inputs are likely a significant determinant of surface water quantity and quality. Moreover, leaf litter from deciduous shrubs and herbaceous vegetation is an important food source for stream food webs and helps fuel the production of macroinvertebrates, a key food for juvenile salmonids (Table 3-3) (Meyer et al. 2007, Dekar et al. 2012). Riparian wetlands with deciduous shrubs and grasses are prevalent in the SFK, NFK, and UTC watersheds and likely provide this energy source to downgradient waters.

The permanent loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters as a result of the discharge of dredged or fill material associated with the 2020 Mine Plan in the SFK and NFK watersheds would result in loss of both habitat and the provision of key ecological subsidies to abutting and downstream waters (Section 3.2.4). Loss of these wetlands and other waters as a result of the discharge of dredged or fill material associated with the 2020 Mine Plan would eliminate structurally complex and thermally and hydraulically diverse habitats, including crucial overwintering areas, that are essential to rearing salmonids. Such headwater wetlands also play a vital role in maintaining diverse, abundant anadromous fish populations via the downstream transport of surface and groundwater inputs and food sources critical to the survival, growth, and spawning success of anadromous fishes in downstream fishery areas (Section 3.2.4).

Downstream waters that would be degraded by the large-scale elimination of wetlands and other waters at the mine site are ecologically important and provide rearing and spawning habitat for Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds (Figures 3-5 through 3-8). In addition, damage to downstream anadromous fish streams would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and the NFK) and Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1).

As explained for the loss of 8.5 miles (13.7 km) of anadromous fish streams, the loss of and damage to downstream anadromous fishery areas in the SFK and NFK watersheds that would result from the elimination of approximately 2,108 acres (8.5 km^2) of wetlands and other waters would further erode habitat complexity and biocomplexity within the SFK and NFK watersheds. The diversity of salmon habitats and associated salmon population diversity help buffer salmon populations from sudden and extreme changes in abundance and ultimately maintain the stability and productivity of these populations. By itself, without contemplation of any other certain losses, the permanent destruction of approximately 2,108 acres (8.5 km^2) of wetlands and other waters from a single project would be unprecedented for the CWA Section 404 regulatory program in the Bristol Bay watershed. Such losses are unprecedented for good reason: the effects of these losses would degrade downstream habitats and adversely affect species such as Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds, all of which support important subsistence, commercial, and recreational fisheries.

Additional wetlands and other waters in the mine site area are hydrologically and ecologically connected to, and in some cases abut, the 2,108 acres of wetlands and other waters that would be eliminated as a result of the discharges of dredged or fill material associated with the 2020 Mine Plan footprint (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22). These additional wetlands and other waters support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24) and are part of the same headwater wetland complex characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figure ES-5).

The FEIS also indicates that additional wetlands and other waters adjacent to the mine site would be degraded by construction and operation of the 2020 Mine Plan. For example, fragmentation would occur between mine site infrastructure (Figure ES-5) (USACE 2020a: Section 4.22) and groundwater drawdown could potentially dewater wetlands located more than half a mile from mine infrastructure (USACE 2020a: Figure 4.22-3). Such indirect impacts would also contribute adverse effects to anadromous fish streams due to the loss of habitat connectivity and loss of ecological subsidies. Although not included as part of the permanent losses of wetlands and other waters identified for the 2020 Mine Plan, if these types of indirect impacts were to continue for more than 5 years they could result in permanent losses of these types of aquatic resources (Box 4-1).

4.2.3.3 Impacts on Other Fish Species

Although this final determination is based solely on adverse effects on anadromous fishery areas, EPA notes that the 2,108 acres (8.5 km^2) of wetlands and other waters at the mine site that would be lost in the SFK and NFK watersheds under the 2020 Mine Plan also provide habitat for non-anadromous fish species. The assemblage of non-anadromous fishes found in and supported by these wetlands and other waters is an important component of these habitats and further underscores the biological integrity and ecological value of these pristine, intact headwater networks. Dolly Varden and sculpin rear in many of the same beaver-modified habitats as Coho and Chinook salmon, and Ninespine Stickleback and sculpin rear in headwater ponds of the SFK watershed (Figures 4-6 and 4-7). Furthermore, waters downstream of the mine site that would be degraded by elimination of wetlands and other waters at the mine site support Rainbow Trout, Dolly Varden, Arctic Grayling, Northern Pike, Ninespine Stickleback, and sculpin—species that support regional biodiversity (Meyer et al. 2007) and are important to subsistence and recreational fisheries and aquatic food webs (Section 3.3.1).

4.2.3.4 Conclusions

EPA has considered and evaluated the information available regarding how the loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters from the discharge of dredged or fill material associated with developing the Pebble deposit would affect abutting and downstream anadromous fishery areas in the SFK, NFK, and UTC watersheds. As described below, the loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters from such discharges will have unacceptable adverse effects on anadromous fishery areas if the losses are located in the mine site area (Figure ES-5) within the SFK and NFK watersheds or elsewhere in the SFK, NFK, and UTC watersheds. The following

conclusions and rationale directly support the recommended prohibition described in Section 5.1 and the restriction described in Section 5.2.

4.2.3.4.1 Adverse Effects of Loss of Wetlands and Other Waters at the Mine Site that Support Anadromous Fish Streams

EPA has determined that the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, resulting in the loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters, will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. This conclusion is based on the following factors described in detail in Sections 4.2.3.1 and 4.2.3.2: the large amount of permanent loss of wetlands and other waters; the importance of wetlands and other waters to salmon populations, both as habitat and as sources of groundwater inputs, nutrients, and other subsidies important to salmon productivity in downstream waters; the degradation of and thus damage to downstream anadromous fish streams, including spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon, due to the loss of ecological subsidies provided by the headwater wetlands and other waters that would be lost; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK and NFK watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds.

Additional wetlands and other waters in the mine site area are hydrologically and ecologically connected to, and in some cases abut, the 2,108 acres (8.5 km^2) of wetlands and other waters that would be eliminated by the discharges of dredged or fill material associated with the 2020 Mine Plan at the mine site in the SFK and NFK watersheds (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22). These wetlands and other waters support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24) and are part of the same headwater wetland complex characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figure ES-5). Thus, the same or greater levels of loss of these additional wetlands and other waters from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds also will have unacceptable adverse effects on anadromous fishery areas in these watersheds. These conclusions support the prohibition described in Section 5.1.

4.2.3.4.2 Adverse Effects of Loss of Wetlands and Other Waters Elsewhere in the SFK, NFK, and UTC Watersheds that Support Anadromous Fish Streams

Over the past decade, EPA has reviewed the large body of available information about the SFK, NFK and UTC watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a), including the role that aquatic resources in these watersheds play in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (e.g., Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019, Raborn and Link 2022). Furthermore, EPA recognizes that the 2020 Mine Plan represents only one configuration of a potential mine at the Pebble deposit and any relocation of mine site components to other locations in the SFK, NFK, and UTC watersheds would result in discharges of

dredged or fill material to water resources beyond the mine site area delineated in the 2020 Mine Plan.[69]

Thus, this final determination considers the effects of relocating the loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters that support anadromous fish streams to other areas of the SFK, NFK, and UTC watersheds, in addition to the specific mine placement included in the 2020 Mine Plan. To determine whether unacceptable adverse effects would result from discharges within this larger area, EPA evaluated the aquatic resource components of the SFK, NFK, and UTC watersheds, including the types and abundance of aquatic habitats (e.g., streams, wetlands, and other waters), their physical and chemical characteristics, and the organisms that use those habitats (Section 3), based on the data available for sites throughout these three watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a).

Based on its evaluation, EPA determined that the diverse, highly connected, and ecologically valuable aquatic habitats in the SFK, NFK, and UTC watersheds provide the foundation for productive fishery areas in these watersheds. All three watersheds comprise largely undeveloped landscapes with intact, high-quality, connected, and free-flowing aquatic habitats from their headwaters to their downstream extents. There are significant similarities in the structure and function of rivers, streams, wetlands, and other waters throughout the three watersheds. The productivity of the SFK, NFK, and UTC watersheds, for anadromous fishes, as well as other biota, depends on the characteristics of these individual habitats and how they are arranged and connected, all of which vary in space and time to create unique and dynamic habitat mosaics throughout these three watersheds. As a result, similar habitats across the three watersheds are not interchangeable, but represent distinct resources that play a crucial role in supporting and stabilizing productive salmon populations in these watersheds. Thus, they are an integral component in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (Box 3-1).

The SFK, NFK, and UTC watersheds all have a similar stream network structure, with numerous headwater tributaries contributing to downstream mainstem reaches (Figure ES-8). Similar stream extents have been mapped in each watershed (194–264 miles) (Table 3-6). Most of these stream miles consist of small channels: small headwater streams (≤5.3 ft^3/s [≤0.15 m^3/s] mean annual streamflow) comprise 65 percent of stream channel length in the SFK, NFK, and UTC watersheds, and small or medium streams (≤100 ft^3/s [≤2.8 m^3/s] mean annual streamflow) comprise 89 percent of stream channel length (Table 3-1). Wetlands (primarily freshwater emergent and freshwater forested scrub/shrub wetlands) cover at least 15 percent of the total area in each watershed (Figure ES-7), and each watershed contains multiple lakes and ponds. Floodplain and off-channel habitats are important habitat components in all three watersheds (USACE 2020a: Table 3-24-3). For example, aerial imagery shows that roughly 70 percent of the mainstem SFK and UTC and roughly 90 percent of the mainstem

[69] The FEIS considers the environmental impacts of discharges of dredged or fill material to construct components associated with developing the Pebble deposit (e.g., TSFs) at other locations in these three watersheds (Section 2.1.2.2) (USACE 2020a: Section 2 and Appendix B).

NFK are bordered by some form of off-channel habitat (USACE 2020a: Section 3.24), most commonly beaver complexes (Section 3.2.2) (USACE 2020a: Section 3.24).

This network of headwater streams and wetlands provides critical support for downstream anadromous fish streams. Existing data show that streams and rivers in the SFK, NFK, and UTC watersheds provide similar levels of high-capacity, high-quality habitats for salmonids. These habitats provide ideal conditions for adult salmon spawning, egg incubation and juvenile rearing, such as clean, cold water; extensive unembedded gravel substrates; abundant areas of groundwater exchange (upwelling and downwelling); and highly suitable stream gradients and sizes. For example, low-gradient streams of medium size (5.3 to 100 ft^3/s [0.15 to 2.8 m^3/s] mean annual streamflow) or greater likely provide high-capacity, high-quality habitats for salmonids (EPA 2014: Chapter 7), and such streams comprise 34 percent of the stream network in the SFK, NFK, and UTC watersheds (Table 3-1).

In fact, multiple Pacific salmon species and life stages have been documented to occur in high numbers and across diverse habitats (Tables 3-7 through 3-10) throughout the three watersheds (Figure 3-18). The SFK, NFK, and UTC watersheds contain similar extents of documented anadromous fish streams (60–76 miles) (Table 3-6). At least 30 percent of streams within the three watersheds are documented anadromous fish streams (Table 3-6), although this value likely represents a significant underestimate (Appendix B). Anadromous fish streams in the SFK, NFK, and UTC watersheds directly support critical life history stages of multiple anadromous fish species. Coho, Sockeye, Chinook, and Chum salmon rely on and are adapted to aquatic habitats in the SFK, NFK, and UTC watersheds for completion of their life cycles: eggs incubate and hatch in spawning gravels, juveniles overwinter and grow in streams and off-channel habitats, smolts migrate downstream through the stream network, and adults migrate upstream to spawn (Section 3.3.1). Timing of life history events (e.g., spawning and emergence) varies by species and by population, and is dictated by the unique conditions of habitats, their positions in the watershed, and their connectivity in space and time, resulting in asynchrony of salmon availability across the landscape (Section 3.3.3.2). Aquatic resource components in each of these three watersheds combine in different ways to create unique habitat mosaics, which over thousands of years have resulted in local adaptation of anadromous fish populations to site-specific conditions in each watershed.

All three watersheds contain documented spawning and rearing habitat for Coho, Chinook, and Sockeye salmon (Figures 3-5 through 3-7) and documented spawning habitat for Chum Salmon (Figure 3-8). Coho Salmon are the most widely distributed salmon species in the three watersheds (Figure 3-5) and have been documented to occur in at least 59 stream miles within each watershed (Table 3-6). Coho Salmon make extensive use of mainstem and tributary habitats, including headwater streams (Figure 3-5). Chinook Salmon have been documented to occur in at least 38 stream miles in each watershed (Table 3-6). Coho and Chinook salmon—the salmon species most reliant on habitats in the SFK, NFK, and UTC watersheds—are the two rarest of North America's five species of Pacific salmon (Healey 1991, Woody 2018) and are particularly vulnerable to losses of small, discrete populations.

An extensive body of scientific evidence demonstrates that headwater wetlands play a critical role in the structure and function of abutting and downstream waters, by providing important fish habitat and

supplying the energy and other resources needed to support fishes in connected habitats (Section 3.2.4). Wetlands and other waters throughout the SFK, NFK, and UTC watersheds support abutting and downstream anadromous fish streams in multiple ways (Sections 3.2.4 and 4.2.3.2). Wetlands moderate streamflows by detaining water at the surface and within soils and serving as groundwater recharge zones. The eventual conveyance of this water to stream and river channels helps to maintain flows during periods without precipitation. Diverse off-channel habitats in the three watersheds provide habitat for Chinook, Coho, and Sockeye salmon, as well as other salmonids (Table 3-10). Thermally diverse habitats in off-channel wetlands provide rearing and foraging conditions that may be unavailable in the mainstream channel (e.g., warmer temperatures, lower water velocities, increased food availability), increasing capacity for juvenile salmon rearing (Brown and Hartman 1988, Nickelson et al. 1992, Cunjak 1996, Collen and Gibson 2001, Sommer et al. 2001, Henning et al. 2006, Lang et al. 2006, PLP 2011). Beaver ponds and wetlands inundated by beaver activity can be especially important for maintaining salmon productivity (Nickelson et al. 1992, Solazzi et al. 2000, Pollock et al. 2004), through the provision of high-quality rearing habitat and important overwintering and flow-velocity refugia (Section 3.2.4). Wetlands also provide ecological subsidies to abutting streams and streams lower in the watershed, in the form of water, nutrients, organic material, macroinvertebrates, algae, and other materials (Section 3.2.4); these inputs can serve as important resources for juvenile salmonids (Vannote et al. 1980, Wipfli and Gregovich 2002, Meyer et al. 2007, Dekar et al. 2012, Doretto et al. 2020).

Discharges of dredged or fill material associated with the 2020 Mine Plan would result in the permanent loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters at the mine site that support anadromous fish streams. The permanent loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters that support anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit, in any part of the SFK, NFK, and UTC watersheds, would result in adverse effects on anadromous fishery areas that are similar to those identified for the 2020 Mine Plan, specifically due to the elimination of salmon habitat and downstream ecological subsidies and the resulting erosion of habitat complexity and biocomplexity. Losses of this magnitude would eliminate nutrient-rich, structurally complex, and thermally and hydraulically diverse habitats, including crucial overwintering areas, that are essential to rearing salmonids. In addition to the direct loss of habitat, loss of these wetlands, lakes, and ponds would also result in a total loss of their fish-habitat support functions for abutting and downstream waters (Section 3.2.4). The disruption of wetland hydrology would eliminate the flow modification functions of these habitats. The provision of ecological subsidies to downstream waters also would be eliminated, resulting in the degradation of downstream salmon spawning and rearing habitat. Ultimately, these significant permanent losses of wetlands and other waters that support anadromous fish streams would therefore reduce the functional and productive capacity of these downstream anadromous fishery areas to support anadromous fishes, as well as resident fishes and other aquatic biota.

Given the significant similarities in structure and function of aquatic resources across the SFK, NFK, and UTC watersheds and the adverse effects that would result from discharges of dredged or fill material

associated with developing the Pebble deposit if mine components were relocated to other locations in these watersheds, EPA has determined that the discharge of dredged or fill material associated with developing the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds, resulting in the loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters that support anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in these watersheds. As explained in detail above, this conclusion is based on the same record and analysis used to evaluate the effects of the 2020 Mine Plan, as well as the following factors: headwater wetlands and other waters throughout the SFK, NFK, and UTC watersheds are among the least developed and least disturbed (i.e., closest to pristine) habitats of this type in North America (Section 3.1) and play an important role in supporting Pacific salmon populations (Section 3.2); these three watersheds have similar amounts and types of wetlands (Table 3-2); headwater wetlands and other waters across these three watersheds function similarly to support productive fishery areas for anadromous fishes (Section 3.3); the large amount of permanent loss of wetlands and other waters; the importance of wetlands and other waters to salmon populations, both as habitat and as sources of groundwater inputs, nutrients, and other subsidies important to salmon productivity in downstream waters; the degradation of and thus damage to downstream anadromous fish streams from the loss of ecological subsidies provided by the lost headwater wetlands and other waters; and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds. This conclusion supports the restriction described in Section 5.2.

4.2.4 Adverse Effects from Changes in Streamflow in Downstream Anadromous Fish Streams

EPA has determined that the discharge of dredged or fill material associated with the construction and routine operation of the 2020 Mine Plan, resulting in streamflow changes greater than 20 percent of average monthly streamflow in at least 29 miles (46.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. This conclusion is based on the extent and magnitude of changes to streamflow in anadromous fish streams downstream of the mine site and associated adverse effects on the extent and quality of anadromous fish habitat, including spawning and rearing habitat, which represent significant damage to these downstream anadromous fishery areas.

This section first describes the methodology used for identifying anadromous fish stream reaches that would experience unacceptable adverse effects as a result of discharges of dredged or fill material associated with the 2020 Mine Plan (Section 4.2.4.1). This section then provides an overview of water management under the 2020 Mine Plan (Section 4.2.4.2), the extent of anadromous fish streams where adverse effects from streamflow changes would occur under the 2020 Mine Plan (Section 4.2.4.3), the anadromous fish habitat that would be affected (Section 4.2.4.4), and the adverse effects on anadromous fish streams that would result from the predicted streamflow alterations (Section 4.2.4.5). Impacts to other fish species are discussed (Section 4.2.4.6) and then conclusions are presented (Section 4.2.4.7).

4.2.4.1 Methodology for Analyzing Streamflow Changes in Downstream Anadromous Fish Streams

The natural flow regime, defined as the characteristic pattern of streamflow magnitude, timing, duration, frequency, and rate of change (Poff et al. 1997), plays a critical role in supporting and maintaining both the ecological integrity of streams and rivers and the services they provide. Each stream or river has a characteristic flow regime and a biotic community adapted to it, reflecting the importance of flow regime in creating and maintaining instream habitat and shaping the evolution of both ecological processes and aquatic biota (Bunn and Arthington 2002, Naiman et al. 2002, Annear et al. 2004). Human-induced alteration of the natural flow regime can degrade the physical, chemical, and biological properties of a waterbody, leading to loss of aquatic life and reduced aquatic biodiversity (e.g., Poff et al. 1997, Bunn and Arthington 2002, Naiman et al. 2002, Annear et al. 2004, Poff and Zimmerman 2010). Maintenance of natural flows and the patterns of longitudinal and lateral connectivity that result from these flows is essential to the viability of many riverine species (Bunn and Arthington 2002). Because flow regime directly or indirectly affects all other functions, flow regime is often considered the most significant stream function (Lytle and Poff 2004, Fischenich 2006, Sofi et al. 2020).

Aquatic ecologists have long recognized that a much fuller spectrum of flow conditions (e.g., base flows, high flows, flood flows) is needed to sustain native species than is provided by instream flow models, such as the Physical Habitat Simulation System (PHABSIM) model used to evaluate streamflow in the FEIS (Postel and Richter 2003). For example, Pahl-Wostl et al. (2013: Page 342) were critical of habitat-based approaches, stating "[e]arly static approaches aimed to define either minimum or average flows to support key fish species or maintain instream habitat (sometimes revealingly termed 'compensation flows'); but these are now viewed as too simplistic to support complex flow-dependent ecosystem functions." Such approaches predict benefits to fishes based on consideration of limited flow metrics such as water depth and velocity (Postel and Richter 2003) and do not account for other ecologically relevant fish habitat parameters, such as groundwater exchange, substrate, water temperature, water chemistry, cover, and habitat complexity (e.g., wetlands and other off-channel habitats) (Appendix B: Section B.4.2.1).

Protecting ecosystem integrity requires maintaining multiple components of the natural flow regime within their typical ranges of variability (Pahl-Wostl et al. 2013). This perspective requires an understanding of both natural flow regimes over space and time and the many ways in which aquatic habitats, species, and life stages respond to varied flow conditions (Warren et al. 2015, Novak et al. 2016, Flitcroft et al. 2016, Flitcroft et al. 2019).

For streams in the Bristol Bay region, natural temporal streamflow variability results from fall storm events, winter low flows under ice cover, spring snowmelt peak flows, and subsequent recession of streamflow into summer (EPA 2014: Chapters 3 and 7, USACE 2020a: Section 3.16). These seasonal flow regimes affect channel development and maintenance; connectivity between active channels and off-channel habitats; transport of sediment and nutrients; timing and success of fish migration and spawning; and survival of fish eggs and juveniles (EPA 2014: Chapter 7).

Recognizing the importance of natural flow regimes to habitat-forming processes and the biotic integrity of salmon ecosystems in the SFK, NFK, and UTC watersheds (EPA 2014: Chapter 7), EPA has evaluated the 2020 Mine Plan using projected streamflow changes from natural conditions in terms of percent change from natural flows. Such an approach targets functional hydrogeomorphic processes in the entire aquatic ecosystem, rather than focusing on a specific species or set of species (e.g., salmon) that may have different habitat requirements than other biota in the natural system.

Based on case studies from around the world and literature on ecological flows dating back to the 1970s, Richter et al. (2012) found that, regardless of geographic location, daily streamflow alterations of greater than 20 percent can cause major changes in the structure and function of streams. Streamflow alterations between 11 and 20 percent can also result in changes in ecosystem structure and function, but to a lesser extent; although Richter et al. (2012) note that limiting daily flow alterations to 20 percent or less may be protective in some circumstances, they also caution that it may be insufficient to fully protect ecological values in certain rivers. Because Pacific salmon are locally adapted to environmental cues such as small differences or changes in water temperature, chemical composition, and the natural flow regime of natal waters (Vannote et al. 1980, Poff et al. 1997, Fausch et al. 2002), it is likely that a lower threshold of streamflow modification would be necessary to adequately protect these species. While predicted flow changes of less than 20 percent can also affect fishes and diminish stream functional capacity, EPA has not made a determination of how such smaller changes to average monthly streamflow (i.e., less than 20 percent) resulting from the 2020 Mine Plan would translate to effects on anadromous fishery areas.

Flow modeling conducted for the 2020 Mine Plan, as presented in the FEIS and outlined in Section 4.2.4.2, describes streamflow alteration in terms of percent changes to average monthly streamflows rather than percent changes to daily streamflows. EPA recognizes that daily flows would be more variable than monthly averages (e.g., Appendix B: Figure B-1); however, EPA believes that average monthly flows are a useful hydrologic metric (Eng et al. 2017, George et al. 2021), particularly for relative comparison between alternatives, and that the extent of impacts identified on a monthly time scale provides a reasonable minimum approximation of the extent of impacts from the 2020 Mine Plan, given the amount of error that can be associated with estimations of daily flows generated by models.[70] In addition, the streamflow impact information provided in the FEIS has been subject to public review. EPA recognizes using average monthly streamflows to identify the extent of impacts may under-represent and under-predict the true extent of unacceptable adverse effects, because relying on average monthly streamflows does not reflect streamflow changes that anadromous fishes and their habitats would experience on a daily or sub-daily basis (Appendix B: Sections B.2.1 and B.3.2). As a result, use of average monthly streamflow provides a broad, generalized indicator of streamflow changes that

[70] USACE did not present or analyze daily flow information in the FEIS. Impacts of predicted changes to fish habitat were run on a daily time step (PLP 2019c: RFI 149), but the daily discharges used in that analysis were estimated from the monthly flows. RFI 161 provides daily streamflow estimates that could be used to evaluate project impacts on daily flows (PLP 2020d: RFI 161), but this information was not subject to public review prior to its release. Questions remain regarding the methods, assumptions, and limitations of the daily streamflow estimates provided in RFI 161 (PLP 2020d: RFI 161).

captures only dramatic changes from natural conditions, particularly when coupled with the narrowed focus on changes in excess of 20 percent.

To evaluate the adverse effects on anadromous fish streams that would result from the construction and routine operation of a mine at the Pebble deposit, EPA first summarizes water management processes of the 2020 Mine Plan in Section 4.2.4.2. This overview explains how the construction and routine operation of a mine at the Pebble deposit would result in streamflow increases and reductions, both of which can have adverse effects on anadromous fishery areas.

Section 4.2.4.3 then identifies the anadromous fish streams where streamflow changes would be persistent and large enough to result in a shift in the average monthly streamflow of more than 20 percent, which is where adverse effects from streamflow changes would occur under the 2020 Mine Plan. Section 4.2.4.4 characterizes the specific ways anadromous fishes use these streams, including identifying spawning and rearing areas for different anadromous fish species.

Section 4.2.4.5 summarizes adverse effects to anadromous fish habitat that would result from streamflow changes greater than 20 percent of average monthly streamflow, which are estimated to occur in at least 29 miles (46.7 km) of anadromous fish streams as a result of discharges of dredged or fill material associated with the construction and routine operation of the 2020 Mine Plan. Although not a basis for EPA's unacceptable adverse effects determination, Section 4.2.4.6 discusses how these streamflow changes would impact other fish species, because the anadromous fish streams that that would be degraded by these streamflow changes also provide habitat for non-anadromous fish species. Section 4.2.4.7 presents conclusions regarding the adverse effects of these streamflow changes on anadromous fishery areas.

4.2.4.2 Overview of Mine Site Operations that Affect Downstream Streamflow

This section summarizes water management processes of the 2020 Mine Plan to explain how the construction and routine operation of a mine at the Pebble deposit would result in streamflow increases and reductions downstream of the mine site. The FEIS describes how the 2020 Mine Plan would change the volume, distribution, and flowpath of surface water and groundwater flows in and beyond the mine footprint (USACE 2020a: Sections 4.16 and 4.17). It describes how construction and routine operation of the 2020 Mine Plan would affect surface water quantity and distribution in the SFK, NFK, UTC, and several tributaries. Operational impacts of mining on streamflow were estimated based on the conditions expected at the end of operations (i.e., end-of-mine) rather than at periodic time steps during operations (USACE 2020a: Section 4.16). Table 4-4 provides estimated percent changes in average monthly streamflows, by river reach, between baseline and end-of-mine.[71]

[71] River reaches are lettered in the upstream direction (i.e., Reach A is the most downstream reach, located just above the confluence of the SFK and NFK; Reach B is the reach upstream of Reach A; and so forth). The reaches located closest to the mine site components are NFK Trib 1.19, NFK Reach D, SFK Reach E, SFK Trib 1.19, SFK Trib 1.24, and UTC Reach F.

Dewatering of the pit area would be necessary during construction and operation, beginning approximately 2 years before the start of ore processing. The groundwater drawdown associated with dewatering the open pit would be responsible for much of the predicted streamflow reduction, along with the collection and rerouting of surface water runoff from the mine site footprint.

During operation, two WTPs would treat water collected within the mine site footprint prior to its release to the environment (Figure 4-1). WTP #1 would treat surplus groundwater and surface water runoff collected in the open pit and the surrounding areas. WTP #2 would collect and treat water from the main WMP, which would receive water from the TSFs and the TSF main embankment seepage. Treated water from the WTPs would be routed to three outfall locations and then discharged into the SFK, NFK, and UTC.[72] In an average year, mean monthly discharges to the SFK, NFK, and UTC would vary between 1.3 to 10 cubic feet per second (cfs), 17 to 27 cfs, and 0.2 to 1.4 cfs, respectively (Knight Piésold 2019a: Table 2).

Although operations would change the availability of surface flows to area streams, surplus-treated water would be released from the mine site to benefit priority fish species and life stages (USACE 2020a: Section 4.24). Monthly habitat flow needs were identified for each month of the year in the SFK, NFK, and UTC, based on priority species and life stages. In the SFK and NFK, the priority species used to determine habitat flow needs were Chinook Salmon, Coho Salmon, Rainbow Trout, and Arctic Grayling; these same species were used to determine habitat flow needs in UTC, except Sockeye Salmon replaced Chinook Salmon. In terms of life stage priorities for flow optimization, the spawning life stage was given a higher priority than juvenile rearing (PLP 2018b: RFI 048). The incubation life stage was not considered for any fish species, resulting in a lack of analysis of flow requirements for this sensitive development stage in all three watersheds.

The FEIS indicates water from both WTPs would be strategically discharged, based on modeling and monitoring during discharge. However, the streamflow monitoring proposed by PLP would occur on a quarterly basis (PLP 2019b: RFI 135).[73] WTP discharges, thus, would be preplanned and would vary on a monthly basis based on modeling and a set of assumptions. WTP discharges would be the amount identified to "optimize" downstream habitat assuming the historic monthly average streamflow (i.e., given an "average climatic year," or 50 percent exceedance probability) was to occur at the representative downstream gage location.[74]

[72] These locations are shown in FEIS Figure 4.18-1 (Knight Piésold 2019b, USACE 2020a: Section 4.18).

[73] The Monitoring Summary provided by PLP states that monitoring of surface water flow and quality is proposed to be conducted downstream of water discharge points on a quarterly basis and will focus on streamflow and fish presence surveys (PLP 2019b: RFI 135).

[74] Wet, average, and dry years were determined for each target species and life stage between 1942 and 2017 at Gage NK100A (USGS Gage 15302250) for WTP #1 and Gage SK100B (USGS Gage 1530220) for WTP #2. (PLP 2018b: RFI 048).

Table 4-4. Change in average monthly streamflow between baseline and end-of-mine with water treatment plant discharge, 2020 Mine Plan. FEIS Table 4.16-3 (USACE 2020a).

Location	Change in Average Monthly Streamflow from Baseline to End of Mine in Percent (50th Percentile Probability)												Annual Mean Monthly Change
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	
NFK, Reach A	+2.2	+10.6	+19.1	+23.5	-6.2	-12.1	-8.7	-9.2	-8.0	-7.2	-3.5	-3.3	-0.2
NFK, Reach B	+2.9	+11.6	+21.5	+29.0	-9.0	-13.5	-9.5	-10.2	-9.1	-8.1	-3.2	-3.4	-0.1
NFK, Reach C	+8.2	+29.0	+68.1	+110.2	-13.3	-20.4	-15.6	-16.4	-13.9	-13.4	-6.3	-5.4	+9.2
NFK, Reach D	+101.2	+127.9	+157.6	+170.0	+26.9	+23.1	+44.2	+46.1	+36.1	+34.3	+44.4	+73.2	+73.7
NFK, Trib 1.19	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0
SFK, Reach A	-2.7	-2.7	-2.1	-0.8	-1.4	-1.6	-2.8	-2.4	-2.3	-2.5	-2.3	-2.7	-2.2
SFK, Reach B	-2.2	-1.7	-0.5	+1.3	-2.4	-2.6	-3.3	-3.0	-3.2	-2.7	-2.5	-2.4	-2.1
SFK, Reach C	+3.8	0.0	0.0	0.0	-2.5	-2.8	-4.5	-3.9	-4.6	-3.1	-1.5	-1.2	-1.7
SFK, Reach D	+14.6	+27.5	+50.9	+109.0	-13.5	-15.0	-12.9	-11.9	-12.5	-10.2	+3.7	+9.3	+11.6
SFK, Reach E	-50.7	-51.5	-53.0	-52.2	-32.1	-33.1	-34.6	-37.4	-35.6	-38.8	-44.9	-49.4	-42.8
SFK, Trib 1.19	-13.4	-15.2	-17.1	-19.0	-3.7	-4.8	-7.2	-6.6	-5.3	-8.1	-10.6	-12.6	-10.3
SFK, Trib 1.24	+18.4	+97.9	0.0	+2.2	+2.7	+7.7	+11.0	+5.8	+4.8	+4.0	+7.0	+7.3	+14.1
UTC, Reach A	+0.4	+0.5	+0.7	+0.8	0.0	-0.1	-0.2	0.0	0.0	-0.1	0.0	+0.2	+0.2
UTC, Reach B	+0.4	+0.5	+0.6	+0.7	0.0	-0.1	-0.2	0.0	0.0	-0.1	0.0	+0.2	+0.2
UTC, Reach C	+0.5	+0.7	+0.8	+0.9	+0.1	-0.1	-0.2	0.0	0.0	-0.1	0.0	+0.3	+0.2
UTC, Reach D	+0.8	+1.1	+1.3	+1.7	+0.1	-0.2	-0.3	0.0	0.0	-0.2	+0.1	+0.4	+0.4
UTC, Reach E	+1.2	+1.9	+2.5	+3.2	+0.1	-0.2	-0.4	-0.1	-0.1	-0.2	+0.1	+0.6	+0.7
UTC, Reach F	+3.8	+5.5	+6.8	+8.6	+0.4	-0.8	-1.3	-0.2	-0.2	-0.7	+0.3	+1.9	+2.0
UTC, Trib 1.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

EPA has concerns with the methods used to identify the "optimal" WTP discharges and predict impacts of streamflow changes on downstream anadromous fish habitat as presented in the FEIS (Appendix B: Sections B.3 and B.4). However, as described previously, the modelled streamflow changes provided in the FEIS provides a reasonable minimum approximation of impacts for this project.

4.2.4.3 Extent of Streamflow Changes in Downstream Anadromous Fish Streams

This section identifies the specific anadromous fish streams that would be subject to streamflow changes greater than 20 percent of average monthly streamflow under the 2020 Mine Plan, which would occur in at least 29 miles (46.7 km) of anadromous fish streams. The FEIS predicts changes in streamflow downstream of the mine site to the confluence of the SFK and NFK, with and without the addition of treated water.[75] These modeling results indicate that reaches of the SFK and NFK closest to the mine site would experience greater changes in average monthly streamflow than reaches farther from the mine site (USACE 2020a: Section 4.16). The FEIS states:

> The duration of impacts to surface water hydrology would vary from temporary to permanent. The geographic extent of the impact on the NFK and the SFK rivers may extend just below the confluence of the two rivers. After the flows combine at the confluence of the NFK and SFK rivers, discernable changes in flow would be unlikely and are expected to be within historic and seasonal variation in the Koktuli River. (USACE 2020a: Page 4.16-2)

The NFK flows approximately 23 miles downstream from the mine site before reaching the SFK confluence, and the SFK extends approximately 38 miles downstream from the mine site before reaching the NFK confluence. Thus, the FEIS indicates streamflow changes would become indiscernible from historic and seasonal variation of streamflow once the NFK and SFK combine in the Koktuli River, suggesting a combined 61 miles of anadromous fish habitat in these two rivers may experience streamflow changes outside the historic and seasonal variation that naturally occurs.[76]

Based on information presented in the FEIS, EPA has estimated that operation of the 2020 Mine Plan, with the addition of treated water, would result in changes (i.e., either increase or decrease) in streamflows of more than 20 percent from baseline average monthly flow in at least 29 miles (46.7 km) of anadromous fish streams downstream of the mine site (Figure 4-9, Table 4-5).[77] These streamflow

[75] EPA's review only evaluated changes to streamflow with the addition of treated water because regular water discharges would be necessary due to limited water storage capacity. If WTPs were unable to discharge treated water for any period, streamflow reductions experienced in downstream anadromous fish streams would be greater than are discussed herein (USACE 2020a: Section 4.16).

[76] The FEIS indicates streamflow in the UTC would not be negatively impacted by the project (USACE 2020a: Section 4.24).

[77] The streamflow alteration values presented in FEIS Table 4.16-3 (Table 4-4 here) were estimated using data from specific PLP stream gages or by averaging two gages in the reach (PLP 2019a: RFI 109f). To provide conservative estimates of changes to streamflow (i.e., to minimize the chance of overestimating streamflow changes), streamflow estimates described herein for the mainstem rivers were assigned to the river location of gages identified in RFI 109f (PLP 2019a: RFI 109f), rather than for extended reach lengths downstream. Streamflow

changes are derived from Table 4-4 (USACE 2020a: Table 4.16-3), which presents changes in average monthly streamflow, relative to natural streamflow conditions, that would result after water captured at the mine site is discharged as treated water from the WTPs. These streamflow changes would affect 18.7 miles (30.1 km), or 29 percent of anadromous fish streams, in the NFK watershed and approximately 10.4 miles (16.7 km), or 17 percent of anadromous fish streams, in the SFK watershed (Figure 4-9) (Giefer and Graziano 2022).

In the majority of the SFK and NFK reaches, streamflow changes would vary seasonally. Reaches that would experience streamflow reductions between spring and winter would also experience streamflow increases between winter and spring. In total, streamflow reductions exceeding 20 percent of average monthly streamflow would occur in at least one month per year in at least 13.1 miles (21.4 km) of anadromous fish streams downstream of the mine site, specifically in NFK Reach C, Tributaries NFK 1.190 and 1.200, and SFK above Frying Pan Lake (i.e., upstream of SK100G) (Table 4-5).

Additionally, WTP discharges associated with the 2020 Mine Plan would increase streamflow by more than 20 percent of baseline average monthly streamflow in at least 25.7 miles (41.3 km) of downstream anadromous fish streams (Table 4-5). Most streamflow increases would occur in the mainstem NFK, where at least 18.1 miles (29.1 km) would experience seasonal streamflow increases of more than 20 percent of baseline average monthly flow. The remaining 7.6 miles (12.2 km) of anadromous fish streams that would experience streamflow increases of more than 20 percent from baseline average monthly flows are in the SFK watershed, in the mainstem at Frying Pan Lake and in Tributary SFK 1.240.

4.2.4.4 Downstream Anadromous Fish Habitats Affected by Streamflow Changes

This section identifies the specific anadromous fish habitat that would be subject to streamflow changes greater than 20 percent of average monthly streamflow under the 2020 Mine Plan, which would occur in at least 29 miles (46.7 km) of anadromous fish streams. Changes in surface water and groundwater contributions to streams associated with the discharge of dredged and fill material for the construction and routine operation of the 2020 Mine Plan would reduce both the extent and quality of anadromous fish habitats downstream of the mine site. As described in Section 4.2.1, little or no spawning or rearing habitat for Coho and Chinook salmon would remain in Tributary NFK 1.190 due to placement of mine site features just upstream of its confluence with the mainstem NFK; most of Tributary NFK 1.200 also would be eliminated by the main WMP (Figure 4-9). The FEIS states that the expected loss of headwater aquatic habitats would affect downstream surface water flows and groundwater exchange, resulting in impacts to aquatic resources in approximately 66 miles (106.2 km) of streams. The duration of streamflow changes would be permanent, beginning at project construction, continuing through mine operations, and remaining post-closure (USACE 2020a: Section 4.24).

change estimates were assumed to extend upstream from the source gage to at least the next gage, major confluence point, the mine footprint, or the most upstream extent of anadromous habitat. As a result, streamflow changes may extend further downstream than estimated herein.

Figure 4-9. Streams and rivers with documented salmon use that would experience streamflow alterations greater than 20 percent of baseline average monthly streamflows as a result of the Pebble 2020 Mine Plan. Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022). Streamflow alteration is assigned at a gage and extends upstream (see Footnote 77 in Section 4.2.4.3 for a discussion of methodology).

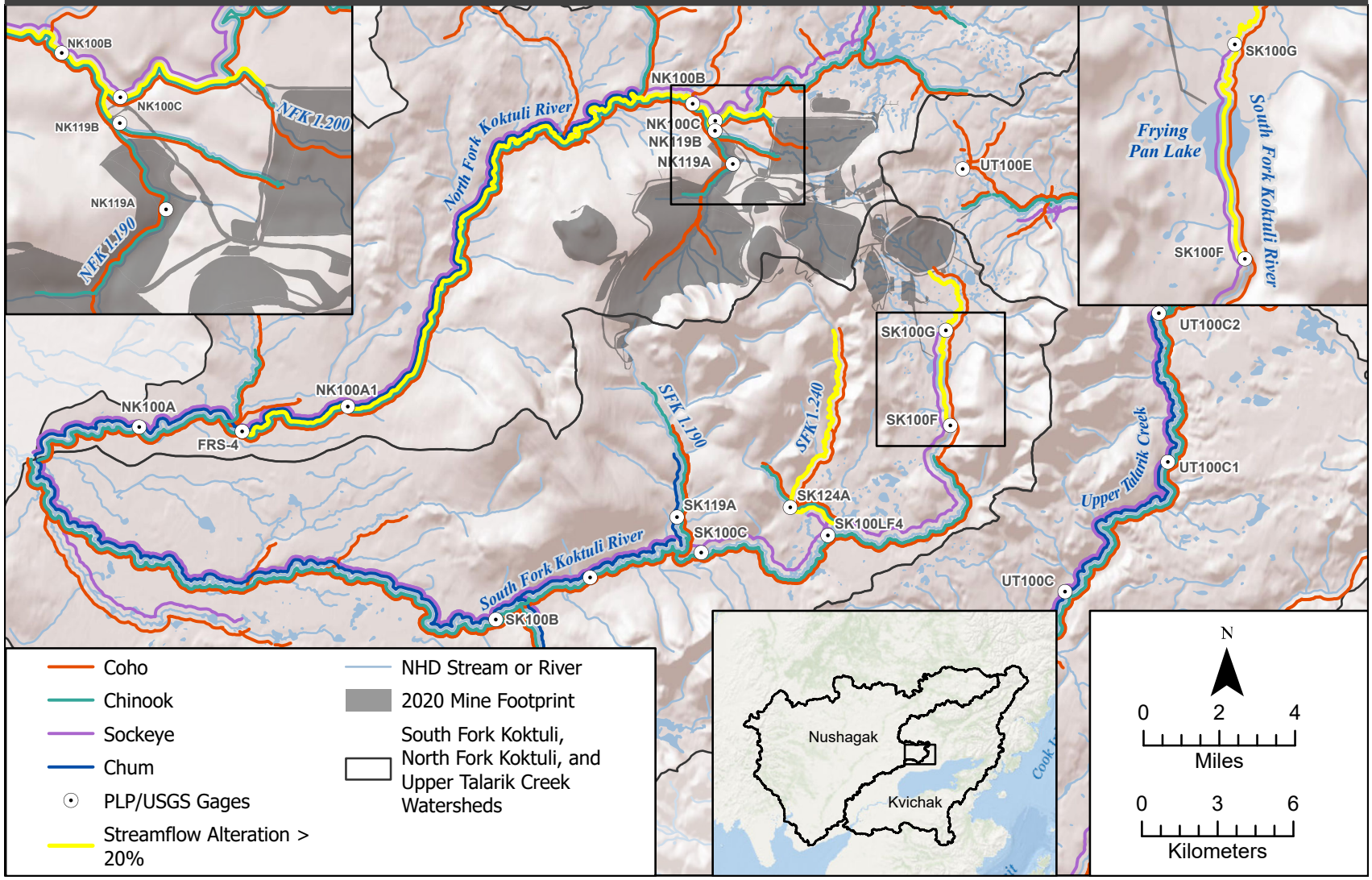


Table 4-5. Salmon species documented to occur in downstream reaches that would experience greater than 20 percent streamflow alterations under the Pebble 2020 Mine Plan.

Stream	Reach [a]	Affected Stream Length (miles) [b]	Information from FEIS Table 4.16-3 (USACE 2020a)		Salmon Species and Life Stages Present [c]			
			Location	Largest Change in Monthly Average Streamflow	Coho	Chinook	Sockeye	Chum
SFK mainstem	Upstream of SK100G	2.1	SFK, Reach E	-53.0%	Rearing	- [g]	- [g]	- [g]
	SK100G to inlet of Frying Pan Lake	0.7			Rearing	- [g]	Rearing [h]	- [g]
	Frying Pan Lake to SK100F	1.4	SFK, Reach D	109.0%	Rearing	- [g]	Rearing	- [g]
SFK tributary	SFK 1.240	6.2 [d]	SFK, Trib 1.24	97.9%	Rearing, present	Present	Rearing	- [g]
NFK tributaries	NFK 1.190	0.27 [e]	NFK, Trib 1.19	-100.0%	Spawning, rearing	Rearing	- [g]	- [g]
	NFK 1.200	0.36 [e]	NFK, Trib 1.20	- [f]	Rearing, present	Rearing	- [g]	- [g]
NFK mainstem	NFK below Tributary 1.200 and above Tributary 1.190	1.2	NFK, Reach D	170.0%	Spawning, rearing	Rearing	Spawning	- [g]
	NFK below Tributary 1.190 to FRS-4	9.6	NFK, Reach C	110.2%	Spawning, rearing	Spawning, rearing	Spawning, rearing	Spawning, rearing
		4.6	NFK, Reach B	29.0%	Spawning, rearing	Spawning, rearing	Spawning, rearing	Spawning
		2.7	NFK, Reach A	23.5%	Spawning, rearing	Spawning, rearing	Spawning, rearing	Spawning

Notes:

[a] Reaches defined by stream gages, as shown in Figure 4-9.

[b] Affected lengths were determined by EPA based on information in the FEIS and typically extend upstream from the source gage to at least the end of the FEIS reach, the next upstream gage, major confluence point, the mine footprint, or the end of documented anadromous fish streams.

[c] From the Anadromous Waters Catalog (Giefer and Graziano 2022).

[d] This length includes the entirety of Tributary SFK 1.240 down to its confluence with Tributary SFK 1.260.

[e] This length is the extent that is assumed would still be accessible to anadromous fishes below the sediment pond.

[f] No streamflow information was provided for this reach in FEIS Table 4.16-3 (Table 4-4).

[g] Blanks indicate that the species has not been documented to occur in that reach in the Anadromous Waters Catalog (Giefer and Graziano 2022).

[h] Sockeye Salmon rearing habitat only extends approximately 0.6 mile upstream of Frying Pan Lake and not all the way up to SK100G (Giefer and Graziano 2022).

The most notable streamflow reductions downstream of the mine site would occur in the 2.8-mile (3.4-km) reach of anadromous fish habitat in the SFK mainstem leading to Frying Pan Lake, immediately below the open pit drawdown zone. Average monthly streamflow in this reach would be reduced by 32 to 53 percent from the baseline average monthly streamflow in every month of the year (Tables 4-4 and 4-5). This reach provides juvenile rearing habitat for Coho Salmon, and the lowermost 0.6 mile above the lake provides juvenile rearing habitat for Sockeye Salmon (Giefer and Graziano 2022).

As a result of dewatering at the pit, streamflow reductions in the SFK would reduce natural inflows to Frying Pan Lake, a 150-acre (0.6-km^2) shallow lake located on the SFK, 2.5 miles (4.0 km) downstream of the open pit (Figure 4-1). Frying Pan Lake provides rearing habitat for juvenile Coho and Sockeye salmon, as well as other resident fishes (ADF&G 2022a). As previously discussed, WTP discharges directly into Frying Pan Lake would be used to mitigate these streamflow reductions. Even with such WTP discharges, there would still be net reductions in streamflow between May and October, when streamflow at gage SK100F is estimated to be reduced by 10.2 to 15 percent below the baseline average monthly flow. During the winter and spring, WTP discharges would go beyond offsetting streamflow reductions and result in significant streamflow increases: average monthly streamflow would increase 27.5 percent over the baseline average monthly streamflow in February, 50.9 percent over baseline in March, and 109 percent over baseline in April (Figure 4-9, Table 4-4). Sustaining such increases above the natural flow regime for months at a time could have significant adverse effects on aquatic resources in this reach of the SFK.

These impacts to streamflow in the SFK would continue some distance downstream of gage SK100F, but it is unclear how far due to a lack of detail in the data used in FEIS (USACE 2020a: Section 4.16). The next downstream location for which streamflow data are presented in Table 4-4 (FEIS Table 4.16-3) is SFK Reach C, which is based on streamflow at gage SK100C (PLP 2019a: RFI 109f). Gage SK100C is located 11.7 river miles (18.9 km) downstream of gage SK100F (PLP 2020d: RFI 161), and streamflow changes in the SFK at gage SK100C resulting from operations at the mine would be less than 5 percent below baseline average monthly flow, assuming streamflow and WTP discharges occurred as modeled for the average climatic year.

Reductions in streamflow would also affect 5.1 miles (8.2 km) of anadromous fish spawning and rearing habitat in Tributary SFK 1.190 (USACE 2020a: Section 4.24), due to water captured in the south seepage recycle pond and returned to the bulk TSF main seepage pond (Figure 4-1) (USACE 2020a: Section 4.16). Tributary SFK 1.190 would experience streamflow reductions every winter and spring ranging between approximately 12.6 percent (in December) to the maximum reduction of 19 percent (in April) below the baseline average monthly streamflow (Table 4-4).[78]

Streamflow estimates for Tributary SFK 1.190 were generated based on streamflow gage SK119A (PLP 2019a: RFI 109f), which is located approximately 3 miles (4.8 km) downstream of mine footprint components associated with the south embankment of the bulk TSF, including a seepage collection system and sediment pond. The upper reaches of Tributary SFK 1.190 closest to the mine are expected to experience even greater reductions in streamflow compared to those estimated at streamflow gage SK119A. The upper extent of anadromous fish habitat is Chinook Salmon rearing habitat, located within approximately 600 feet (182.9 m) of the mine footprint. Coho Salmon also use this tributary for rearing beginning approximately 1.3 miles (2.1 km) downstream of the mine footprint, and Chum Salmon are

[78] Because the modelled streamflow changes in SFK Tributary 1.190 do not equal or exceed 20 percent of baseline average monthly streamflow, EPA has not included this tributary in the 29 miles of anadromous fish habitat that would experience streamflow changes greater than 20 percent. Yet, the FEIS disclosed adverse effects of the 2020 Mine Plan on anadromous fish habitat in SFK Tributary 1.190 are noteworthy in these discussion of adverse effects.

present approximately 1.8 miles (2.9 km) downstream of the mine footprint (Giefer and Graziano 2022). Although streamflow reductions in Tributary SFK 1.190 are estimated to reach only 19 percent below baseline average monthly streamflow, the FEIS predicts these reductions would nonetheless result in losses of spawning habitat area in Tributary SFK 1.190, eliminating 18.1, 13, 5.9, and 8.6 percent of spawning habitat for Chinook, Coho, Chum, and Sockeye salmon, respectively, in Tributary SFK 1.190 during an average climatic year (USACE 2020a: Table K4.24-1).[79]

Streamflow reductions would also be expected in mainstem reaches of the SFK and NFK during spring, summer, and fall. In total, approximately 21.4 miles (34.4 km) of the SFK and NFK would experience some degree of streamflow reduction from baseline conditions between May through late fall or winter due to loss of headwater and groundwater contributions. These reaches would also experience seasonal increases from baseline average monthly streamflow between January and April due to discharges of surplus water. For example, average monthly streamflow in the mainstem NFK below the mine site (i.e., NFK Reach C) would vary from 110.2 percent more flow in April to 20.4 percent less in June relative to baseline average monthly streamflows (Table 4-4).

Streamflow reductions in the NFK would extend 16.9 miles (27.2 km) downstream of the mine site. These reductions would begin in NFK Reach C below the confluence with Tributary NFK 1.190 (Figure 4-9), where streamflow would be reduced by more than 20 percent from the baseline average monthly flow. Streamflow reductions would continue downstream to at least stream gage FRS-4, where streamflow is estimated to be reduced by 12 to 13 percent from the baseline average monthly flow (Tables 4-4 and 4-5, Figure 4-9). These NFK reaches provide spawning and rearing habitat for Chinook, Coho, Sockeye, and Chum salmon (Table 4-5, Figure 4-9) and these streamflow reductions would affect at least 26 percent of the documented anadromous fish streams in the NFK watershed (Giefer and Graziano 2022). The FEIS predicts a loss of Chinook Salmon spawning habitat in all NFK reaches downstream of the mine site: 9.9 percent in NFK Reach C, 3.3 percent in NFK Reach B, and 1.8 percent in NFK Reach A (USACE 2020a: Table K4.24-1).[80]

Even with treated water discharges included in these estimates, streamflows in the SFK and NFK watersheds would still be reduced by more than 20 percent from the baseline average monthly flow in at least one month of the year in approximately 13.1 miles of anadromous fish streams, specifically in NFK Reach C, Tributaries NFK 1.190 and 1.200, and SFK above Frying Pan Lake (i.e., upstream of SK100G) (Table 4-5, Figure 4-9).

Operation of the 2020 Mine Plan would also increase streamflow by more than 20 percent of baseline average monthly streamflow in at least 25.7 miles (41.3 km) of anadromous fish streams due to WTP discharges (Table 4-5). Most streamflow increases would occur in the mainstem NFK, where at least 18.1 miles (29.1 km) would seasonally experience streamflow increases of more than 20 percent of

[79] Habitat losses described in the FEIS likely under-represent impacts on downstream anadromous fish streams (Appendix B: Sections B.3 and B.4).

[80] Habitat losses described in the FEIS likely under-represent impacts on downstream anadromous habitat area (Appendix B: Sections B.3 and B.4).

baseline average monthly flow. These 18.1 miles (29.1 km) include the 16.9 miles (27.2 km) of the mainstem NFK (i.e., down to gage FRS-4) that would also experience some degree of streamflow reduction between May and December, and the remaining 1.2 miles (1.9 km) of the NFK between the confluence of Tributaries NFK 1.200 and 1.190, where WTP discharges would result in year-round increases in flow.

The remaining 7.6 miles (12.2 km) of anadromous fish streams that would experience streamflow increases of more than 20 percent from baseline average monthly flow are the SFK between SK100G and SK100F and Tributary SFK 1.240 (Table 4-5, Figure 4-9). Increases in the SFK would result from WTP discharges to Frying Pan Lake, as well as discharges from a diversion channel of non-contact water collected around the mine site infrastructure to Tributary SFK 1.240 (Knight Piésold 2019b).

To optimize fish habitat farther downstream, reaches closest to the WTP discharge points would experience more dramatic increases in streamflow velocities that could impede salmon migration, particularly for juveniles. For example, NFK Reach D, immediately downstream of the WTP discharge point, would experience streamflow increases of 101 to 170 percent from baseline average monthly flow every month between January and April (Table 4-4). This reach provides spawning habitat for Coho and Sockeye salmon, and rearing habitat for juvenile Coho and Chinook salmon (Giefer and Graziano 2022). Habitat quality for juvenile salmon rearing and benthic macroinvertebrates would likely be degraded due to increased scour and mobilization of sediments and increased turbidity. Streamflow increases would be expected to dissipate farther downstream from the mine site, but streamflows at even the most downstream NFK point evaluated (i.e., PLP's project-specific stream gage FRS-4, which was used to estimate streamflow in NFK Reach A) would vary from 23.5 percent more to 12.1 percent less than the baseline average monthly streamflow (Table 4-4). Based on information in the FEIS, these streamflow increases would likely extend downstream to the confluence of the SFK and NFK (USACE 2020a: Section 4.16).

4.2.4.5 Adverse Effects of Streamflow Changes in Downstream Anadromous Fish Streams

This section summarizes the adverse effects to anadromous fish habitat that would occur as a result of streamflow changes that are greater than 20 percent of average monthly streamflow, which would occur in at least 29 miles (46.7 km) of anadromous fish streams as a result of discharge of dredged or fill material associated with the construction and routine operation of the 2020 Mine Plan. These streamflow changes include either increases or decreases relative to baseline average monthly streamflows (Table 4-4). Streamflow reductions would result from groundwater drawdown due to pit dewatering, the loss of upstream tributaries, and the collection and rerouting of surface water runoff from the mine site, particularly between spring and winter (USACE 2020a: Sections 4.16 and 4.17). Streamflow increases would occur between winter and spring as a result of WTP discharges and discharges of surface water runoff captured at the mine site. Both streamflow increases and streamflow reductions that are greater than 20 percent of baseline average monthly streamflow can have adverse effects on anadromous fishery areas. These adverse effects on anadromous fishery areas would result from any mine at the Pebble deposit if such streamflow changes greater than 20 percent average

monthly flow were expected to occur over such a large extent [29 miles (46.7 km)] of anadromous fish streams.

Streamflow reductions of the extent and duration predicted by analysis of streamflow data in the FEIS would reduce instream habitat availability, particularly during periods of natural low flows; fragment stream habitats; and preclude normal seasonal movements by anadromous and migratory resident fishes (West et al. 1992, Cunjak 1996, EPA 2014: Chapter 7). Diminished streamflows would also likely reduce the frequency and duration of connectivity to off-channel habitats such as side channels, riparian wetlands, and beaver ponds, reducing the spatial extent of such habitats or eliminating them altogether. At present, some off-channel habitats likely connect to the main channels at least during annual spring and fall floods (Section 3.2.4). The loss of access to off-channel areas, particularly those with groundwater connectivity, would remove critical rearing habitats for several species of juvenile salmonids (Table 3-10) (Quinn 2018, Huntsman and Falke 2019).

Reduced streamflows would also likely change sediment transport dynamics, resulting in the deposition of more or finer sediment that would smother eggs or render stream substrates less suitable for spawning. Streambed aggradation from increased sedimentation could lead to further hydrologic modification, loss of habitat complexity, simplification of pools important for rearing salmon, and outright loss or fragmentation of habitat. Lower streamflows could also result in reduced dissolved oxygen levels. Taken together, streamflow changes would likely alter channel geometry and destabilize channel structure, with effects propagating downstream.

The interaction between surface and groundwater has been shown to strongly influence the structure, function, and biodiversity of aquatic communities (Woody and Higman 2011). Groundwater drawdown due to pit dewatering would reduce the volume of groundwater available to surface waters and wetlands surrounding the mine site (USACE 2020a: Section 4.17). This loss of groundwater contributions to surface waters would have significant repercussions for fishes, as groundwater is known to play an important role in redd site selection by Pacific salmon by sustaining stream baseflows (preventing redds from drying or freezing), providing stable temperatures, and supplying nutrients (Bjornn and Reiser 1991, Anderson and Bromaghin 2009, Curran et al. 2011, Mouw et al. 2014, McCracken 2021). The FEIS indicates that salmon spawning aggregations in both the SFK and NFK are associated with areas of groundwater discharge. Predicted changes in groundwater flows could result in impacts to salmonid egg incubation, juvenile salmon imprinting and rearing, and adult salmon natal homing. These changes in habitat function could reduce fish productivity in the Koktuli River watershed (USACE 2020a: Page 4.24-19).

At the other extreme, streamflow increases greater than 20 percent likely would degrade habitat suitability for salmon (EPA 2014: Chapter 7). Brekkan et al. (2022: Page 8) conclude that the stream type at the mainstem SFK, NFK, and UTC immediately downstream of the mine site is “very susceptible to scour and erosion and can be significantly altered and rapidly de-stabilized by channel or landscape disturbances and changes in the flow or sediment regimes of the contributing watershed.” As result, increases in streamflow could increase mobilization of sediments, leading to altered spawning gravel

quality, reduced survival of salmon eggs that are scoured or buried (Buffington et al. 2004), or reduced foraging efficiency of juvenile salmon (Bjornn and Reiser 1991). Increased streamflows could also eliminate off-channel habitat through the erosion of streambanks, and could reduce invertebrate populations as a result of streambed scour and erosion.

As previously discussed, proposed water management under the 2020 Mine Plan uses treated discharges to offset some of the streamflow reductions and address stream habitat losses. According to the FEIS, treated water releases would be discharged in direct proportion to the water captured from each of the three watersheds in the mine footprint area, and discharges would be "optimized to benefit priority fish species and life-stages for each month and stream" (USACE 2020a: Page 4.24-12). However, the complexity inherent in surface water–groundwater interactions in the SFK, NFK, and UTC watersheds makes it difficult to predict, regulate, and control such interactions when large-scale human alteration of the landscape occurs (Hancock 2002). Discharges of treated water will not replicate natural surface water–groundwater interactions, which will have already been significantly altered by reductions in groundwater and surface water flows to downgradient habitats. Adequately protecting the critical services that groundwater provides to fishes, via its influence on surface waters, is complicated by the fact that groundwater flow paths vary at multiple scales and connections between distant recharge areas and local groundwater discharge areas are difficult to predict (Power et al. 1999).

The reduction of downgradient groundwater and surface water flows and resulting changes in surface water–groundwater interactions also will affect water temperatures in downstream anadromous reaches, further impacting salmon populations. Winter streamflow and water temperature are both predicted to increase in the NFK as a result of the 2020 Mine Plan and would continue to be increased through April each year (USACE 2020a: Sections 4.18 and 4.16).[81] The threshold between completely frozen and partially frozen streams can be a narrow one (Irons et al. 1989), especially for small streams with low winter groundwater inputs (i.e., like many of the headwater streams in the SFK, NFK, and UTC watersheds). As a result, even small increases in winter water temperatures can have large effects. These predicted increases in winter streamflow and temperature would likely reduce ice cover and increase flow velocities, resulting in substantial alteration of fish habitats (Huusko et al. 2007, Brown et al. 2011) and reduced spawning success due to the scouring of redds.

Because the timing of salmon migration, spawning, and incubation are closely tied to seasonal water temperatures, any change in thermal regimes could also disrupt life history timing cues and result in mismatches between fishes and their environments, which would adversely affect survival (Angilletta et al. 2008). Streamflow reductions resulting from the loss of temperature-moderating groundwater inputs or streamflow and temperature increases resulting from WTP discharges could reduce diversity of run timing and other salmon life history traits (Hodgson and Quinn 2002, Rogers and Schindler 2011, Ruff et al. 2011), which play an important role in creating and maintaining biocomplexity (Section 3.3.3). Although fish populations may be adapted to periodic disturbances associated with natural flow

[81] The extent and duration of temperature changes would depend on the temperature, quantity, and timing of WTP discharges, as well as the influence of other inputs such as groundwater and tributary inflows.

variability (Poff et al. 1997, Matthews and Marsh-Matthews 2003), changes that disrupt life history timing cues can adversely affect survival; prolonged changes in streamflow regimes can have longer-term impacts on fish populations (Jensen and Johnsen 1999, Lytle and Poff 2004). See Appendix B (Section B.5.1) for further discussion of water quality effects on aquatic resources.

Overall, the adverse effects of streamflow changes on stream and off-channel habitats would substantially reduce spawning success for Coho Salmon, survival of overwintering Coho, Chinook, and Sockeye salmon, and ultimately productivity of Coho, Chinook, and Sockeye salmon in the SFK and NFK watersheds. Many effects of substantially changed streamflows would reverberate downstream beyond the directly affected waters due to reduced quantity and diversity of available food sources, such as macroinvertebrates and reduced success of upstream salmon spawning and rearing. Streamflow changes associated with operation of the 2020 Mine Plan also would affect many other factors that determine high-quality salmon habitat (e.g., water depth and velocity, substrate size, groundwater exchange, water temperature, food availability), although effects of streamflow on these other factors are not evaluated in the FEIS (see Appendix B).

Streamflow changes of greater than 20 percent of baseline average monthly streamflow will adversely affect and degrade downstream anadromous fish habitat (Sections 3.2.4 and 4.2.1, Figures 4-3 through 4-5). The downstream waters that would experience such streamflow changes are ecologically important and provide spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds (Figures 4-2 and 4-3). The large extent of these streamflow changes (29 miles [46.7 km]) would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK) and Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3). The damage to downstream anadromous fishery areas in the SFK and NFK watersheds that would result from these streamflow changes of more than 20 percent of baseline average monthly flow also would erode habitat complexity and biocomplexity within these watersheds, which are critical for buffering salmon populations from sudden and extreme changes in abundance and ultimately maintaining the stability and productivity of these populations.

Furthermore, discharges of dredged or fill material into waters of the United States located anywhere in the mine site area (Figure 4-1) for the construction and routine operation of a mine at the Pebble deposit would result in streamflow changes in the same anadromous fish streams that were characterized in the evaluation of the 2020 Mine Plan (Figures 4-3 and 4-9, Table 4-4). Also, the anadromous fish streams in the SFK, NFK, and UTC watersheds support the same anadromous fish species and life stages as those that would be affected by the 2020 Mine Plan (Section 3.3) (USACE 2020a: Section 3.24). If discharges of dredged or fill material placed anywhere in the mine site area resulted in 29 miles (46.7 km) of streamflow changes greater than 20 percent of baseline average monthly streamflow, then the same adverse effects to downstream anadromous fishery areas would occur as described for the 2020 Mine Plan due to the large extent of streamflow changes to downstream anadromous fishery areas that support the same anadromous fish species and life stages as those affected by the 2020 Mine Plan.

4.2.4.6 Impacts on Other Fish Species

Although this final determination is based solely on adverse effects on anadromous fishery areas, EPA notes that anadromous fish streams that would be degraded by these alterations in streamflow also provide habitat for non-anadromous fish species (Figures 4-10 and 4-11). The assemblage of non-anadromous fishes found in and supported by these streams is an important component of these habitats and further underscores the biological integrity and ecological value of these largely undeveloped watersheds with intact stream networks. The SFK mainstem that would be subject to streamflow alterations downstream from the mine provides habitat for Arctic Grayling, Northern Pike, sculpin, and stickleback. Streamflow alterations in Tributary SFK 1.190 would affect habitat for Arctic Grayling, Dolly Varden, sculpin, and stickleback. Streamflow alterations in Tributary SFK 1.240 would affect habitat for these same species plus Northern Pike (ADF&G 2022a).

In the NFK watershed, secondary effects of downstream flow alteration would affect mainstem NFK habitats for Arctic Grayling, Dolly Varden, Rainbow Trout, Round Whitefish, and sculpin. Dolly Varden, Northern Pike, and Arctic Grayling are harvested in downstream subsistence and recreational fisheries (Section 4.2.1). Thus, in addition to providing salmon habitat, streams that would be affected by streamflow alterations also provide habitat for other non-anadromous fish species important to subsistence and recreational fisheries.

Figure 4-10. Streams and rivers with occurrence of Arctic Grayling, Rainbow Trout, and Dolly Varden that would experience streamflow changes as a result of the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a). Streamflow alteration is assigned at a gage and extends upstream (see Footnote 77 in Section 4.2.4.3 for a discussion of methodology).

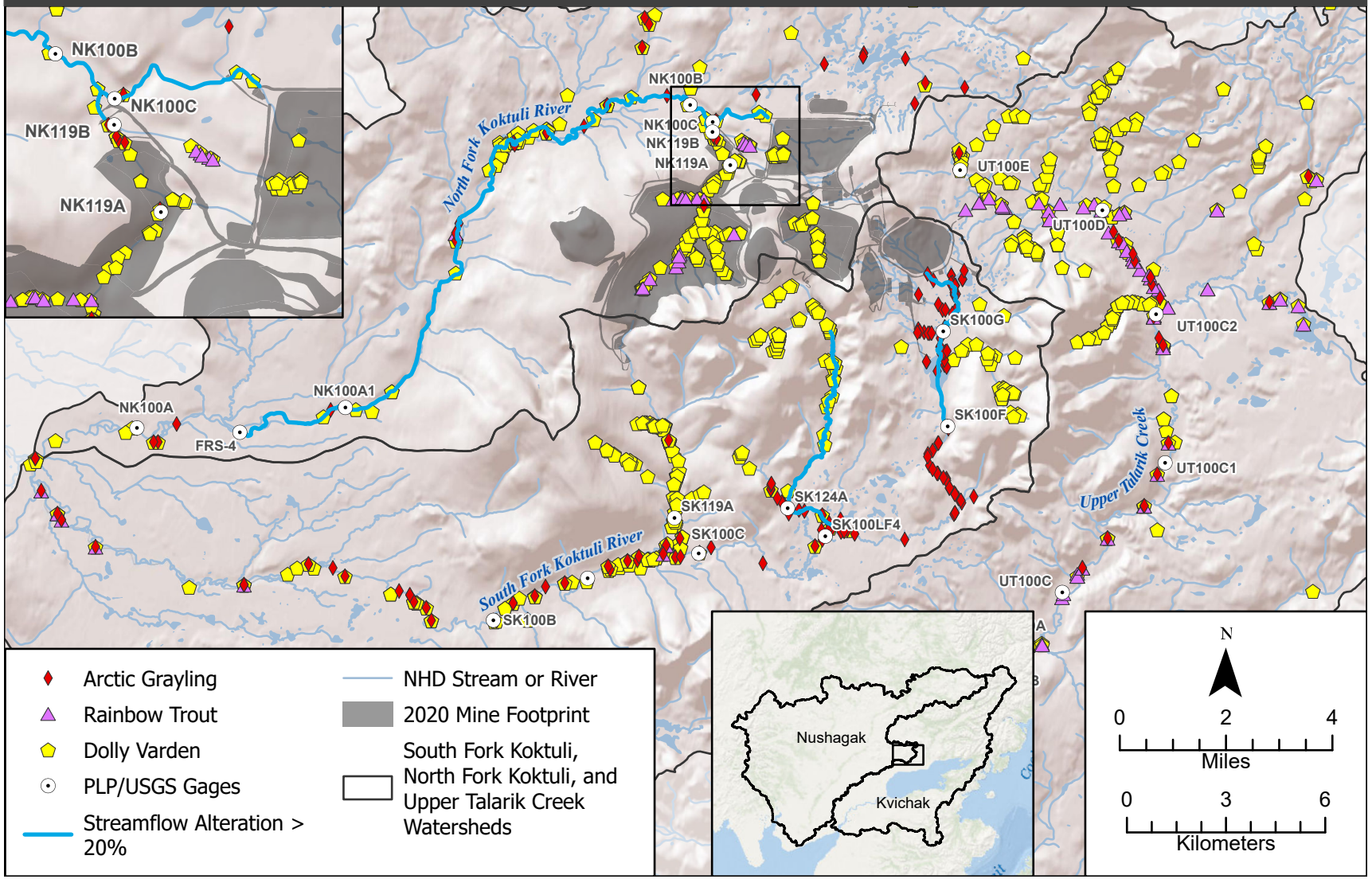
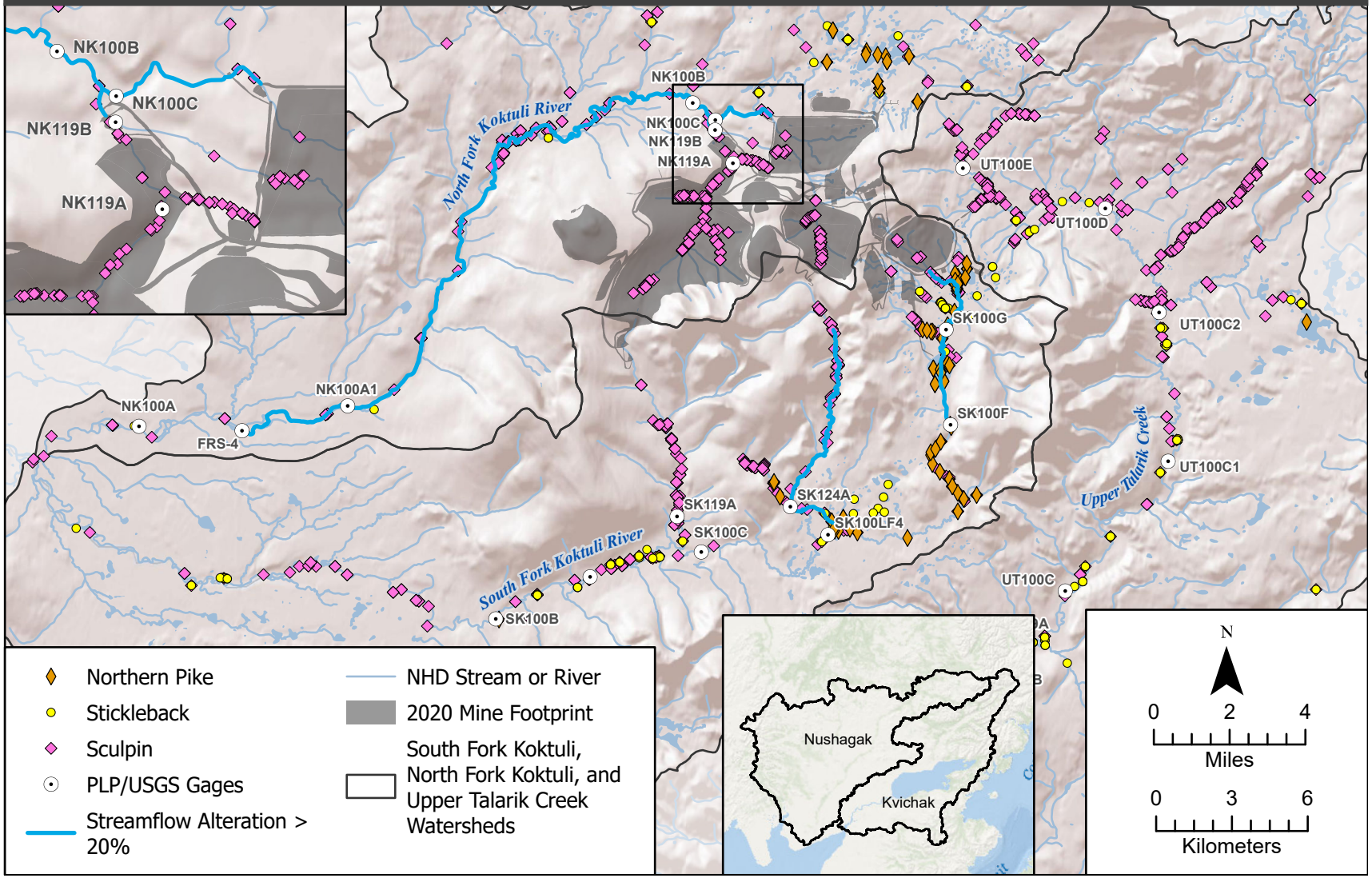


Figure 4-11. Streams and rivers with occurrence of other resident fish species that would experience streamflow changes as a result of the Pebble 2020 Mine Plan. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a). Streamflow alteration is assigned at a gage and extends upstream (see Footnote 77 in Section 4.2.4.3 for a discussion of methodology).



4.2.4.7 Conclusions

EPA has considered and evaluated the information available regarding how streamflow alterations greater than 20 percent of average monthly streamflow in approximately 29 miles (46.7 km) of anadromous fish streams from the discharge of dredged or fill material associated with developing the Pebble deposit would affect anadromous fishery areas in the SFK, NFK, and UTC watersheds. As described below, such streamflow changes will have unacceptable adverse effects on anadromous fishery areas if the discharges of dredged or fill material are located in the mine site area (Figure 4-1) within the SFK and NFK watersheds or elsewhere in the SFK, NFK, and UTC watersheds. The following conclusions and rationale directly support the prohibition described in Section 5.1 and the restriction described in Section 5.2.

4.2.4.7.1 Adverse Effects from Discharges of Dredged or Fill Material at the Mine Site that Result in Streamflow Changes in Anadromous Fish Streams

EPA has determined that the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, resulting in streamflow alterations greater than 20 percent of average monthly streamflow in approximately 29 miles (46.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds. This conclusion is based on the following factors described in detail in Sections 4.2.4.1 through 4.2.4.5: the large extent and magnitude of streamflow changes in anadromous fish streams; the corresponding degradation of and thus damage to anadromous fish streams, including spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon, resulting from these streamflow changes; and the resulting erosion of and thus damage to both habitat complexity and biocomplexity within the SFK and NFK watersheds, which are key to the abundance and stability of salmon populations within these watersheds.

Discharges of dredged or fill material anywhere in the mine site area (Figure 4-1) for the construction and routine operation of a mine at the Pebble deposit would result in streamflow changes in the same anadromous fish streams downstream of the mine site that were characterized in the evaluation of the 2020 Mine Plan (Figures 4-3 and 4-9; Table 4-4). These anadromous fish streams support the same anadromous fish species and life stages as those that would be affected by the 2020 Mine Plan (Section 3.3) (USACE 2020a: Section 3.24). Thus, the same or greater levels of streamflow changes in anadromous fish streams downstream of the mine site resulting from discharges of dredged or fill material associated with developing the Pebble deposit located anywhere in the mine site area (Figures ES-5 and 4-1) within the SFK and NFK watersheds also will have unacceptable adverse effects on anadromous fishery areas in these watersheds. These conclusions support the prohibition described in Section 5.1.

4.2.4.7.2 Adverse Effects from Discharges of Dredged or Fill Material Elsewhere in the SFK, NFK, and UTC Watersheds that Result in Streamflow Changes in Anadromous Fish Streams

Over the past decade, EPA has reviewed the large body of available information about the SFK, NFK and UTC watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a), including the role that aquatic resources in these watersheds play in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (e.g., Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019, Raborn and Link 2022). Furthermore, EPA recognizes that the 2020 Mine Plan represents only one configuration of a potential mine at the Pebble deposit and any relocation of mine site components to other locations in the SFK, NFK, and UTC watersheds would result in discharges of dredged or fill material to water resources beyond the mine site area delineated in the 2020 Mine Plan.[82]

Thus, this final determination considers the effects of relocating streamflow changes greater than 20 percent of average monthly streamflow in approximately 29 miles (46.7 km) of anadromous fish streams to other areas of the SFK, NFK, and UTC watersheds, in addition to the specific mine placement included in the 2020 Mine Plan. To determine whether unacceptable adverse effects would result from discharges within this larger area, EPA evaluated the aquatic resource components of the SFK, NFK, and UTC watersheds, including the types and abundance of aquatic habitats (e.g., streams, wetlands, and other waters), their physical and chemical characteristics, and the organisms that use those habitats (Section 3), based on the data available for sites throughout these three watersheds (e.g., PLP 2011, EPA 2014, PLP 2018a, USACE 2020a).

Based on its evaluation, EPA determined that the diverse, highly connected, and ecologically valuable aquatic habitats in the SFK, NFK, and UTC watersheds provide the foundation for productive fishery areas in these watersheds. All three watersheds comprise largely undeveloped landscapes with intact, high-quality, connected, and free-flowing aquatic habitats from their headwaters to their downstream extents. There are significant similarities in the structure and function of rivers, streams, wetlands, and other waters throughout the three watersheds. The productivity of the SFK, NFK, and UTC watersheds, for anadromous fishes, as well as other biota, depends on the characteristics of these individual habitats and how they are arranged and connected, all of which vary in space and time to create unique and dynamic habitat mosaics throughout these three watersheds. As a result, similar habitats across the three watersheds are not interchangeable, but represent distinct resources that play a crucial role in supporting and stabilizing productive salmon populations in these watersheds. Thus, they are an integral component in maintaining the integrity, productivity, and sustainability of the Bristol Bay watershed's fishery resources over time (Box 3-1).

The SFK, NFK, and UTC watersheds all have a similar stream network structure, with numerous headwater tributaries contributing to downstream mainstem reaches (Figure ES-8). Similar stream

[82] The FEIS considers the environmental impacts of discharges of dredged or fill material to construct components associated with developing the Pebble deposit (e.g., TSFs) at other locations in these three watersheds (Section 2.1.2.2) (USACE 2020a: Section 2 and Appendix B).

extents have been mapped in each watershed (194–264 miles) (Table 3-6). Most of these stream miles consist of small channels: small headwater streams (≤5.3 ft^3/s [≤0.15 m^3/s] mean annual streamflow) comprise 65 percent of stream channel length in the SFK, NFK, and UTC watersheds, and small or medium streams (≤100 ft^3/s [≤2.8 m^3/s] mean annual streamflow) comprise 89 percent of stream channel length (Table 3-1). Wetlands (primarily freshwater emergent and freshwater forested scrub/shrub wetlands) cover at least 15 percent of the total area in each watershed (Figure ES-7), and each watershed contains multiple lakes and ponds. Floodplain and off-channel habitats are important habitat components in all three watersheds (USACE 2020a: Table 3-24-3). For example, aerial imagery shows that roughly 70 percent of the mainstem SFK and UTC and roughly 90 percent of the mainstem NFK are bordered by some form of off-channel habitat (USACE 2020a: Section 3.24), most commonly beaver complexes (Section 3.2.2) (USACE 2020a: Section 3.24).

This network of headwater streams and wetlands provides critical support for downstream anadromous fish streams. Existing data show that streams and rivers in the SFK, NFK, and UTC watersheds provide similar levels of high-capacity, high-quality habitats for salmonids. These habitats provide ideal conditions for adult salmon spawning, egg incubation and juvenile rearing, such as clean, cold water; extensive unembedded gravel substrates; abundant areas of groundwater exchange (upwelling and downwelling); and highly suitable stream gradients and sizes. For example, low-gradient streams of medium size (5.3 to 100 ft^3/s [0.15 to 2.8 m^3/s] mean annual streamflow) or greater likely provide high-capacity, high-quality habitats for salmonids (EPA 2014: Chapter 7), and such streams comprise 34 percent of the stream network in the SFK, NFK, and UTC watersheds (Table 3-1).

In fact, multiple Pacific salmon species and life stages have been documented to occur in high numbers and across diverse habitats (Tables 3-7 through 3-10) throughout the three watersheds (Figure 3-18). The SFK, NFK, and UTC watersheds contain similar extents of documented anadromous fish streams (60–76 miles) (Table 3-6). At least 30 percent of streams within the three watersheds are documented anadromous fish streams (Table 3-6), although this value likely represents a significant underestimate (Appendix B). Anadromous fish streams in the SFK, NFK, and UTC watersheds directly support critical life history stages of multiple anadromous fish species. Coho, Sockeye, Chinook, and Chum salmon rely on and are adapted to aquatic habitats in the SFK, NFK, and UTC watersheds for completion of their life cycles: eggs incubate and hatch in spawning gravels, juveniles overwinter and grow in streams and off-channel habitats, smolts migrate downstream through the stream network, and adults migrate upstream to spawn (Section 3.3.1). Timing of life history events (e.g., spawning and emergence) varies by species and by population, and is dictated by the unique conditions of habitats, their positions in the watershed, and their connectivity in space and time, resulting in asynchrony of salmon availability across the landscape (Section 3.3.3.2). Aquatic resource components in each of these three watersheds combine in different ways to create unique habitat mosaics, which over thousands of years have resulted in local adaptation of anadromous fish populations to site-specific conditions in each watershed.

All three watersheds contain documented spawning and rearing habitat for Coho, Chinook, and Sockeye salmon (Figures 3-5 through 3-7) and documented spawning habitat for Chum Salmon (Figure 3-8). Coho Salmon are the most widely distributed salmon species in the three watersheds (Figure 3-5) and

have been documented to occur in at least 59 stream miles within each watershed (Table 3-6). Coho Salmon make extensive use of mainstem and tributary habitats, including headwater streams (Figure 3-5). Chinook Salmon have been documented to occur in at least 38 stream miles in each watershed (Table 3-6). Coho and Chinook salmon—the salmon species most reliant on habitats in the SFK, NFK, and UTC watersheds—are the two rarest of North America's five species of Pacific salmon (Healey 1991, Woody 2018) and are particularly vulnerable to losses of small, discrete populations.

The natural flow regime is a critical component of streams and rivers and their hydrologically connected aquatic habitats because flow directly or indirectly affects all other physical, chemical, and biological components of these systems (Bunn and Arthington 2002, Lytle and Poff 2004, Poff and Zimmerman 2010, Sofi et al. 2020, Tonkin et al. 2021). The body of published scientific literature on the functional consequences of hydrograph alteration is extensive (e.g., Poff et al. 1997, Tonkin et al. 2021, Freeman et al. 2022). Streamflow changes that exceed 20 percent of average monthly streamflow would constitute a significant change in the natural hydrograph, with repercussions for the physical, chemical, and biological characteristics of both the affected reaches and downstream areas. Although fish populations may be adapted to periodic disturbances associated with natural flow variability (Poff et al. 1997, Matthews and Marsh-Matthews 2003), changes that persist disrupt life history timing cues for adult migration to natal spawning sites, spawn timing, emergency timing, and juvenile outmigration. Changes in these cues will adversely affect survival, and prolonged changes in streamflow regimes can have longer-term impacts on fish populations (Jensen and Johnsen 1999, Lytle and Poff 2004).

The 2020 Mine Plan would result in streamflow changes greater than 20 percent of average monthly streamflow in at least 29 miles of anadromous fish streams. These streamflow changes would include both streamflow reductions due to losses of headwater and groundwater contributions and streamflow increases due to WTP discharges of treated water. These streamflow alterations would vary spatially and seasonally, with areas closest to the open mine pit and WTP discharge sites experiencing the most significant streamflow changes.

As discussed in Section 4.2.4.5, WTP discharges that increase streamflow by more than 20 percent of baseline average monthly streamflow would alter channel geometry and destabilize channel structure, with effects propagating downstream. Such streamflow increases will degrade habitat suitability for salmon by increasing mobilization of sediments, leading to altered spawning gravel quality, reduced survival of salmon eggs that could be scoured or buried (Buffington et al. 2004), and reduced foraging efficiency of juvenile salmon (Bjornn and Reiser 1991). Increased streamflows could also eliminate off-channel habitats through the erosion of streambanks and could reduce invertebrate populations due to streambed scour and erosion.

Operations at the mine site would also result in streamflow reductions in anadromous fish streams due to losses of headwater and groundwater contributions. These losses would reduce instream habitat availability, particularly during periods of natural low flows; fragment stream habitats; and preclude normal seasonal movements by anadromous and migratory resident fishes (West et al. 1992, Cunjak 1996, EPA 2014: Chapter 7). Diminished streamflows would also likely reduce the frequency and

duration of connectivity to off-channel habitats such as side channels, riparian wetlands, and beaver ponds, reducing the spatial extent of such habitats or eliminating them altogether. The loss of access to off-channel areas, particularly those with groundwater connectivity, would remove critical rearing habitats for several species of juvenile salmonids (Table 3-10) (Quinn 2018, Huntsman and Falke 2019). Reduced hydrologic connectivity between streams and riparian wetlands would also likely reduce or eliminate the export of detritus, macroinvertebrates, and other ecological subsidies from wetlands and off-channel habitats to streams.

The loss of groundwater inputs combined with WTP discharges would result in increased winter streamflow and water temperature, which would have profound adverse effects on stream thermal regimes (EPA 2014: Chapter 7). These predicted increases in winter streamflow and temperature would likely reduce ice cover and increase flow velocities, resulting in substantial alteration of fish habitats (Huusko et al. 2007, Brown et al. 2011) and reduced spawning success due to the scouring of redds. Because the timing of salmon migration, spawning, and incubation are closely tied to seasonal water temperatures, any change in the thermal regime could disrupt life history timing cues and result in mismatches between fishes and their environments, which would adversely affect survival (Angilletta et al. 2008).

Overall, the adverse effects of streamflow changes greater than 20 percent of average monthly flows on stream and off-channel habitats would substantially reduce spawning success, overwinter survival, and ultimately salmon productivity in anadromous fish streams. The large extent of these streamflow changes (29 miles [46.7 km]) would adversely affect salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3) and significantly damage downstream anadromous fishery areas in the SFK, NFK, and UTC watersheds by eroding habitat complexity and biocomplexity within these watersheds, which are critical for buffering salmon populations from sudden and extreme changes in abundance and ultimately maintaining stability and productivity of these populations.

Given the significant similarities in the structure and function of aquatic resources across the SFK, NFK, and UTC watersheds and the adverse effects that would result from the discharges of dredged or fill material associated with developing the Pebble deposit if mine components were relocated to other locations in these watersheds, EPA has determined that the discharge of dredged or fill material associated with developing the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds, resulting in streamflow alterations greater than 20 percent of average monthly streamflow in approximately 29 miles (46.7 km) of anadromous fish streams, will have unacceptable adverse effects on anadromous fishery areas in these watersheds. As explained in detail above, this conclusion is based on the same record and analysis used to evaluate the effects of the 2020 Mine Plan and the following factors: the presence of anadromous fish streams throughout the SFK, NFK, and UTC watersheds, which directly support critical life history stages (e.g., spawning, rearing, migration) of at least one anadromous fish species (Section 3.3); that these three watersheds have similar amounts of total anadromous fish streams, as well as similar amounts of anadromous fish streams for each of the five Pacific salmon species (Table 3-6, Figure 3-18); that the anadromous fish streams throughout these watersheds are

currently among the least developed and least disturbed (i.e., closest to pristine) habitat of this type in North America (Section 3.1); that anadromous fish streams across these three watersheds function similarly to support multiple species and life stages of anadromous fishes that are adapted to the unique set of environmental conditions each stream provides (Section 3.3); the large extent and magnitude of streamflow changes in anadromous fish streams and the corresponding degradation of and thus damage to anadromous fish streams, including spawning and rearing habitat, resulting from these streamflow changes (Section 4.2.4.5); and the resulting erosion of and thus damage to habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds. This conclusion supports the restriction described in Section 5.2.

4.2.5 Summary of Effects on Fishery Areas from Discharges of Dredged or Fill Material from Developing the Pebble Deposit

In summary, EPA has determined that certain discharges of dredged or fill material into waters of the United States for the construction and routine operation of the 2020 Mine Plan will have unacceptable adverse effects on anadromous fishery areas in the SFK and NFK watersheds (Sections 4.2.1 through 4.2.4). EPA has also determined that discharges of dredged or fill material associated with developing the Pebble deposit anywhere in the mine site area (Figure 4-1) within the SFK and NFK watersheds that would result in the same or greater levels of loss or streamflow changes as the 2020 Mine Plan also will have unacceptable adverse effects on anadromous fishery areas in these watersheds, because such discharges would involve the same aquatic resources characterized as part of the evaluation of the 2020 Mine Plan. Further, EPA has determined that discharges of dredged or fill material associated with developing the Pebble deposit anywhere in the SFK, NFK, and UTC watersheds will have unacceptable adverse effects on anadromous fishery areas in these watersheds if the effects of such discharges are similar or greater in nature and magnitude to those described in Sections 4.2.1 through 4.2.4. Because of the nature and magnitude of the aquatic resource losses and streamflow changes described in Sections 4.2.1 through 4.2.4, EPA considers each “a large impact” and “one that the aquatic and wetland ecosystem cannot afford” (44 FR 58078).

4.3 Compliance with Relevant Portions of the CWA Section 404(b)(1) Guidelines

EPA has broad discretion under CWA Section 404(c) to evaluate and determine whether a discharge would result in an “unacceptable adverse effect” on fishery areas, including breeding and spawning areas. EPA has determined that certain discharges of dredged or fill material for the construction and routine operation of a mine at the Pebble deposit will have unacceptable adverse effects on anadromous fishery areas, as described in Section 4.2.

EPA's CWA Section 404(c) regulations at 40 CFR 231.2(e) provide that in evaluating the “unacceptability” of effects, consideration should be given to the “relevant portions of the CWA Section

404(b)(1) Guidelines." As detailed in this section, evaluation of compliance with relevant portions of the Guidelines supports and confirms EPA's determination that discharges of dredged or fill material for the construction and routine operation of a mine at the Pebble deposit as described in Section 4.2 will have unacceptable adverse effects on anadromous fishery areas.

For the purposes of evaluating the unacceptability of effects from discharges of dredged or fill material associated with the 2020 Mine Plan, EPA evaluated the following portions of the CWA Section 404(b)(1) Guidelines in the manner discussed in this section:

- Significant degradation of waters of the United States (40 CFR 230.10(c))
    - Cumulative effects (40 CFR 230.11(g))
    - Secondary effects (40 CFR 230.11(h))
- Minimization of adverse impacts on aquatic ecosystems (40 CFR 230.10(d))

4.3.1 Significant Degradation

The CWA Section 404(b)(1) Guidelines direct that no discharge of dredged or fill material shall be permitted if the discharge will cause or contribute to significant degradation of waters of the United States (40 CFR 230.10(c)). Of particular relevance, the Guidelines state that effects contributing to significant degradation, considered individually or collectively, include the following:

1. Significantly adverse effects of the discharge of pollutants on human health or welfare, including but not limited to effects on municipal water supplies, plankton, fish, shellfish, wildlife, and special aquatic sites;
2. Significantly adverse effects of the discharge of pollutants on life stages of aquatic life and other wildlife dependent on aquatic ecosystems, including the transfer, concentration, and spread of pollutants or their byproducts outside of the disposal site through biological, physical, and chemical processes;
3. Significantly adverse effects of the discharge of pollutants on aquatic ecosystem diversity, productivity, and stability. Such effects may include, but are not limited to, loss of fish and wildlife habitat or loss of the capacity of a wetland to assimilate nutrients, purify water, or reduce wave energy; and
4. Significantly adverse effects of discharge of pollutants on recreational, aesthetic, and economic values.

Findings of significant degradation related to proposed discharges must be based on appropriate factual determinations, evaluations, and tests, as described in 40 CFR 230.11, with special emphasis on the persistence and permanence of the effects evaluated.

EPA's regulations at 40 CFR 230.5 identify the stepwise process to assess the potential for significant degradation. The assessment of impacts pursuant to subparts C through F (40 CFR 230.20–230.54) informs the required factual determinations found in 40 CFR 230.11. The factual determinations, in turn, inform the significant degradation finding and the finding of compliance or non-compliance with the

Guidelines. The Guidelines require the consideration of potential losses of environmental characteristics or values resulting from direct, secondary, and cumulative impacts.

4.3.1.1 Direct and Secondary Effects of the 2020 Mine Plan

USACE provided its evaluation of the anticipated impacts from the discharge of dredged or fill material associated with the 2020 Mine Plan under the 404(b)(1) Guidelines (40 CFR Part 230) in its CWA Section 404 ROD (USACE 2020b). USACE concluded the 2020 Mine Plan did not comply with the CWA Section 404(b)(1) Guidelines because impacts to waters of the United States "from discharges of dredged or fill material at the mine site have been determined to cause significant degradation to the aquatic ecosystem" (USACE 2020b: Page B2-2). USACE (2020b) concluded that the discharge of dredged or fill material associated with the 2020 Mine Plan would result in significant adverse effects in all four effects categories in 40 CFR 230.10(c):

- Human health or welfare (40 CFR 230.10 (c)(1)).
- Life stages of aquatic life and other wildlife dependent on aquatic ecosystems (40 CFR 230.10 (c)(2)).
- Aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10 (c)(3)).
- Recreational, aesthetic, and economic values (40 CFR 230.10 (c)(4)).

USACE also concluded that "[t]he proposed avoidance, minimization, or compensatory mitigation measures would not reduce the impacts to aquatic resources from the proposed project to below a level of significant degradation" (USACE 2020b: Page B2-6).

EPA also considered relevant portions of the CWA Section 404(b)(1) Guidelines when evaluating the unacceptability of the potential direct and secondary effects of the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, pursuant to EPA's CWA Section 404(c) regulations at 40 CFR 231.2(e). The following discussion provides an overview of EPA's evaluation.

4.3.1.1.1 Adverse Effects of Loss of Anadromous Fish Streams

As discussed in Section 4.2.1, the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in the permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams. This loss represents approximately 13 percent of the anadromous waters in the NFK watershed.

The anadromous fish streams that the discharge of dredged or fill material associated with the 2020 Mine Plan would permanently eliminate are ecologically valuable, particularly for juvenile salmon (Section 3.2.4). Tributary NFK 1.190 is hydrologically connected with ponds and seasonally to permanently inundated wetlands that result from beaver activity (USFWS 2021).[83] These features

[83] Connection to such floodplain wetlands and ponds can greatly enhance the carrying capacity and productive potential of anadromous fish streams (Section 3).

provide excellent rearing habitat and important overwintering and flow velocity refugia for salmonids (Section 3.2.4) (Nickelson et al. 1992, Cunjak 1996, Collen and Gibson 2001, Lang et al. 2006). The permanent loss of anadromous fish streams resulting from discharges of dredged or fill material associated with the 2020 Mine Plan would also result in the loss of salmon spawning habitat, which would, in turn, result in the loss of marine-derived nutrients transported upstream by those fishes. Given the naturally low nutrient concentrations in these streams, these inputs of marine-derived nutrients may be especially important in supporting primary and secondary production and, thus, food for juvenile salmonids in these and downstream habitats (Section 3.3.4). These streams also support production via inputs of leaf litter from deciduous shrubs and grasses in riparian areas (Meyer et al. 2007, Dekar et al. 2012), which help fuel the production of macroinvertebrates, a key food for salmonids (Table 3-3). Thus, the anadromous fish streams that the 2020 Mine Plan would eliminate, as well as similar habitats in the SFK, NFK, and UTC watersheds, play an important role in the life cycle of salmon.

These anadromous fish stream losses would adversely affect Coho and Chinook salmon populations uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1). Such adaptation to local environmental conditions results in discrete, genetically distinct populations. This biocomplexity—operating across a continuum of integrated, nested spatial and temporal scales—depends on the abundance and diversity of aquatic habitats in the area and acts to stabilize overall salmon production and fishery resources (Section 3.3.3) (Schindler et al. 2010, Schindler et al. 2018, Brennan et al. 2019). The substantial spatial and temporal extent of stream habitat losses resulting from the discharge of dredged or fill material associated with the 2020 Mine Plan suggest that these losses would reduce the overall capacity and productivity of Coho and Chinook salmon in the entire NFK watershed.

The 8.5 miles (13.7 km) of anadromous fish streams that would be lost are mapped as upper perennial streams (PLP 2020b) and considered special aquatic sites with riffle/pool complexes (USACE 2020b). Under Subpart E of the Guidelines (40 CFR 230.41 and 230.45), special aquatic sites "are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region" (40 CFR 230.3 (m)). Loss of these 8.5 miles (13.7 km) of anadromous fish streams is significant due to effects on fishery areas in the NFK watershed. These special aquatic sites act as fish habitat and as sources of groundwater inputs, nutrients, and other subsidies important for salmon productivity (Section 3.2.4). Their loss would result in significant adverse effects on fishes (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in this watershed.

Other anadromous fish streams in the mine site area (Figure 4-1) are part of the same hydrologically connected network of headwater streams as the 8.5 miles (13.7 km) of anadromous fish streams that would be eliminated by the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8). Thus, the same or

greater levels of loss of these anadromous fish streams from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds also would result in significant adverse effects on fishes (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in these watersheds.

Further, based on the record, EPA has determined that eliminating approximately 8.5 miles (13.7 km) of anadromous fish streams anywhere in the SFK, NFK, and UTC watersheds, due to the discharge of dredged or fill material associated with developing the Pebble deposit, would result in similar significantly adverse effects on anadromous fish habitats and populations. This conclusion is based on the following factors: the presence of anadromous fish streams throughout the SFK, NFK, and UTC watersheds, which directly support critical life history stages (e.g., spawning, rearing, migration) of at least one anadromous fish species (Section 3.3); anadromous fish streams throughout these watersheds that are currently among the least developed and least disturbed (i.e., closest to pristine) habitat of this type in North America (Section 3.1); that these three watersheds have similar amounts of total anadromous fish streams, as well as similar amounts of anadromous fish streams for each of the five Pacific salmon species (Table 3-6, Figure 3-18); that anadromous fish streams across these three watersheds function similarly to support multiple species and life stages of anadromous fishes that are adapted to the unique set of environmental conditions each stream provides (Section 3.3); the large amount of permanent loss of anadromous fish habitat; the degradation of additional downstream anadromous fish habitat due to the loss of ecological subsidies provided by the eliminated anadromous fish streams; and the resulting erosion of habitat complexity and biocomplexity within the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations in these watersheds.

4.3.1.1.2 Adverse Effects of Loss of Additional Streams that Support Anadromous Fish Streams

As discussed in Section 4.2.2, the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in the permanent loss of 91 miles (147 km) of additional streams that support anadromous fish streams in the SFK and NFK watersheds. The permanent loss of additional streams would result in reduced stream productivity in downstream reaches of the SFK and NFK due to the loss of physical, chemical, and biological inputs to downstream channels. Most of these permanently lost streams (77.0 miles [124 km]) are mapped as upper perennial streams (PLP 2020b) and considered special aquatic sites (USACE 2020b). The loss of upper perennial streams is likely to reduce water-holding capacity of the watershed by eliminating stream pools and meanders, thereby degrading downstream anadromous fish habitat through the reduced capacity for aeration and filtration (USACE 2020b).

The permanent loss of additional streams would adversely affect downstream habitat for salmon and other fish species (Section 3.2.4, Figures 4-3 through 4-5). These downstream waters are ecologically important and provide spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon in

the SFK and NFK watersheds (Figures 4-3 and 3-5 through 3-8). Permanent loss of these habitats would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK), as well as Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1). As explained for the loss of 8.5 miles (13.7 km) of anadromous fish streams, the loss and degradation of downstream anadromous fishery areas in the SFK and NFK watersheds that would result from elimination of 91 miles (147 km) of additional streams would further erode habitat complexity and biocomplexity within these watersheds. The diversity of salmon habitats and associated salmon population diversity helps buffer salmon populations from sudden and extreme changes in abundance and ultimately maintain the stability and productivity of these populations.

These losses would result in significant adverse effects on fish and special aquatic sites (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in the SFK and NFK watersheds. These impacts are significant due to the effects on downstream anadromous fishery areas (Section 4.2.2) and the extensive loss of special aquatic sites, which are important sources of groundwater inputs, nutrients, and other subsidies crucial to salmon productivity (Section 3.2.4).

Other streams in the mine site area (Figure 4-1) are part of the same hydrologically connected network of headwater streams as the 91 miles of additional streams that would be eliminated by the 2020 Mine Plan at the mine site (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22); support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24); and are part of the same headwater stream network characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figures ES-5, 4-1, 4-2, and 4-8). Thus, the same or greater levels of loss of these additional streams from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds also would result in significant adverse effects on fishes and special aquatic sites (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in these watersheds.

Further, based on the same record, EPA has determined that eliminating approximately 91 miles (147 km) of additional streams that support anadromous fish streams anywhere in the SFK, NFK, and UTC watersheds, due to the discharge of dredged or fill material associated with developing the Pebble deposit, would result in similar significantly adverse effects on anadromous fish habitats and populations. This conclusion is based on the following factors: headwater streams throughout the SFK, NFK, and UTC watersheds that are currently among the least developed and least disturbed (i.e., closest to pristine) habitat of this type in North America (Section 3.1) and play an important role in supporting Pacific salmon populations (Section 3.2); that these three watersheds have similar amounts of total stream miles (relative to their watershed areas) (Table 3-6); that headwater streams across these three watersheds function similarly to support productive fishery areas for anadromous fishes (Section 3.3); the large amount of outright loss of stream habitat and the crucial role that these headwater streams play in providing ecological subsidies to downstream anadromous fish streams; the degradation of

downstream anadromous fish streams from the loss of ecological subsidies provided by the lost headwater streams; and the resulting erosion of habitat complexity and biocomplexity in the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations within these watersheds.

4.3.1.1.3 Adverse Effects of Loss of Wetlands and Other Waters that Support Anadromous Fish Streams

As discussed in Section 4.2.3, the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in the permanent loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters in the SFK and NFK watersheds.

Approximately 2,047 acres (8.3 km^2) of this permanently lost habitat are wetlands, a special aquatic site under the Guidelines. Wetlands and other waters that would be permanently lost play a critically important role in the life cycles of anadromous fishes in the SFK and NFK watersheds (Section 3.2.3) (PLP 2011: Appendix 15.1.D), given that "…all wetlands are important to the greater function and value of ecosystems and subsistence cultures they support" (USACE 2020a: Page 3.22-8). Moreover, wetlands and other waters affected by the 2020 Mine Plan "possess unique ecological characteristics of productivity, habitat, wildlife protection, and other important and easily disrupted values" (USACE 2020a: Page 3.22-1). The permanent removal of wetlands and other waters would destroy habitat, cause mortality of aquatic organisms, and reduce the collective functional capacity and value of wetlands and other waters across multiple watersheds. These permanent losses also would cause the displacement, injury, and/or mortality of species that rely on these aquatic environments for all or part of their life cycles (USACE 2020a: Section 4.22).

The discharge of dredged or fill material to these aquatic resources would reduce the biological productivity of wetland ecosystems by smothering, dewatering, permanently flooding, altering substrate elevation, or altering the periodicity of water movement (USACE 2020a: Section 4.22). The loss of such wetlands and other waters would eliminate structurally complex and thermally and hydraulically diverse habitats, including crucial overwintering areas, that are essential to rearing salmonids.

In addition to the direct loss of habitat, loss of these wetlands and other waters would result in a total loss of their functions that support fish habitat, such as supplying nutrients and organic material and maintaining baseflows, in both abutting and downstream waters (Section 3.2.4). Downstream waters that would be degraded by the elimination of wetlands and other waters at the mine site are ecologically important and provide rearing and spawning habitat for Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds (Figures 3-5 through 3-8). This degradation of downstream anadromous fish streams would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK) and Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1). As explained for the loss of 8.5 miles (13.7 km) of anadromous fish streams, the loss and degradation of downstream anadromous fishery areas in the SFK and NFK watersheds that would result from elimination of 2,108 acres (8.5 km^2) of wetlands and other waters would further erode both habitat complexity and

biocomplexity within these watersheds. This diversity of salmon habitats and associated salmon population diversity help buffer salmon populations from sudden and extreme changes in abundance and ultimately maintain the stability and productivity of these populations.

These losses would result in significant adverse effects on fishes and special aquatic sites (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in the SFK and NFK watersheds. These losses are significant due to their effects on downstream anadromous fishery areas and the extensive loss of special aquatic sites, which are key sources of groundwater inputs, nutrients, and other subsidies important for salmon productivity (Section 3.2).

Additional wetlands and other waters in the mine site area (Figure ES-5) are hydrologically and ecologically connected to, and in some cases abut, the 2,108 acres (8.5 km^2) of wetlands and other waters that would be eliminated by the 2020 Mine Plan at the mine site in the SFK and NFK watersheds (Section 3.2) (EPA 2015, USACE 2020a: Sections 3.16, 3.17, and 3.22). These wetlands and other waters support the same anadromous fish species and life stages (Section 3.3) (USACE 2020a: Section 3.24) and are part of the same headwater wetland complex characterized in the evaluation of the 2020 Mine Plan in the mine site area (Figure ES-5). Thus, the same or greater levels of loss of these additional wetlands and other waters from discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds also would result in significant adverse effects on fishes and special aquatic sites (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in these watersheds.

Further, based on the same record, EPA has determined that eliminating approximately 2,108 acres (8.5 km^2) of wetlands and other waters anywhere in the SFK, NFK, and UTC watersheds, due to the discharge of dredged or fill material associated with developing the Pebble deposit, would result in similar significantly adverse effects on anadromous fish habitats and populations. This conclusion is based on the following factors: headwater wetlands and other waters throughout the SFK, NFK, and UTC watersheds that are currently among the least developed and least disturbed (i.e., closest to pristine) habitat of this type in North America (Section 3.1) and play an important role in supporting Pacific salmon populations (Section 3.2); that these three watersheds have similar amounts and types of wetlands (Table 3-2); that headwater wetlands and other waters across these three watersheds function similarly to support productive fishery areas for anadromous fishes (Section 3.3); the large amount of outright loss of wetlands and other waters; the importance of wetlands and other waters to salmon populations, both as habitat and as sources of groundwater inputs, nutrients, and other subsidies important to salmon productivity in downstream waters; the degradation of downstream anadromous fish streams from the loss of ecological subsidies provided by the lost headwater wetlands and other waters; and the resulting erosion of habitat complexity and biocomplexity in the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations in these watersheds.

4.3.1.1.4 Adverse Effects from Changes in Streamflow in Downstream Anadromous Fish Streams

As discussed in Section 4.2.4, the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in streamflow alterations greater than 20 percent of average monthly streamflow from natural conditions in approximately 29 miles (46.7 km) of documented anadromous fish streams in the SFK and NFK watersheds. These changes in streamflow would alter the natural flow regimes of these systems (Poff et al. 1997) and could result in major changes in ecosystem structure and function (Richter et al. 2012), which could significantly reduce the extent and quality of anadromous fish habitats downstream of the mine site. Streamflow reductions would reduce habitat availability for salmon and other fishes, particularly during low-streamflow periods (West et al. 1992, Cunjak 1996); reduce macroinvertebrate production (Chadwick and Huryn 2007); and increase stream habitat fragmentation due to increased frequency and duration of stream drying. Increases in streamflow from natural conditions could result in increased scour and transport of gravels, affecting important salmon spawning areas (Brekken et al. 2022). Increased streamflows could also adversely affect distributions of water velocities favorable for various fish life stages (Piccolo et al. 2008, Donofrio et al. 2018).

As with the habitat losses and degradation described previously (Section 4.3.1.1) and in Sections 4.2.1 through 4.2.3, streamflow alterations would adversely affect downstream habitats for salmon and other fish species (Section 3.2.4, Figures 4-3 through 4-5). These downstream waters are ecologically important and provide spawning and rearing habitat for Coho, Chinook, Sockeye, and Chum salmon in the SFK and NFK watersheds (Figures 4-3 and 3-5 through 3-8).

These streamflow changes would result in significant adverse effects on fishes and special aquatic sites (40 CFR 230.10(c)(1)), on life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in the SFK and NFK watersheds. These streamflow changes would degrade downstream anadromous fish streams, adversely affecting genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK) and Coho and Chinook salmon populations that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1). The loss and degradation of downstream anadromous fishery areas in the SFK and NFK watersheds that would result from streamflow alterations greater than 20 percent of average monthly streamflow from natural conditions in approximately 29 miles (46.7 km) of anadromous fish streams would further erode both habitat complexity and biocomplexity within these watersheds. The diversity of salmon habitats and associated salmon population diversity help buffer salmon populations from sudden and extreme changes in abundance and ultimately maintain the stability and productivity of these populations.

Discharges of dredged or fill material anywhere at the mine site area (Figure 4-1) for the construction and routine operation of a mine at the Pebble deposit would result in streamflow changes in the same anadromous fish streams downstream of the mine site that were characterized in the evaluation of the 2020 Mine Plan (Figures 4-3 and 4-9, Table 4-4). These anadromous fish streams support the same anadromous fish species and life stages as those that would be affected by the 2020 Mine Plan (Section

3.3) (USACE 2020a: Section 3.24). Thus, the same or greater levels of streamflow changes in anadromous fish streams downstream of the mine site resulting from discharges of dredged or fill material associated with developing the Pebble deposit located anywhere in the mine site area within the SFK and NFK watersheds also would result in significant adverse effects on fishes and special aquatic sites (40 CFR 230.10(c)(1)), life stages of anadromous fishes (40 CFR 230.10(c)(2)), anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability (40 CFR 230.10(c)(3)) in these watersheds.

Further, based on the same record, EPA has determined that streamflow alterations greater than 20 percent of average monthly streamflow in approximately 29 miles (46.7 km) of anadromous fish streams anywhere in the SFK, NFK, and UTC watersheds, due to the discharge of dredged or fill material associated with developing the Pebble deposit, would result in similar significantly adverse effects on anadromous fish habitats and populations. This conclusion is based on the following factors: the presence of anadromous fish streams throughout the SFK, NFK, and UTC watersheds, which directly support critical life history stages (e.g., spawning, rearing, migration) of at least one anadromous fish species (Section 3.3); anadromous fish streams throughout these watersheds that are currently among the least developed and least disturbed (i.e., closest to pristine) habitat of this type in North America (Section 3.1); that these three watersheds have similar amounts of total anadromous fish streams, as well as similar amounts of anadromous fish streams for each of the five Pacific salmon species (Table 3-6, Figure 3-18); that anadromous fish streams across these three watersheds function similarly to support multiple species and life stages of anadromous fishes that are adapted to the unique set of environmental conditions each stream provides (Section 3.3); the large extent and magnitude of streamflow changes in anadromous fish streams; the corresponding degradation of anadromous fish streams, including spawning and rearing habitat, resulting from these streamflow changes (Section 4.2.4.5); and the resulting erosion of habitat complexity and biocomplexity in the SFK, NFK, and UTC watersheds, both of which are key to the abundance and stability of salmon populations in these watersheds.

4.3.1.1.5 Conclusion

EPA has determined that direct and secondary effects of the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would result in significant degradation under the CWA Section 404(b)(1) Guidelines. Additionally, EPA has determined that direct and secondary effects of the discharge of dredged or fill material associated with future proposals to construct and operate a mine at the Pebble deposit that would result in adverse effects that are the same, similar, or greater than the adverse effects of the 2020 Mine Plan would also result in significant degradation under the CWA Section 404(b)(1) Guidelines. These findings are based on the significantly adverse effects of the discharge of dredged or fill material on special aquatic sites; life stages of anadromous fishes; anadromous fish habitat; and aquatic ecosystem diversity, productivity, and stability under the CWA Section 404(b)(1) Guidelines.

4.3.1.2 Cumulative Effects of Mine Expansion

EPA recognizes that losses and degradation of these aquatic resources could be even more pronounced when the extensive cumulative impacts on the aquatic ecosystem that are expected to occur with successive stages of mine expansion are considered. The Guidelines describe as "fundamental" the "precept that dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated that such a discharge will not have an unacceptable adverse impact either individually or in combination with known and/or probable impacts of other activities affecting the ecosystems of concern" (40 CFR 230.1(c)). The Guidelines require consideration of cumulative impacts in determining whether a project complies with the significant degradation prohibition of 40 CFR 230.10(c). The Guidelines state that "cumulative effects attributable to the discharge of dredged or fill material…should be predicted to the extent reasonable and practical." 40 CFR 230.11(g)(2). The Guidelines describe "cumulative effects" as:

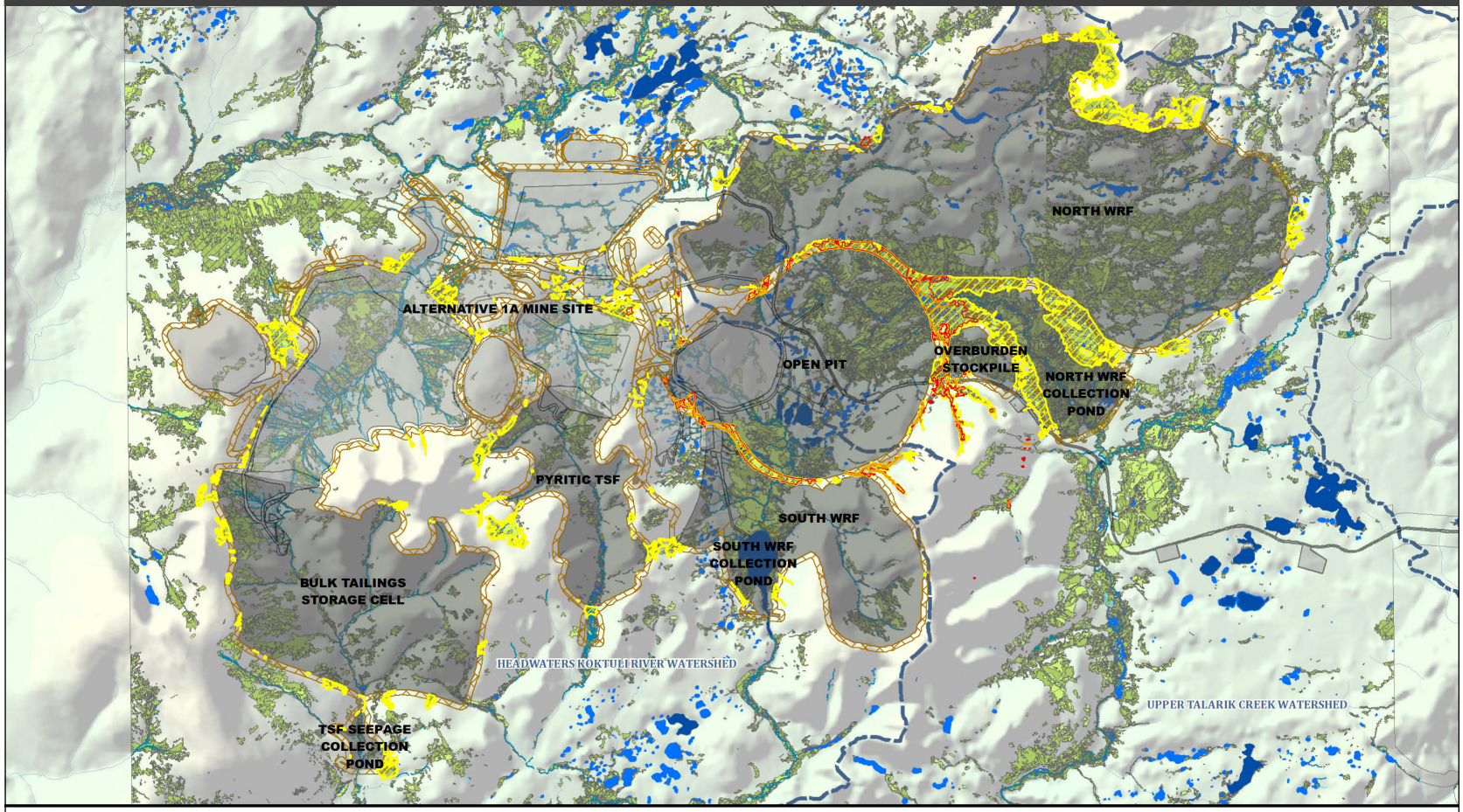
> The changes in an aquatic ecosystem that are attributable to the collective effect of a number of individual discharges of dredged or fill material. Although the impact of a particular discharge may constitute a minor change in itself, the cumulative effect of numerous such piecemeal changes can result in a major impairment of the water resources and interfere with the productivity and water quality of existing aquatic ecosystems. (40 CFR 230.11(g)(1))

USACE considered expansion of the 2020 Mine Plan (hereafter the Expanded Mine Scenario) a reasonably foreseeable future action and, therefore, evaluated the Expanded Mine Scenario for cumulative effects during its CWA Section 404 permitting process (Figure 4-12) (USACE 2020a: Section 4.1).[84] PLP's 2021 Preliminary Economic Assessment evaluated mine expansion as part of its projected production economics (Kalanchey et al. 2021), indicating that mine expansion continues to be reasonably foreseeable. The Expanded Mine Scenario is not part of the 2020 Mine Plan, has not otherwise been proposed, and would require additional and separate permitting (USACE 2020a: Section 4.1, PLP 2018c: RFI 062). Therefore, it is not a basis for this final determination.

EPA has concluded that the direct and secondary effects of the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, as well as discharges that would result in effects similar or greater in nature and magnitude to the 2020 Mine Plan, would result in significant degradation under the CWA Section 404(b)(1) Guidelines. However, the Guidelines also require EPA to evaluate cumulative effects.

[84] For the purposes of the FEIS, "cumulative effects are interactive, synergistic, or additive effects that would result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions (RFFAs) regardless of what agency (federal or non-federal) or person undertakes those other actions (40 CFR 1508.7)" (USACE 2020a: Page 4.1-3).

Figure 4-12. Mine site cumulative impacts under the Expanded Mine Scenario. Figure 4.22-5 from the FEIS (USACE 2020a: Section 4.22)



Under the Expanded Mine Scenario, approximately 8.6 billion tons of ore would be mined (Kalanchey et al. 2021) over 58 years, with additional milling occurring over another 20 to 40 years, for a total of 78 to 98 years of additional activity at the mine site (USACE 2020a: Table 4.1-2). The Expanded Mine Scenario would use infrastructure included in the 2020 Mine Plan, such as the transportation facilities, power plant, and natural gas pipeline facilities, but would include a larger open pit; development of additional tailings storage, water storage, and waste rock storage facilities; and a concentrate pipeline and deepwater loading facility (USACE 2020a: Section 4.1).

The following subsections evaluate the cumulative effects on fishery areas associated with the mine site of the 2020 Mine Plan and the Expanded Mine Scenario. The following analysis does not consider associated facilities and transportation corridors.

4.3.1.2.1 Cumulative Effects of Loss of Anadromous Fish Streams

As discussed in Section 4.2.1, the 2020 Mine Plan would result in the permanent loss of approximately 8.5 miles (13.7 km) of streams in the NFK watershed with documented occurrence of anadromous fishes, specifically Coho and Chinook salmon. The Expanded Mine Scenario would eliminate an additional 35 miles (56.3 km) of streams in the SFK and UTC watersheds with documented occurrence of anadromous fishes (Figures 4-13 and 4-14) (USACE 2020a: Section 4.24). These additional stream losses represent 25.7 percent of anadromous fish streams across the SFK and UTC watersheds combined.[85] The Expanded Mine Scenario would also result in the complete loss of 544 acres (2.2 km^2) of lakes and ponds with documented anadromous fish use (Giefer and Graziano 2022), including the 150-acre (0.6-km^2) Frying Pan Lake in the SFK watershed. Frying Pan Lake, which would be inundated by the south collection pond, provides rearing habitat for Sockeye Salmon, Arctic Grayling, Northern Pike, whitefish, stickleback, and sculpin. Across the SFK, NFK, and UTC watersheds, the Expanded Mine Scenario would cause losses to documented Sockeye, Coho, Chinook, and Chum salmon habitats (Table 4-6) (USACE 2020a: Section 4.24).

The 2020 Mine Plan and the Expanded Mine Scenario would cumulatively eliminate nearly 33 miles (53.1 km) of documented Coho Salmon habitat, 13.7 miles (22 km) of documented Chinook Salmon habitat, and 7.8 miles (12.6 km) of documented Sockeye Salmon habitat across the SFK, NFK, and UTC watersheds. Each species would lose both spawning and rearing habitat (Table 4-6). The 2020 Mine Plan and the Expanded Mine Scenario would also cumulatively eliminate 1.6 miles (2.6 km) of Chum Salmon habitat across the three watersheds.

Eliminated and dewatered habitat likely would permanently lose the ability to support salmon. As discussed for the NFK watershed in Section 4.2.1, the substantial spatial and temporal extent of stream habitat losses under the Expanded Mine Scenario would also reduce the overall capacity and productivity of Coho, Chinook, and Sockeye salmon in the SFK and UTC watersheds. The genetic structure of these populations varies across fine spatial scales, and such extensive habitat losses within

[85] The SFK watershed contains 60.0 miles of anadromous waters and the UTC watershed contains 76.2 miles of anadromous waters, based on AWC and PLP stream layers (USACE 2020a: Section 3.24).

these three watersheds would adversely affect genetically distinct populations of Sockeye Salmon in the Koktuli River (including the SFK and NFK) and the UTC, as well as Coho and Chinook salmon populations in these watersheds that may be uniquely adapted to the spatial and temporal conditions of their natal streams (Section 3.3.1). Coho Salmon may be particularly susceptible to extirpation through the loss of such populations (Olsen et al. 2003). Losses of small Chinook Salmon populations with diverse life histories have been reported in other regions (Lindley et al. 2009), with resulting impacts on overall population resilience (Healey 1991). Because Coho and Chinook salmon are the rarest of the Pacific salmon species, losses that eliminate unique local populations could result in the loss of significant amounts of overall genetic variability. The extensive habitat losses associated with the Expanded Mine Scenario would likely put such populations at risk.

The loss of 8.5 miles (13.7 km) of documented anadromous fish streams associated with the 2020 Mine Plan would already represent an unprecedented loss of documented anadromous fish streams in the context of the CWA Section 404 regulatory program in Alaska (Section 4.2.1). The loss of an additional 35 miles (56.3 km) of documented anadromous fish streams associated with the Expanded Mine Scenario would represent an extraordinary loss of anadromous fish habitat, which would be compounded by the complete loss of 544 acres (2.2 km^2) of lakes and ponds with documented anadromous fish use, including the destruction of the 150-acre (0.6-km^2) Frying Pan Lake.

Table 4-6. Anadromous stream habitat that would be permanently lost in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds under the 2020 Mine Plan plus the Expanded Mine Scenario.

Species	Life History / Habitat	Length of Stream (miles) by Watershed [a]			
		SFK	NFK	UTC	TOTAL [b]
Coho Salmon	Spawning	0.4	3.7	9.2	13.4
	Rearing	8.0	7.1	16.9	32.0
	Present	1.3	-	0.4	1.7
	Total Lost Habitat	8.0	7.1	17.8	32.8
Chinook Salmon	Spawning	-	-	3.6	3.6
	Rearing	2.7	2.3	6.6	12.4
	Present	-	1.4	2.7	3.3
	Total Lost Habitat	2.7	3.7	7.3	13.7
Sockeye Salmon	Spawning	-	-	4.8	4.8
	Rearing	1.6	-	3.7	5.3
	Present	-	-	1.1	1.1
	Total Lost Habitat	1.6	-	6.2	7.8
Chum Salmon	Spawning	-	-	0.5	0.5
	Present	1.2	-	-	1.2
	Total Lost Habitat	1.2	-	0.5	1.6

Notes:

[a] From the Anadromous Waters Catalog (Giefer and Graziano 2022).

[b] Salmon habitat types overlap and may be coincident, so these numbers cannot be added together.

Figure 4-13. Streams, rivers, and lakes with documented salmon use overlain with the footprints of the Pebble 2020 Mine Plan and the Expanded Mine Scenario. Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).

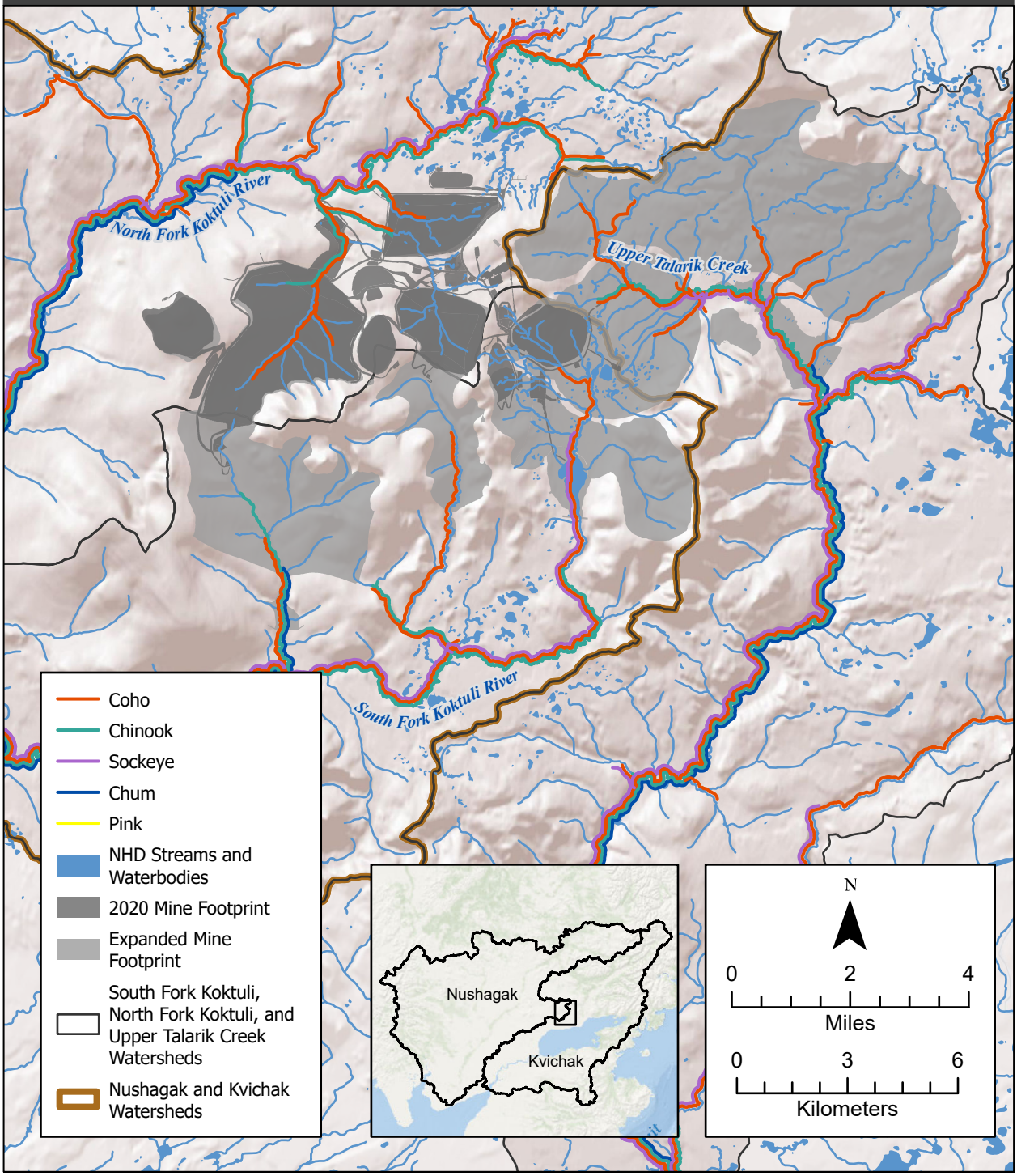
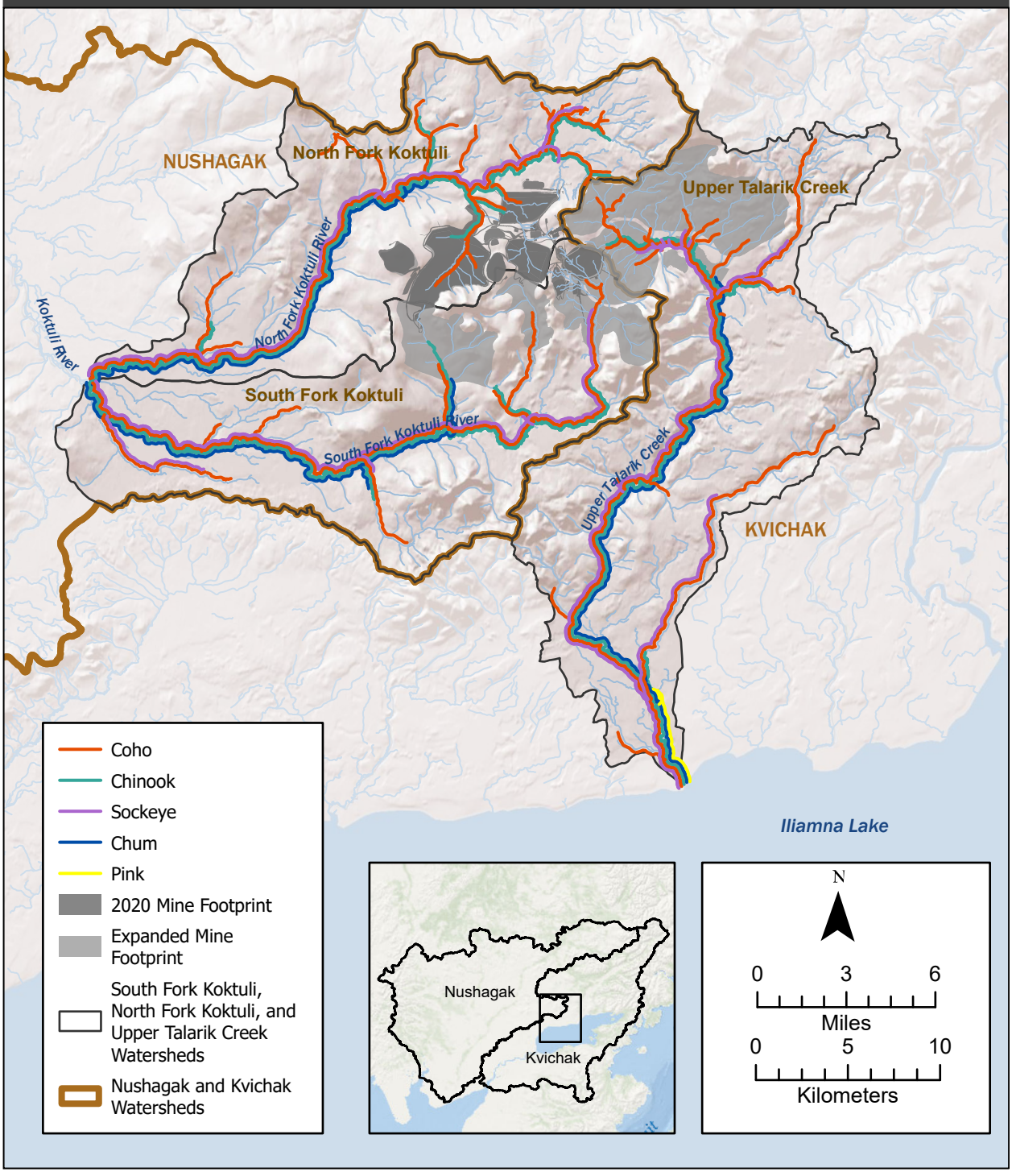


Figure 4-14. Streams, rivers, and lakes with documented salmon use in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan and Expanded Mine Scenario. Species distributions are based on the Anadromous Waters Catalog (Giefer and Graziano 2022).



4.3.1.2.2 Cumulative Effects of Loss of Additional Streams that Support Anadromous Fish Streams

As discussed in Sections 4.2.1 and 4.2.2, the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would eliminate 8.5 miles (13.7 km) of anadromous fish streams and 91 miles (147 km) of additional streams that support anadromous fish streams. The discharge of dredged or fill material for the Expanded Mine Scenario would eliminate 35 additional miles (56.3 km) of anadromous fish streams and result in the permanent loss of 295.5 miles (475.6 km) of additional streams that support downstream anadromous fish streams across the SFK and UTC watersheds, most of which would be perennial streams (USACE 2020a: Table 4.22-40). These permanent losses would substantially increase adverse impacts on anadromous fishes in the SFK and UTC watersheds (USACE 2020a: Section 4.22). Many of the eliminated streams likely contain anadromous fish habitat that has not yet been documented (Sections 3.2.4 and 4.2.1) but may be particularly valuable for juvenile salmonids. The unprecedented habitat losses in the SFK and UTC watersheds that would result from the Expanded Mine Scenario would exacerbate any unacceptable adverse effects on salmon and other fish populations caused by the 2020 Mine Plan.

Rainbow Trout, Dolly Varden, Arctic Grayling, Northern Pike, Ninespine Stickleback, and Slimy Sculpin also would lose additional habitat under the Expanded Mine Scenario (Figures 4-15 through 4-18). The Expanded Mine Scenario would eliminate Rainbow Trout habitat beyond the NFK watershed and include losses in the UTC watershed (Figures 4-15 and 4-17). The Expanded Mine Scenario would eliminate Dolly Varden habitat beyond the NFK watershed and include losses in the SFK and UTC watersheds (Figures 4-15 and 4-17). The Expanded Mine Scenario would increase habitat losses for Arctic Grayling, Northern Pike, Ninespine Stickleback, and Slimy Sculpin in the SFK watershed. The Expanded Mine Scenario would also eliminate habitat for Arctic Grayling, Ninespine Stickleback, and Slimy Sculpin in the UTC watershed (Figures 4-15 through 4-18). In addition to direct habitat losses, increased loss of stream habitat under the Expanded Mine Scenario would substantially alter streamflows and other ecological subsidies provided to downstream fish habitats in the SFK and UTC watersheds (Figures 4-14 and 4-18). Associated reductions in streamflow to downstream fishery areas would likely reduce the extent and frequency of stream connectivity to off-channel habitats, as well as alter the thermal regimes of downstream habitats (Section 4.2.4). These habitats also would no longer support or export macroinvertebrates, an important food source for juvenile salmon and other fish species.

Figure 4-15. Reported Arctic Grayling, Rainbow Trout, and Dolly Varden occurrence overlain with the footprints of the Pebble 2020 Mine Plan and the Expanded Mine Scenario. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).

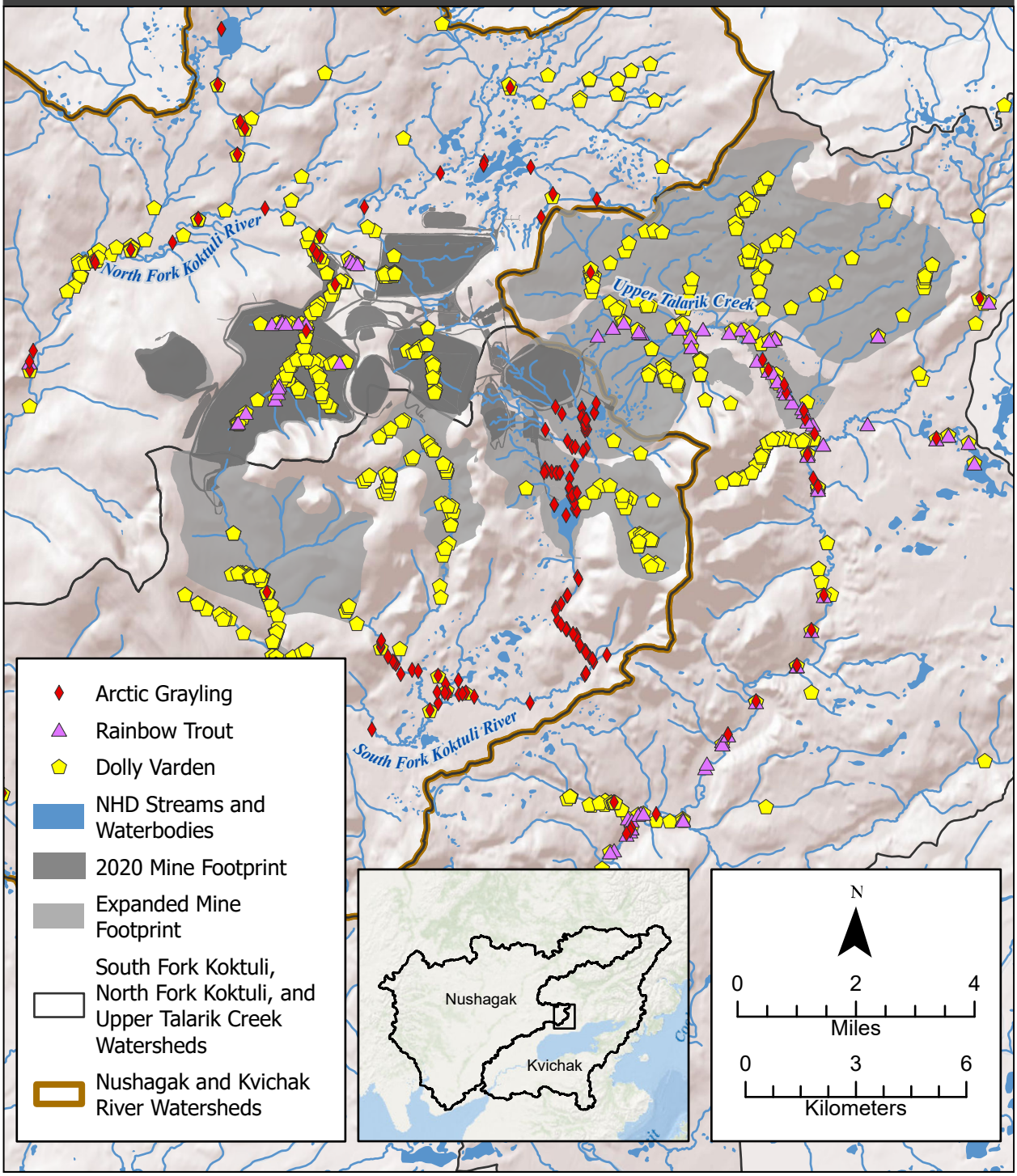


Figure 4-16. Reported occurrence of other resident fish species overlain with the footprints of the Pebble 2020 Mine Plan and the Expanded Mine Scenario. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).

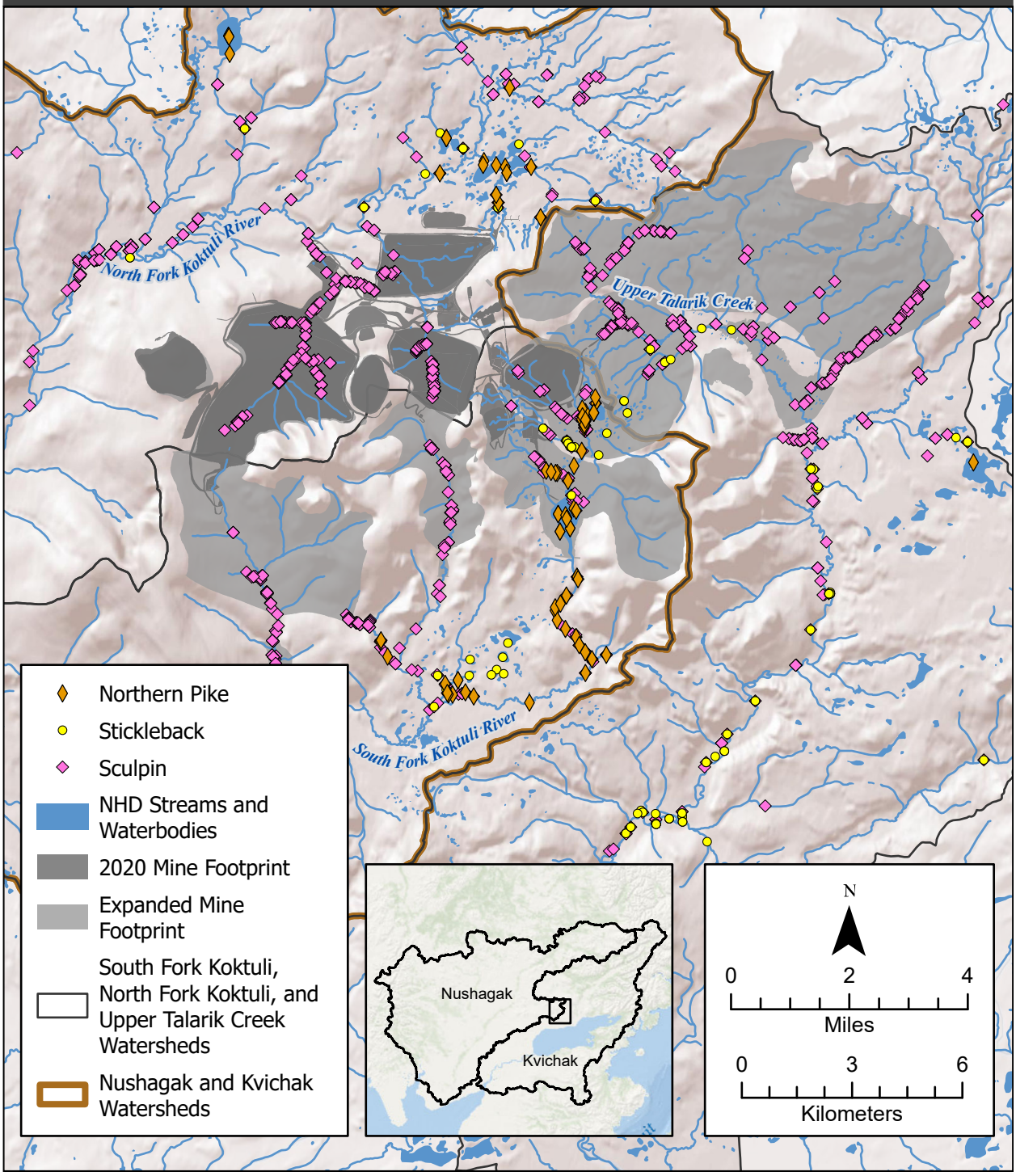


Figure 4-17. Reported Arctic Grayling, Rainbow Trout, and Dolly Varden occurrence in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan and Expanded Mine Scenario. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).

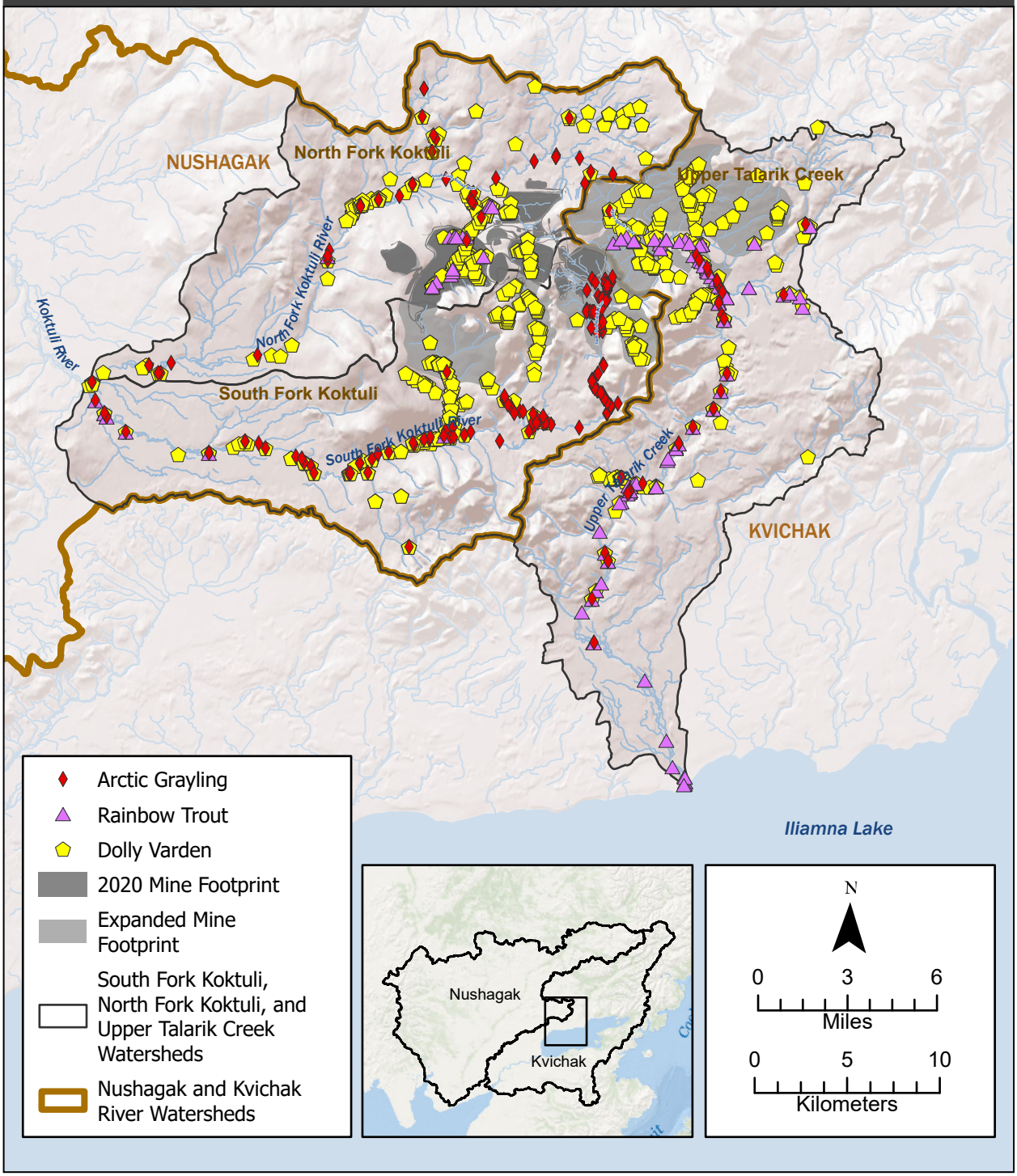
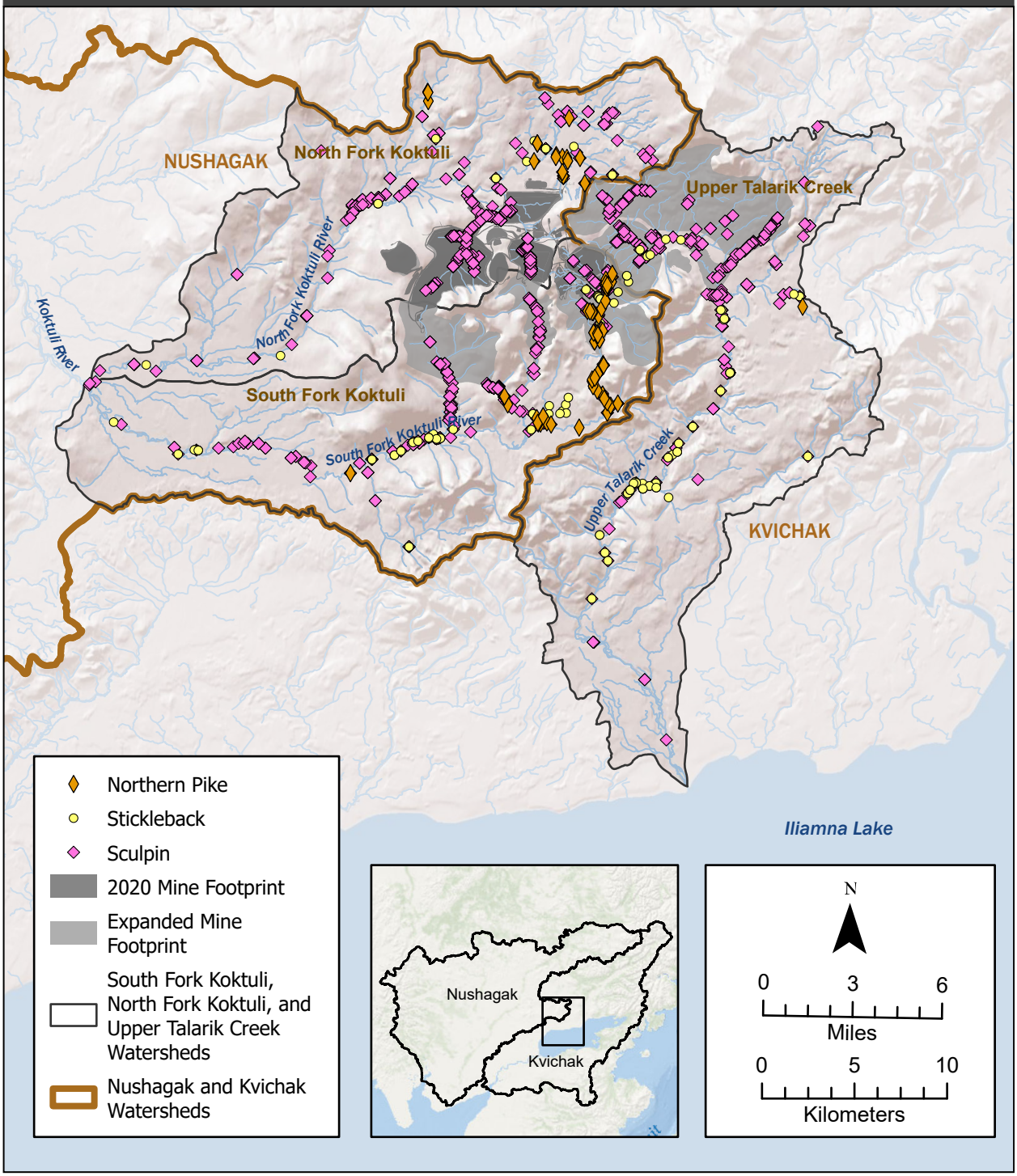


Figure 4-18. Reported occurrence of other non-salmon fish species in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2020 Mine Plan and Expanded Mine Scenario. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2022a).



4.3.1.2.3 Cumulative Effects of Loss of Wetlands and Other Waters that Support Anadromous Fish Streams

In addition to the 2,108 acres (8.5 km^2) of wetlands and other waters that would be permanently lost under the 2020 Mine Plan, the Expanded Mine Scenario would result in the permanent loss of an additional 8,756 acres (35.4 km^2) of wetlands and other waters in the SFK and UTC watersheds, primarily affecting broad-leaved deciduous shrub and herbaceous type wetlands (Figure 4-12) (USACE 2020a: Table 4.22-40). The greatest losses of wetlands and other waters under the Expanded Mine Scenario would occur in the Headwaters Koktuli River (i.e., the SFK, NFK, and Middle Koktuli River HUC-12 watersheds) and UTC watersheds, with losses of wetlands and other waters in these watersheds increasing from 6 percent[86] under the 2020 Mine Plan to 23 percent (USACE 2020a: Section 4.22). The unprecedented loss of thousands of acres of wetlands under the Expanded Mine Scenario would eliminate nutrient-rich, structurally complex, and thermally and hydraulically diverse habitats, including crucial overwintering areas, that are essential to rearing salmonids (EPA 2014: Chapter 7). Coho, Chinook, Sockeye, and Chum salmon would be adversely affected under the Expanded Mine Scenario (Figures 4-13 and 4-14). The Expanded Mine Scenario would also result in a loss or reduction of water, nutrient, detritus, and macroinvertebrate exports to downstream areas, the losses of which would affect downstream food webs. These losses, of an even greater scope and scale than losses anticipated from the 2020 Mine Plan, would reduce the overall capacity and productivity of Coho, Chinook, Sockeye, and Chum salmon across the SFK, NFK, and UTC watersheds.

In addition to salmon, Rainbow Trout, Arctic Grayling, and Northern Pike rear in these wetland areas; Northern Pike also spawn in these habitats (Figures 4-15 and 4-16). These species support both subsistence and recreational fisheries in downstream areas. Because these species can move significant distances across diverse freshwater habitats throughout their life cycles, large losses of wetland rearing habitat could adversely affect these downstream fisheries.

4.3.1.2.4 Cumulative Effects of Additional Degradation of Streams, Wetlands, and Other Waters Beyond the Mine Site Footprint

The 2020 Mine Plan would be expected to degrade additional wetlands, streams, and other waters beyond the mine site footprint due to dewatering, fragmentation, and fugitive dust. These secondary effects of the discharge of dredged or fill material from construction and routine operation of the 2020 Mine Plan would result in adverse impacts to approximately 845 additional acres of wetlands and other waters (3.4 km^2) and 29.9 miles (48.1 km) of streams at the mine site (PLP 2020b, USACE 2020b). Impacts from dewatering, fragmentation, and fugitive dust would increase under the Expanded Mine Scenario and further reduce the quality and extent of fish habitats in the SFK and UTC watersheds (USACE 2020a: Section 4.22).

Under the Expanded Mine Scenario, aquatic resources could experience multiple secondary impacts, resulting in overlap in the area or miles affected when accounting for the effects of dewatering, habitat

[86] In its comments on the proposed determination, PLP indicated that following publication of the FEIS it provided information to USACE that this value is 4.8 percent based on updated mapping results.

fragmentation, and fugitive dust deposition individually. After correcting for this overlap, the Expanded Mine Scenario would adversely affect an additional 1,829 acres (7.4 km^2) of wetlands and other waters and 17 miles (27.4 km) of streams at the mine site from dewatering, habitat fragmentation, and fugitive dust. The following discussion considers these secondary impacts individually, without adjusting for overlap (USACE 2020a: Table 4.22-40).

Dewatering associated with the Expanded Mine Scenario would impact 338 acres (1.4 km^2) of wetlands and other waters and 3.2 miles (5.1 km) of streams (USACE 2020a: Table 4.22-40). Dewatering of wetlands and other waters causes the alteration or loss of wetland hydrology and may result in the conversion of habitats to more mesic types. Drawdown of groundwater is expected primarily around the open pit due to dewatering activities, but would also occur around quarries, TSFs, and WMPs due to diversions and drainage/underdrain systems. Altered saturated surface flow and shallow interflow resulting from a depression of the groundwater table is expected to adversely affect wetlands, surface waters, and vegetation in the drawdown area (USACE 2020a: Section 4.22). Dewatering impacts to slope wetlands (which constitute the majority of wetland acres impacted at the mine site) would be severe and "[d]ue to the groundwater storage and organic matter production and nutrient cycling capacity of slope wetlands, their loss would likely reduce the functional capacity of the watershed to maintain downstream baseflows, as well as reducing the subsidy of organic matter and nutrients to downstream aquatic ecosystems and organisms" (USACE 2020a: Page 4.22-30). Dewatering represents a secondary but permanent impact to streams, wetlands, and other waters (USACE 2020a: Section 4.22).

Fragmentation associated with the Expanded Mine Scenario would affect 1,538 acres (6.2 km^2) of wetlands and other waters and 8.4 miles (13.5 km) of streams (USACE 2020a: Table 4.22-40). This represents a nearly 600 percent increase in fragmentation impacts on wetlands and other waters and a 91 percent increase in fragmentation impacts on streams when compared to the 2020 Mine Plan. Fragmentation of wetlands and other waters results when development divides a formerly continuous aquatic resource into smaller, more isolated remnants. Habitat fragmentation represents a secondary but permanent impact on wetlands, streams, and other waters (USACE 2020a: Section 4.22). Decreased connectivity of aquatic ecosystems could preclude the completion of aquatic organisms' life cycles; for example, anadromous fish may be unable to reach spawning grounds or access off-channel habitat (USACE 2020a: Section 4.22). For anadromous fishes, the most severe form of fragmentation occurs when discontinuities are created that either separate an aquatic habitat (stream, wetland, lake, or pond) or complex of aquatic habitats from the tributary network in such a way that precludes use (e.g., spawning, rearing, feeding, migration, overwintering) by anadromous fish species and life stages documented to occur in the habitat or eliminate the movement of water or dissolved or suspended materials to downstream anadromous fish streams (Box 4-1).

Fragmentation of stream channels and adjacent wetlands without hydrologic surface connections are expected to result in a complete loss of function. Partial loss of function would be expected for other types of wetlands, such as slope and depressional wetlands, which would likely become drier due to the diversion of shallow groundwater and surface water and the reduction of catchment areas (USACE 2020a: Section 4.22). Habitat fragmentation would likely reduce the functional capacity of the

watershed to maintain downstream baseflows, as well as reduce subsidies of organic matter and nutrients to downstream aquatic ecosystems and organisms (USACE 2020a: Section 4.22).

Fugitive dust associated with the Expanded Mine Scenario would affect 1,093 acres (4.4 km^2) of wetlands and other waters and 15 miles (24.1 km) of streams (USACE 2020a: Table 4.22-40). Fugitive dust would be produced from ground-disturbing actions during construction, operations, and closure, and from wind or vehicle dispersal of exposed soil in the post-closure period (USACE 2020a: Section 4.22). Fugitive dust has the potential to collect on wetland vegetation and accumulate in waters, with adverse consequences for plant physiology, water quality, biotic community composition, and the overall function and value of wetlands, streams, and other waters (USACE 2020a: Section 4.22). The majority of the potentially affected wetlands at the mine site are particularly susceptible to the adverse effects of dust deposition because of their vegetation type and structure (USACE 2020a: Section 4.22).

4.3.1.1.3 Summary

EPA has determined that direct and secondary effects of the discharge of dredged or fill material from construction and routine operation of the 2020 Mine Plan would result in significant degradation under the CWA Section 404(b)(1) Guidelines. Additionally, EPA has determined that direct and secondary effects of the discharge of dredged or fill material associated with future proposals to construct and operate a mine at the Pebble deposit that would result in adverse effects that are the same, similar, or greater than the adverse effects of the 2020 Mine Plan would also result in significant degradation under the CWA Section 404(b)(1) Guidelines (40 CFR 230.10(c), Section 4.3.1.1). These findings are based on the significantly adverse effects that the discharge of dredged or fill material would have on special aquatic sites, life stages of anadromous fishes, anadromous fish habitat, and aquatic ecosystem diversity, productivity, and stability under the CWA Section 404(b)(1) Guidelines.

The Expanded Mine Scenario represents a reasonably foreseeable expansion of mine size over time, from 1.3 billion tons up to 8.6 billion tons. This expansion would dramatically increase the amount of destruction and degradation of anadromous fishery areas in the SFK, NFK, and UTC watersheds, including a more than 400 percent increase in the length of anadromous fish streams permanently lost. There are no examples of other projects resulting in this level of permanent loss of anadromous fish streams in the CWA Section 404 regulatory program in Alaska; thus, there are no analogous Section 404 permitting cases with which to make any meaningful comparisons.

In addition to the losses estimated for the 2020 Mine Plan, estimated impacts of the Expanded Mine Scenario include the permanent loss of an additional 35 miles (56.3 km) of documented anadromous fish streams, an additional 295.5 miles (475.6 km) of streams that support anadromous fish streams, and an additional 8,756 acres (35.4 km^2) of wetlands and other waters across the SFK and UTC watersheds (USACE 2020a: Table 4.22-40). These losses would represent extraordinary and unprecedented levels of anadromous fish habitat loss and degradation, significantly expanding the unacceptable adverse effects identified for the 2020 Mine Plan.

Secondary effects of the discharge of dredged or fill material from construction and routine operation of the 2020 Mine Plan would result in adverse impacts to approximately 845 acres (3.4 km^2) of wetlands and other waters and 29.9 miles (48.1 km) of streams at the mine site from dewatering, habitat fragmentation, and fugitive dust (PLP 2020b, USACE 2020b). The FEIS estimates that these secondary effects of the discharge of dredged or fill material from the construction and routine operation of the Expanded Mine Scenario would adversely affect an additional approximately 1,829 acres (7.4 km^2) of wetlands and other waters and 17 miles (27.4 km) of streams at the mine site (USACE 2020a: Table 4.22-40) and would further reduce the quality and extent of anadromous fish habitat in the SFK and UTC watersheds.

The losses of and impacts on salmon habitat could cause the extirpation of unique local populations of Coho, Sockeye, and Chinook salmon that would affect the overall genetic diversity of each species. This reduction in genetic diversity could adversely affect the stability and sustainability of valuable subsistence, commercial, and recreational salmon fisheries. Subsistence harvests and recreational fishing of non-salmon species could also suffer. For example, Rainbow Trout, Dolly Varden, and Northern Pike are found in the affected waters, and would experience additional habitat losses due to mine expansion.

Species with extended freshwater rearing periods, such as Coho, Chinook, and Sockeye salmon, are more likely to be extinct, endangered, or threatened than species that spend less time in freshwater habitats (NRC 1996, Gustafson et al. 2007). Therefore, the losses and degradation of discrete, productive freshwater habitats for salmon estimated under the Expanded Mine Scenario could threaten multiple distinct populations of species such as Coho, Chinook, and Sockeye salmon. Losses of these populations would degrade the overall stability of fisheries within the SFK, NFK, and UTC watersheds. Ultimately, cumulative effects on streams, wetlands, and other aquatic resources from the discharge of dredged or fill material associated with the Expanded Mine Scenario would impair the health of the SFK, NFK, and UTC watersheds and cause or contribute to significant degradation (40 CFR 230.10(c)) of the watersheds' fishery areas.

4.3.2 Compensatory Mitigation Evaluation

EPA has determined that certain discharges of dredged or fill material into waters of the United States for the construction and routine operation of the 2020 Mine Plan will have unacceptable adverse effects on anadromous fishery areas (Sections 4.2.1 through 4.2.4). EPA has also determined that discharges of dredged or fill material associated with the development of the Pebble deposit anywhere at the mine site area within the SFK and NFK watersheds that would result in the same or greater levels of loss or streamflow changes as the 2020 Mine Plan also will have unacceptable adverse effects on anadromous fishery areas in these watersheds, because such discharges would involve the same aquatic resources characterized as part of the evaluation of the 2020 Mine Plan. Further, EPA has determined that discharges of dredged or fill material associated with future plans to develop the Pebble deposit will have unacceptable adverse effects on anadromous fishery areas in the SFK, NFK, and UTC watersheds if

the effects of such discharges are similar or greater in nature and magnitude to those described in Sections 4.2.1 through 4.2.4.

The CWA Section 404(b)(1) Guidelines direct that no discharge of dredged or fill material shall be permitted unless all appropriate and practicable steps have been taken to minimize and compensate for the project's adverse impacts on the aquatic ecosystem (40 CFR 230.10(d)). Discharges of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would have extensive unavoidable adverse impacts to aquatic resources that would require compensatory mitigation (USACE 2020b).

Under Section 404(c) of the CWA, EPA has discretionary authority to deny or restrict the use of any defined area as a disposal site "whenever" it determines that the discharge of dredged or fill material will have an unacceptable adverse effect on statutorily enumerated aquatic resources. The statutory standard does not direct EPA to consider mitigation when determining what constitutes an unacceptable adverse effect, nor restrict EPA to exercising its authority unless and until EPA has before it a USACE permit identifying required mitigation. EPA's regulations provide that "[i]n evaluating the unacceptability of such impacts, consideration should be given to the relevant portions of the section 404(b)(1) guidelines" (40 CFR 231.2). EPA does not view the mitigation provisions to be a relevant portion of the Guidelines that should be considered in determining unacceptability in this circumstance because there is no permit requiring mitigation and, in fact, USACE expressly rejected PLP's proposed mitigation.

Nonetheless, although not required, EPA evaluated the two compensatory mitigation plans (CMPs) PLP submitted to USACE in 2020. As described in Section 4.3.2.2, both plans fail to adequately mitigate the adverse effects that are the subject of this final determination to an acceptable level.

In addition to the two CMPs PLP proposed to USACE in 2020, during development and finalization of the 2014 BBA, PLP and other commenters suggested an array of measures as having the potential to compensate for the nature and magnitude of adverse impacts on wetlands, streams, and fishes from the discharge of dredged or fill material associated with developing the Pebble deposit. EPA evaluated the numerous additional measures that PLP and others proposed prior to issuing the 2014 Proposed Determination. During the public comment period for the 2014 Proposed Determination, several commenters, including PLP, suggested additional measures as having the potential to compensate for the nature and magnitude of adverse impacts on aquatic resources from the discharge of dredged or fill material associated with developing the Pebble deposit.

PLP did not propose such measures to USACE during the CWA Section 404 permit review process. EPA provides, for informational purposes, an updated evaluation of these measures in Appendix C. Available information demonstrates that known compensation measures are unlikely to adequately mitigate effects described in this final determination to an acceptable level.

Neither PLP, the State of Alaska, USACE, nor any other party suggested any additional compensation measures during (1) the initial stakeholder consultation with EPA prior to issuance of the 2022

Proposed Determination, (2) the public comment period on the 2022 Proposed Determination, or (3) final consultation on the recommended determination in December 2022.

4.3.2.1 Overview of Compensatory Mitigation Requirements

Compensatory mitigation refers to the restoration, establishment, enhancement, and/or in certain circumstances preservation of wetlands, streams, or other aquatic resources. Compensatory mitigation regulations jointly promulgated by EPA and USACE state that "the fundamental objective of compensatory mitigation is to offset environmental losses resulting from unavoidable impacts to waters of the United States authorized by [Clean Water Act Section 404 permits issued by the USACE]" (40 CFR 230.93(a)(1)). Compensatory mitigation enters the analysis only after a proposed project design has incorporated all appropriate and practicable means to avoid and minimize adverse impacts on aquatic resources (40 CFR 230.91(c)).

4.3.2.2 Review of Compensatory Mitigation Plans Submitted by the Pebble Limited Partnership

During the permit review process, PLP submitted two CMPs in an effort to address the project's unavoidable aquatic resource impacts, the first in January 2020 (PLP 2020a) and the second in November 2020 (PLP 2020c). Provided in this section is a discussion of both CMPs and why they failed to adequately address the unacceptable adverse effects that are the subject of this final determination.

Consistent with the CWA Section 404(b)(1) Guidelines, PLP first evaluated whether its project impacts fell within the service area(s)[87] of an approved mitigation bank or in-lieu fee program with appropriate credits available when developing its CMPs. Because mitigation bank and in-lieu fee program options were not available, both of PLP's CMPs involved permittee-responsible compensatory mitigation proposals.[88]

4.3.2.2.1 January 2020 Compensatory Mitigation Plan

PLP's January 2020 CMP included the following three components (PLP 2020a):

1. Improvements to wastewater collection and treatment systems in three villages in the Kvichak River watershed.
2. Rehabilitation of 8.5 miles (13.7 km) of salmon habitat through replacement or removal of some number of unidentified culverts.
3. One-time clean-up of 7.4 miles (11.9 km) of coastal habitat on Kamishak Bay (Cook Inlet).

In an August 20, 2020 letter to PLP, USACE stated "that discharges at the mine site would cause unavoidable adverse impacts to aquatic resources and, preliminarily, that those adverse impacts would

[87] The service area is the watershed, ecoregion, physiographic province, and/or other geographic area within which the mitigation bank or in-lieu fee program is authorized to provide compensatory mitigation (40 CFR 230.98(d)(6)(ii)(A)).

[88] Permittee-responsible mitigation means an aquatic resource restoration, establishment, enhancement, and/or preservation activity undertaken by the permittee to provide compensatory mitigation for which the permittee retains full responsibility (40 CFR 230.92).

result in significant degradation to those aquatic resources" (USACE 2020c: Page 1). Because of its concerns that adverse impacts at the mine site would not be adequately mitigated by the January 2020 CMP, USACE "determined that in-kind compensatory mitigation within the Koktuli River watershed will be required to compensate for all direct and indirect [secondary] impacts caused by discharges into aquatic resources at the mine site" (USACE 2020c: Page 1). In its letter, USACE requested that PLP submit a new CMP that would (1) comply with all requirements of the compensatory mitigation regulations, (2) be "sufficient to offset the unavoidable adverse impacts to aquatic resources" (USACE 2020c: Page 2), and (3) "overcome significant degradation at the mine site" (USACE 2020c: Page 2).

EPA shares USACE's concerns regarding the nature and magnitude of the adverse effects on aquatic resources in the Koktuli River watershed that would result from discharges of dredged or fill material at the mine site. Like USACE, EPA also identified deficiencies in the January 2020 CMP. As discussed here, EPA also does not believe that the January 2020 CMP adequately mitigates the adverse effects of the 2020 Mine Plan that are the subject of this final determination to an acceptable level.

- **Improvements to wastewater collection and treatment systems in three villages in the Kvichak River watershed.** Ninety-four percent of the 2020 Mine Plan's impacts on wetlands, streams, and other aquatic resources occur in the Koktuli River watershed. However, all of these infrastructure projects would occur in other watersheds, and none would address the substantial impacts in the Koktuli River watershed that are the subject of this final determination.[89] Further, such wastewater infrastructure projects would not qualify as acceptable compensatory mitigation under the regulations.[90]

- **Rehabilitation of 8.5 miles (13.7 km) of salmon habitat through replacement or removal of some number of unidentified culverts.** The Koktuli River watershed is an almost entirely roadless area and, thus, offers few, if any, viable culvert replacement or removal opportunities (none are identified in the January 2020 CMP). Therefore, to the extent that such a component would provide any environmental benefits, those benefits would not approach the level necessary to reduce the adverse effects from the discharges of dredged or fill material associated with the 2020 Mine Plan that are the subject of this final determination to an acceptable level.[91]

- **One-time clean-up of 7.4 miles (11.9 km) of coastal habitat on Kamishak Bay (Cook Inlet).** Like the proposed wastewater infrastructure projects, this component does nothing to address the substantial impacts in the Koktuli River watershed that are the subject of this final determination. This component is not even located in the larger Bristol Bay watershed. Further, to the extent that this component provides an environmental benefit, it would be *temporary* and would not address

[89] None of these infrastructure projects would occur in the UTC watershed either, and thus would not address any substantial impacts in that watershed as well.

[90] Such infrastructure construction projects do not meet the definition of compensatory mitigation, which can only occur through four methods: aquatic resource restoration, establishment, enhancement, or in certain circumstances, preservation (40 CFR 230.93(a)(2)).

[91] The UTC watershed is also an almost entirely roadless area, thus this compensation measure would suffer from the same deficiencies if it were applied to address impacts in the UTC watershed.

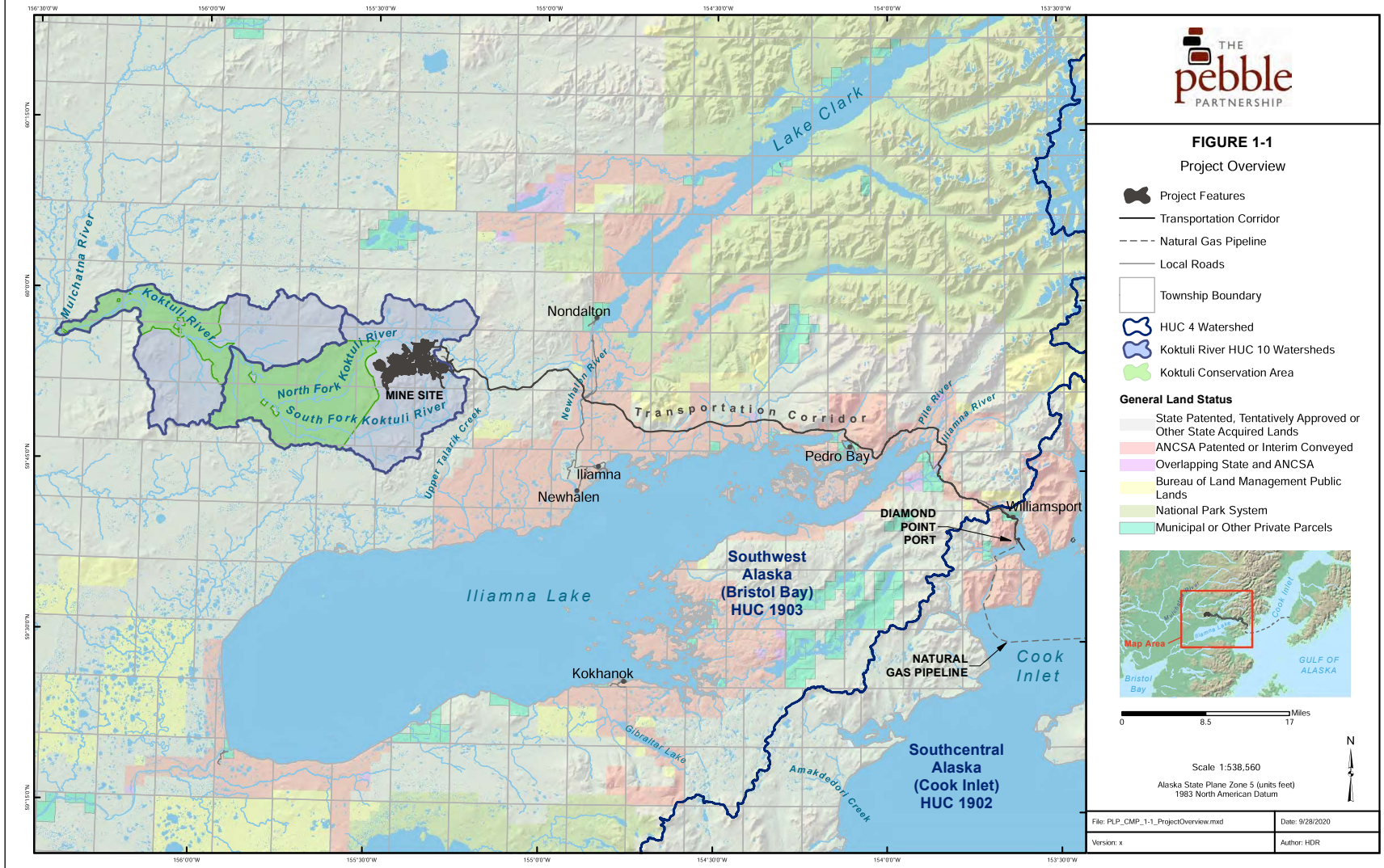
the nature and magnitude of the *permanent* aquatic resource losses at the mine site from construction and routine operation of the 2020 Mine Plan.[92]

4.3.2.2.2 November 2020 Compensatory Mitigation Plan

In response to USACE's August 20, 2020 letter, PLP submitted a new CMP in November 2020 that superseded the January 2020 CMP. When evaluating what compensation measures could reduce the severity of the adverse effects estimated for the Koktuli River watershed, PLP ruled out all other potential measures aside from preservation stating that "[r]estoration, establishment, or enhancement projects within the identified watershed are not plentiful enough in size or scale to mitigate for the identified acreage of direct and indirect impacts to be mitigated; therefore, preservation is the only available compensatory mitigation option" (PLP 2020c: Page 6). The November 2020 CMP includes a single component, proposed preservation of 112,445 acres (455.0 km^2) of state-owned land within the Koktuli River watershed, downstream from the mine site (Figure 4-19). The November 2020 CMP proposed to do this by recording a deed restriction that would limit future uses of the land. The proposed "Koktuli Conservation Area" may contain approximately 31,026 acres (125.6 km^2) of wetlands, lakes, and ponds, and 814 miles (1310 km) of streams (PLP 2020c).

[92] Similarly, this compensation measure would fail to address impacts in the UTC watershed for the same reasons—it is not located in the Bristol Bay watershed and, to the extent that this component provides an environmental benefit, it would be *temporary* and would not address the nature and magnitude of the *permanent* aquatic resource losses at the mine site from construction and routine operation of the 2020 Mine Plan.

Figure 4-19. Proposed Koktuli Conservation Area. Figure 1-1 from PLP's November 2020 Compensatory Mitigation Plan (PLP 2020c).



In its ROD, USACE determined that the November 2020 CMP did not overcome significant degradation at the mine site, and that it failed to comply with all requirements of the compensatory mitigation regulations (USACE 2020b). Specifically, the ROD found the following regulatory compliance deficiencies with the November 2020 CMP and provided the following explanation (USACE 2020b: Attachment B6):

> **Lacks Sufficient Detail-Not Compliant:** The level of detail of the mitigation plan is not commensurate with the scale and scope of the impacts. [33 CFR 332.4(c)(1)]
>
> **Preservation Waiver-Not Compliant:** Preservation shall be done in conjunction with aquatic resource restoration, establishment, and/or enhancement activities. This requirement may be waived by the district engineer where preservation has been identified as a high priority using a watershed approach. No restoration, establishment, and/or enhancement were proposed and justification identifying the proposed preservation as a high priority using a watershed approach was not submitted. [33 CFR 332.3(h)(2)]
>
> **Amount of Compensatory Mitigation-Not Compliant:** No compensatory mitigation was proposed by the applicant to offset impacts from the port site. [33 CFR 332.3(f)]
>
> **Site Protection-Not Compliant:** Deed restrictions proposed for 99 years. The goal of 33 CFR 332 is to ensure permanent protection of all compensatory mitigation project sites. Justification not provided as to why a perpetual conservation easement with third-party holder is not practicable. A site protection instrument was not provided; therefore, could not be evaluated. The Final Plan did provide partial deed restriction language; however, the site protection information was not complete, e.g. the Final Plan did not provide the required 60-day advance notification language. No supporting real estate information was submitted; therefore, could not review title insurance, reserved rights, rights-of-way, etc. Baseline information was also not submitted; therefore, could not determine existing disturbances such as roads, culverts, trails, fill pads, etc. USACE cannot enforce the deed restrictions since third-party enforcement rights were not given to USACE. [33 CFR 332.7(a)]
>
> **Maintenance Plan-Not Compliant:** No maintenance plan was submitted. [33 CFR 332.4(c)(8)]
>
> **Performance Standards-Not Compliant:** No ecological performance standards were submitted. Submitted performance standards are administrative in nature, such as the act of monitoring, the act of enforcement, and the act of documentation of the deed restriction requirements. [33 CFR 332.4(c)(9) and 33 CFR 332.5]
>
> **Monitoring-Not Compliant:** One monitoring event is proposed. One event is not sufficient to demonstrate that the compensatory mitigation project has met and maintained performance standards. [33 CFR 332.6]
>
> **Long-Term Management-Not Compliant:** No long-term endowment mechanism was submitted. No supporting information was submitted for cost estimate. Cost estimate did not include items such as capitalization rate, inflationary adjustments, legal defense costs, etc.; therefore, could not determine sufficiency. Long-term manager unclear and unsupported. [33 CFR 332.4(c)(11) and 33 CFR 332.7(d)]
>
> **Financial Assurances-Not Compliant:** No financial assurances were provided. [33 CFR 332.4(c)(13) and 33 CFR 332.3(n)]

Based on its review of the November 2020 CMP, EPA finds that it would not adequately mitigate the adverse effects of the 2020 Mine Plan that are the subject of this final determination to an acceptable level. Deficiencies identified by EPA are as follows:

- **The November 2020 CMP does not qualify as compensatory mitigation under the regulations.** Compensatory mitigation is defined as "the restoration (re-establishment or rehabilitation), establishment (creation), enhancement, and/or in certain circumstances preservation of aquatic resources for the purposes of offsetting unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved" (40 CFR 230.92). The November 2020 CMP "proposes permittee-responsible mitigation in the form of preservation" (PLP 2020c: Page 1). For the proposal to qualify as preservation, it must meet the regulatory definition and requirements for preservation.

  Preservation is defined at 40 CFR 230.92 as "the removal of a threat to, or preventing the decline of, aquatic resources by an action in or near those aquatic resources." Preservation is only allowed when the resources to be preserved "are under threat of destruction or adverse modification" (40 CFR 230.93(h)(1)(iv)). Though PLP would give up mining claims within the proposed Conservation Area, development of those claims was not included in the FEIS, the CWA Section 404(b)(1) evaluation, or the Public Interest Review for the 2020 Mine Plan, and it was not considered for development under the Expanded Mine Scenario. Further, the State of Alaska's MCO 393, issued in 1984, already precludes mining in the Koktuli River and 100 feet of its banks within the proposed Koktuli Conservation Area (Section 2.2.1). The primary "threat of destruction or adverse modification" for the proposed Conservation Area comes from the destruction and degradation of streams, wetlands, lakes, and ponds upstream of the Conservation Area at the proposed mine site for PLP's 2020 Mine Plan.

  As discussed in Sections 4.2 and 4.3, discharges at the mine site for the 2020 Mine Plan would result in a number of significant secondary effects that would degrade aquatic resources downstream of the mine site, including the aquatic resources proposed for preservation in the Conservation Area. For example, Sections 4.2 and 4.3.1.1 describe how aquatic resource losses at the mine site would result in the loss or reduction of water, nutrient, detritus, and macroinvertebrate exports to downstream areas, the losses of which would adversely affect downstream food webs and anadromous fish spawning and rearing habitat.

  The November 2020 CMP would not qualify as preservation because it does not involve "the removal of a threat to, or preventing the decline of, aquatic resources by an action in or near" (40 CFR 230.92) the proposed Conservation Area. Indeed, PLP is seeking to obtain as mitigation credit "preserving" aquatic resources that the record shows would be permanently degraded by its own mine plan.

- **The November 2020 CMP does not meet the higher bar for "permanent protection" of preservation sites under the regulations.** The general provisions for site protection in the regulations provide that the "overall compensatory mitigation project must be provided long-term protection through real

estate instruments or other available mechanisms" (40 CFR 230.97(a)(1)). However, preservation can only be used in "certain circumstances," including when the resources to be preserved would be "*permanently protected* through an appropriate real estate or other legal instrument" (emphasis added) (40 CFR 230.93(h)(1)(iv)). The November 2020 CMP proposes to protect the site by recording a 99-year deed restriction on state lands (PLP 2020c). This arrangement is not permanent, and PLP failed to identify a mechanism that would allow it to record a deed restriction over state-owned lands. PLP cannot restrict the uses of state lands and provided no evidence that the State has agreed to do so.

- **The November 2020 CMP does not adequately mitigate the unacceptable adverse effects from the 2020 Mine Plan to an acceptable level.** As discussed in Sections 4.2 and 4.3.1.1, discharges of dredged or fill material associated with construction and routine operation of the 2020 Mine Plan would result in significant aquatic resource losses and degradation. PLP's November 2020 preservation proposal would not adequately mitigate the adverse effects on anadromous fishery areas to an acceptable level because discharges of dredged or fill material at the mine site would result in secondary effects that would degrade the aquatic resources proposed for preservation and thus would not adequately protect or maintain them. [93]

4.3.2.3 Summary Regarding Compensatory Mitigation Measures

As described in Section 4.2, EPA finds that discharges of dredged or fill material for the construction and routine operation of the 2020 Mine Plan will have unacceptable adverse effects on anadromous fishery areas. EPA evaluated PLP's two compensatory mitigation plans and neither plan adequately mitigates adverse effects described in this final determination to an acceptable level. For informational purposes, EPA also evaluated additional potential compensation measures proposed by PLP and others over the past decade (Appendix C). Available information demonstrates that known compensation measures are unlikely to adequately mitigate effects described in this final determination to an acceptable level (Appendix C).

4.4 Alternative Basis for EPA's Determination

As described in Section 4.1, EPA's longstanding position is that the Agency's determination of "unacceptable adverse effects" under CWA Section 404(c) must be narrowly focused on the significance of adverse effects on the resources enumerated in the statute—municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, and recreational areas. *See* 40 CFR 231.2 ("Unacceptable adverse effect means impact on an aquatic or wetland ecosystem which is likely to result in significant degradation of municipal water supplies (including surface or ground water) or

[93] This proposed preservation in the Koktuli River watershed would also fail to address any impacts that would occur in the UTC watershed because those impacts would be in an entirely different river basin watershed (i.e., the Kvichak River watershed).

significant loss of or damage to fisheries, shellfishing, or wildlife habitat or recreation areas."); 44 Fed. Reg 57,076, at 58,078 (Oct. 9, 1979) ("The term 'unacceptable' in EPA's view refers to the significance of the adverse effect—e.g. is it a large impact and is it one that the aquatic and wetland ecosystem cannot afford."). Under EPA's longstanding position, CWA Section 404(c) does not require the balancing of various adverse and non-adverse factors that are unconnected to the statutory text. *See* 44 Fed. Reg. at 58,078 ("In EPA's view, section 404(c) does not require a balancing of environmental benefits against non-environmental costs such as the benefits of the foregone [*sic*] project.").

The best interpretation of CWA Section 404(c) is that EPA is not required to consider non-environmental costs in making its determination. However, as part of an alternative basis for its action EPA has evaluated those non-environmental costs, including the economic value of the forgone project.

In considering whether the discharges of dredged or fill material evaluated in this final determination will have unacceptable adverse effects on anadromous fishery areas when non-environmental costs are considered, EPA employed a totality-of-the-circumstances analysis to "pay attention to the advantages and disadvantages of [EPA's] decision." *Michigan v. EPA*, 576 U.S. 743, 753 (2015). Under this alternative basis, EPA considered and weighed a broad range of advantages (benefits) and disadvantages (costs), which are described in this final determination and in the document *Consideration of Potential Costs Regarding the Clean Water Act Section 404(c) Final Determination for the Pebble Deposit Area, Southwest Alaska* (EPA 2023b). The Agency has further described its weighing of these considerations in response to public comments (EPA 2023a; see EPA's response to comment 6.F.7). After consideration of the totality of the circumstances, including quantitative and qualitative advantages and disadvantages, EPA has determined that the discharges of dredged or fill material evaluated in this final determination will have unacceptable adverse effects on anadromous fishery areas in the SFK, NFK, and UTC watersheds. To the extent that EPA's alternative basis applies, these conclusions and rationale directly support the prohibition described in Section 5.1 and the restriction described in Section 5.2.

After consideration of the totality of the circumstances, including quantitative and qualitative advantages and disadvantages, EPA has determined that the discharges of dredged or fill material evaluated in this final determination will have unacceptable adverse effects on anadromous fishery areas in the SFK, NFK, and UTC watersheds. Specifically, EPA has determined that each of the losses or streamflow changes described in Sections 4.2.1 through 4.2.4 independently will have unacceptable adverse effects on anadromous fishery areas if such discharges occur anywhere at the mine site area (Figure 4-1) within the SFK and NFK watersheds or anywhere within the SFK, NFK, and UTC watersheds. In this alternative basis for EPA's unacceptable adverse effects determinations, EPA expressly incorporates the information and findings in Sections 2 through 4 of this final determination. To the extent that EPA's alternative basis applies, these conclusions and rationale directly support the prohibition described in Section 5.1 and the restriction described in Section 5.2.

SECTION 5. FINAL DETERMINATION

Section 404(c) of the CWA authorizes EPA to (1) prohibit or withdraw the specification of any defined area as a disposal site and (2) restrict, deny, or withdraw the use of any defined area for specification as a disposal site whenever it determines that the discharge of dredged or fill material into such area will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas (33 USC 1344(c)).

The following final determination includes two parts. First, EPA prohibits the specification of a defined area as a disposal site for certain discharges (Section 5.1). Second, EPA restricts the use of a defined area for specification as a disposal site for certain discharges (Section 5.2). EPA is exercising its CWA Section 404(c) authority to issue this final determination because it has determined that certain discharges of dredged or fill material into waters of the United States within these defined areas will have unacceptable adverse effects on fishery areas (including spawning and breeding areas).

For the purpose of identifying which discharges of dredged and fill material are subject to the prohibition and restriction, the prohibition and restriction presented below reference the "Pebble deposit." Although the full extent of the Pebble deposit is not yet defined, it is known to extend at least 1.9 by 2.8 miles in area (Ghaffari et al. 2011). For administrative convenience, EPA describes the "Pebble deposit" to encompass its approximate known extent based on publicly available and commonly understood property boundaries, i.e., Public Land Survey System (PLSS) quarter sections (ADNR 2022d), which is depicted as a rectangular area measuring 2.5 miles north–south by 3.5 miles east–west. As illustrated in Figures 5-1, 5-2, and 5-3, this area covers:

> The southeast quarter of Section 17, Township 3 South, Range 35 West, Seward Meridian (S003S035W17); the south half of S003S035W14, S003S035W15, and S003S035W16; the east half of S003S035W20; the entirety of S003S035W21, S003S035W22, S003S035W23, S003S035W26, S003S035W27, and S003S035W28; and the east half of S003S035W29, with corners at approximately latitude 59.917 degrees north (59.917 N) and longitude 155.233 degrees west (155.233 W), latitude 59.917 N and longitude 155.333 W, latitude 59.881 N and longitude 155.333 W, and latitude 59.881 N and longitude 155.233 W.

5.1 Prohibition

The EPA Assistant Administrator for Water has determined that the discharges of dredged or fill material for the construction and routine operation of the mine identified in the 2020 Mine Plan (PLP 2020b) at the Pebble deposit will have unacceptable adverse effects on anadromous[94] fishery areas in

[94] Anadromous fishes hatch in freshwater habitats, migrate to sea for a period of relatively rapid growth, and then return to freshwater habitats to spawn. For the purposes of this final determination, "anadromous fishes" refers

the SFK and NFK watersheds. Based on information in PLP's CWA Section 404 permit application, the FEIS, and the ROD, such discharges would result in the following aquatic resource losses and streamflow changes:

1. The loss of approximately 8.5 miles (13.7 km) of documented anadromous fish streams (Section 4.2.1).
2. The loss of approximately 91 miles (147 km) of additional streams that support anadromous fish streams (Section 4.2.2).
3. The loss of approximately 2,108 acres (8.5 km^2) of wetlands and other waters that support anadromous fish streams (Section 4.2.3).
4. Adverse impacts on approximately 29 additional miles (46.7 km) of anadromous fish streams resulting from greater than 20 percent changes in average monthly streamflow (Section 4.2.4).

EPA has also determined that discharges of dredged or fill material for the construction and routine operation of a mine to develop the Pebble deposit anywhere in the mine site area (Figure 4-1) within the SFK and NFK watersheds that would result in the same or greater levels of loss or streamflow changes as the 2020 Mine Plan also will have unacceptable adverse effects on anadromous fishery areas in these watersheds, because such discharges would involve the same aquatic resources characterized as part of the evaluation of the 2020 Mine Plan.

Sections 4.2.1 through 4.2.4 describe the basis for EPA's determination that each of the above losses and changes to streamflow independently will have unacceptable adverse effects on anadromous fishery areas (including spawning and breeding areas).

Accordingly, the Assistant Administrator for Water prohibits the specification of waters of the United States within the Defined Area for Prohibition, as identified in Section 5.1.1, as disposal sites for the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan. For purposes of the prohibition, the "2020 Mine Plan" is (1) the mine plan described in PLP's June 8, 2020 CWA Section 404 permit application (PLP 2020b) and the FEIS (USACE 2020a); and (2) future proposals to construct and operate a mine to develop the Pebble deposit with discharges of dredged or fill material into waters of the United States within the Defined Area for Prohibition that would result in the same or greater levels of loss or streamflow changes as the mine plan described in PLP (2020b)(i.e., the aquatic resource losses and streamflow changes identified in #1-4 above).[95] Because each of the

only to Coho or Silver salmon (*Oncorhynchus kisutch*), Chinook or King salmon (*O. tshawytscha*), Sockeye or Red salmon (*O. nerka*), Chum or Dog salmon (*O. keta*), and Pink or Humpback salmon (*O. gorbuscha*).

[95] By clarifying that the "2020 Mine Plan" includes, for the purposes of the prohibition, future proposals to construct and operate a mine to develop the Pebble deposit with discharges of dredged or fill material in the Defined Area for Prohibition that would result in the same or greater levels of loss or streamflow changes as the mine plan described in PLP's June 8, 2020 CWA Section 404 permit application, EPA ensures that future applicants cannot circumvent the prohibition by proposing small changes in the location of discharges within the mine site that would not result in any change to the levels of aquatic resource loss or streamflow change, or that would result in greater levels of aquatic resource loss or streamflow change. In doing so, EPA gives full effect to the purpose of the prohibition to prevent adverse effects at the mine site that EPA has already determined are unacceptable.

losses or streamflow changes described in Sections 4.2.1 through 4.2.4 independently will have unacceptable adverse effects on anadromous fishery areas, future proposals to construct and operate a mine to develop the Pebble deposit that result in any one of these losses or streamflow changes will be subject to the prohibition.

Dredged or fill material need not originate within the boundary of the Pebble deposit defined above to be associated with developing the Pebble deposit and, thus, potentially subject to the prohibition. For additional information regarding applicability of the prohibition, see Box 5-1.

5.1.1 Defined Area for Prohibition

The Defined Area for Prohibition identifies the geographic boundary within which the prohibition applies to waters of the United States. EPA has determined that the discharges of dredged or fill material proposed in PLP (2020b) within the SFK and NFK watersheds will have unacceptable adverse effects on anadromous fishery areas in these watersheds. EPA has also determined that discharges of dredged or fill material associated with developing the Pebble deposit anywhere at the mine site that result in any one of the losses or streamflow changes described in Sections 4.2.1 through 4.2.4 will have unacceptable adverse effects on anadromous fishery areas (Section 4). EPA identified the Defined Area for Prohibition (Figure 5-1) by outlining a contiguous area around the portions of the mine site footprint identified in PLP (2020b) that are located within the SFK and NFK watersheds.

The Defined Area for Prohibition encompasses certain headwaters of the SFK and NFK watersheds. The Defined Area for Prohibition is approximately 24.7 square miles (63.9 km^2) and is delineated by the entirety of the PLSS quarter sections where mine site discharges were proposed in PLP (2020b) within the headwaters of the SFK and NFK watersheds (ADNR 2022d). Use of publicly available and commonly understood property and watershed boundaries to delineate the Defined Area for Prohibition accounts for the clarified scope of the "2020 Mine Plan" and provides clarity and administrative convenience, enabling EPA, USACE, and the public, including future proponents to develop the Pebble deposit, to easily identify the locations of water resources that are subject to the prohibition.

BOX 5-1. APPLICABILITY DATA REQUIREMENTS

EPA must have sufficient information to assess applicability of the determination to proposed discharges of dredged or fill material. Proponents who seek an applicability assessment from EPA must provide to the Agency detailed information about the proposed discharges of dredged or fill material, including, but not limited to, location(s) and characteristics of potentially affected waters. At a minimum, proponents must provide geographic and quantified impact information, including:

- Losses of documented anadromous waters (miles),
- Losses of additional streams (miles),
- Losses of wetlands and other waters (acres), and
- Anadromous fish streams (miles) that would experience changes (percent) to average monthly streamflow.

Estimates must be based on field-verified, project-specific aquatic resource mapping. See Box 4-3 for an example of project-specific stream and wetland mapping information. EPA may request additional information to support the proponent's estimates.

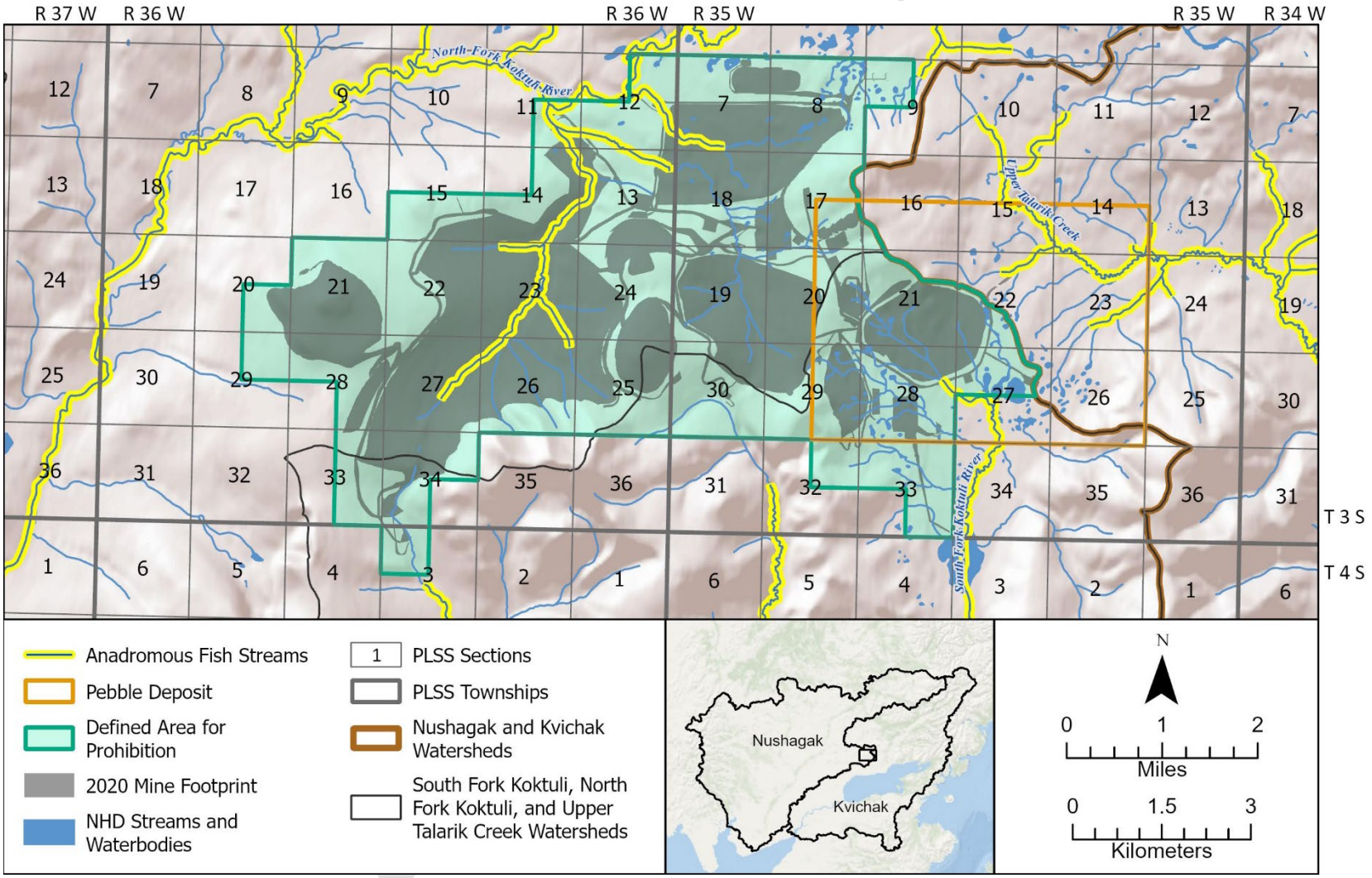
For purposes of this final determination, **Loss**, as in loss of streams, wetlands, or other waters, can result either directly from the discharge of dredged or fill material for the construction and routine operation of a mine to develop the Pebble deposit or indirectly from the secondary effects of such discharges. A loss would result in the following effects for 5 years or more (Box 4-1):

- Elimination of streams, wetlands, or other waters within the footprints of mine components (e.g., TSFs, WMPs, stockpiles, roads, and the open pit);
- Dewatering (see definition below); or
- Fragmentation, meaning creation of discontinuities that separate an aquatic habitat (stream, wetland, lake, pond) or complex of aquatic habitats from the tributary network in such a way that either precludes use (e.g., spawning, rearing, feeding, migration, overwintering) by anadromous fish species and life stages documented to occur in the habitat or eliminates the downstream movement of water or dissolved or suspended materials.

Dewatering includes:

- For documented anadromous waters, removing sufficient flow to eliminate access to or use of habitat for the anadromous fish species and life stages documented to occur in the reach in question;
- For additional streams, removing sufficient flow to eliminate the downstream movement of water or dissolved or suspended materials;
- For ponds or lakes, reducing the spatial extent of the pond or lake; and
- For wetlands, changing the hydrologic regime such that the wetland no longer exhibits wetland hydrology, as defined in the *Corps of Engineers Wetland Delineation Manual* (USACE 1987).

Figure 5-1. The Defined Area for Prohibition. Figure based on information from PLP (2020b), USGS (2021a), and USGS (2021b).



The description of the Defined Area for Prohibition (Figure 5-1) is as follows:

> Beginning in the northeast corner at the intersection of the north-south half-section line and the northern boundary of Section 9, Township 3 South, Range 35 West, Seward Meridian (S003S035W09), at approximately latitude 59.938 north (59.938 N) and longitude 155.305 degrees west (155.305 W), it extends 3 miles westward, along the northern boundary of S003S035W09, the entire northern boundaries of S003S035W08 and S003S035W07 to the north-south half-section line of S003S036W12; then south approximately 0.5 mile along the north-south half-section line of S003S036W12 to the east-west half-section line of S003S036W12; then west approximately 1.0 mile along the east-west half-section lines of S003S036W12 and S003S036W11 to the north-south half-section line of S003S036W11; then south approximately 1.0 mile along the north-south half-section line of S003S036W11 and S003S036W14 to the east-west half-section line of S003S036W14; then west approximately 1.5 miles along the east-west half-section lines of S003S036W14 and S003S036W15 to the western boundary of S003S036W15; then south approximately 0.5 mile along the western boundary of S003S036W15 to the northern boundary of S003S036W21; then west approximately 1.0 mile along the northern boundary of S003S036W21 to the western boundary of S003S036W21; then south approximately 0.5 mile along the western boundary of S003S036W21 to the east-west half section line of S003S036W20; then west approximately 0.5 mile along the east-west half-section line of S003S036W20 to the north-south half-section line of S003S036W20; then south approximately 1.0 mile along the north-south half-section line of S003S036W20 and S003S036W29 to the east-west half-section line of S003S036W29; then east approximately 1.0 mile along the east-west half-section line of S003S036W29 and S003S036W28 to the north-south half-section line of S003S036W28; then south approximately 1.5 miles along the north-south half-section line of S003S036W28 and S003S036W33 to the southern boundary of S003S036W33; then east approximately 0.5 mile along the southern boundary of S003S036W33 to the western boundary of S004S036W03; then south approximately 0.5 mile along the western boundary of S004S036W03 to the east-west half-section line of S004S036W03; then east approximately 0.5 mile along the east-west half-section boundary of S004S036W03 to the north-south half-section line of S004S036W03; then north approximately 1.0 mile along the north-south half-section line of S004S036W03 and S003S036W34 to the east-west half-section line of S003S036W34; then east approximately 0.5 mile along the east-west half-section line of S003S036W34 to the eastern boundary of S003S036W34; then north approximately 0.5 mile along the eastern boundary of S003S036W34 to the southern boundary of S003S036W26; then east approximately 3.5 miles along the southern boundaries of S003S036W26, S003S036W25, S003S035W30, and S003S035W29 to the north-south half-section line of S003S035W32; then south approximately 0.5 mile along the north-south half-section line of S003S035W32 to the east-west half-section line of S003S035W32; then east approximately 1.0 mile along the east-west half-section line of S003S035W32 and S003S035W33 to the north-south half-section line of S003S035W33; then south approximately 0.5 mile along the north-south half-section line of S003S035W33 to the southern boundary of S003S035W33; then east approximately 0.5 mile along the southern boundary of S003S035W33 to the eastern boundary of S003S035W33; then north approximately 1.5 miles along the eastern boundary of S003S035W33 and S003S035W28 to the east-west half-section line of S003S035W27; then east approximately 0.84 mile along the east-west half-section line of S003S035W27 to the intersection with the border between the Nushagak and Kvichak watersheds at approximately latitude 59.888 N and longitude 155.266 W; then generally northwest approximately 3.60 miles along the boundary between the Nushagak and Kvichak watersheds to the northernmost intersection of the watershed boundary with the eastern boundary of S003S035W17 at approximately latitude 59.922 N and longitude 155.319 W; then north approximately 0.64 mile along the eastern boundary of S003S035W17 and S003S035W08 to the east-west half-section line of S003S035W09; then east approximately 0.5 mile along the east-west half-section line of S003S035W09 to the north-south half-section line of S003S035W09; then north approximately 0.5 mile along the north-south half-section line of S003S035W09 to the northern boundary of S003S035W09, the initial starting point.

5.2 Restriction

The Assistant Administrator for Water has determined that discharges of dredged or fill material associated with future proposals to construct and operate a mine to develop the Pebble deposit will have unacceptable adverse effects on anadromous fishery areas (including spawning and breeding areas) anywhere in the SFK, NFK, and UTC watersheds if the adverse effects of such discharges are similar or greater in nature[96] and magnitude[97] to the adverse effects of the 2020 Mine Plan described in Sections 4.2.1 through 4.2.4.

Accordingly, the Assistant Administrator for Water restricts the use of waters of the United States within the Defined Area for Restriction, as identified in Section 5.2.1, for specification as disposal sites for the discharge of dredged or fill material associated with future proposals to construct and operate a mine to develop the Pebble deposit that would either individually or cumulatively result in adverse effects similar or greater in nature and magnitude to those described in Sections 4.2.1 through 4.2.4. Because each of the losses or streamflow changes described in Sections 4.2.1 through 4.2.4 independently will have unacceptable adverse effects on anadromous fishery areas, proposals to discharge dredged or fill material that result in any one of these losses or streamflow changes will be subject to the restriction. To the extent that future discharges are subject to the prohibition, the restriction will not apply.

Dredged or fill material need not originate within the boundary of the Pebble deposit defined above to be associated with developing the Pebble deposit and, thus, potentially subject to the restriction. For additional information regarding applicability of the restriction, see Box 5-1 and Section 5.2.2.

5.2.1 Defined Area for Restriction

The Defined Area for Restriction identifies the geographic boundary within which the restriction applies to waters of the United States. EPA has determined that certain discharges of dredged or fill material associated with developing the Pebble deposit will have unacceptable adverse effects on anadromous fishery areas anywhere within the SFK, NFK, and UTC watersheds (Section 4). EPA has identified the Defined Area for Restriction by outlining a contiguous area within the boundaries of the SFK, NFK and UTC watersheds that includes the areas that have the potential to be disposal sites for the discharge of dredged or fill material associated with developing the Pebble deposit.

The Pebble deposit is wholly located within the SFK, NFK, and UTC watersheds. To identify areas within the boundaries of the three watersheds with the potential to be a disposal site for the discharge of dredged or fill material associated with developing the Pebble deposit, EPA identified the location of mine claims in and around the Pebble deposit within the three watersheds. Alaska State law specifically recognizes the opportunity for mineral claims to be converted to leases to use the State's surface land

[96] *Nature* means type or main characteristic (see Cambridge Dictionary available at: https://dictionary.cambridge.org/us/dictionary/english/nature).

[97] *Magnitude* refers to size or importance (see Cambridge Dictionary available at: https://dictionary.cambridge.org/us/dictionary/english/magnitude).

for mining activity, including for a mill site, tailings disposal, or another use necessary for mineral development, making the surface lands above mineral claims areas with potential to be disposal sites for the discharge of dredged or fill material associated with mining.[98] Accordingly, the areas within the boundaries of the three watersheds where mine claims are currently held and areas where mine claims are available (ADNR 2022c) represent locations that have the potential to be a disposal site for the discharge of dredged or fill material associated with developing the Pebble deposit. Use of publicly available and commonly understood property[99] and watershed boundaries to delineate the Defined Area for Restriction provides clarity and administrative convenience by enabling EPA, USACE, and the public, including future proponents to develop the Pebble deposit, to easily identify the locations of water resources that are subject to the restriction.

The Defined Area for Restriction encompasses certain headwaters of the SFK, NFK, and UTC watersheds. The size of the Defined Area for Restriction is approximately 309 square miles (800 km^2). The description of the Defined Area for Restriction (Figures 5-2 and 5-3) is as follows:

> Beginning in the northeast at the intersection between the Upper Talarik Creek, Newhalen River, and Chulitna River watersheds, at approximately latitude 59.955 degrees north (59.955 N) and longitude 154.994 degrees west (154.994 W), it extends generally westward, along the boundary between the Upper Talarik Creek and Chulitna River watersheds to the intersection between the Upper Talarik Creek, Chulitna River, and Koktuli River watersheds, at approximately latitude 59.972 N and longitude 155.193 W; then generally west along the boundary between the Koktuli River and Chulitna River watersheds to approximately latitude 59.979 N and longitude 155.583 W; then generally southward along the boundary between the North Fork Koktuli River and mainstem Koktuli River watersheds, to the south boundary of Section 11, Township 4 South, Range 38 West, Seward Meridian (S004S038W11), at approximately latitude 59.837 N and longitude 155.774 W; then east approximately 0.38 mile along the south section line of S004S038W11 to the north-south half-section line of S004S038W14 at approximately latitude 59.837 N and longitude 155.763 W; then south, approximately 1.5 mile, along the north-south half-section lines of S004S038W14 and S004S038W23 to the center of S004S038W23 at approximately latitude 59.816 N and longitude 155.763 W; then west approximately 1.09 mile along the east-west half-section line of S004S038W23 and S004S038W22 to the boundary between the Upper Koktuli River and Middle Koktuli River subwatersheds at approximately latitude 59.816 N and longitude 155.794 W; then generally southwest, approximately 0.46 mile, along the boundary between the Upper Koktuli River and Middle Koktuli River subwatersheds to the west boundary of S004S038W22 at approximately latitude 59.812 N and longitude 155.806 W; then south along the section line, approximately 0.26 mile, to the south boundary of S004S038W22, at approximately latitude 59.808 N and longitude 155.806 W; then east along the south section line, approximately 1.0 mile to the east boundary of S004S038W27 at approximately latitude 59.808 N and longitude 155.777 W; then south approximately 2.0 miles along the east section line of S004S038W27 and S004S038W34 until the south boundary of S004S038W34 at approximately latitude 59.780 N and longitude 155.777 W; then west along the south section line, approximately 0.04 mile, until the boundary between the Koktuli River and Stuyahok River watersheds at approximately latitude 59.780 N and longitude 155.778 W; then generally southeast, approximately 0.59 mile, along the watershed boundary between the Koktuli River and Stuyahok River watersheds until the intersection between the Koktuli River, Stuyahok River, and Kaskanak Creek watersheds at approximately latitude 59.775 N and longitude 155.764 W; then generally east along the boundary between the Koktuli River and Kaskanak Creek watersheds, approximately 4.14 miles, to the north boundary of S005S037W06 at approximately latitude 59.780 N and longitude 155.645 W; then east, approximately 0.09 mile, along the north section line of S005S037W06 to the north-south half-section

[98] 11 Alaska Administrative Code 86.600.

[99] The boundaries of mine claims are defined by the PLSS (ADNR 2022d).

line of S005S037W06 at approximately latitude 59.780 N and longitude 155.642 W; then south along the north-south half-section line of S005S037W06, approximately 0.07 mile, to the boundary between the Koktuli River and Kaskanak Creek watersheds at approximately latitude 59.778 N and longitude 155.642 W; then generally eastward, along the watershed boundary between the Koktuli River and Kaskanak Creek watersheds until the intersection between the Koktuli River, Kaskanak Creek, and Iliamna Lake watersheds at approximately latitude 59.767 N and longitude 155.541 W; then generally eastward, along the boundary between the Koktuli River and Iliamna Lake watersheds to the intersection of the Koktuli River, Iliamna Lake, and Upper Talarik Creek watersheds at approximately latitude 59.762 N and longitude 155.363 W; then generally southeastward, along the boundary between the Upper Talarik Creek and Iliamna Lake watersheds, to the south boundary of S005S036W24, at approximately latitude 59.722 N and longitude 155.329 W; then east along the south section line approximately 0.52 mile to the east section line of S005S036W24, at approximately latitude 59.722 N and longitude 155.314 W; then north along the section line 1.0 mile to the south boundary of S005S035W18, at approximately latitude 59.736 N and longitude 155.314 W; then east along the south section line 2.0 miles to the east boundary of S005S035W17, at approximately latitude 59.736 N and longitude 155.259 W; then north approximately 1.0 mile along the east section line of S005S035W17 to the south boundary of S005S035W09, at approximately latitude 59.751 N and longitude 155.259 W; then east approximately 1.0 mile along the south section line of S005S035W09 to the east section line of S005S035W09, at approximately latitude 59.751 N and longitude 155.230 W; then north approximately 1.0 mile along the east section line of S005S035W09 to the south boundary of S005S035W03, at approximately latitude 59.765 N and longitude 155.230 W; then east approximately 1.0 mile along the south section line of S005S035W03 to the east section line of S005S035W03, at approximately latitude 59.765 N and longitude 155.202 W; then north approximately 1.0 mile along the east section line of S005S035W03 to the south boundary of S004S034W31, at approximately latitude 59.780 N and longitude 155.202 W; then west approximately 0.09 mile along the south section line of S004S034W31 to the west section line of S004S034W31, at approximately latitude 59.780 N and longitude 155.204 W; then north approximately 2.0 miles along the west section line of S004S034W31 and S004S034W30, to the south boundary of S004S034W19, at approximately latitude 59.808 N and longitude 155.204 W; then east approximately 1.0 mile along the south section line of S004S034W19 to the east section line of S004S034W19, at approximately latitude 59.808 N and longitude 155.176 W; then north approximately 1.0 mile along the east section line of S004S034W19 to the south boundary of S004S034W17, at approximately latitude 59.823 N and longitude 155.176 W; then east approximately 3.0 miles along the south section lines of S004S034W17, S004S034W16, and S004S034W15 to the east boundary of S004S034W15, at approximately latitude 59.823 N and longitude 155.090 W; then north approximately 2.0 miles along the east section line of S004S034W15 to the south boundary of S004S034W02, at approximately latitude 59.852 N and longitude 155.090 W; then east approximately 2.64 miles along the south section lines of S004S034W02, of S004S034W01, and of S004S033W06 to the boundary between the Upper Talarik Creek and Newhalen River watersheds, at approximately latitude 59.852 N and longitude 155.014 W; then generally north along the watershed boundary until the east boundary of S003S034W12 at approximately latitude 59.936 N and longitude 155.032 W; then north approximately 1.15 mile along the section line to the south boundary of S002S033W31 at approximately latitude 59.953 N and longitude 155.032 W; then east approximately 1.23 mile along the section line to the boundary between the Upper Talarik Creek and Newhalen River watersheds, at approximately latitude 59.953 N and longitude 154.997 W; then generally north, approximately 0.17 mile, along the watershed boundary to the starting point, at the intersection between the Upper Talarik Creek, Newhalen River, and Chulitna River watersheds (coordinates above).

Figure 5-2. The Defined Area for Restriction and Defined Area for Prohibition overlain on wetlands from the National Wetlands Inventory (USFWS 2021).

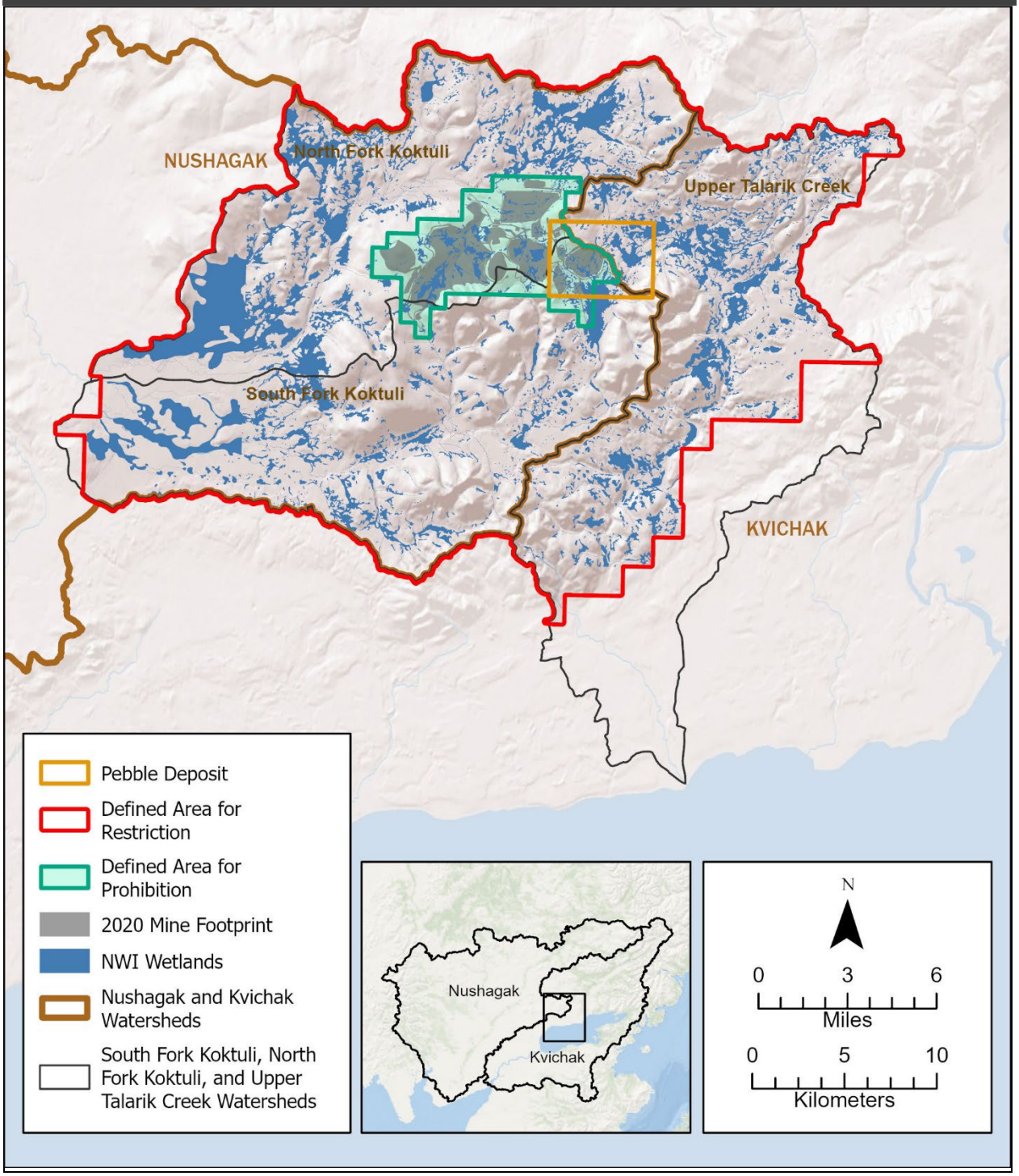
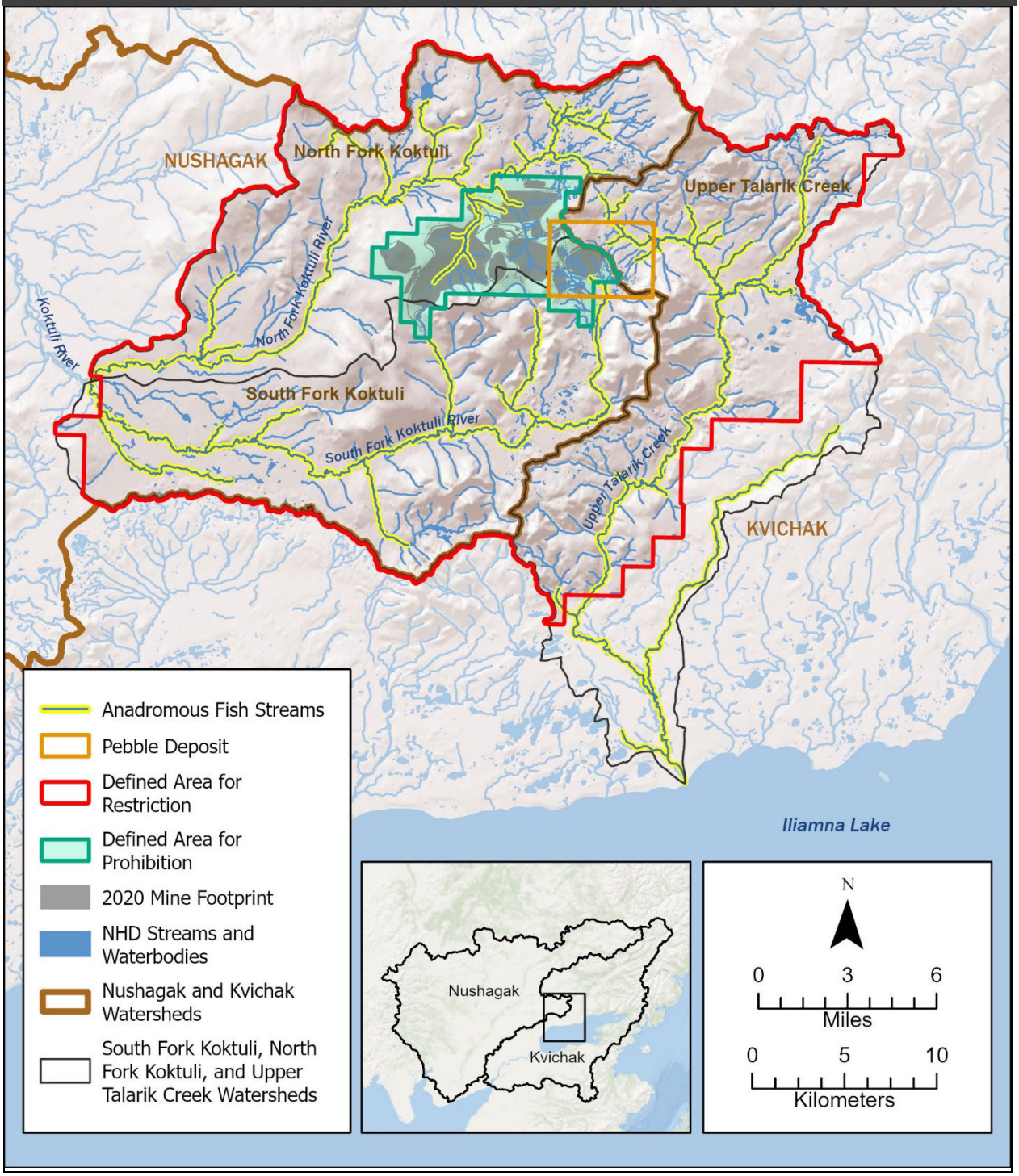


Figure 5-3. The Defined Area for Restriction and Defined Area for Prohibition overlain on streams and waterbodies from the National Hydrography Dataset (USGS 2021b).



5.2.2 Applicability of the Restriction

The restriction applies to proposed discharges of dredged or fill material into waters of the United States associated with developing the Pebble deposit within the Defined Area for Restriction if such discharges would result in adverse effects similar in nature and magnitude to the adverse effects of the discharges described in Sections 4.2.1 through 4.2.4. The restriction also applies to proposed discharges if such discharges would result in adverse effects greater in nature and magnitude than the adverse effects of the discharges described in Sections 4.2.1 through 4.2.4.

Discharges of dredged or fill material within the Defined Area for Restriction associated with developing the Pebble deposit would individually be subject to the restriction if such discharges, from a single proposal, would result in any one of the losses or streamflow changes found in Sections 4.2.1 through 4.2.4. Discharges of dredged or fill material within the Defined Area for Restriction associated with developing the Pebble deposit would cumulatively be subject to the restriction if the effects of such discharges together with other discharges within the Defined Area for Restriction associated with developing the Pebble deposit combine to result in any one of the losses or streamflow changes described in Sections 4.2.1 through 4.2.4 in the SFK, NFK, and UTC watersheds. In evaluating whether the restriction would apply on a cumulative basis, EPA will consider losses and streamflow changes associated with developing the Pebble deposit that have occurred or that are authorized to occur. The restriction would apply to discharges of dredged or fill material associated with developing the Pebble deposit cumulatively whether multiple proposals are submitted by the same entity, such as when discharges are proposed over multiple phases of the same project, or by different entities.

To evaluate whether a future proposal involves discharges that "would either individually or cumulatively result in adverse effects" such that it would be subject to the restriction, EPA will verify and then compare the estimates of losses of anadromous fish streams; losses of additional streams, wetlands, and other waters that support anadromous fish streams; and changes to streamflow of anadromous fish streams to assess whether the estimated losses and streamflow changes are similar to or greater than the losses or changes identified in Section 4.2, specifically:

- The loss of approximately 8.5 miles of documented anadromous fish streams (Section 4.2.1),
- The loss of approximately 91 miles of additional streams that support anadromous fish streams (Section 4.2.2),
- The loss of approximately 2,108 or more acres of wetlands and other waters that support anadromous fish streams (Section 4.2.3), or
- Adverse impacts to approximately 29 miles of anadromous fish streams resulting from greater than 20 percent changes in average monthly streamflow (Section 4.2.4).

Specifically, EPA will review:

- The location(s) of the proposed discharges, including whether the location is within the Defined Area for Restriction;
- The location(s) of the waters that will be impacted, including whether the location is within the SFK, NFK, and UTC watersheds;
- The type(s) of waters that will be impacted (e.g., streams, lakes, ponds, wetlands) and whether such waters are documented anadromous fish streams or support anadromous fish streams; and
- The type(s) of water resource impact(s) (e.g., habitat losses caused by elimination, dewatering, and fragmentation; degradation of downstream habitat caused by streamflow changes) and the duration of impact(s) (Box 5-1).

The restriction will apply if any one of the estimated losses or streamflow changes from the proposed discharges are similar or greater to those described in Section 4.2. The restriction is based on the determinations in Section 4.2 that these losses and streamflow changes will have unacceptable adverse effects. In evaluating applicability of the restriction, EPA will evaluate all proposed discharges associated with developing the Pebble deposit that would occur within the Defined Area for Restriction.

5.3 When a Proposal is Not Subject to this Determination

Proposals to discharge dredged or fill material into waters of the United States associated with developing the Pebble deposit that are not subject to this determination remain subject to all statutory and regulatory authorities and requirements under CWA Section 404.

In light of the immense and unique economic, social, cultural, and ecological value of the aquatic resources in the region, including the fishery areas in the SFK, NFK, and UTC watersheds, and their susceptibility to damage, EPA will carefully evaluate all future proposals to discharge dredged or fill material in the region.

SECTION 6. OTHER CONCERNS AND CONSIDERATIONS

The basis for EPA's final determination is the unacceptable adverse effects on fishery areas from certain discharges of dredged or fill material associated with proposed mining at the Pebble deposit, which is discussed in detail in Section 4. This section describes additional concerns and information that, while not the basis for EPA's final determination, are related to discharges of dredged or fill material associated with developing the Pebble deposit.

6.1 Other Potential CWA Section 404(c) Resources

CWA Section 404(c) authorizes EPA to exercise its discretion to act whenever it determines that the discharge of dredged or fill material will have an unacceptable adverse effect on specific aquatic resources. CWA Section 404(c) provides the following:

> The Administrator is authorized to prohibit the specification (including the withdrawal of specification) of any defined area as a disposal site, and he is authorized to deny or restrict the use of any defined area for specification (including the withdrawal of specification) as a disposal site, whenever he determines, after notice and opportunity for public hearings, **that the discharge of such materials into such area will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas**. Before making such determination, the Administrator shall consult with the Secretary. The Administrator shall set forth in writing and make public his findings and his reasons for making any determination under this subsection. [33 USC 1344(c)] [emphasis added]

Section 4 of this final determination considers the adverse effects from the discharge of dredged or fill material on fishery areas. Section 6.1 evaluates the potential for adverse effects on wildlife, recreation, and water supplies.

6.1.1 Wildlife

Unlike most terrestrial ecosystems, the Bristol Bay watershed has undergone little development and remains largely intact. Thus, it still supports its historical complement of species, including large carnivores, such as brown bears, bald eagles, and gray wolves; ungulates such as moose and caribou; and numerous bird species. For example, more than 40 mammal species are thought to regularly occur in the Nushagak and Kvichak River watersheds (Brna and Verbrugge 2013). At least 13 of these species are known, or have the potential based on the presence of suitable habitat, to occur in the SFK, NFK, and UTC watersheds: brown bear, moose, caribou, gray wolf, red fox, river otter, wolverine, arctic ground squirrel, red squirrel, beaver, northern red-backed vole, tundra vole, and snowshoe hare (PLP 2011: Chapter 16). One of two freshwater harbor seal populations in North America is found in Iliamna Lake (Smith et al. 1996).

As many as 134 species of birds occur in the Nushagak and Kvichak River watersheds (Brna and Verbrugge 2013), and at least 37 waterfowl species have been observed in the SFK, NFK, and UTC watersheds, 21 of which have been confirmed as breeders (PLP 2011: Chapter 16). The region's aquatic habitats support migratory and wintering waterfowl. These habitats include an important staging area for many species, including emperor geese, Pacific brant, and ducks, during spring and fall migrations. Twenty-eight landbird and 14 shorebird species have also been documented in the SFK, NFK, and UTC watersheds (PLP 2011: Chapter 16). The Bristol Bay watershed supports millions of marine birds throughout the year and is one of the world's most productive areas for marine birds (Warnock and Smith 2018). Two areas in the region, Kvichak Bay and Nushagak Bay, are designated as Western Hemisphere Shorebird Reserve Network sites (WHSRN 2022a, 2022b). The FEIS identifies bird species protected under the Migratory Bird Treaty Act of 1918, the Bald and Golden Eagle Protection Act, and bird species of concern within its mine site analysis area (USACE 2020a: Section 4.23).

Species found in the Nushagak and Kvichak River watersheds may have home ranges or migration patterns that extend beyond the watersheds as well (e.g., brown bears, caribou, and migratory birds). Several bird species found within the watersheds are considered species of special concern and are already experiencing population declines due to climate change effects on their preferred foraging fish (USACE 2020b). Within the Nushagak and Kvichak River watersheds, there are no known breeding or otherwise significant occurrences of any species listed as threatened or endangered under the Endangered Species Act, nor is there any designated critical habitat.

Wildlife present in the SFK, NFK, and UTC watersheds—several of which are essential subsistence species (Section 6.3.1)—would likely be adversely affected by large-scale mining at the Pebble deposit. Direct impacts of mining on resident and migratory wildlife species would include, but are not limited to, loss of terrestrial and aquatic habitat, reduced habitat effectiveness (e.g., in otherwise suitable habitats adjacent to the mine area), habitat fragmentation, increased stress and avoidance due to noise pollution, and increased conditioning on human food (EPA 2014: Chapter 12). Direct habitat loss and secondary habitat avoidance would affect the Mulchatna Caribou Herd (USACE 2020b), an important subsistence resource and prey species for wolves and brown bears (EPA 2014: Chapter 12). Brown bears, which are an important recreation species in the region, would experience direct loss of foraging and denning habitat. Impacts on wildlife habitat and consequential wildlife displacement would likely result in a cascading effect, as species compete for new feeding, breeding, and nesting habitats (USACE 2020b). Direct copper toxicity to wildlife resulting from mine operations is less of a concern than indirect effects from copper-related reductions in aquatic communities (EPA 2014: Chapter 12).

In addition to direct mine-related effects, wildlife species would also likely be affected indirectly via any reductions in salmon populations. Marine-derived nutrients imported into freshwater systems by spawning salmon provide the foundation for the region's aquatic and terrestrial foodwebs, via direct consumption of salmon in any of its forms (spawning adults, eggs, carcasses, or juveniles) and nutrient recycling (e.g., transport and distribution of marine derived nutrients from aquatic to terrestrial environmental by wildlife) (Section 3.3.4). Availability and consumption of these salmon-derived resources can have significant benefits for terrestrial mammals and birds, including increases in growth

rates, litter sizes, nesting success, and population densities (Brna and Verbrugge 2013). Waterfowl prey on salmon eggs, parr, and smolts and scavenge salmon carcasses. Carcasses are an important food source for bald eagles, water birds, other land birds, other freshwater fishes, and terrestrial mammals. Aquatic invertebrate larvae also benefit from carcasses and are an important food source for water birds and land birds. Decomposing salmon acts as an organic input to streambed substrate (Cederholm et al. 1999). It is likely that the species identified above would be adversely affected by any mine-related reductions in salmon production.

The FEIS identifies direct and indirect impacts to wildlife that could result at the proposed mine site, including behavioral disturbances, injury and mortality, and habitat changes. Noise and the presence of humans, vehicles, aircraft, and other equipment could result in avoidance of the mine site by wildlife throughout construction, operations, and closure. Mortality of, and injury to, wildlife at the proposed mine site could occur due to vegetation clearing; collisions with vehicles, equipment, and structures; defense of life and property; altered predator and prey relationships; changes in water quality; nest abandonment and/or disturbance; exposure to contaminants; and possible spills. The FEIS estimates the direct loss of 8,390 acres of habitat and the indirect loss of additional habitat surrounding the mine site due to avoidance, which would occur throughout the life of the project and longer in areas that are not restored. Wildlife habitat may also see long-term changes due to the introduction or spread of invasive species, changes in water quality and air quality, and potential spills (USACE 2020a: Section 4.23).

The Expanded Mine Scenario would contribute to cumulative effects of wildlife habitat loss, disturbance, injury, and mortality. The FEIS estimates that 31,541 acres of habitat would be lost at the expanded mine site, as well as additional habitat surrounding the expanded mine site due to avoidance (USACE 2020a: Section 4.23).

The FEIS provides more detailed information not summarized in this final determination regarding other potential direct, indirect, and cumulative impacts that may result from the 2020 Mine Plan and the Expanded Mine Scenario, including species-specific information in some cases.

6.1.2 Recreation

Next to commercial salmon fishing and processing, recreation is the largest private economic sector in the Bristol Bay region (EPA 2014: Appendix E) due mainly to the watershed's remote, pristine wilderness setting and abundant natural resources. Key recreational uses include sport fishing, sport hunting, and other tourism/wildlife viewing recreational trips—all of which are directly or indirectly dependent on the intact, salmon-based ecosystems of the region. Direct regional expenditures on these recreational uses, expressed in terms of 2021 dollars,[100] are estimated at more than $210 million (EPA 2014: Table 5-4). Much of these expenditures are by non-residents, highlighting the fact that the recreational value of Bristol Bay watershed is recognized even by people that live a significant distance from the region. Total visitors to the Bristol Bay region are estimated at 40,00 to 50,000 people annually (McKinley Research Group 2021). In 2019, tourism spending in the Bristol Bay region generated $155

[100] Values adjusted using Anchorage Consumer Price Index.

million in total economic output and 2,300 jobs in Alaska. Recreation in the region diversifies the region's economy through the use of sustainable resources (McKinley Research Group 2021).

In particular, the abundance of large game fishes makes the region a world-class destination for recreational anglers. The 2005 Bristol Bay Angler Survey confirmed that the freshwater rivers, streams, and lakes of the region are a recreational resource equal or superior in quality to other world-renowned sport fisheries (EPA 2014: Appendix E). In 2009, sport anglers took approximately 29,000 sport-fishing trips to the Bristol Bay region (12,000 trips by people living outside of Alaska, 4,000 trips by Alaskans living outside of the Bristol Bay area, and 13,000 trips by Bristol Bay residents) (EPA 2014: Chapter 5). These sport-fishing activities directly employed over 800 full- and part-time workers. At peak times, 92 businesses and 426 guides have operated in the Nushagak and Kvichak River watersheds alone (EPA 2014: Chapter 5). More than 90 lodges and camps operate in the Bristol Bay region, primarily focusing on sport fishing and bear viewing. Lodge and camp guests spent an estimated $77 million in 2019 (McKinley Research Group 2021).

Much of the sport fishery in the region is relatively low-impact catch-and-release, although there is some recreational harvest. Sockeye, Chinook, and Coho salmon are the predominant fishes harvested, although Rainbow Trout, Dolly Varden, Arctic Char, Arctic Grayling, Northern Pike, Chum Salmon, Lake Trout, and whitefish are also important recreational species (Dye and Borden 2018). From 2007 to 2017, the total annual recreational harvest in the Bristol Bay Management Area ranged from roughly 42,000 to 59,000 fish (Dye and Borden 2018). In 2017, an estimated 30,282 Rainbow Trout were caught and 241 Rainbow Trout were harvested in the Nushagak, Wood, and Togiak River watersheds. The same year, an estimated 114,431 Rainbow Trout were caught and 66 Rainbow Trout were harvested in the Kvichak River watershed (Table 3-12) (Romberg et al. 2021).

Sport fishing in the Bristol Bay region is a large and well-recognized share of recreational use and associated visitor expenditures (Section 3.3.7). In addition, thousands of trips to the region each year are made for sport hunting and wildlife viewing. For example, Lake Clark and Katmai National Parks are nationally significant protected lands and are important visitor destinations. Between 2012 and 2021, Katmai National Park and Preserve attracted an average of 41,139 visitors annually, and Lake Clark National Park and Preserve averaged 15,728 visitors annually (NPS 2022). Rivers within Katmai National Park provide the best locations in North America to view wild brown bears (EPA 2014: Appendix E). A 2019 study found that activities related to bear viewing resulted in approximately $34.5 million in sales and $10 million in direct wages and benefits in Southcentral Alaska, and that bear viewing opportunities are "inextricably linked" to Lake Clark and Katmai National Parks (Young and Little 2019). The region is also used for recreational water activities, hiking, backpacking, biking, flightseeing, and other activities, especially in Katmai National Park and Preserve and Lake Clark National Park and Preserve (USACE 2020a: Section 4.5).

Sport hunting for caribou, moose, brown bear, and other species also plays a role in the local economy of the Bristol Bay region. In recent years, approximately 1,323 non-residents and 1,319 non-local residents of Alaska traveled to the region to hunt, spending approximately $6,395 (non-residents) and $1,631

(non-local residents) per trip (expressed in 2021 dollars[101]), respectively (EPA 2014: Chapter 5). These hunting activities result in an estimated $10 million per year in direct hunting-related expenditures (values expressed in 2021 dollars[102]) and directly employ over 100 full- and part-time workers (EPA 2014: Chapter 5).

The 2020 Mine Plan would result in the permanent alteration and loss of 8,391 acres of land at the mine site that are currently available for recreation, including the loss of 2,113 acres of wetlands and other waters that support fish and wildlife and attract recreational anglers and hunters (USACE 2020a: Section 4.5). As described in Section 4.2.1.1, the 2020 Mine Plan would permanently remove 8.5 miles (13.7 km) of streams with documented occurrence of Coho and Chinook salmon, disrupting the spawning cycle and displacing spawners. The substantial spatial and temporal extents of stream habitat losses under the 2020 Mine Plan suggest that these losses would reduce the overall capacity and productivity of Chinook and, particularly, Coho salmon in the NFK watershed. The Nushagak River—to which the SFK and NFK flow—supports the largest Chinook Salmon sport fishery in the United States and, in turn, a network of private and commercial sport-fishing camps overseen by Choggiung, Ltd., the Alaska Native village Corporation for Dillingham, Ekuk, and Portage Creek (NMWC 2007, Choggiung, Ltd. 2014, Dye and Borden 2018). The loss of habitat at the mine site would affect downstream trout habitat, possibly displacing trout and, therefore, anglers (USACE 2020a: Section 4.6). The FEIS acknowledges the potential for economic impacts borne by recreational anglers and affiliated guides and lodges, stating that "affected operators could substitute fishing on different streams, albeit at potentially higher costs to themselves and their consumers" (USACE 2020a: Page 4.6-12).

The FEIS indicates that the mine site itself does not support much recreational use, though construction, operations, and closure of the mine site would affect recreational activities on surrounding lands, including Lake Clark National Park and Katmai National Park (USACE 2020a, 2020b). Noise and the presence of humans, vehicles, aircraft, and other equipment is likely to result in avoidance of the mine site by wildlife that support recreational uses. Changes to the landscape due to visibility of the mine and night sky light pollution would alter the recreational experience for visitors and potentially displace recreation visitors and activities to other areas. These impacts together would reduce the opportunities for solitude (USACE 2020a: Section 4.5). Further, there exists the possibility of a loss in recreational visitors and activity in areas not impacted by the 2020 Mine Plan resulting from the perceived loss of habitat or fishery quality due to the construction and operation of the mine (Glasgow and Train 2018, English et al. 2019, Glasgow and Train 2019).

The Expanded Mine Scenario, which would extend impacts in the SFK and UTC watersheds, would contribute to cumulative effects similar in nature to those described above but over a larger area. The larger mine footprint would further displace wildlife and increase the amount of disturbance in the NFK

[101] Values adjusted using Anchorage Consumer Price Index.
[102] Values adjusted using Anchorage Consumer Price Index.

and SFK watersheds, reducing opportunities for hunting, fishing, and wildlife viewing (USACE 2020a: Section 4.5).

6.1.3 Public Water Supplies

Alaska Native residents of the Nushagak and Kvichak River watersheds consistently stress the importance of clean water to their way of life, not only in terms of providing habitat for salmon and other fishes, but also in terms of providing high-quality drinking water (EPA 2014: Appendix D). Drinking water sources in the region include municipal treated water, piped but untreated water, individual wells, and water hauled directly from rivers and lakes (EPA 2014: Appendix D, Table 3).

At this time, it is difficult to determine what level of effects routine operations of a mine at the Pebble deposit could have on public water supplies in the Nushagak and Kvichak River watersheds. Private wells are a primary drinking water source for many residents of the Nushagak and Kvichak River watersheds, and communities also rely on groundwater for their public water supply. The extent that surface water influences the quality or quantity of the groundwater source for these wells is unknown. However, there are also communities in the area that rely on surface water sources, which may be more susceptible to mine-related contamination. Although no communities are currently located in the SFK, NFK, or UTC watersheds (Figure ES-2), residents of nearby communities use these areas for subsistence hunting and fishing and other activities and may drink from surface waters and springs in these watersheds.

Development of a large-scale mine at the Pebble deposit would require a work force of more than 1,700 people during construction and more than 850 people during mine operation (USACE 2020a: Chapter 2). Thus, the mine site would rival Dillingham as the largest population center in the Bristol Bay watershed during construction and would remain the second-largest population center during operation. This population would require sufficient water supplies in the Pebble deposit region, and these supplies would be vulnerable to contamination or degradation resulting from mine development and operation. The 2020 Mine Plan includes installation of groundwater wells on the northern side of the mine site to supply potable water (USACE 2020a: Section 3.18).

Other public water supplies (e.g., at Iliamna, Newhalen, and Pedro Bay) could be affected by construction of and transport along a roadway and/or pipelines connecting the Pebble deposit region to Cook Inlet. The Safe Drinking Water Act requires states and utilities to assess the source water for public water systems, and there are CWA provisions designed for protecting source waters from contamination. The ADEC Drinking Water Program has delineated drinking water source protection areas for all public water system sources and includes areas along the proposed transportation corridor, the region surrounding Iliamna Lake, and the adjacent communities. Currently, there are no designated drinking water protection areas for private wells in Newhalen, Iliamna, and other villages along the transportation corridor, nor at the mine site (USACE 2020a: Section 3.18).

6.2 Effects of Spills and Failures

This final determination does not consider impacts from potential spills, accidents, and failures as a basis for its findings; however, as discussed in this section there is a likelihood that some spills would occur over the life of the mining operation. A recent report documenting spills that have occurred at Alaska mining operations found that more spills, particularly transportation-related spills, occurred than were predicted in the EISs for these mining operations (Lubetkin 2022). The report did not document the cleanup actions that occurred for these spills, or the resulting environmental impacts. Failure of major infrastructure (e.g., concentrate and tailings pipelines, water treatment plants, or TSF dams), while less likely, could result in severe impacts on aquatic resources in the SFK, NFK, and UTC watersheds.

The FEIS and the BBA evaluated potential impacts of an array of possible accidents and failures that could result in releases and spills of concentrate, tailings, and contaminated water, including their potential effects on fishery areas (EPA 2014, USACE 2020a). This section summarizes the potential impacts of mine area spill scenarios on aquatic resources that were evaluated in the FEIS and also summarizes the potential impacts of a tailings dam failure.

6.2.1 Final Environmental Impact Statement Spill and Release Scenarios

The FEIS evaluates the spill risk associated with the 2020 Mine Plan, including spills and releases of diesel fuel, natural gas, chemical reagents, copper-gold flotation concentrate, tailings, and untreated contact water (USACE 2020a: Section 4.27). The FEIS includes a detailed analysis of seven hypothetical spill scenarios that would generally have a low probability of occurring, but with potential environmental consequences that could be high. Some of the scenarios considered in the FEIS are vehicle and marine transportation-related and are not mentioned here because this final determination focuses on the mine site impacts. The spill scenarios analyzed in the FEIS applicable to the mine site include a spill of concentrate slurry, a bulk tailings release from the tailings delivery pipeline, and a partial breach of the pyritic tailings impoundment that results in a pyritic tailings release. The FEIS evaluates potential environmental impacts of these spill scenarios and uncertainties. A summary of the potential environmental impacts of these scenarios on aquatic resources is provided below.

6.2.1.1 Release of Concentrate Slurry from the Concentrate Pipeline

The copper-gold flotation concentrate that would be produced under the 2020 Mine Plan would be composed of a slurry containing finely ground rock and mineral particles that have been processed from the mined ore to concentrate the economic minerals containing copper and gold. The concentrate particles in the slurry would be potentially acid generating (PAG) and capable of metal leaching over time, depending on conditions. The concentrate slurry would also contain approximately 45 percent mine contact water, which would have elevated concentrations of metals, including copper, and residual amounts of chemical reagents. Under the 2020 Mine Plan, the concentrate would be transported from the mine site to the port site by a pipeline. The FEIS evaluates the potential impacts due to a release of

concentrate slurry from the pipeline. The concentrate slurry release scenario was based on historic spill data and a statistical evaluation of probabilities. The FEIS estimates a concentrate pipeline failure rate of 0.013, which equates to a probability of one or more pipeline failures of 1.3 percent in any given year; 23 percent in 20 years; or 64 percent in 78 years.

The analysis in the FEIS determines that a concentrate slurry spill into flowing waters could have the following impacts on water quality, aquatic resources, and subsistence, commercial, and recreational fisheries users (extent and magnitude of impacts would depend on the size of the spill and spill response actions):

- If a concentrate spill occurs to flowing water, the concentrate would be difficult to recover and would be transported downstream. The distance downstream would depend on the amount and location of the release but could extend into Iliamna Lake.
- Concentrate solids would cause a temporary increase in total suspended solids (TSS) and sedimentation to downstream waters.
- Potential impacts to fish from increased TSS and sedimentation include decreased success of incubating salmon eggs; reduced food sources for rearing juvenile salmon; modified habitat; and in extreme cases, mortality to eggs and rearing fish in the immediate area of the spill.
- Contact water contained in the concentrate slurry would result in exceedances of water quality criteria for copper and other metals.
- Sulfide minerals in the concentrate slurry would slowly dissolve in the subaqueous environment over years to decades and result in metal leaching. The dissolved metals in the aqueous phase of the concentrate slurry could have acute impacts to the aquatic environment that would likely be temporary and localized, but would depend on the size of the release.
- A concentrate spill into flowing water could temporarily displace recreational angling efforts in the vicinity of the spill if the event or cleanup occurred during the open water fishing season.
- A concentrate release would likely cause concerns over contamination for local subsistence users.

6.2.1.2 Tailings Releases

Tailings are the leftover mixture of ground ore and process water following separation of the copper-gold concentrate and molybdenum concentrate. Processing associated with the 2020 Mine Plan would result in the production of two separate tailings waste streams: bulk tailings and pyritic tailings. Approximately 88 percent of the tailings would be bulk tailings and approximately 12 percent would be pyritic tailings. The bulk tailings would consist of tailings that are primarily non-acid generating. The pyritic tailings would have a high level of PAG minerals.

The bulk tailings would be transported by pipeline to a bulk TSF. The pyritic tailings would be transported by a pipeline to a pyritic TSF. Table 6-1 lists some of the key features of the TSFs.

Table 6-1. Summary description of Tailings Storage Facilities.

TSF	Design Features
Bulk TSF	• 1.1 billion tons of tailings would be disposed in the bulk TSF. • Tailings would be thickened before disposal in the TSF. • TSF would have a minimal supernatant pool (pond) during operations. • TSF would have two embankments (dams). The main dam would be 13,700 ft long and 545 ft high. The south dam would be 4,900 ft long and 300 ft high. • The main dam would be a flow-through design and would be constructed using the centerline method. • The south dam would be constructed using downstream method and would be lined on the upstream face. • At closure, the TSF would be covered and allowed to dewater with the goal of becoming a stable landform.
Pyritic TSF	• 155 million tons of pyritic tailings and up to 93 million tons of PAG waste rock would be stored in the pyritic TSF. • TSF would have a full water cover during operations. • TSF would have three dams. The south dam would be 4,500 ft long and 215 ft high. The north dam would be 335 ft high and the east dam 225 ft high with combined length of 2,500 ft. • These dams would be constructed using the downstream method. • Impoundment would be fully lined. • At closure, the pyritic tailings and waste rock would be backfilled into the open pit.

Source: USACE 2020a.

The FEIS evaluates the potential environmental impacts associated with two hypothetical tailings release scenarios, including a release of 1.56 million cubic feet of bulk tailings associated with shearing of the tailings delivery pipelines and a partial breach of the pyritic tailings facility embankment that would result in a release of 185 million cubic feet of tailings and pond water. These scenarios were based on an EIS-Phase Failure Modes Effects Analysis (FMEA) risk assessment that was conducted by USACE. The FEIS determines that tailings releases under these scenarios could result in the following impacts:

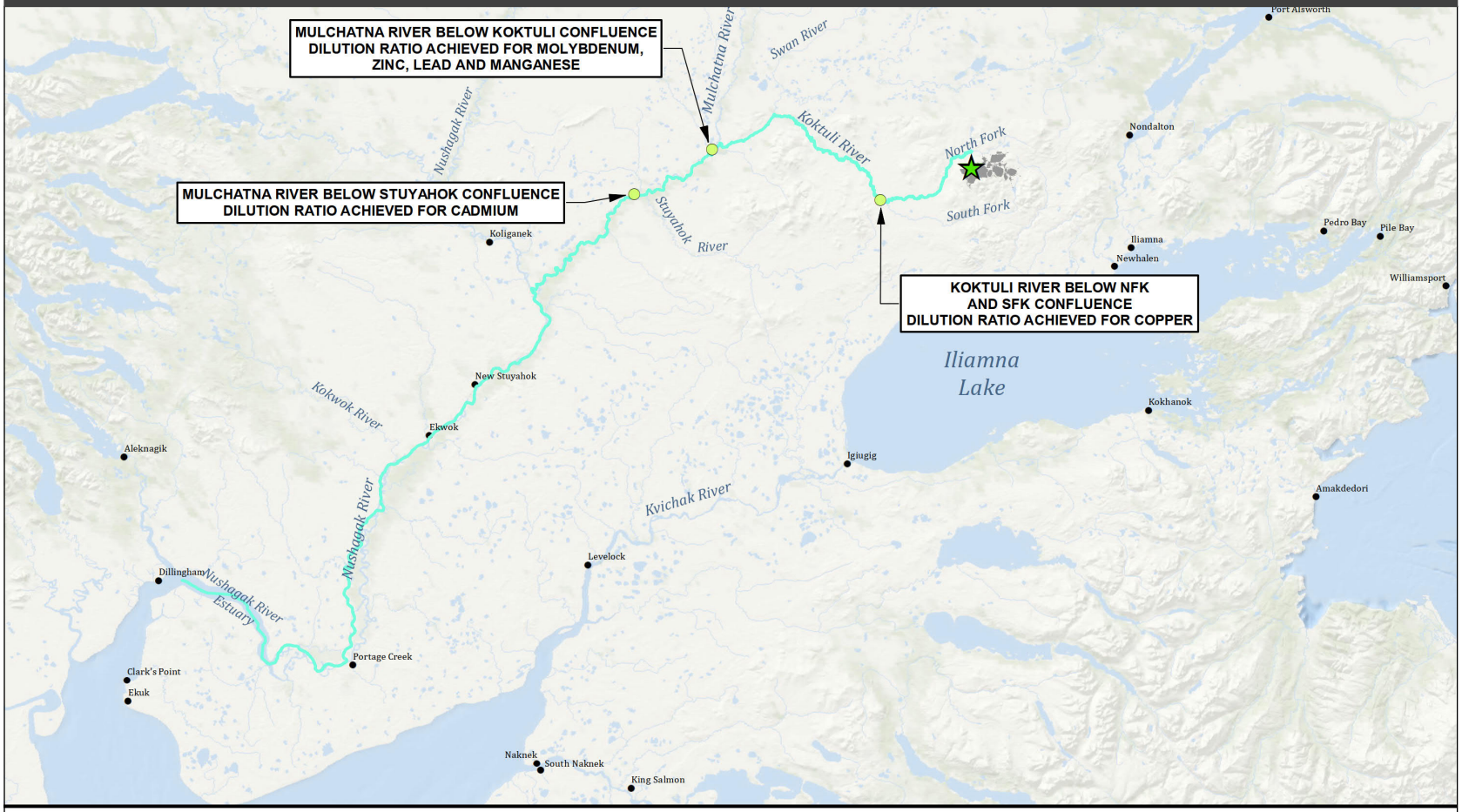
- Under both tailings release scenarios, most of the fine tailings particles would be transported downstream, causing elevated TSS in exceedance of water quality criteria (WQC) for approximately 230 miles downstream as far as the Nushagak River Estuary, where the river feeds into Nushagak Bay. Additional TSS would be generated due to ongoing erosion and sedimentation from potential stream destabilization during the release floods and could persist for months to years, depending on the speed and effectiveness of stream reclamation efforts that would control streambed erosion.
- Tailings fluids (contact water used to mix the bulk tailings slurry and pyritic supernatant fluid) would contain concentrations of some metals that exceed WQC. The dissolved metals would be transported downstream and diluted to various degrees, depending on stream flow. Metals with the highest concentrations would continue to exceed WQC for tens of miles downstream. The estimated extent of impacts for the specific scenarios modeled in the FEIS are as follow:
    - **Bulk tailings release:** Copper concentrations would exceed the most stringent WQC to the Koktuli River below the NFK and SFK confluence, about 23 miles downstream from the mine site. Molybdenum, zinc, lead, and manganese concentrations would exceed the most stringent WQC until the Mulchatna River below the Koktuli River confluence, about 62 miles downstream. Cadmium concentrations would exceed the most stringent WQC until the Mulchatna River below the Stuyahok River confluence, about 78 miles downstream from the mine site. The modeled extent of elevated metals for this scenario is shown in Figure 6-1.

- **Pyritic tailings release:** Copper would remain at levels exceeding the most stringent WQC until the Mulchatna River below the Koktuli River confluence, about 80 miles downstream of the mine site. Zinc, lead, and manganese would remain at levels exceeding the most stringent WQC until the Nushagak River below the Mulchatna River confluence, about 122 miles downstream of the mine site. Cadmium and molybdenum would remain at levels exceeding the most stringent WQC as far downstream as the Nushagak River Estuary, about 230 miles downstream from the mine site.

- Fish and other aquatic organisms would be simultaneously affected by the elevated TSS and metals concentrations in the water, leading to physical injury, loss of habitat and food, and lethal metals toxicity. In the short term, and immediately downstream of the spill, lethal acute metal toxicity may occur in fish species and other sensitive aquatic species. Over days to weeks in downstream locations, sub-lethal effects, such as impairment of olfaction, behavior, and chemo/mechanosensory responses, may also occur in these receptors, specifically due to copper. Impacts from elevated metals could last for 5 to 6 weeks after the pyritic release scenario, while TSS impacts could last for months to years, depending on the effectiveness of stream restoration efforts.
- Although predicted mercury concentrations in tailings are low, even very low amounts of total mercury could result in bioaccumulation and biomagnification in fishes.
- Commercial fishing could be affected, depending on impacts to fish in the affected drainages. Recreational anglers fishing these waters could experience a temporary reduction in harvest rates or catch per unit effort rates if the sub-lethal effects reduced target species' ability or desire to feed or strike at anglers' lures.
- Tailings spills could cause psychosocial stress resulting from community anxiety over a tailings release, particularly in areas of valued subsistence and fishing activities. There could be exposures to potentially hazardous materials, including metals, particularly in the pyritic tailings release. Subsistence users may choose to avoid the area and alter their harvest patterns, due to actual and potential perceptions of subsistence food contamination that extend throughout the area.

In the event of a tailings release, efforts would be made to recover tailings. A small release near the mine site could be recoverable. However, once tailings are actively transported downstream full recovery efforts may not be practicable or possible. This issue is discussed further in Section 6.2.2.

Figure 6-1. Modeled extent of elevated metals downstream of bulk tailings release. Figure 4.27-4 from the FEIS (USACE 2020a: Section 4.27)



6.2.1.3 Untreated Contact Water Release

Untreated contact water is surface water or groundwater that has been in contact with mining infrastructure or mining wastes. Under the 2020 Mine Plan, contact water would be stored in several facilities, including the main WMP, the open pit WMP, and six seepage collection ponds downstream of the TSFs. The main WMP is the largest water storage facility and would include a 750- to 825-acre reservoir contained by a 150-ft-high embankment. According to the FEIS, the main WMP would be among the largest lined water storage reservoirs in the world. The FEIS predicts that contact water would contain elevated levels of several metals in exceedance of WQC. The FEIS evaluates a scenario of a slow release of untreated contact water from the main WMP over a month for a total release of 5.3 million cubic feet into the NFK. The scenario was developed by USACE based on the EIS-Phase FMEA. The FEIS determines that the release could result in the following impacts:

- Untreated contact water released into the downstream drainages would contain elevated levels of aluminum, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, and zinc in exceedance of the most stringent aquatic life WQC. The released untreated contact water would be diluted by stream water as it flows downstream, yet some metal concentrations could remain elevated above WQC for up to 45 miles downstream of the mine site; exceedances would last through the duration of the release.
- Impacts to fish from the release of untreated contact water would be similar to those described for elevated metal impacts from the pyritic tailings release scenario. Acute toxicity due to metals would not likely occur; however, prolonged exposure to metal concentrations in slight exceedance of WQC may result in sub-lethal effects.
- Commercial fishing could be affected, depending on impacts to fish in the affected drainages. Recreational anglers fishing these waters could experience a temporary reduction in harvest rates or catch-per-unit effort rates if the sub-lethal effects reduced target species' ability or desire to feed or strike at anglers' lures.
- Subsistence users may choose to avoid the area and alter their harvest patterns. Spills of untreated contact water could cause psychosocial stress, particularly in areas of valued subsistence and fishing activities.

6.2.2 Tailings Dam Failure

While the FEIS assesses impacts of a partial breach of the pyritic TSF, as discussed above, it does not quantify or model the extent of impacts that could be caused by a catastrophic failure of the pyritic or bulk TSF dams. USACE determined that a full breach analysis was not necessary because it determined that the probability that a full breach could occur is very remote based on the tailings management plans and TSF designs.

However, EPA believes there could be uncertainty with this conclusion due to the conceptual nature of the TSF designs, potential future changes to the TSF water balances due to climate change, the

possibility that design or operational changes could occur during implementation, and the very long time frames over which the bulk TSF dams would need to be maintained. In addition, the FEIS identifies that there is uncertainty associated with the ability of the bulk tailings to drain sufficiently, which would result in the majority of the tailings remaining in a saturated condition and a higher phreatic surface than assumed in the main dam drainage design. The FEIS identifies that this could be monitored during operations and corrected by changes to designs of future dam raises. The FEIS acknowledges that the common factor in all major TSF failures has been human error, including errors in design, construction, operations, maintenance, and regulatory oversight. Even well-designed dams can fail due to human errors during construction or operations. FEIS Appendix K4.27 includes a review of recent tailings dam failures including Mount Polley (Canada, 2014), Fundao (Brazil, 2015), Cadia (Australia, 2018), and Feijao (Brazil, 2019). Some of these failures have caused severe environmental damage and fatalities. It is possible that the 2020 Mine Plan TSF failure probabilities are very low as described in the FEIS (USACE 2020a: Section 4.27). However, due to the uncertainties described above and in the FEIS, the public interest in this issue, and the likely severe environmental consequences of a failure, EPA believes that it is appropriate to describe potential impacts of a failure scenario.

EPA evaluated potential dam failure scenarios in the BBA. The quantitative aspects of the BBA scenarios are not applicable to the 2020 Mine Plan due to differences in the TSF designs and assumptions. However, some of the general conclusions regarding the potential for severe impacts on aquatic resources if such an event were to occur are still applicable. In addition, the FEIS contains a general discussion of the fate and behavior of released tailings from which a potential range of impacts can be discerned.

Failure of the bulk TSF main dam would result in the release of a thickened tailings slurry into the NFK. The FEIS estimates that a release from the bulk TSF main dam would travel only about 2.2 miles downstream due to the thickened nature of the tailings. However, as noted above, it is possible that the tailings could remain saturated, which would result in more fluidized conditions and would travel further. In addition, the FEIS notes that slumping can occur and that upon entering a flowing stream, tailings particles would become entrained in the water and be carried further downstream. Failure of any of the fluid-filled pyritic TSF dams would result in a flood of water and tailings slurry, which could move far downstream.

Tailings slurry releases can result in the following effects:

- Spilled tailings would bury habitat and streamflow would transport some of the spilled tailings downstream, where further deposition would occur, burying stream substrate and altering habitat.
- Tailings entrained in water would create turbid water conditions and sedimentation downstream. Upstream erosion would also contribute to ongoing downstream turbidity and sedimentation.
- Downstream sedimentation and elevated TSS and turbidity would continue until spilled tailings are recovered, naturally flushed out of the drainage, or incorporated into the bedload. Complete recovery of spilled tailings is not possible, because tailings spilled in flowing water would be widely

dispersed. If no tailings were recovered or if the volume of release was extremely high, decades to centuries may be required to naturally flush tailings out of the drainages.

- Metals could leach from unrecovered tailings on a timescale of years to decades. Metals that accumulate in streambed sediments could adversely affect water quality on a timescale of decades.
- The bulk tailings fluid contains antimony, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, selenium, zinc, total dissolved solids, hardness, and sulfate in exceedance of WQC. Water quality characteristics of the pyritic TSF fluids are discussed in Section 6.2.1. Elevated metals and other constituents contained in released tailings process fluids would affect water quality downstream. Released fluids would be diluted by stream water, but streams could fail to meet WQC for many miles downstream. Depending on the volume and the rate of release, the downstream water quality would be in exceedance of WQC for an unknown length of time and an unknown distance before the released fluid is sufficiently diluted below WQC.
- Deposited tailings would severely degrade habitat quality for fishes and the invertebrates they eat due to extensive smothering effects. In addition, based largely on their copper content, deposited tailings would be toxic to benthic macroinvertebrates; existing data concerning toxicity to fishes are less clear.
- The affected streams would provide low-quality spawning and rearing habitat for decades.
- Recovery of suitable substrates via mobilization and transport of tailings would take years to decades and would affect much of the watershed downstream of the failed dam.
- For some years, periods of high streamflow would be expected to suspend sufficient concentrations of tailings to cause avoidance, reduced growth and fecundity, and even death of fishes.
- Loss of NFK fishes downstream of the TSF and additional fish losses in the mainstem Koktuli, Nushagak, and Mulchatna Rivers would be expected to result from these habitat losses.

The extent of water quality changes and habitat and fisheries losses due to failure of any of the TSF dams would depend on many factors, including when the breach occurs during the operational life of the facility, the amount of tailings released, the water content of the tailings, the speed and duration of release, seasonality (winter vs spring/summer conditions), and failure mode. However, the extent of impacts would go much further beyond the extent of the bulk TSF pipeline release and pyritic TSF partial breach described in the FEIS and summarized in Section 6.2.1, and the duration of impacts would be much longer. The USACE ROD acknowledges that although the probability of a full dam breach is low, the consequences would be high and catastrophic failure could have severe and irreversible impacts to subsistence, commercial, and recreational fisheries. USACE states “In the event of human error and/or a catastrophic event, the commercial and/or subsistence resources would be irrevocably harmed, and there is no historical scientific information from other catastrophic events to support restoration of the fishery to its pre-impacted state” (USACE 2020b: Page B3-27).

6.3 Other Tribal Concerns

EPA's policy is to consult on a government-to-government basis with federally recognized tribal governments whenever EPA actions and decisions may affect tribal interests, consistent with Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments*.[103] Consultation is a process of meaningful communication and coordination between EPA and tribal officials. Separately, pursuant to Public Law 108-199, 118 Stat. 452, as amended by Public Law 108-447, 118 Stat. 3267, EPA is required to consult and engage with Alaska Native Corporations on the same basis as tribes under Executive Order 13175.[104]

Throughout development of the BBA (EPA 2014: Chapter 1), the 2014 Proposed Determination, and the 2017 proposal to withdraw the 2014 Proposed Determination, EPA Region 10 provided opportunities for consultation and coordination with federally recognized tribal governments, as well as consultation and engagement with Alaska Native Corporations. On all actions, EPA invited all 31 Bristol Bay tribal governments and all 26 Alaska Native Corporations in Bristol Bay to participate.

On January 27, 2022, consistent with Executive Order 13175 and EPA Region 10 Tribal Consultation and Coordination Procedures (EPA 2012), EPA Region 10 invited all 31 Bristol Bay tribal governments to participate in consultation. Separately, it also invited consultation with 5 Alaska Native Corporations and offered engagement to 21 Alaska Native Corporations with lands in the Bristol Bay watershed. EPA Region 10 hosted three informational webinars for tribal governments and one informational webinar for Alaska Native Corporations to review the CWA Section 404(c) process and answer questions. In addition, EPA Region 10 engaged in multiple consultations with tribal governments and Alaska Native Corporations from February through October 2022. EPA's Office of Water continued the tribal consultation process initiated by EPA Region 10 for this CWA Section 404(c) action. The Assistant Administrator for Water engaged in multiple consultations with tribal governments and Alaska Native Corporations in January 2023. A summary of EPA's tribal consultation process can be found in the docket for this effort at www.regulations.gov, see docket ID No. EPA-R10-OW-2022-0418.

This section describes additional concerns and information that may affect tribal interests regarding potential effects of discharges of dredged or fill material associated with developing the Pebble deposit on subsistence use, traditional ecological knowledge (TEK), and environmental justice.

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[103] In May 2011, EPA issued the *EPA Policy on Consultation and Coordination with Indian Tribes*, which established national guidelines and institutional controls for consultation. In October 2012, EPA Region 10 issued the EPA Region 10 Tribal Consultation and Coordination Procedures, which established regional procedures for the consultation process. On January 26, 2021, President Biden issued the Presidential Memorandum, *Tribal Consultation and Strengthening Nation-to-Nation Relationships*, which charges each federal agency to engage in regular, meaningful, and robust consultation and to implement the policies directed in Executive Order 13175.

[104] As described in EPA's *Guiding Principles for Consulting with Alaska Native Claims Settlement Act Corporations* (EPA 2021), it is EPA's practice to consult with Alaska Native Corporations on a regulatory action that has a substantial direct effect on an Alaska Native Corporation and imposes substantial direct compliance costs and to notify Alaska Native Corporations of impending agency actions that may be outside of the scope of consultation.

6.3.1 Subsistence Use and Potential Mining Impacts

The use and importance of subsistence fisheries in the Nushagak and Kvichak River watersheds and the SFK, NFK, and UTC watersheds are discussed in detail in Section 3.3.6. Although salmon and other fish provide the largest portion of subsistence harvests for Bristol Bay communities, non-fish resources make up a significant portion of subsistence use (Table 6-2). On average, non-fish resources, such as moose, caribou, waterfowl, plants, and other organisms represent just over 30 percent of subsistence harvests by local communities (Table 6-2). The relative importance of non-fish subsistence resources varies throughout the Bristol Bay watershed, and per capita subsistence harvest of non-fish resources exceeds fish harvests in two communities (Table 6-2).

Table 6-2. Harvest of subsistence resources for communities in the Nushagak and Kvichak River watersheds.

Community	Year	Total Harvest (pounds) [a]	Estimated Per Capita Harvest (pounds)		
			All Resources	Fish	Non-Fish Resources
Aleknagik	2008	51,738	296	169	127
Dillingham	2010	486,533	212	138	74
Ekwok	1987	77,268	793	524	269
Igiugig	2005	22,310	541	264	277
Iliamna	2004	34,160	469	404	65
Kokhanok	2005	107,644	680	549	131
Koliganek	2005	134,779	898	655	243
Levelock	2005	17,871	527	192	335
New Stuyahok	2005	163,927	389	216	173
Newhalen	2004	86,607	692	534	158
Nondalton	2004	58,686	357	253	104
Pedro Bay	2004	21,026	305	265	40
Port Alsworth	2004	14,489	133	101	32

Notes:

[a] Total harvest values represent usable weight and include fishes, land mammals, freshwater seals, beluga, other marine mammals, plant-based foods, birds or eggs, and marine invertebrates.

Sources: Schichnes and Chythlook 1991 (Ekwok), Fall et al. 2006 (Iliamna, Newhalen, Nondalton, Pedro Bay, and Port Alsworth); Krieg et al. 2009 (Igiugig, Kokhanok, Koliganek, Levelock, New Stuyahok); Holen et al. 2012 (Aleknagik); Evans et al. 2013 (Dillingham).

Numerous studies on TEK have been completed for the Nushagak and Kvichak River watersheds.[105] These studies provide extensive information from villages in the watersheds, including primary and secondary subsistence species, subsistence use areas and critical habitat, subsistence practices, and observed changes in abundance and timings for subsistence species (Boraas and Knott 2013). For example, the *Nushagak River Watershed Traditional Use Area Conservation Plan* identifies that the species most integral to subsistence were all five species of Pacific salmon, whitefish, winter freshwater fish, moose, caribou, waterfowl, and edible and medicinal plants. The plan also identified probable threats to the watershed and identified as one of its strategic actions "prevent[ing] habitat damage that

[105] Boraas and Knott (2013) summarized additional studies in Appendix D of the BBA (EPA 2014).

could result from mining" (NMWC 2007: Page 3). Section 6.3.2 provides more information about the role of TEK in the Bristol Bay watershed.

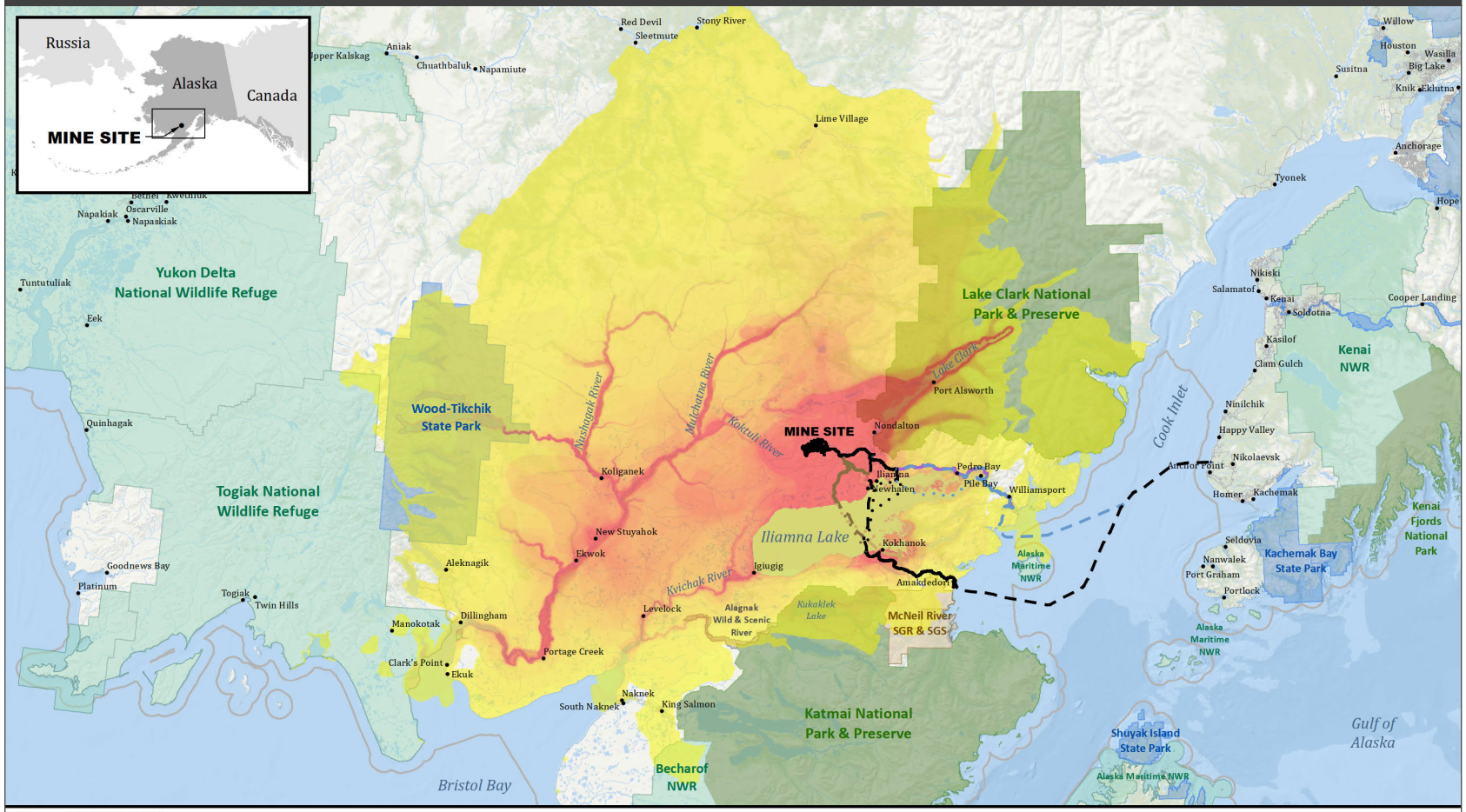
Figure 6-2 highlights areas of subsistence use for fish, wildlife, and waterfowl in the Nushagak and Kvichak River watersheds as identified in the FEIS (USACE 2020a: Table 3.9-1). Subsistence use patterns do not follow watershed boundaries, and communities outside the Nushagak and Kvichak River watersheds also rely on these areas for subsistence resources. For example, Clark's Point subsistence use areas for caribou and moose overlap with the Nushagak and Kvichak River watersheds; South Naknek, Naknek, and King Salmon subsistence use areas for waterfowl, moose, and berry picking, as well as caribou search areas, overlap both watersheds, particularly the Kvichak (Holen et al. 2011). Subsistence data are coarse and incomplete, and it is likely that subsistence activities occur outside the areas identified in Figure 6-2. In addition, Figure 6-2 indicates only use, not abundance or harvest.

Section 4 of the FD provides the basis for EPA's determination that discharges of dredged or fill material from developing the Pebble deposit will have unacceptable adverse effects on anadromous fishery areas in the SFK, NFK, and UTC watersheds. All subsistence resources could be directly affected by discharges associated with the identified mining activities, for example, via habitat destruction or modification of habitat use by different subsistence species. In addition, non-salmon subsistence resources could be indirectly affected by any adverse effects on salmon fisheries that result from discharges associated with the mine; as explained in Section 3.3, the loss or reduction of salmon populations would have repercussions on the productivity of the region's ecosystems.

Any effects on fish—particularly salmon—and other subsistence resources that result from discharges associated with the mine could have significant adverse effects on the Bristol Bay communities that rely on these subsistence foods (EPA 2014: Chapter 12). Given the nutritional and cultural importance of salmon and other subsistence foods to Alaska Native populations, these communities would be especially vulnerable to impacts to subsistence resources; however, non-Alaska Native populations in the region also rely heavily on subsistence resources.

As discussed in EPA (2014) and Section 4 above, routine development and operation of a large-scale mine at the Pebble deposit would likely affect salmon and other important fish resources in the Nushagak and Kvichak River watersheds. The FEIS confirms that the 2020 Mine Plan would result in adverse impacts to the availability of and access to subsistence resources (USACE 2020a: Section 4.9). Although no subsistence salmon fisheries are documented directly in the 2020 proposed mine site, subsistence use of the mine area is high and centers on hunting caribou and moose and trapping small mammals (PLP 2011: Chapter 23). Tribal Elders have expressed concerns about ongoing mine exploration activities directly affecting wildlife resources, especially the caribou herd range (EPA 2014: Appendix D). Tribal members and subsistence hunters have anecdotally reported to EPA that noise during the exploration phase of the Pebble deposit has already disturbed moose populations and altered caribou migration patterns (EPA 2018).

Figure 6-2. Subsistence use intensity for salmon, other fishes, wildlife, and waterfowl within the Nushagak and Kvichak River watersheds. Figure 3.9-1 from the FEIS (USACE 2020a: Section 3.9).



Sources: PLP 2020; ADNR
Subsistence Use Areas by
Stephen R. Braund & Associates

US Army Corps of Engineers

10 0 10 20
Miles

Action Alternatives
- Ferry Routes
- Natural Gas Pipelines
- Alternative 1a
- Alternative 1
- Alternative 1 Kokhanok East Ferry Terminal Variant
- Alternative 2
- Alternative 2 Newhalen River North Crossing Variant
- Alternative 3

Other Features
- Local Roads
- Three Nautical Mile Line
- National Park
- National Wildlife Refuge
- Alaska State Park
- Wild and Scenic River
- State Game Refuge/Sanctuary

Overlapping Subsistence Use Areas
All Resources
12 Communities*
1996/97 - 2005/06
(SRB&A 2018)

*The 12 communities are Ekwok, Igiugig, Iliamna, Kokhanok, Koliganek, Levelock, New Stuyahok, Newhalen, Nondalton, Pedro Bay, Port Alsworth, and Portage Creek.

SUBSISTENCE USE AREAS

PEBBLE PROJECT EIS **FIGURE 3.9-1**

Negative impacts to downstream fisheries from headwater disturbance (Section 4) could affect subsistence fish resources beyond the 2020 Mine Plan footprint. Those residents using the upper reaches of the SFK, NFK, and UTC rivers downstream of the mine footprint for subsistence harvests would be most affected. Access to subsistence resources is also important. A reduction in downstream seasonal water levels caused by mine-related withdrawals during and after mine operation could pose obstacles for subsistence users who depend on water for transportation to fishing, hunting, gathering, or other culturally important areas.

Changes in subsistence resources may affect the health, welfare, and cultural stability of Alaska Native populations in several ways (EPA 2014: Appendix D):

- The traditional diet is heavily dependent on wild foods. If fewer subsistence resources were available, diets would move from highly nutritious wild foods to increased reliance on purchased processed foods.
- Social networks are highly dependent on procuring and sharing wild food resources, so the current social support system would be degraded.
- The transmission of cultural values, language learning, and family cohesion would be affected because meaningful family-based work takes place in fish camps and similar settings for traditional ways of life.
- Values and belief systems are represented by interaction with the natural world through salmon practices, clean water practices, and symbolic rituals. Thus, core beliefs would be challenged by a loss of salmon resources, potentially resulting in a breakdown of cultural values, mental health degradation, and behavioral disorders.
- The region exhibits a high degree of cultural uniformity tied to shared traditional and customary practices, so significant change could provoke increased tension and discord both between villages and among village residents.

Dietary transition away from subsistence foods in rural Alaska carries a high risk of increased consumption of processed simple carbohydrates and saturated fats, which has occurred in urban communities that have low availability and high cost of fresh produce, fruits, and whole grains (Kuhnlein et al. 2001, Bersamin et al. 2006). Available alternative food sources may not be economically obtainable and are not as healthful. Section 3 describes the replacement value of subsistence salmon. Compounding the detrimental shift to a less healthful diet, the physical benefits of engaging in a subsistence lifestyle also would be reduced (EPA 2014: Appendix D).

The magnitude of human health and cultural effects related to potential decreases in resources would depend on the magnitude of these reductions. A small reduction in salmon quality or quantity may not have significant effects on subsistence food resources, human health, or cultural and social organization. However, a significant reduction in salmon quality or quantity would significantly negatively affect these salmon-based cultures. Ultimately, the magnitude of overall impacts would depend on many factors,

including the location and temporal scale of effects, cultural resilience, the degree and consequences of cultural adaptation, and the availability of alternative subsistence resources.

However, even a negligible reduction in salmon quantity or quality related to mining activities could decrease use of salmon resources, based on the perception of subtle changes in the salmon resource. Interviews with tribal Elders and culture bearers indicate that perceptions of subtle changes to salmon quality are essential to subsistence users, even if there are no measurable changes in the quality and quantity of salmon (EPA 2014: Appendix D). In addition to actual exposure to environmental contamination, the perception of exposure to contamination is linked to known health consequences, including stress and anxiety about the safety of subsistence foods and avoidance of subsistence food sources (Joyce 2008, CEAA 2010, Loring et al. 2010, USACE 2020a: Section 4.9).

The 2020 Mine Plan would likely adversely affect access to subsistence harvest areas, as well as the availability, abundance, and quality of subsistence resources due to impacts on fishery areas (Section 4.2) and wildlife (Section 6.1.1). These impacts would endure long beyond mine closure, though with diminishing intensity following closure, unless there are any impoundment failures creating mine waste releases. The FEIS confirms reduced availability of subsistence resources due to habitat loss, disturbance, displacement, and contamination from fugitive dust deposition. The FEIS also states that the reduction of available harvest areas would result in increased costs and time for traveling to alternative harvest areas (USACE 2020a: Section 4.9). However, this assumes that subsistence users would adapt to changes in harvest areas. EPA recognizes that subsistence users may not adapt to these changes due to the ability, capacity, or cultural willingness to access alternate areas and make dietary substitutions across all sectors of the population. However, increased economic opportunity and income could enable subsistence users to afford necessary subsistence technologies (USACE 2020a: Section 4.9).

Further, the FEIS confirms that long-term sociocultural impacts to subsistence users and communities could occur due to the adverse impacts to resource abundance, availability, quality, and access due to the 2020 Mine Plan. These sociocultural impacts could result in adverse effects on community health and well-being, cultural identity and continuity, traditional knowledge transfer, language, spirituality, and social relations (USACE 2020a: Section 4.9).

6.3.2 Traditional Ecological Knowledge

In November 2021, the White House issued a memo, *Indigenous Traditional Ecological Knowledge and Federal Decision Making,* regarding the federal government's commitment to incorporate indigenous

traditional ecological knowledge[106] (ITEK) into its decision-making and scientific inquiry where appropriate.[107] As defined by the 2021 White House memo:

> ITEK is a body of observations, oral and written knowledge, practices, and beliefs that promote environmental sustainability and the responsible stewardship of natural resources through relationships between humans and environmental systems. It is applied to phenomena across biological, physical, cultural and spiritual systems. ITEK has evolved over millennia, continues to evolve, and includes insights based on evidence acquired through direct contact with the environment and long-term experiences, as well as extensive observations, lessons, and skills passed from generation to generation. ITEK is owned by Indigenous people—including, but not limited to, Tribal Nations, Native Americans, Alaska Natives, and Native Hawaiians.

In the Nushagak and Kvichak watersheds, home primarily to the Yup'ik and Dena'ina, indigenous peoples have been harvesting wild resources for at least 12,000 years and harvesting salmon for at least 4,000 years. Salmon and other subsistence resources continue to make up the large majority of the diet in the Nushagak and Kvichak River watersheds. For millennia, the Yup'ik and Dena'ina peoples and their predecessors have depended on the ecosystems that support salmon and other wild resources, and for millennia these ecosystems have remained relatively pristine (Section 3). Traditional subsistence management practices have proven to be sustainable in the Bristol Bay watershed (Boraas and Knott 2013).

The Yup'ik and Dena'ina cultures are inseparably connected to wild salmon and subsistence resources, with one Bristol Bay resident stating that salmon "defines who we are" (Boraas and Knott 2013: Page 1). Parents, grandparents, and Elders transfer knowledge about fish-harvesting practices and the environment to younger generations through demonstration and supervision (Boraas and Knott 2013, USACE 2020a: Section 4.9). The transmission of cultural values, language learning, and family cohesion often takes place in fish camps and similar settings for traditional ways of life (Boraas and Knott 2013). Social mechanisms, such as rituals, folklore, and language, all serve to encode and transmit TEK (Berkes et al. 2000). For instance, the Dena'ina words to indicate direction are based on the concept of upstream or downstream rather than cardinal direction (Boraas and Knott 2013).

Subsistence users in the Bristol Bay watershed are uniquely positioned to track important subsistence metrics, including primary and secondary subsistence species, subsistence use areas and critical habitat, subsistence practices, and observed changes in abundance and timings for subsistence species (Boraas and Knott 2013). Historically, TEK was primarily used in western science to compare and confirm the

[106] There are many terms and definitions used to refer to the concept of traditional ecological knowledge, such as "cultural knowledge," "indigenous knowledge," and "native science." The 2021 White House memo refers to this concept as "indigenous traditional ecological knowledge" or "ITEK." The FEIS refers to this concept as "traditional knowledge." This final determination uses the term "traditional ecological knowledge" or "TEK" consistent with the BBA.

[107] On November 31, 2022, the White House released *Guidance for Federal Departments and Agencies on Indigenous Knowledge* and an accompanying memorandum titled *Implementation of Guidance for Federal Departments and Agencies on Indigenous Knowledge.* While the 2022 guidance was issued near the end of EPA's CWA Section 404(c) review, the tribal consultation process and EPA's consideration of tribal concerns are consistent with the goals of the 2022 guidance.

presence of species documented by indigenous peoples against those documented by western scientists (Knott 1998). More recently, western scientists have begun to include the larger body of TEK into their research, including to inform land and species management plans (Boraas and Knott 2013). The Alaska Department of Fish and Game, for instance, has begun to incorporate TEK into subsistence reports and databases for the Bristol Bay and Alaska Peninsula region, identifying information, such as taxonomy, subsistence use, harvest areas, habitat changes, and changes to local stocks or populations (Kenner 2003, ADF&G 2018a, ADF&G 2020).

Traditional management of wild resources, especially salmon, incorporates a deep recognition of the connection between communities and ecosystems (Boraas and Knott 2013, Berkes et al. 2000). Incorporating TEK into fisheries management can promote more equitable fishing opportunities for communities (Atlas et al. 2021). This is apparent in interviews with Alaska Native Bristol Bay residents, with one resident stating "when the fish first come up here we don't put our nets out here before a bunch of them go by for the people who live at the end of the river up in Nondalton and all those guys… We just kind of watch the salmon go by for the people who live upstream from us" (Boraas and Knott 2013: Page 100).

TEK is also incorporated in watershed- and community-level reports in the region. The Nushagak-Mulchatna Watershed Conservation Plan (NMWC 2007) conducted interviews with watershed Elders, residents, and others to develop maps of critical subsistence resources and habitats, identify traditional use areas, and document subsistence species. These data were used to inform a conservation plan for the watershed, which included identification of probable threats and strategic actions. The *K'ezghlegh: Nondalton Traditional Ecological Knowledge of Freshwater Fish* study (Stickman et al. 2003) documented TEK regarding subsistence salmon and other freshwater fish harvest through interviews with Nondalton residents. Residents provided observed changes in salmon run strength and timing, salmon appearance, environment, and the impacts of human activities on salmon and other freshwater fishes. TEK can enhance understanding of the spatial patterns of subsistence species, facilitate planning for long-term monitoring, improve management practices, track climate and environmental change, and contribute to local-capacity building for research (Berkes et al. 2000, USFWS 2011, Woll et al. 2013, Atlas et al. 2021).

TEK is inherently connected to the millennia-long subsistence way of life in Bristol Bay. The subsistence lifestyle enables Alaska Native Bristol Bay residents to continue to develop, evolve, and pass down their knowledge of the ecosystems supporting subsistence resources. As described in Section 6.3.1 and the FEIS, the 2020 Mine Plan could adversely affect participation in subsistence activities due to impacts to subsistence resource availability, abundance, and quality; changes in the perception of subsistence resource quality; personal comfort harvesting near mining facilities; and time available due to alternative, cash-paying employment. As described in the FEIS, changes such as these could have a "compounding effect on the subsistence way of life" by decreasing the transmission of TEK to younger generations (USACE 2020a: Page 4.9-12). Further, retention of TEK for traditional subsistence harvest areas and resources could be lost as subsistence users adapt to alternative areas and resources (USACE 2020a: Section 4.9).

6.3.3 Environmental Justice

In discussing environmental justice issues, it is useful to consider the following terms, as defined by EPA:

- *Environmental justice* is defined as the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.
- *Fair treatment* means that no group of people should bear a disproportionate burden of environmental harms and risks, including those resulting from negative environmental consequences of industrial, governmental, and commercial operations or programs and policies.
- *Meaningful involvement* means that potentially affected community members have an appropriate opportunity to participate in decisions about a proposed activity that will affect their environment and/or health; the public's contribution can influence EPA's decisions; the concerns of all participants involved will be considered in the decision-making process; and the decision-makers seek out and facilitate the involvement of those potentially affected.

Executive Order 12898, titled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, and its accompanying presidential memorandum establish executive branch policy on environmental justice. To the greatest extent practicable and permitted by law, Section 1-101 of the Executive Order directs each federal agency, as defined in the Executive Order, to make environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.

Furthermore, Section 4-401 of the Executive Order states the following about subsistence consumption of fish and wildlife:

> In order to assist in identifying the need for ensuring protection of populations with differential patterns of subsistence consumption of fish and wildlife, Federal agencies, whenever practicable and appropriate, shall collect, maintain, and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence. Federal agencies shall communicate to the public the risks of those consumption patterns.

In implementing the Executive Order, EPA considers whether there would be "disproportionately high and adverse human health or environmental effects" from its regulatory action and ensures meaningful involvement of potentially affected minority or low-income communities. The scope of the inquiry for any environmental justice analysis by EPA is directly tied to the scope of EPA's potential regulatory action. Because a CWA Section 404(c) action has the potential to affect human health and the environment of minority or low-income populations, including tribal populations, EPA evaluates environmental justice concerns when undertaking an action pursuant to its authorities under CWA Section 404(c).

Though not addressed in Executive Order 12898, the issues and concerns shared with EPA by federally recognized tribal governments during consultation meetings is considered in the environmental justice analysis because of related issues and concerns among Alaska Native communities regarding safety of subsistence foods and cultural impacts, including the sustainability of the subsistence way of life. Consultation is discussed further in Sections 2 and 6.3.

The Bristol Bay communities of the Nushagak and Kvichak River watersheds are predominantly Alaska Native, primarily Yup'ik and Dena'ina (EPA 2014: Chapter 5). Although there are other Bristol Bay communities that are concerned with potential impacts to fishery resources and, consequently, their way of life, EPA focused on communities who practice subsistence within the SFK, NFK, and UTC watersheds for this environmental justice analysis.

As described in Section 2, EPA has conducted extensive community outreach throughout its engagement in the Bristol Bay watershed. Public hearings or meetings were held in May and June 2012, August 2012, August 2014, October 2017, and June 2022, in which community members expressed concerns about the potential impacts of large-scale mining on Alaska Natives' subsistence way of life. Community members expressed concern about adverse environmental and cultural aspects of the project. They also expressed concerns about job loss, the sustainability of villages (e.g., schools closing because enrollment drops as parents make tough choices to go where jobs are available), potential tax revenue, Alaska Native Corporation economic opportunities, and the State of Alaska's concerns regarding economic opportunities for the citizens of Alaska.

Traditional and more modern spiritual practices place salmon in a position of respect and importance, as exemplified by the First Salmon Ceremony and the Great Blessing of the Waters, which symbolically purifies the water in preparation for return of the salmon. The salmon harvest provides a basis for many important cultural and social practices and values, including sharing resources, fish camp, gender and age roles, and the perception of wealth. Although a small minority of tribal Elders and culture bearers interviewed expressed a desire to increase market economy opportunities (including large-scale mining), most equated wealth with stored and shared subsistence foods. In interviews conducted for the BBA (Appendix D), the Yup'ik and Dena'ina communities of the Nushagak and Kvichak River watersheds consistently define a "wealthy person" as one with food in the freezer, a large extended family, and the freedom to pursue a subsistence way of life in the manner of their ancestors, Further, interviews of residents in the Nushagak and Kvichak River watersheds described subsistence as a year-round, full-time occupation. However, subsistence is not captured in labor statistics because it is not based on wages or a salary (EPA 2014: Appendix D).

The Alaska Native community also depends in part on the regional economy, which is primarily driven by commercial salmon fishing and tourism. The commercial fishing and recreation-based market economies provide seasonal employment for many residents, giving them both the income to purchase goods and services needed for subsistence and the time to participate year-round in subsistence activities. The fishing industry provides half of all jobs in the region, followed by government (32 percent), recreation (15 percent), and mineral exploration (3 percent) (EPA 2014: Appendix E). It is

estimated that local Bristol Bay residents held one-third of all jobs and earned almost $78 million (28 percent) of the total income traceable to the Bristol Bay watershed's salmon ecosystems in 2009 (EPA 2014: Appendix E).

The Bristol Bay Regional Vision Project convened over 50 meetings in 26 communities in 2011 to create a guidance document for communities, regional organizations, and all entities that have an interest in the Bristol Bay region. Their final report stated that the residents of the Bristol Bay watershed want "excellent schools, safe and healthy families, local jobs, access to subsistence resources, and a strong voice in determining the future direction of the region" (Bristol Bay Vision 2011: Page 1).

Several common themes emerged during this process, which were similar to themes reflected in public comments EPA received during development of the BBA:

- Family, connection to the land and water, and subsistence activities are the most important parts of people's lives, today and in the future.
- Maintaining a subsistence focus by teaching children how to engage in subsistence activities and encouraging good stewardship practices is important.
- People welcome sustainable economic development that is based largely on renewable resources. Any large development must not threaten land or waters.
- True economic development will require a regionally coordinated approach to reduce energy costs, provide business training, and ensure long-term fish stock protection.
- There should be joint planning meetings among tribes, local governments, and Corporations to create community-wide agreement on initiatives or projects.

Development of the 2020 Mine Plan would result in employment opportunities in the region, primarily for those communities nearest the mine site (Nondalton, Iliamna, and Newhalen), leading to increased revenues and year-round job opportunities throughout the lifespan of the mine, though these jobs could vary based on economic conditions and business decisions. Increased revenue in the region may lead to investments in infrastructure and services, and provide revenue needed for subsistence hunters and anglers to purchase subsistence-related technology and equipment (USACE 2020a: Section 4.9).

As discussed in Sections 3.3.6 and 6.3.1, subsistence foods make up a substantial proportion of the human diet in the Nushagak and Kvichak River watersheds, and likely contribute a disproportionately high amount of protein and certain nutrients.[108] EPA acknowledges that human health within the communities near the Pebble deposit is directly related to the subsistence way of life practiced by many residents of these communities. Additionally, EPA recognizes that subsistence use areas and related subsistence activities provide not only food but also support important cultural and social connections

[108] The BBA did not evaluate threats to human health due to physical exposure to discharged pollutants or consumption of exposed organisms, because these effects were outside the scope of the assessment (EPA 2014: Chapter 2).

within the region's communities. Social networks in the Bristol Bay region are highly dependent on procuring and sharing wild food resources, especially for cash-poor households in which members are unable to fish or hunt, such as Elders, single parents, or people with disabilities (ADF&G 2018b). If a significant adverse impact on the Nushagak and Kvichak River watersheds were to occur, the Alaska Native community reliant on these areas for food supply and cultural and social connections could experience disproportionately high and adverse effects.

SECTION 7. CONCLUSION

Discharges of dredged or fill material to construct and operate the 2020 Mine Plan's proposed mine site alone would result in the permanent loss of approximately 8.5 miles (13.7 km) of anadromous fish streams, 91 miles (147 km) of additional streams that support anadromous fish streams, and approximately 2,108 acres (8.5 km^2) of wetlands and other waters in the SFK and NFK watersheds that support anadromous fish streams. These discharges would also result in streamflow alterations that would adversely affect approximately 29 miles (46.7 km) of additional anadromous fish streams downstream of the mine site due to greater than 20 percent changes in average monthly streamflow. The aquatic resources that would be lost or damaged play an important role in supporting salmon populations in the SFK, NFK, and UTC watersheds.

EPA has determined that the large-scale loss of and damage to headwater streams, wetlands, and other aquatic resources that support salmon populations in the SFK, NFK, and UTC watersheds from the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan will have unacceptable adverse effects on anadromous fishery areas in the SFK, NFK, and UTC watersheds.

To prevent these unacceptable adverse effects, this final determination prohibits the specification of certain waters of the United States in the SFK and NFK watersheds as disposal sites for the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan, including future proposals to construct and operate a mine to develop the Pebble deposit with discharges of dredged or fill material into waters of the United States that would result in the same or greater levels of aquatic resource loss or streamflow changes as the 2020 Mine Plan.

This final determination also restricts the use for specification of certain waters of the United States in the SFK, NFK, and UTC watersheds as disposal sites for the discharge of dredged or fill material associated with future proposals to construct and operate a mine to develop the Pebble deposit with discharges of dredged or fill material into waters of the United States that would result in adverse effects similar or greater in nature and magnitude to the adverse effects of the 2020 Mine Plan (see Section 5 of this final determination).

Proposals to discharge dredged or fill material into waters of the United States associated with developing the Pebble deposit that are not subject to this determination remain subject to all statutory and regulatory authorities and requirements under CWA Section 404.

In light of the immense and unique economic, social, cultural, and ecological value of the aquatic resources in the region, including the fishery areas in the SFK, NFK, and UTC watersheds, and their

susceptibility to damage, EPA will carefully evaluate all future proposals to discharge dredged or fill material in the region.

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SECTION 8. REFERENCES

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Lestochi, Christopher D., Colonel. USACE Alaska District. March 14, 2014—Letter to Dennis McLerran, Regional Administrator, EPA Region 10.

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APPENDIX A

REVIEW PROCESS CONSULTATION LETTERS

APPENDIX A. REVIEW PROCESS CONSULTATION LETTERS

Appendix A provides copies of the Clean Water Act (CWA) Section 404(c) review process consultation letters sent during the CWA Section 404(c) review process for the Pebble deposit area in southwest Alaska.

As described in Section 1 of this final determination, the U.S. Environmental Protection Agency's (EPA) regulations at 40 Code of Federal Regulations (CFR) Part 231 establish a four-step CWA Section 404(c) review process. Before the Regional Administrator issues a proposed determination under Step 2 of the review process, he must notify the U.S. Army Corps of Engineers (USACE),[1] the owner(s) of record of the site, and the permit applicant (if any), that he intends to issue a public notice of a proposed determination and provide the opportunity for USACE, the owner(s) of record of the site, and the applicant (if any) to demonstrate to the satisfaction of the Regional Administrator that no unacceptable adverse effects will occur (40 CFR 231.3(a)) as a result of the discharges of dredged or fill material at issue. USACE may also notify the Regional Administrator of its intent to take corrective action to prevent unacceptable adverse effects to the Regional Administrator's satisfaction. On January 27, 2022, EPA Region 10 notified USACE, the Alaska Department of Natural Resources (ADNR), the Pebble Limited Partnership (PLP), Pebble East Claims Corporation, Pebble West Claims Corporation, and Chuchuna Minerals (the Parties) of EPA's intention to issue a proposed determination for the Pebble deposit area.

If, after the public comment period on a proposed determination, the Regional Administrator prepares and forwards a recommended determination to the Assistant Administrator for Water, the Assistant Administrator for Water shall initiate a final consultation with the Parties, who shall each have 15 days to notify the Assistant Administrator for Water of their intent to take corrective action, satisfactory to the Assistant Administrator for Water, to prevent unacceptable adverse effects (40 CFR 231.6). The Assistant Administrator for Water initiated the final consultation with the Parties[2] on December 2, 2022, providing the Parties through December 19, 2022 to notify her of their intent to take corrective action to prevent unacceptable adverse effects on anadromous fishery areas from certain discharges of dredged or fill material associated with developing the Pebble deposit.

Copies of the responses to these letters can be found at http://www.epa.gov/bristolbay.

[1] Consistent with EPA's regulations, EPA notified USACE because the State of Alaska has not assumed, pursuant to CWA Section 404(g), responsibility to issue permits for discharges of dredged or fill material in waters of the United States under CWA Section 404 (40 CFR 231.3(a)(1)).

[2] Consistent with EPA's regulations, the USACE representative who received this notification was the Chief of Engineers.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
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OFFICE OF THE REGIONAL ADMINISTRATOR

January 27, 2022

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Dear Colonel Damon Delarosa, Ms. Corri Feige, Ms. Michelle Johnson, and Mr. John Shively:

On November 23, 2021, the Environmental Protection Agency Region 10 published notice in the Federal Register providing an update on the status of its 2014 Clean Water Act section 404(c) Proposed Determination regarding the Pebble deposit area located in Alaska's Bristol Bay watershed (Enclosed). The U.S. District Court for the District of Alaska vacated and remanded the EPA's 2019 decision to withdraw the 2014 Proposed Determination. The EPA Region 10's Federal Register notice extended applicable time requirements until May 31, 2022, to consider available information and to determine appropriate next steps in this 404(c) review process. This review includes information that has become available since the EPA issued the 2014 Proposed Determination.

The 2014 Proposed Determination proposed restrictions on the discharge of dredged or fill material into certain waters within the Bristol Bay watershed associated with mining the Pebble deposit. It was issued because of concerns that such discharges could result in unacceptable adverse effects on ecologically important streams, wetlands, lakes and ponds and the fishery areas they support including spawning and breeding areas.

I am writing to inform you that based on our evaluation to date of available information, the EPA Region 10 continues to have reason to believe that the discharge of dredged or fill material associated with mining the Pebble deposit could result in unacceptable adverse effects on important fishery areas. Accordingly, I am notifying you of my intention to issue a revised Proposed Determination. The EPA is sending letters at this time to ensure there is ample opportunity for full consideration of available information to determine next steps before May 31, 2022.

The Clean Water Act's section 404(c) regulations provide an opportunity for consultation at this stage among the EPA, the U.S. Army Corps of Engineers, the owners of record of the site and the permit applicant (if any). The EPA is sending this notice to the same entities it notified in 2014 as well as

Chuchuna Minerals. The U.S. Army Corps of Engineers' 2020 Final Environmental Impact Statement for the Pebble Mine indicates that discharges associated with mining the Pebble deposit could expand in the future into portions of areas where Chuchuna Minerals holds mining claims.

You may submit information for the record to demonstrate that no unacceptable adverse effects to fishery areas would result from discharges associated with mining the Pebble deposit, or that actions could be taken to prevent unacceptable adverse effects to waters from such mining. Consistent with the section 404(c) regulations, please provide your response by February 11, 2022. The EPA can provide additional time if requested.

I appreciate your prompt attention to this matter. If you have any questions or wish to arrange a meeting to discuss any of these issues, please contact me or have your staff contact Cami Grandinetti, at (206) 390-8890 or by email at Grandinetti.cami@epa.gov.

Sincerely,

MICHELLE PIRZADEH

Digitally signed by MICHELLE PIRZADEH
Date: 2022.01.27 08:16:15 -08'00'

Michelle L. Pirzadeh
Acting Regional Administrator

Enclosure

cc: Mr. Doug Mecum, Acting Administrator, Alaska Region
National Marine Fisheries Service

Mr. Greg Siekaniec, Regional Director
U.S. Fish and Wildlife Service

Mr. David Hobbie, Chief of Regulatory Division
U.S. Army Corps of Engineers – Alaska District

Ms. Sara Longan, Deputy Commissioner
Alaska Department of Natural Resources

Mr. Robert Retherford, Director and Vice President
Chuchuna Minerals

Mr. Reeves Amodio, LLC, Registered Agent
Pebble East Claims Corporation and Pebble West Claims Corporation

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 155
Seattle, WA 98101

OFFICE OF THE REGIONAL ADMINISTRATOR

February 2, 2022

Colonel Damon Delarosa
Commander
U.S. Army Corps of Engineers
Alaska District
PO Box 6898
JBER, Alaska 99506

Ms. Corri A. Feige
Commissioner
Alaska Department of Natural Resources
550 West 7th Avenue, Suite 1400
Anchorage, Alaska 99501

Ms. Michelle Johnson
Director
Chuchuna Minerals Company
11401 Olive Lane
Anchorage, Alaska 99515

Mr. John Shively
Chairman and CEO
Pebble Limited Partnership
2525 Gambell Street, Suite 405
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Mr. John Shively
Director and President
Pebble East Claims Corporation
3201 C Street, Suite 404
Anchorage, Alaska 99503

Mr. John Shively
Director and President
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3201 C Street, Suite 505
Anchorage, Alaska 99503

Dear Colonel Damon Delarosa, Ms. Corri Feige, Ms. Michelle Johnson, and Mr. John Shively:

On January 27, 2022, the Environmental Protection Agency Region 10 transmitted a letter providing an opportunity for consultation under the Clean Water Action section 404(c) regulations among the EPA, the U.S. Army Corps of Engineers, the owners of record of the site and the permit applicant regarding the Pebble deposit area located in Southwest Alaska.

On January 29, 2022, the EPA Region 10 received a request for a 45-day extension, until March 28, 2022, from the Pebble Limited Partnership. The EPA is granting that request and is providing this extension to all recipients of this letter.

As a result, you have until March 28, 2022, to submit information for the record to demonstrate that no unacceptable adverse effects to fishery areas would result from discharges associated with mining the Pebble deposit, or that actions could be taken to prevent unacceptable adverse effects to waters from such discharges.

If you have any questions or wish to arrange a meeting to discuss any of these issues, please contact me or have your staff contact Cami Grandinetti, at (206) 390-8890 or by email at *Grandinetti.cami@epa.gov*.

Sincerely,

MICHELLE PIRZADEH
Digitally signed by MICHELLE PIRZADEH
Date: 2022.02.02 17:42:53 -08'00'

Michelle L. Pirzadeh
Acting Regional Administrator

cc: Mr. Doug Mecum, Acting Administrator, Alaska Region
National Marine Fisheries Service

Mr. Greg Siekaniec, Regional Director
U.S. Fish and Wildlife Service

Mr. David Hobbie, Chief of Regulatory Division
U.S. Army Corps of Engineers – Alaska District

Ms. Sara Longan, Deputy Commissioner
Alaska Department of Natural Resources

Mr. Robert Retherford, Director and Vice President
Chuchuna Minerals

Mr. Reeves Amodio, LLC, Registered Agent
Pebble East Claims Corporation and Pebble West Claims Corporation

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF WATER

December 2, 2022

Lieutenant General Scott Spellmon
Chief of Engineers
U.S. Army Corps of Engineers
441 G Street NW
Washington, DC 20314

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Acting Commissioner
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Dear Lieutenant General Spellmon, Mr. Gialopsos, Ms. Johnson, and Mr. Shively

On December 1, 2022, I received from the U.S. Environmental Protection Agency's (EPA) Region 10 Regional Administrator Casey Sixkiller a Clean Water Act Section 404(c) Recommended Determination to prohibit and restrict the use of certain waters of the United States in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds as disposal sites for certain discharges of dredged or fill material associated with developing the Pebble deposit.

After evaluating the available information, including extensive scientific and technical information and the public comments received on the 2022 Proposed Determination, Regional Administrator Sixkiller determined that such discharges into certain waters of the United States in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds would be likely to result in unacceptable adverse effects on anadromous fishery areas.

EPA Region 10's Recommended Determination is available online at www.epa.gov/bristolbay.

EPA's Clean Water Act Section 404(c) regulations require EPA to initiate consultation with you at this stage and to offer you the opportunity to notify EPA, within fifteen (15) days, of your intent to take corrective action to prevent unacceptable adverse effects on anadromous fishery areas from discharges of dredged or fill material associated with developing the Pebble deposit. By this letter, consistent with the regulation at 40 C.F.R. § 231.6, EPA is initiating consultation with you. Should you decide to provide notification of your intent to take corrective action, please do so by December 19, 2022. Information previously provided to EPA Region 10 will be considered by EPA Headquarters and need not be resubmitted.

I appreciate your prompt attention to this matter. If you have any questions regarding the Recommended Determination or would like to arrange a consultation meeting, please have your staff contact Lynsey Lanier with the Office of Water, at (202) 566-1951 or Lanier.Lynsey@epa.gov or Laura Shumway with the Office of Wetlands, Oceans, and Watersheds, at (202) 566-2514 or Shumway.Laura@epa.gov.

Sincerely,

Radhika Fox
Assistant Administrator

CC: Mr. Casey Sixkiller, Regional Administrator, Region 10
EPA

Colonel Damon Delarosa
Commander, U.S. Army Corps of Engineers – Alaska District

Mr. David Hobbie, Chief of Regulatory Division
U.S. Army Corps of Engineers – Alaska District

Mr. John Crowther, Deputy Commissioner
Alaska Department of Natural Resources

Mr. Brent Goodrum, Deputy Commissioner
Alaska Department of Natural Resources

Mr. Robert Retherford, Director and Vice President
Chuchuna Minerals

Mr. Reeves Amodio, LLC, Registered Agent
Pebble East Claims Corporation and Pebble West Claims Corporation

APPENDIX B

ADDITIONAL INFORMATION RELATED TO THE ASSESSMENT OF AQUATIC HABITATS AND FISHES

APPENDIX B. ADDITIONAL INFORMATION RELATED TO THE ASSESSMENT OF AQUATIC HABITATS AND FISHES

Appendix B provides additional supporting information related to aquatic habitats within and downstream of the mine site in the South Fork Koktuli River (SFK), North Fork Koktuli River (NFK), and Upper Talarik Creek (UTC) watersheds and their role in supporting fish populations. As discussed in detail in Section 4, the impacts on aquatic resources that are predicted to occur from the 2020 Mine Plan, based on the available data (e.g., PLP 2011, PLP 2018a) and analyses reported in the Final Environmental Impact Statement (FEIS) (USACE 2020), would likely result in significant loss of or damage to fishery areas in the SFK and NFK watersheds. This appendix addresses additional issues related to two key points: (1) in many cases, the FEIS states that impacts would not result in significant adverse effects on aquatic resources, conclusions that often are not supported by the evidence provided in the FEIS; and (2) the impacts reported in the FEIS likely underestimate or underpredict the actual impacts that the 2020 Mine Plan would have on aquatic resources in the SFK, NFK, and UTC watersheds.

B.1 Quality, Importance, and Productivity of Lost Habitats for Fish Life Stages, Species, and Communities

As detailed in Sections 3 and 4 of this final determination, the evidence presented in the FEIS supports the U.S. Environmental Protection Agency's (EPA's) conclusion that aquatic habitats lost or degraded by the 2020 Mine Plan are of high quality, importance, and value as fishery areas.[1] This section provides an overview of EPA's approach and assumptions for assessing habitat quality and fish use when determining the "quality" of the stream habitats degraded by the 2020 Mine Plan and the "importance" or "value" of that lost habitat and altered functions for fish populations.

B.1.1 Assessing Stream Habitat Quality

The FEIS concludes that loss of stream habitats under the 2020 Mine Plan would be inconsequential for fish populations (USACE 2020: Section 4.24). This conclusion appears to be based on an assumption that the relative quality of these habitats is low and they have minimal influence on downstream waters. These assumptions and conclusions are not supported by the available information about these habitats (including information provided in the FEIS), or the current science surrounding the importance of headwater systems (Section 3.2.4, USACE 2020: Sections 4.16 and 4.24), their contributions to the

[1] A few commenters on the proposed determination cited specific FEIS conclusions as potentially contradicting EPA's conclusions in the final determination. See Attachment 1 of this appendix for the specific conclusions cited by commenters and a detailed discussion of why these FEIS conclusions do not contradict EPA's conclusions in the final determination.

spatial and temporal availability of aquatic resources (Section 3.3.3, USACE 2020: Sections 4.16 and 4.24), and the spatial and temporal scales at which those aquatic resources vary.

B.1.1.1 Quality of Lost Stream Habitats

The headwater streams draining the mine site were found to have low nutrient and dissolved organic carbon (DOC) concentrations (PLP 2018a: Appendix 9.1A), but these values do not suggest a low capacity to support biological productivity. Nutrient and DOC concentrations in downstream reaches and the mainstem Koktuli River generally are similar to those at the mine site (PLP 2018a: Appendix 9.1A). These mainstem habitats are productive salmon habitat, which highlights that nutrient and DOC concentrations are not the only or even most relevant indicators of biological productivity in this region.

According to the FEIS, streams that would be lost to the 2020 Mine Plan "…tend to have higher gradients, fewer off-channel and overwintering habitats, lower proportions of spawning gravels, and less woody debris…" (USACE 2020: Page 3.24-5) than downstream channels. In general, channels with gradients less than 3 percent most frequently meet the substrate and hydraulic conditions required by stream-spawning salmon (Montgomery and Buffington 1997, Montgomery et al. 1999). Many streams draining the mine site, particularly the smallest ones, do have gradients exceeding 3 percent (USACE 2020: Table 3.24-2); however, the anadromous fish stream losses under the 2020 Mine Plan (Table 4-1) are dominated by reaches with gradients less than 3 percent (USACE 2020: Table 3.24-2). Furthermore, the largest stream lengths affected, NFK tributaries 1.190 and 1.200, are documented in the FEIS as having gradients less than 3 percent and suitable spawning substrates (USACE 2020: Table 3.24-2). No data on off-channel habitats, woody debris, or overwintering habitats are reported for these tributaries, although off-channel habitats were quantified at mainstem sites (USACE 2020: Section 3.24, Table 3-10). As a result, FEIS conclusions about the quality of streams that would be lost under the 2020 Mine Plan, relative to downstream mainstem habitats, are not supported by evidence presented in the FEIS. This comparison between mainstem and tributary habitats also misrepresents the relationship between these habitats. Mainstems and tributaries perform overlapping, but not duplicative, roles—mainstem spawning habitats are productive because the headwaters that support them are currently undeveloped and undisturbed.

B.1.1.2 Downstream Effects of Lost Stream Habitats

Losses of stream habitats under the 2020 Mine Plan also will affect downstream waters, due to reduced inputs from lost upstream reaches. According to the FEIS,

> Based on project baseline surveys, the streams directly impacted in the mine site are not considered major contributors of marine-derived nutrients (MDN) from spawning salmon relative to downstream portions of the river network, making terrestrial nutrient sources relatively more important. This can be attributed to the comparatively small numbers of spawning fish, high flushing flows in the fall after spawning has occurred, and the lack of large woody debris or pool habitats for carcass retention (USACE 2020: Page 4.24-21).

As discussed in greater detail below (Sections B.1.2 and B.2.2), the project baseline surveys looked at highly variable spawning densities over only four or five spawning seasons (PLP 2018a: Chapter 15,

Tables 15-14 through 15-17). For this reason, these surveys provide a poor estimate of the temporal variation in spawning densities that has been observed in the region and may be expected over the time scales capturing the life of the mine and its attendant impacts (Rogers et al. 2013). In addition, the methods used to assess spawner abundance provide minimum estimates (Section B.1.2) of the abundance of spawners within a given reach and, thus, their potential contributions of marine-derived nutrients (MDN) to that reach.

The FEIS concludes, "There are abundant small headwater streams in the Koktuli River drainage that would be unaffected by mine site development, and would continue to provide downstream inputs important for stream productivity" (USACE 2020: Page 4.24-21). Although it is true that there are headwater streams that would remain unaffected and continue to provide downstream inputs, there would still be a loss of inputs from 91 miles of streams that support downstream anadromous habitats. The FEIS indicates that approximately 20 percent of available stream habitat in the Headwaters Koktuli watershed (i.e., the SFK and NFK watersheds) and 12 percent of available stream habitat in the larger Koktuli River watershed would be lost to the 2020 Mine Plan (USACE 2020: Section 4.24).[2] At both spatial scales, these impacts represent a considerable and unacceptable loss of upstream habitats that would necessarily affect downstream transport of energy and nutrients. Although the effects of these losses would be increasingly dampened as one moves farther downstream in the river network, reaches immediately downstream of the lost habitats would experience a complete loss of inputs from upstream habitats, which would necessarily affect their downstream transport of energy and nutrients. Thus, impacts to a specific downstream reach result not only from direct loss of headwater habitats under the 2020 Mine Plan, but also from how those direct losses cascade downstream through intervening reaches that are also affected by those direct losses.

B.1.2 Assessing Fish Distribution and Abundance

The SFK, NFK, and UTC are relatively well-sampled streams, compared with other streams in the region, due to Pebble Limited Partnership's (PLP's) efforts to collect environmental baseline data in areas draining the Pebble deposit area (PLP 2011, 2018a). However, accurately and comprehensively assessing fish distribution and abundance in stream and wetland habitats in the larger SFK, NFK, and UTC watersheds, as well as at the mine site area, is difficult. Because the region is inaccessible by road and subject to a challenging and variable climate, sampling occurs on intermittent site visits only during periods when the region and its aquatic habitats are accessible and effective fish sampling is possible. For example, densities of juvenile salmon in most of the tributaries that would be lost under the 2020 Mine Plan were only assessed in a single year (USACE 2020: Table 3.24-10). In addition, fish sampling efforts were not conducted during the winter, resulting in a lack of fish distribution and abundance information in overwintering areas. Given these logistical challenges, the currently available data provide an incomplete description of the full seasonal distribution and abundance of fish species and

[2] EPA acknowledges that water resources have not been consistently mapped throughout these watersheds (USACE 2020a: Page 4.24-8), which affects these percentage estimates. Nonetheless, the 2020 Mine Plan would result in the permanent loss of nearly 100 miles of headwater streams.

life-history stages across the region's high diversity and density of aquatic habitats. Because habitat use by fishes is highly variable in space and time, and because all habitats in the region have not been sampled for all species and life stages, in all seasons, over multiple years, it is reasonable to conclude that the data provide an underestimate of the distribution and abundance of fish species and life stages within these habitats.

This likely underestimation of fish distributions is true not only of the data reported by PLP (2011, 2018a), but also of the Anadromous Waters Catalog (AWC) (Giefer and Graziano 2022) and the Alaska Freshwater Fish Inventory (AFFI) (ADF&G 2022a). These databases do not characterize all potential fish-bearing streams due to the large number of and lack of access to streams in Alaska. The AWC and the AFFI are not comprehensive, meaning that not all streams have been sampled and unsampled streams cannot be assumed to be non-fish bearing. The AWC website acknowledges this limitation, stating that the database "…lists almost 20,000 streams, rivers, or lakes around the state which have been specified as being important for the spawning, rearing or migration of anadromous fish. However, based upon thorough surveys of a few drainages it is believed that this number represents a fraction of the streams, river, and lakes actually used by anadromous species" (ADF&G 2022b). Even within the footprint of the 2020 Mine Plan, the FEIS indicates that the majority of mapped streams have not been sampled for fish (USACE 2020: Section 4.24, Figure 4.24-1). Similarly, life stage-specific designations in the AWC likely represent underestimates, given the challenges inherent in surveying all streams that may support life-stage use throughout the year. These same challenges—and thus likely underestimation of habitat use—also pertain to other aquatic habitat types (e.g., wetlands and other off-channel habitats).

Moreover, the methods used to assess fish distribution and abundance have included several sampling techniques, including snorkeling, electrofishing, seining, angling, and visual observation (aerial and on-the-ground). All of these methods have limitations. Aerial surveys of spawning salmon only account for a portion of the spawning populations, and estimates based on these surveys should be considered minimum counts (Jones et al. 2007, Morstad et al. 2009). Many of these methods, as applied, appear to lack quantitative estimates of capture efficiency: for example, PLP (2011) acknowledges that many of the methods used "were not conducive to estimate catch-per-unit-effort (CPUE)" (PLP 2011: Chapter 15). As a result, estimates of abundance or density with confidence bounds cannot be derived, these methods are most useful for estimating presence of species and life-history stages, and any estimates of distribution and abundance derived from such methods are necessarily minimums because fish species may use certain habitats at times of the year other than when sampling has been conducted to date.

B.1.3 Assessing Habitat Importance or Value

The importance of individual streams and wetlands is not fully captured by fish presence. Stream and river fishes depend on the interconnected suite of watershed processes that shape physical habitat, structure the flow of energy through the system, provide the trophic basis for growth, and regulate the chemical, physical, and biological conditions experienced by fishes and other aquatic life. As discussed in Section 3.2.4, headwater streams and wetlands and their associated functions are crucial contributors to

the quality of downstream waters inhabited by fishes, even if those habitats do not themselves contain fish (Cummins and Wilzbach 2005).

Where fishes are observed in headwater streams and wetlands, density is not always a reliable indicator of habitat quality or productive potential. PLP has undertaken a significant effort to assess fish populations in the SFK, NFK, and UTC watersheds (PLP 2011, 2018a), and the resulting data provide useful baseline information. However, these data are insufficient to conclude that aquatic habitats with no or low fish densities are unimportant for supporting and maintaining fishery resources over the lifespan of potential impacts under the 2020 Mine Plan.

Productivity for Pacific salmon, sometimes defined as the ratio of recruits or offspring per spawner, varies over space and time (Rogers and Schindler 2008). Based on evidence that the component watersheds and associated marine waters yield large quantities of salmon biomass annually, the Bristol Bay watershed—including the SFK, NFK, and UTC watersheds—is highly productive. Watersheds with a high capacity to support salmon production will not always contain high densities of fish at all given times and locations, for numerous reasons (Warren 1971, Van Horne 1983). This may be particularly true for anadromous salmonids and other fish species (e.g., Northern Pike) that use an array of habitats to complete their life cycles. For these species, local abundances may be influenced by population dynamics that occurred elsewhere, during an earlier life stage.

Salmon populations may cycle at decadal to centennial scales (Rogers et al. 2013), and locations of high salmon productivity in the region shift in time and space (Brennan et al. 2019). Some aquatic habitats are seasonally important: salmon may be present in high abundances at certain times of the year, and absent at other times. Some aquatic habitats may have no or low abundances of salmon in some years, but high abundances in other years, reflecting how populations respond to changing environmental conditions across habitats (Section 3.3.3). This variability is illustrated by annual differences in aerial counts of salmon spawners in the SFK, NFK, and UTC mainstems between 2004 and 2008 (PLP 2018a: Table 3-7). Highest index spawner counts differed substantially across species and years, with no consistent pattern across sites: for example, the maximum highest index spawner count for Chinook Salmon occurred in 2004 in the SFK but in 2005 in the NFK (Table 3-7). These data show how variable counts are over a 5-year period. Over longer time scales, this variability is even greater. Available data for total inshore Sockeye Salmon runs in Bristol Bay illustrate this point. Between 2004 and 2008, the period during which most of the fish abundance and distribution data reported in the FEIS were collected, Bristol Bay's total inshore run of Sockeye Salmon ranged from 39.4 million to 44.8 million fish (Tiernan et al. 2021). In 2022, the total inshore run of Sockeye Salmon was 79.0 million fish (ADF&G 2022c)—a roughly 100 percent increase from 2004 through 2008 values. This significant increase in Bristol Bay's Sockeye Salmon runs over the past decade is not captured in the fish abundance and distribution data used to estimate impacts in the FEIS.

These same patterns of spatial and temporal variability also apply to other fish species, macroinvertebrates, and other components of the food web essential for ecosystem function. Given these considerations and the spatial and temporal limitations of the available data, it is impossible to

conclude with any certainty that the aquatic habitats lost to the 2020 Mine Plan are not and would not be important to Pacific salmon over the life of the mine and beyond.

B.1.4 Summary

PLP (2011, 2018a) presents results of the most extensive fish-sampling regime that currently has been conducted in the SFK, NFK, and UTC watersheds. These data show that streams in these watersheds, including those that will be lost under the 2020 Mine Plan, provide spawning and rearing habitat for multiple Pacific salmon species. However, limitations of the sampling regime mean that these data provide an incomplete description of—and likely underestimate—actual seasonal fish distributions and abundances in the region. Aquatic habitats at the mine site and in downstream mainstem reaches, including lateral floodplain habitats, vary in importance across species and life stages, both seasonally and annually (see Section B.2.2). Given these factors, EPA cautions against making conclusions that certain habitats are not important based solely on the numbers of fish observed under PLP's sampling regime. The quality of a given aquatic habitat as a fishery area does not depend solely on fish abundance within that habitat, particularly when fish abundance is assessed infrequently and over limited time scales. Many other factors, including the contributions that habitat makes to the quality and maintenance of downstream reaches, determine the importance of aquatic habitat as fishery areas. It is not valid to conclude that aquatic habitats with no or low observed fish abundances under the sampling regime conducted to date are somehow unimportant as, or unimportant in maintaining, fishery areas. The measure of value, importance, or significance of a given habitat includes not just the fish found there at a specific point in time, but also the fish that have used those habitats in the past, those that will use those habitats in the future, and the larger watershed functions to which that habitat contributes. The headwater streams and wetlands that would be impacted by the 2020 Mine Plan are, in fact, very important for Pacific salmon and other fishes, both directly by providing fish habitat at particular times (i.e., in specific years or seasons, or for specific life stages) and indirectly by provisioning and regulating downstream fish habitats (Section 3.2.4). As a result, these habitats are integral parts of their immensely productive watersheds.

B.2 Spatial and Temporal Scales and Variability

This section examines the importance of (1) considering the spatial and temporal scales at which potential effects of the 2020 Mine Plan on aquatic resources are evaluated, and (2) sufficiently capturing and considering spatial and temporal variability in environmental parameters and aquatic resources when evaluating those effects.

B.2.1 Spatial and Temporal Scales Used in Assessment of the 2020 Mine Plan

When conducting an assessment, defining and selecting appropriate spatial and temporal scales for the analysis are essential. Assessments and models evaluate the system of inquiry at specific spatial and temporal scales, which may be explicitly or implicitly determined. The selection of scales of inquiry is

critical, as they must be appropriate to capture biologically and ecologically meaningful patterns and processes (Levin 1992). Often, the identification of meaningful and relevant impacts to resources of concern requires that assessments consider impacts at multiple scales.

In evaluating potential effects of the 2020 Mine Plan on fish populations, an appropriate spatial scale would capture the extents of adult spawning, egg incubation, juvenile rearing and seasonal movement, and migration as potentially affected by changes in chemical, physical, or biological conditions or processes at and downstream of the mine site. For mine site development and operations, this spatial scale would include all waters under the mine footprint and extend downstream as far as effects could be measured or reasonably expected to have ecological consequences. For example, the spatial scale might be determined by the downstream extent that key constituents were altered for chemical changes and that fluvial geomorphic processes were altered for physical changes. Pacific salmon, due to their mobile and migratory nature, use habitats across these spatial scales over the course of their life cycles.

This selection of appropriate scale is important because assessment of whether "measurable impacts" occur is scale dependent. For example, if an assessment considers a large-enough spatial scale, relative to the assessed area, when evaluating impacts, the relative magnitude of those impacts will diminish as a function of increasing scale (although the absolute magnitude of those impacts remains unchanged). If an assessment considers a short enough temporal scale, relative to the life histories of the species affected and the time frames over which habitat use by species and life stages vary, when evaluating impacts, it may fail to detect what over longer time periods becomes irreparable harm to those habitats and populations (Schindler and Hilborn 2015). Thus, assessment of effects should be conducted at spatial and temporal scales that are most relevant to the resources being evaluated (EPA 2019a, EPA 2019b).

This scale-dependence is illustrated clearly in the FEIS, which concludes that "impacts to Bristol Bay salmon are not expected to be measurable" (USACE 2020: Page 4.24-7). This statement presupposes that the only scale at which impacts matter is the entire Bristol Bay watershed—that is, only impacts at the level of the entire Bristol Bay salmon population are important. Reporting conclusions about impacts at this regional scale results in impacts appearing to be less severe, relatively. The direct loss of 99.7 miles of streams within the initial 2020 Mine Plan footprint is reported as "…about 20 percent of available habitat in the Headwaters Koktuli drainage [i.e., the SFK and NFK watersheds], 12 percent of available habitat in the larger Koktuli River drainage, and 0.3 percent of available stream and river habitat in the Nushagak watershed" (USACE 2020: Page 4.24-8). Basing conclusions on relative effects at the largest spatial extent suggests that individual habitats and the fishes they support are similar and interchangeable throughout the Nushagak River watershed, and evidence suggests that is not the case (Section 3.3.3). It also does not change the fact that 99.7 miles of streams in the SFK, NFK, and UTC watersheds would be lost under the 2020 Mine Plan footprint, an amount of loss that will have an unacceptable adverse effect on fishery areas in these watersheds (Section 4.2.1).

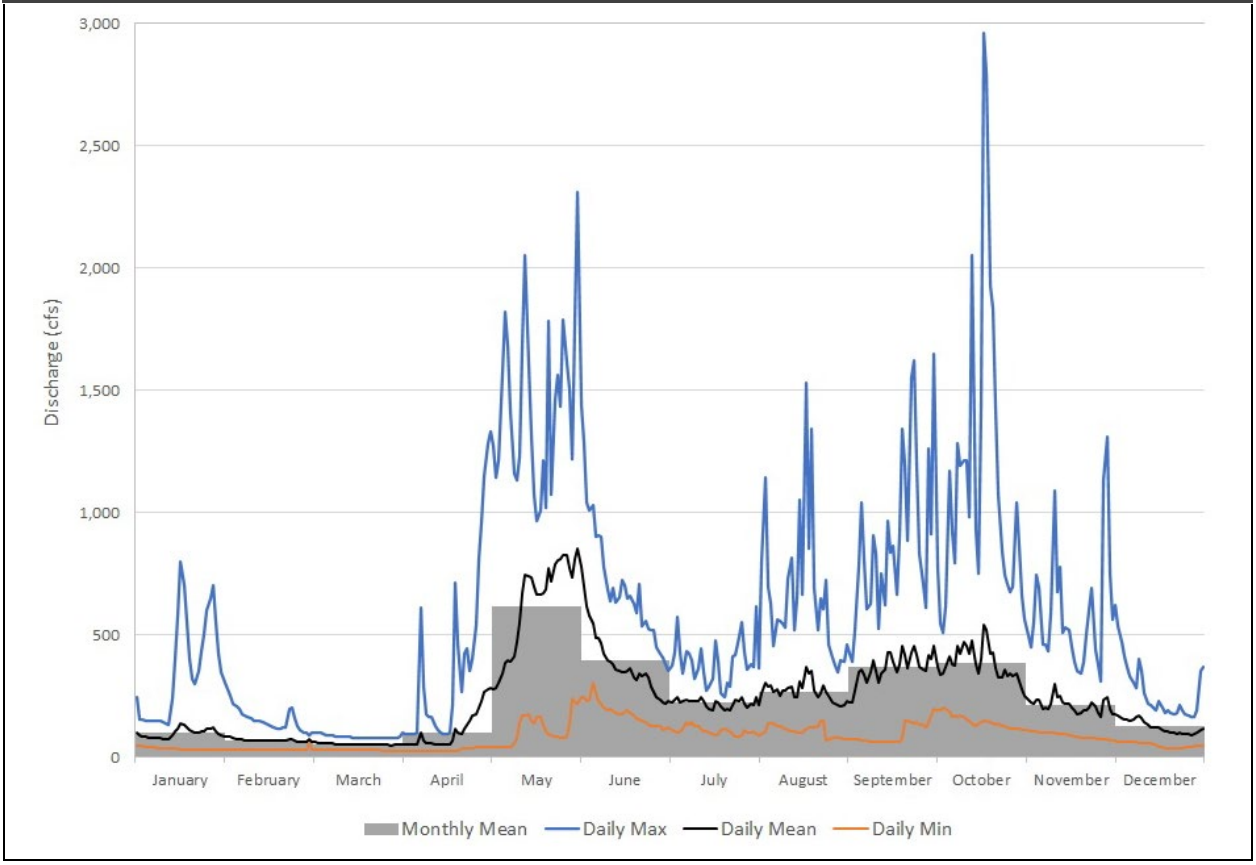
Ninety-four percent of the 2020 Mine Plan's impacts to streams, wetlands, and other aquatic resources would occur in the Koktuli River watershed. The miles of streams and acres of wetlands and other

waters that would be lost reflect local conditions and provide habitat to specific fish communities that are part of a portfolio of local populations of multiple Pacific salmon and other fish species (Section 3.3.3). Thus, the FEIS conclusion does not disclose impacts at the smaller, more relevant and appropriate scale where impacts would be measurable. Loss of any genetically distinct populations in the Koktuli River watershed would constitute a measurable, adverse effect, in addition to any effects these losses may have at the entire Bristol Bay watershed scale via the portfolio effect (Section 3.3.3).

Selection of appropriate temporal scales is also important for evaluating impacts to fishes and their habitats. For example, the FEIS presents streamflows and estimates of streamflow change in terms of average monthly flows (USACE 2020: Section 4.16, Table 4.16-3). Although hydrologists consider average monthly flows to be a meaningful measure of a stream's hydrograph, evaluating impacts of streamflow changes at a monthly temporal scale does not address key ecological considerations relevant to fishes. A stream's annual hydrograph can be characterized by monthly averages, the annual extremes of low and high flows, and short-duration flow pulses (Richter et al. 1996, George et al. 2021). A stream's hydrograph may also be characterized by components that include baseflow, frequent floods, seasonal timing of flows, and interannual variation in flow. In all cases, the magnitude, timing, duration, frequency, and rate of change of streamflows are important in characterizing the natural hydrograph (Poff et al. 1997).

The life histories and behaviors of aquatic organisms are attuned to streamflow cues at different timescales and may be affected by daily (and even sub-daily) variations in streamflow that affect physical and ecological processes (Bevelhimer et al. 2015, Freeman et al. 2022). The use of monthly averages without consideration of daily and interannual variation ignores impacts of predicted flow changes on other important streamflow components. Evaluating streamflow changes using only average monthly flows masks the severity of impacts, because percent changes in daily flows are more variable than changes to monthly averages. This dampening of variability is clearly illustrated by comparing average daily to average monthly flows (Figure B-1): during both low flow and high flow periods, average monthly streamflow does not capture the range of flows that occur in the system. However, such daily flow information is not reported or analyzed in the FEIS. Evaluating streamflow changes using monthly averages provides only a minimum estimate of the actual streamflow changes likely to result from the 2020 Mine Plan. The same is true for changes in water temperature, which the FEIS also presents as monthly averages grouped by winter and summer months (USACE 2020: Section 4.24, Table 4.24-3). The FEIS acknowledges that the potential for daily temperature variations beyond the monthly ranges exists, but states, without any supporting evidence, that the monthly ranges are representative of potential temperature changes (USACE 2020: Section 4.24).

Figure B-1. Average monthly versus minimum, average, and maximum daily streamflow in the North Fork Koktuli River. Averages are based on data at site NK100A (USGS Gage #15302250), from 2004–2015 (USGS 2022).



B.2.2 Spatial and Temporal Variability in Assessment of the 2020 Mine Plan

Streams and rivers are dynamic, highly variable systems. Oversimplification of this variability, or failure to account for rare, but disproportionately influential, spatial features or temporal events, can lead to faulty conclusions. In streams and rivers, infrequent but extreme flow events (i.e., floods or droughts) can strongly shape ecology. The timing and duration of ecologically important flow events, for example, can be difficult to predict, but can profoundly affect both physical habitat structure and population dynamics (Poff et al. 1997, Freeman et al. 2022). Similarly, uncommon or infrequent habitat features can be disproportionately important. For example, shelters or refuges from environmental conditions that may be briefly limiting can serve as "bottlenecks," constraining the abundance of future life stages; for Pacific salmon, critical "bottleneck" habitats can include off-channel habitats and beaver ponds (Pollock et al. 2004).

To fully consider this variability in an assessment of potential impacts, all components of these aquatic systems (i.e., chemical, physical, and biological) should be sampled over spatial and temporal extents that capture the full range of variability in each component. In addition, connectivity between headwater streams and wetlands and downstream waters is dynamic, shifting on both short-term and long-term time frames in response to changing environmental conditions (Fritz et al. 2018). A complete accounting of how headwaters affect downstream waters should consider aggregate physical, chemical, and biological connections over multiple years to decades (Fritz et al. 2018, Schofield et al. 2018).

A significant amount of baseline environmental data has been collected in the SFK, NFK, and UTC watersheds, primarily between 2004 and 2008 (PLP 2011, 2018a). These data demonstrate the natural variability of these systems, in terms of biological communities, streamflow, water chemistry, and myriad other factors, across both sites and sampling dates (e.g., see discussion of adult salmon spawner counts in Section B.1.3). There is no reason to expect that these data, primarily collected over a 5-year period nearly 15 years ago, fully capture how much these factors vary over longer time scales and more finely resolved spatial scales. The nearly 100 percent increase in Bristol Bay's total inshore Sockeye Salmon run in 2022 (ADF&G 2022c), relative to runs between 2004 and 2008 (Tiernan et al. 2021), provides just one example of the variability in environmental conditions that has not been captured in the FEIS and, thus, not considered in its evaluation of impacts of the 2020 Mine Plan.

Streamflow data provide another illustration of this point. Accurate quantification of streamflow metrics requires data collected over sufficient areas and time periods to account for spatial and temporal variability (George et al. 2021). Multiple studies have shown that streamflow data collected over a limited number of years are associated with high levels of uncertainty (Kennard et al. 2010, Goguen et al. 2020). For example, Goguen et al. (2020) evaluated the variability of flow metrics calculated with data collected over different time periods. They found that uncertainty or variability (measured as coefficient of variation) in monthly flow metrics was 30 percent when metrics were calculated over 5 years but decreased rapidly when metrics were calculated over 15 or more years (Goguen et al. 2020).

The high natural variability of these systems also makes FEIS claims that impacts of the 2020 Mine Plan would not be significant because they "would be expected to fall within the range of natural variability" (e.g., USACE 2020: Page 4.24-46) meaningless. This is easily illustrated by considering streamflow variability in Figure B-1. Between 2004 and 2015, average daily streamflow at NK100A, the downstream-most site on the NFK mainstem considered in the FEIS, ranged from roughly 0 to 3,000 cfs; in May alone, average daily streamflow ranged from 40 to more than 2,000 cfs (Figure B-1). Streamflow changes that occur within this range of "natural variability" could still have significant impacts on aquatic resources if they are occurring more or less frequently than under natural, undisturbed conditions.

Like streamflow, fish populations can be highly dynamic in time and space, limiting the ability of short-term, spatially unbalanced sampling designs to adequately characterize population dynamics that may be important for long-term persistence (Davis and Schindler 2021). The baseline data on fish abundance and distribution used in the FEIS were primarily collected between 2004 and 2008, and many sites were

not sampled in multiple seasons across multiple years; thus, data were not collected over sufficient spatial and temporal scales to fully characterize the bounds of the natural spatial and temporal variability of fish populations in the region, for all species and life stages, to adequately support the FEIS conclusions about impacts to fishes. Based on 57 years of continuous monitoring data, Davis and Schindler (2021) conclude that long-term assessments are needed to fully understand the contributions of individual populations. The FEIS assessment of fish abundance and habitat use relies on data collected over a much shorter time period. As a result, FEIS conclusions about the long-term impacts on aquatic resources resulting from the 2020 Mine Plan based on these data should be viewed as minimum estimates—and, as detailed in Section 4.2, even these minimum estimates constitute an unacceptable adverse effect on fishery areas.

B.3 FEIS Assessment of Streamflow Changes

The models and methods used in the FEIS to estimate streamflow changes in the SFK, NFK, and UTC watersheds associated with the 2020 Mine Plan have several shortcomings. This section summarizes the FEIS conclusions regarding streamflow and identifies several issues with those conclusions or the underlying methods, many of which EPA expressed throughout the EIS development process (e.g., EPA 2019a, EPA 2019b).

The FEIS presents impacts of the 2020 Mine Plan that were estimated using an end-of-mine watershed model that incorporated inputs from three primary components: a baseline watershed model, a groundwater flow model, and a mine-site water-balance model (PLP 2019a: RFI 109g). Streamflow changes are reported in terms of changes in average monthly streamflow between baseline (i.e., under natural conditions) and end-of-mine, assuming discharge of treated water in an "average climate year" (i.e., at a 50-percent exceedance probability), based on 76 synthetic monthly average flows (USACE 2020: Section 4.16 and Appendix K4.16) calculated from runoff estimates derived from long-term precipitation and temperature data at a site roughly 17 miles from the mine site. The FEIS states that water would be strategically discharged from wastewater treatment plants (WTPs) to benefit a priority fish species (Chinook Salmon, Coho Salmon Sockeye Salmon, Rainbow Trout, or Arctic Grayling) and life stage (spawning or juvenile rearing) selected for each month in each watershed (USACE 2020: Table 4.24-2).

As detailed in Section 4.2.4, downstream flow changes associated with the 2020 Mine Plan, as reported in the FEIS (USACE 2020: Section 4.16), would exceed 20 percent of average monthly flows in at least 29 miles of documented anadromous fish streams. Reaches of the SFK and NFK closest to the mine site would experience greater changes in average monthly streamflow than reaches farther downstream (USACE 2020: Section 4.16). NFK Tributary 1.190 would be dewatered entirely—that is, experience a 100-percent loss of flow—due to construction of the bulk tailings storage facility and seepage-collection system (USACE 2020: Section 4.16). SFK Tributary 1.190 is predicted to experience a maximum change in average monthly flow of 19 percent during operations, whereas SFK Tributary 1.24 is predicted to

experience a maximum change of 98 percent (USACE 2020: Section 4.16). A total of 9.2 miles of anadromous habitat have been documented within these two SFK tributaries.

Significant streamflow alterations also would extend down the NFK and SFK mainstems. For example, NFK Reaches A, B, and C would experience a greater than 20-percent increase in streamflow during April; NFK Reach C could see a 105-percent increase in April and a 20-percent decrease in June. These alterations are predicted to occur despite attempts to "optimize" the discharge of treated water to benefit priority fish species and life stages. SFK Reach E would see a 52-percent decrease in average monthly streamflow in April, whereas SFK Reach D would see a 109-percent increase (USACE 2020: Table 4.16-3) due to WTP discharges. According to the FEIS, the extent of impacts on streamflow could extend to just below the confluence of the SFK and NFK (USACE 2020: Page 4.16-2),[3] meaning that up to 61 miles of the SFK and NFK mainstems could experience "discernible" streamflow alterations. This level of change from natural streamflows represents an unacceptable adverse effect on fishery areas in the SFK and NFK watersheds (Section 4.2.4).

Despite the importance of natural flow regimes as a "master variable" determining the structure and function of stream and river ecosystems (Bunn and Arthington 2002, Lytle and Poff 2004, Poff and Zimmerman 2010, Sofi et al. 2020, Tonkin et al. 2021), the FEIS fails to evaluate the myriad ways that anticipated streamflow changes would affect these systems. The FEIS also likely underestimates the actual extent to which streamflow in the SFK, NFK, and UTC watersheds would be affected by mine operations resulting from the 2020 Mine Plan, in terms of percentage change in streamflow, length of affected streams, and changes in streamflow variability. This underestimation of streamflow changes in the FEIS results from several issues.

The following sections highlight three specific areas of concern in the FEIS assessment of streamflow changes: the failure to consider ecological impacts of streamflow changes; the use of average monthly streamflows to assess impacts; and the failure to sufficiently consider interactions between surface waters and groundwater.

B.3.1 Impacts of Streamflow Changes

The natural flow regime is a critical component of streams and rivers and their hydrologically connected aquatic habitats because water flow directly or indirectly affects all other physical, chemical, and biological components of these systems (Bunn and Arthington 2002, Lytle and Poff 2004, Poff and Zimmerman 2010, Sofi et al. 2020, Tonkin et al. 2021). The body of published scientific literature on the functional consequences of hydrograph alteration is extensive (e.g., Poff et al. 1997, Tonkin et al. 2021, Freeman et al. 2022). Despite its importance, the FEIS does not address the numerous effects of predicted flow changes directly. There is no explanation of how streamflow changes associated with the

[3] The FEIS indicates streamflow in the UTC and the Koktuli River below the confluence of the NFK and SFK would not be negatively impacted by the project (USACE 2020: Section 4.24).

2020 Mine Plan would affect natural flow patterns and variability,[4] nor consideration of how these streamflow changes would alter physical habitat, water quality, and the full suite of organisms adapted to natural flows in these systems (Section B.5.2).

The FEIS instead uses estimates of streamflow change solely to inform its fish habitat modeling, presenting summaries of monthly changes to "suitable fish habitat" as defined in the PHABSIM model (Section B.4). Flow changes that alter monthly averages by more than 100 percent are viewed only through the lens of the PHABSIM model and are predicted to increase available habitat, notwithstanding the elimination of nearly 100 miles of streams and the myriad effects the loss of these flows and their ecological subsidies would have on downstream reaches. There is no distinction made in the FEIS between flows that create and maintain habitat (e.g., channel-maintenance flows) and those that affect habitat utilization. As a result, the FEIS presents an extremely simplified assessment of how streamflow changes will affect mainstem and tributary reaches of the SFK, NFK, and UTC watersheds. As detailed in Section 4.2.4, even this simplified assessment shows that streamflow alterations associated with the 2020 Mine Plan would constitute an unacceptable adverse effect on fishery areas, and the actual ecological impact of these changes would likely be more extensive than estimated in the FEIS.

Furthermore, stream lengths in which flow regimes would be significantly altered from natural conditions are not quantified or discussed in the FEIS. The FEIS states that flow changes may extend to reaches just below the confluence of the SFK and NFK mainstems (USACE 2020: Page 4.16-2), but the FEIS does not mention that there are 61 miles combined in the SFK and NFK mainstems before reaching that confluence. Additionally, the distance between locations at which streamflow information was collected and modeled limits the ability to accurately predict the extent of streamflow impacts. For example, WTP discharges to Frying Pan Lake would increase outflows to the SFK up to 109 percent above average monthly flows. However, it is unclear how far downstream these flow increases would extend because the next downstream gage at which streamflow information was estimated (i.e., SFK Reach C) is located 11.7 river miles downstream. At that point, streamflow changes were estimated at less than 5 percent below baseline average monthly flow (USACE 2020: Table 4.16-3).[5] The actual extent of streamflow changes in the SFK most likely extends some distance downstream of Frying Pan Lake, but the FEIS does not provide an estimate of that distance.

[4] The FEIS acknowledges that "[f]lood magnitude and frequency on the NFK and SFK rivers could potentially change as a result of mine development" and that "[t]he geographic extent of potential changes to flood magnitude on the NFK and SFK could extend just below the confluence of the two rivers," (USACE 2020: Page 4.16-18), but does not discuss how specific flood events, such as channel-forming flows or bankfull flows that occur every 1.5 to 2 years, would be altered; what such changes would mean for stream stability; or how such changes would affect aquatic habitats and species.

[5] The next downstream location for which streamflow data are presented in FEIS Table 4.16-3 is SFK Reach C, which is based on streamflow at gage SK100C (PLP 2019b: RFI 109f), 11.7 river miles (18.9 km) downstream of SK100F (PLP 2020d: RFI 161).

B.3.2 Use of Average Monthly Flows and Climate Conditions

The FEIS presents streamflows and estimates of streamflow change in terms of average monthly flows (USACE 2020: Section 4.16, Table 4.16-3). Percentage flow differences between baseline and end-of-mine conditions are computed based on monthly averages, which as discussed below provide a relatively coarse measure of potential impacts to fishes and other aquatic resources. Even at this coarse level of assessment, greater than 20 percent changes in average monthly flows are predicted during at least 1 month per year in at least 29 miles of documented anadromous fish streams.

In reality, the use of average monthly flows to evaluate impacts of the 2020 Mine Plan likely underestimates downstream flow changes that would have meaningful ecological effects. Average monthly flows do not capture ecologically important aspects of the natural hydrograph (Section B.2) or represent the full magnitude of potential daily flow fluctuations. As a result, the use of monthly averages downplays the extent of impacts on the natural hydrograph and the aquatic life that is adapted to and relies on it. Fish do not experience average monthly flows; rather, they experience the dynamic continuum of flows occurring over much shorter time periods (i.e., daily or even sub-daily flows). As discussed in Section B.2.1, evaluation of streamflow changes using only average monthly flows masks the severity of impacts, because percent changes in average monthly flows are less variable than changes in daily flows (Figure B-1). If average monthly streamflows differ from baseline conditions, aquatic resources are likely to be altered; if average monthly streamflows do not differ from baseline conditions, it does not necessarily mean that streamflow patterns on shorter time scales—and, thus, aquatic resources—will not be affected.

In the FEIS analysis of streamflow changes, WTP discharges would be preplanned for each month based on modeling and a set of assumptions. Monthly WTP discharges would be the amount needed to "optimize" downstream habitat for specific anadromous fish species and life stages assuming that the historic monthly average streamflow was to occur (i.e., given an "average climatic year," or 50 percent exceedance probability). However, the only monitoring proposed by PLP appears to be quarterly streamflow and fish presence surveys (PLP 2019c: RFI 135), indicating that water discharges were never proposed to be altered in response to current climatic conditions. Managing water discharges based on average long-term streamflows would dampen variability in the system (Section B.2.2). The proposed discharges would transform the naturally varying and unregulated surface water and groundwater flows in the headwaters into uniform, regulated process-water discharges to surface waters. The loss of this streamflow variability, which is critical to the structure and function of these ecosystems (Poff et al. 1997, Bunn and Arthington 2002, Freeman et al. 2022), is not described or characterized in the FEIS.

Despite these shortcomings, the streamflow change estimates documented in the FEIS provide a reasonable minimum approximation of the streamflow impacts expected to result from the 2020 Mine Plan. Even these minimum estimates of changes in average monthly flows, over the stream lengths documented in the FEIS, would affect the physical, chemical, and biological characteristics of these streams and constitute an unacceptable adverse effect on fishery areas.

B.3.3 Interactions between Groundwater and Surface Waters

As discussed in Section 3.2.1, surface waters and groundwater in the SFK, NFK, and UTC watersheds are highly connected and interact in complex ways (USACE 2020: Section 3.17). These interactions influence streamflow patterns—and thus aquatic resources—in both space and time. The FEIS provides limited characterization or simulation of the coupled surface water-groundwater interactions critical to maintaining the region's aquatic ecosystems (Wobus and Prucha 2020). As a result, the FEIS underestimates the extent of groundwater impacts likely to occur under the 2020 Mine Plan and, thus, potential effects on downstream flows. Examples of the failure of the FEIS to adequately consider groundwater impacts and interactions with surface waters are included below.

- The baseline watershed model and the groundwater flow model used to assess streamflow changes were not integrated, and instead they were developed and operated independently (Wobus and Prucha 2020). The baseline watershed model was configured and calibrated prior to development of the refined groundwater model (MODFLOW). Together, these points indicate that estimates of streamflow change in the FEIS did not represent a comprehensive, integrated assessment of how changes in both surface waters and groundwater would affect streamflows under the 2020 Mine Plan.

- A review of the model calibration shows the groundwater model overestimates groundwater elevation in the NFK headwaters area and underestimates NFK streamflow downstream of the headwaters, which may be an indication of poor model calibration (PLP 2019d: RFI 109d). MODFLOW simulations resulted in groundwater elevations that were up to 35 feet deeper than observed water table elevations (e.g., Figure 6-10 in PLP [2019d]), suggesting poor model calibration and the need to expand the alluvial aquifer in the headwaters of the NFK to properly account for groundwater and surface water observations.

- Within and across the mine site boundary, streamflow changes due to well pumping and groundwater table depression were not well characterized. Streamflow losses during mine operation were only characterized by conditions at the end-of-mine (e.g., 20 years). Changes in shallow groundwater conditions and associated stream losses within and across the mine site boundary were not rigorously accounted for when estimating streamflow impacts, as indicated by the significant differences between MODFLOW's simulated groundwater elevations and observed groundwater elevations (discussed above). Impacts on gaining reaches downstream of the mine, attributed to groundwater sources under pre-mine conditions in the FEIS, were not considered.

- The majority of surface water and groundwater flows within the mine site boundary were assumed to be captured, contained, and released via WTP discharge to surface waters. There was no assessment of impacts associated with the loss of groundwater recharge at the mine site, which provides baseflow contributions to discharge under low flow conditions (including under surficial ice) and stabilizes water temperatures under low and transitional flow conditions.

As these examples illustrate, the FEIS likely underestimates the impacts of groundwater pumping and processing demands, the extent of groundwater drawdown both within and across watersheds, and, thus, the influence these groundwater-related factors would have on downstream flow changes associated with the 2020 Mine Plan.

B.4 FEIS Assessment of Fish Habitat Changes

Assessment of streamflow and fish habitat changes under the 2020 Mine Plan are closely related, given the fish habitat assessment methods used in the FEIS. This section considers potential issues associated with how the FEIS evaluated fish habitat changes and how those issues affect conclusions about impacts of the 2020 Mine Plan. The issues raised here do not affect EPA's conclusion that the habitat losses (i.e., losses of anadromous fish streams, additional streams, and wetlands and other waters) or streamflow changes predicted to occur under the 2020 Mine Plan each constitute an unacceptable adverse effect on fishery areas. Rather, these issues highlight concerns that the FEIS evaluation of fish habitat changes did not represent an accurate and thorough assessment of likely impacts.

B.4.1 Overview of Fish Habitat Assessment Methods

The FEIS relied on the PHABSIM modeling approach, which is part of the Instream Flow Incremental Methodology developed by the U.S. Fish and Wildlife Service (Bovee et al. 1998) to model changes in fish habitat in response to changes in streamflow. In the FEIS fish habitat analysis, PHABSIM was used to predict effects of streamflow changes on the amount of available habitat for multiple fish species and life stages. There are two basic components of a PHABSIM model: (1) the hydraulic representation of the stream at a stream transect; and (2) the habitat simulations at a stream transect using defined hydraulic parameters (i.e., water depth and velocity and, for some life stages, substrate). Habitat suitability curves (HSCs) for different fish species and life stages are used to calculate weighted usable habitat area for a stream segment represented by the transect.

In addition, the HABSYN program developed by R2 Resource Consultants was used to expand the standard transect-based component of PHABSIM to unsampled habitat areas (USACE 2020: Appendix K4.24, PLP 2018b: RFI 048). To EPA's knowledge, the HABSYN model has never been validated or documented in the scientific literature. The basic premise of extending sampled transect data to unsampled habitats was not evaluated, but was assumed in the FEIS to be valid for assessing fish habitat in unsampled areas.

Together, PHABSIM and HABSYN models were used to estimate total acres of fish habitat—by species, life stage, and reach—for wet, average, and dry climate conditions during pre-mine (baseline), end-of-mine, and post-closure phases of mine development. The following sections focus on potential issues associated with the modeling of fish habitat changes under the 2020 Mine Plan, as reported in the FEIS (USACE 2020: Section 4.24, Appendix K4.24). Many of these issues were previously identified in EPA (2019) and National Marine Fisheries Service (NMFS) (2020).

B.4.2 Use of PHABSIM Models to Estimate Fish Habitat Changes

PHABSIM is a one-dimensional physical model that has been used for decades to model habitat and manage streamflows for fish populations, including salmon. Because PHABSIM is a method that does not have a direct relationship to fish population biology (Waddle 2001), it has several limitations that have long been acknowledged (e.g., Anderson et al. 2006, Railsback 2016) and should be addressed during application and considered in interpreting results when PHABSIM is used. The FEIS did not consider many of these issues in its fish habitat analysis; as a result, its estimates of changes to fish habitat resulting from the 2020 Mine Plan likely underestimate the extent of those changes. This section explores specific assumptions and limitations of how PHABSIM models were implemented in the FEIS (USACE 2020: Section 4.24, Appendix K4.24), as well as factors that were omitted from fish habitat analyses.

B.4.2.1 Assumption that Streamflow Equals Fish Habitat

The FEIS bases its conclusions about changes in the availability of fish habitat under the 2020 Mine Plan on PHABSIM modeling (USACE 2020: Section 4.24, Appendix K4.24), which, as implemented in the FEIS, assumes that water depth and velocity are the only determinants of fish habitat. This assumption cannot defensibly be made unless (1) field data and analysis show that water depth and velocity are related to fish habitat in the region, and (2) there is a comprehensive evaluation of the other factors determining fish habitat that would potentially be affected by the 2020 Mine Plan.

Importantly, the FEIS and its supporting documents did not establish that relationships between discharge (water depth and velocity) and fish habitat exist in the SFK, NFK, and UTC. This is of particular concern because these watersheds are groundwater-driven systems. When the assumption that habitat use primarily is structured by surface water hydraulics is not valid, hydraulic habitat modeling methods such as PHABSIM are not appropriate (Waddle 2001). Field data demonstrate that fish occurrence in areas of differing water depths and velocities changed with streamflow and over time (PLP 2011: Appendix 15.1C)—that is, a consistent relationship between water depth and velocity and fish habitat use was not observed. These data demonstrate variability in fish habitat use among survey years, an indication that the underlying PHABSIM assumptions are not valid.

The PHABSIM model used in the FEIS incorrectly assumed that habitat can be reduced to discharge. Even if this assumption were valid—as discussed above, it was not—the PHABSIM analysis also failed to account for or consider other ecologically relevant fish habitat parameters, such as groundwater exchange, substrate, water temperature, water chemistry, cover, and habitat complexity (e.g., wetlands and other off-channel habitats). While water depth and velocity are important determinants of fish habitat, they are only two variables interacting with a suite of other factors that determine overall fish habitat suitability.

PHABSIM models are not appropriate as the sole means to evaluate habitat for fish species that key into specific habitat variables unrelated to water depth and velocity. For example, the SFK, NFK, and UTC watersheds experience complex interactions between surface water and groundwater, with

repercussions for fish habitat. Spawning Sockeye Salmon (*Oncorhynchus nerka*) and Coho Salmon (*O. kisutch*) select habitats based on groundwater upwelling and downwelling, respectively. Changes in these habitat determinants were not reflected in the PHABSIM analysis; in general, the utility of PHABSIM approaches may be extremely limited in areas such as the SFK, NFK, and UTC watersheds, with extensive and complex surface water-groundwater interactions (NMFS 2020).

In addition, the PHABSIM analysis did not consider how disruption of surface water flows, groundwater pathways, and aquifer characteristics would alter water temperatures and thermal patterns within the SFK, NFK, and UTC watersheds. The alteration of water temperatures is a concern because fishes are at risk from disruption of the heterogeneity and spatial distribution of thermal patterns, which drive their metabolic energetics. Fish populations rely on groundwater-surface water connectivity, which has a strong influence on stream thermal regimes throughout the Nushagak and Kvichak River watersheds and provides a moderating influence against both summer and winter temperature extremes (Woody and Higman 2011). Coho Salmon may move considerable distances over short time periods in response to food resources and temperature to enhance growth and survival (Armstrong et al. 2013). The PHABSIM analysis also does not account for the benefits of complex stream features resulting from off-channel habitats (e.g., side channels, sloughs) or other habitats, such as islands or tributary junctions. These can be important features for fish populations: for example, tributary junctions are biological hotspots, and off-channel habitats are often the most important factors in salmonid distribution (e.g., Swales and Levings 1989, Benda et al. 2004).

By considering only water depth and velocity, the one-dimensional PHABSIM analysis simplifies and homogenizes the complexity of fish habitat into combinations of only water depth and velocity. This simplified approach provides only a coarse assessment of suitable fish habitat and predicted impacts resulting from the 2020 Mine Plan. As a result, this approach likely underestimates actual changes to fish habitat that would be likely to result from changes to the full suite of variables determining available fish habitat.

B.4.2.2 Data Collection Issues

The approach taken to develop valid fish-habitat associations typically involves mapping defined, representative, hierarchical habitats; conducting fish surveys at sites both used and unused by fish across the full seasonal distribution (i.e., spring, summer, fall, and winter) of all fish species and life stages (including incubation, emergence, and fry); and then selecting study sites for analysis (e.g., Rosenfeld 2003). Data collection efforts to support fish habitat modeling in the FEIS did not follow this approach and do not appear to be structured or consistently implemented to inform the PHABSIM model in a meaningful way. As a result, there are several issues of concern regarding the data used in the fish habitat analysis, in terms of both data-collection methods and data completeness; some examples are discussed below.

Additional environmental baseline data relevant to fish habitat use were collected, but these data were not used in the habitat impact analysis. Data on off-channel habitats are reported in PLP (2011, 2018a) (see Table 3-10) but were not used in analyses related to fish habitat. The SFK, NFK, and UTC were

modeled as single-channel systems in the PHABSIM analysis, despite the frequent occurrence of riparian wetland complexes, floodplains, beaver ponds, and other off-channel habitats throughout the area (Table 3-10; PLP 2011, 2018: Chapter 15). For example, up to 70 percent of the mainstem SFK downstream of Frying Pan Lake appears to be bordered by off-channel habitats (USACE 2020: Section 3.24). This complexity is not captured in the instream habitat classification, despite its prevalence and importance for different life stages of salmon (especially Coho Salmon) and other fish species.

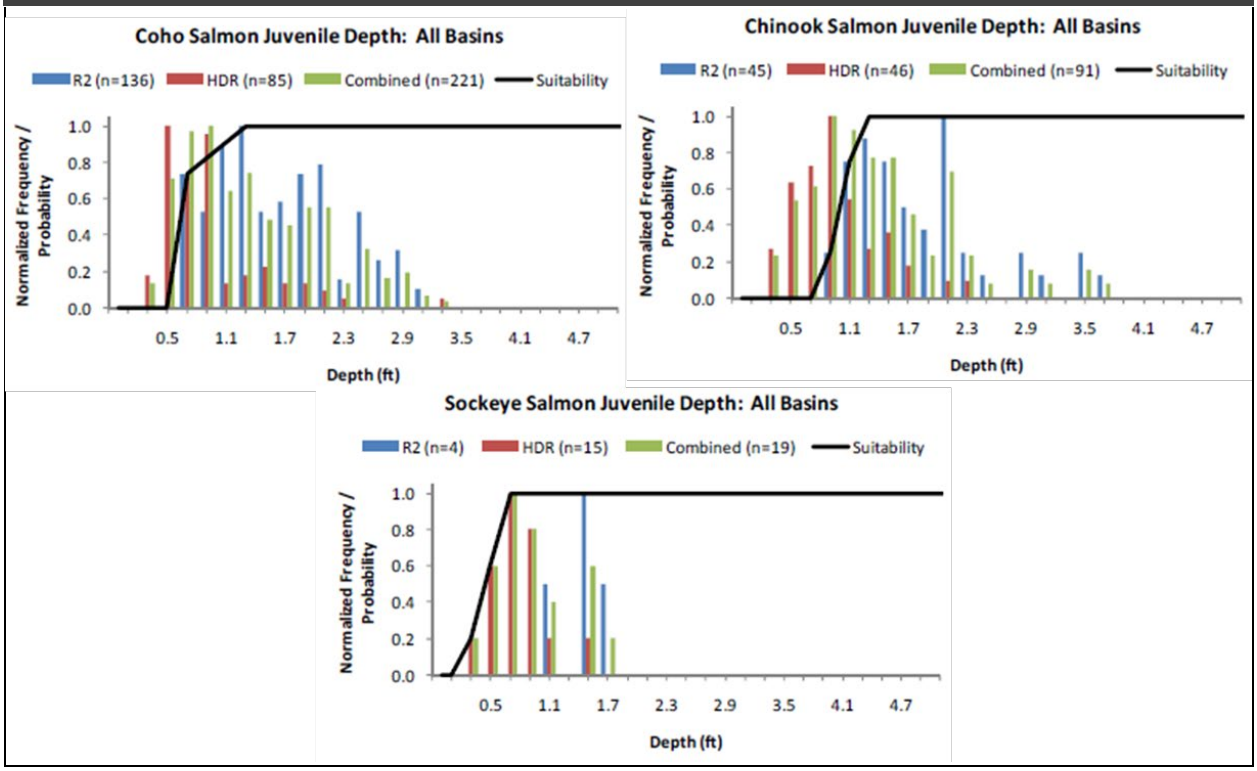
B.4.2.3 Habitat Suitability Curves

Biology is attempted to be incorporated into PHABSIM through the use of HSCs. The underlying premise of HSCs is that more fish will occur in more suitable habitats; thus, HSCs look at occurrence of a given fish species and life stage relative to a single habitat variable (e.g., water depth or velocity) (Naman et al. 2020). Generally speaking, the univariate nature of HSCs greatly oversimplifies the concept of habitat suitability for fishes (Section B.4.2.1). In addition, HSCs developed for evaluation of fish habitat impacts resulting from the 2020 Mine Plan do not reflect field data collected at the mine site (Figure B-2). PLP (2011: Appendix 15.1C) reported that the HSCs generally track the shape of the normalized observed data histograms, with the exception of maximum depth. However, they concluded that maximum depth is not a limiting factor for fish habitat use; thus, HSCs used in the fish habitat analysis do not include a descending limb for depth (Figure B-2). This is an indication that appropriate steps described by developers of PHABSIM and HSCs (Bovee 1986) were not taken to validate the ecological relevance of depth before applying a model that forces a relationship with depth.

The HSCs assume that more water means better fish habitat, and that fish will use deeper water if it is available. This assumption is problematic as applied in the FEIS, given that the field data actually demonstrate decreased habitat use by juvenile Coho, Sockeye, and Chinook (*O. tshawytscha*) salmon with increasing depth (Figure B-2). For example, Figure B-2 shows that as water depth increased above approximately 2.1 ft, the probability that juvenile Coho and Chinook salmon would be found decreased, with no juveniles of either species found at water depths above roughly 3.7 ft.

Railsback (2016) considers univariate HSCs obsolete and suggests that they introduce considerable error to habitat modeling. Modern multivariate resource selection models or HSCs based on bioenergetic models (which relate habitat conditions to net energy gain by fishes) can address some of these limitations and provide a better fit to observed fish habitat-use data (Naman et al. 2019, Naman et al. 2020). Particularly for drift-feeding fishes like salmonids, univariate HSCs may introduce systematic bias related to factors such as density-dependent territoriality and failure to consider water-velocity effects on prey availability (Rosenfeld and Naman 2021).

Figure B-2. Sample habitat suitability curves used in the PHABSIM fish habitat modeling. Models are for juvenile Coho, Chinook, and Sockeye salmon and water depth. From PLP 2011: Appendix 15.1C.



In addition, HSCs were not developed (or not included in the PHABSIM analysis) for all relevant life stages. For example, the fry life stage (salmonids less than 50 mm) was not included in the PHABSIM analysis; according to RFI 147, they were excluded because they occupy low velocity areas with cover and the "habitat needs of fry are generally met with flows much lower than those for other life stages" (PLP 2019e: RFI 147). This document also states that fry habitat generally is not limiting, although no support for this statement is provided (PLP 2019e: RFI 147). Hardy et al. (2006) discuss the importance of evaluating fry response to streamflow changes and present an approach for evaluating fry habitat availability. No HSCs were developed for the egg-incubation stage; in fact, impacts to the egg incubation stage were not considered in any assessment of impacts resulting from the 2020 Mine Plan. Early salmonid life stages (i.e., eggs and alevins) are particularly susceptible to adverse effects associated with changes in flow (Warren et al. 2015). Potential impacts to these life stages include scouring of redds and egg mortality with increased streamflows, freezing and desiccation with decreased streamflows, and loss of water-temperature buffering, waste removal, and aeration during the incubation stage due to changes in groundwater exchange. These early developmental stages are also when imprinting to natal waters begins; flow changes that alter the physical and chemical signatures of the water during these stages may impair imprinting and, thus, adult homing capabilities. Failure to evaluate impacts of the 2020 Mine Plan on these important life stages represents a significant omission in the FEIS.

B.4.3 Results and Conclusions of PHABSIM Modeling Related to Fish Habitat

The PHABSIM models used in the FEIS provide an oversimplification of fish habitat changes under the 2020 Mine Plan that does not account for the inherent complexity of aquatic habitats in the SFK, NFK, and UTC watersheds. As a result, the magnitude of fish habitat changes identified in the FEIS likely is an underestimate of actual effects of the project. However, even this underestimate represents an unacceptable adverse effect on fishery areas in the SFK and NFK watersheds (Section 4.2).

Examples of specific issues related to FEIS conclusions about fish habitat changes associated with the 2020 Mine Plan are provided below.

- Based on PHABSIM flow modeling, Figure K4.24.1 (USACE 2020: Appendix K4.24) depicts that most habitat units would not decrease under the 2020 Mine Plan. Because this figure only includes information about mainstem channels and omits tributaries and off-channel habitats, it does not present a complete depiction of potential effects. Exclusion of these non-mainstem habitats—which are critical habitats for many fish species and life stages—from estimates of fish habitat changes under 2020 Mine Plan results in a significant underestimate of impacts.
- As detailed in Section B.3, adjacent mainstem reaches of the SFK are predicted to experience both large decreases (52 percent) and increases (110 percent) in average monthly streamflows in April. The FEIS did not assess changes to suitable fish habitat in these SFK reaches, despite their documented use by juvenile salmon. The portion of SFK Reach E above Frying Pan Lake (and stream gage SK100G) is specified as rearing habitat for Coho Salmon; Frying Pan Lake and portions of the SFK down to stream gage SK100F are used for rearing by both Coho and Sockeye salmon (USACE 2020: Section 3.24, Giefer and Graziano 2022).
- The FEIS states that treated discharges would be "optimized to benefit priority species and life stages for each month and stream" (USACE 2020: Section 4.24, Table 4.24-2). Specific details about how discharges would be managed and monitored are not provided, and EPA has concerns that the goal of habitat optimization would not come to fruition. These concerns are due in part to limitations of the flow-habitat model development and application, in addition to limitations of the planned streamflow monitoring program. The Monitoring Summary provided by PLP states that monitoring of surface-water flow and quality is proposed to be conducted downstream of water-discharge points on a quarterly basis and would focus on streamflow and fish presence surveys (PLP 2019e: RFI 135). Because streamflow monitoring is not described as being used for real-time WTP discharge decisions, the optimization approach appears to be pre-planned, based on numerous assumptions that would not reflect the natural hydrologic regime. The FEIS does not indicate that adaptive management would be applied to ensure that habitat optimization is achieved or consider how differences across species and life stages would result in adverse effects for species other than each month's priority species and life stage.

These and other issues support the contention that application of the PHABSIM flow-routing model to evaluate fish habitat changes under the 2020 Mine Plan is flawed for two key reasons: (1) it does not

consider habitat complexity, which is a critical component of the extremely complex aquatic system that exists in the SFK, NFK, and UTC watersheds; and (2) it does not integrate losses resulting from critical habitat components other than water depth and velocity, such as water temperature, groundwater interactions, and off-channel habitats. Cumulatively, the results of the analysis thus underestimate the project effects and its consequences for fish and fish habitat.

B.4.4 Summary

The fish habitat assessment included in the FEIS relies heavily on the PHABSIM modeling approach. Because the PHABSIM model only considers water depth and velocity and does not account for complex interactions between surface waters and groundwater, the FEIS necessarily provides an overly simplistic characterization of fish habitat. EPA (2019) and NMFS (2020) highlighted the value of conducting a comprehensive analysis of the suite of environmental drivers associated with distributions and abundances of the fish species and life stages found throughout the SFK, NFK, and UTC watersheds. The FEIS acknowledges that PHABSIM does not account for other factors affecting fish habitat and ultimately fish survival and that losses of headwater streams and wetlands and changes to streamflows, groundwater inputs, water chemistry, and water temperature would occur under the 2020 Mine Plan (USACE 2020: Appendix K4.24)—all of which are likely to affect fish habitat use, as well as other components of these aquatic resources. However, the integrated effect that these changes are predicted to have on fish habitat was not assessed adequately to conclude in the FEIS that there will be no effects on fish habitat, abundance, and productivity. The FEIS likely underestimates both direct and indirect effects on fish habitat under the 2020 Mine Plan, and its conclusion of no "measurable impact" on fish populations is not supported by the evidence, particularly at spatial scales relevant to the 2020 Mine Plan (i.e., the SFK, NFK, and UTC watersheds; see Section B.2.1). Even the underestimate of fish habitat changes resulting from the 2020 Mine Plan documented in the FEIS represents unacceptable adverse effect on fishery areas in the SFK and NFK watersheds (Section 4.2).

B.5 Other Effects on Aquatic Resources

The prohibition and restriction included in this final determination focus on direct losses of aquatic habitats and losses of the ecological subsidies that these habitats provide to downstream waters (Sections 4.2.1 through 4.2.3), as well as additional secondary effects caused by streamflow alterations (Section 4.2.4). These impacts, as evaluated in the FEIS, would result in unacceptable adverse effects on fishery areas in the SFK, NFK, and UTC watersheds and are the basis for the prohibition and restriction detailed in Section 5. However, the impacts underpinning this prohibition and restriction are only a subset of the many ecological effects likely to result from implementation of the 2020 Mine Plan. This section considers other key impacts that development of the 2020 Mine Plan would have on aquatic habitats and fish populations in the SFK, NFK, and UTC.

B.5.1 Water Quality Effects

The FEIS states that adaptive management strategies would be employed at the WTPs to address water quality issues prior to discharging to the environment, including adding further treatment, as needed (USACE 2020: Section 4.18). However, the FEIS also acknowledges that "over the life of the mine, it is possible that [Alaska Pollutant Discharge Elimination System] permit conditions may be exceeded for various reasons (e.g., treatment process upset, record-keeping errors) as has happened at other Alaska mines" (USACE 2020: Page 4.18-13). It is likely that the predicted water quality of effluents is overly optimistic (Sobolewski 2020), further suggesting that water quality effects are underestimated in the FEIS.

Despite acknowledgement of the potential for water quality exceedances, Section 4.24 of the FEIS states that treated water discharges are expected to result in "no noticeable changes" in water chemistry and only slight increases in water temperature immediately below discharge points (USACE 2020). This misrepresents the information presented in the FEIS, which indicates that treated water discharges would substantially increase concentrations of 11 constituents (e.g., chloride, sulfate, calcium, magnesium, sodium, nitrate-N, ammonia, hardness) in receiving waters relative to baseline concentrations (USACE 2020: Section 4.18). For example, chloride loads in the NFK are predicted to increase by 1,620 percent (USACE 2020: Page 4.18-19); nitrate-nitrite and ammonia are predicted to be 30 times and 12 times higher than baseline concentrations, respectively (USACE 2020: Tables K3.18-7 and K4.18-13); total dissolved solids are predicted to be more than three times higher than baseline concentrations in UTC, and approximately 12 times higher than baseline concentrations in the NFK (USACE 2020: Tables K3.18-7, K3.18-9, and K4.18-13).

Section 4.18 of the FEIS does not identify environmental consequences from these predicted changes in water chemistry, and Section 4.24 of the FEIS suggests that there would be no impacts to fishes because point-source discharges are not expected to exceed water quality criteria. However, FEIS modeling indicates that discharges from WTP #1 during operations would exceed the standard for ammonia; it is also possible that the treated water discharges would result in seasonal exceedances of the turbidity standard (USACE 2020: Section 4.18). Furthermore, fishes and other aquatic organisms are adapted to the naturally occurring water chemistry in the SFK, NFK, and UTC headwaters, and the ambient concentrations of many water chemistry parameters in these systems are much lower than existing water quality criteria (O'Neal 2020). For this reason, water chemistry changes that do not exceed water quality criteria but that significantly alter natural conditions may adversely affect aquatic biota. For example, research has shown that low concentrations of copper can result in olfactory impairment in salmonids (e.g., McIntyre et al. 2012, Morris et al. 2019), with potential repercussions for homing abilities and predator avoidance.

In addition to water quality changes resulting from treated water releases, there is also the potential for accidents and spills to affect water quality. Although the FEIS acknowledges the potential for acute toxicity and sublethal effects on fish, conclusions regarding impacts to fishes from potential spills appear to be based on the potential for direct habitat loss. For example, regarding the modeled pyritic tailings

release scenario, the FEIS states that "[c]admium and molybdenum would remain at levels exceeding the most stringent [water quality criteria] as far downstream as the Nushagak River Estuary, approximately 230 miles downstream from the mine site" and "[t]hese metals would remain at elevated levels above WQC [water quality criteria] for several weeks..." (USACE 2020: Page 4.27-139). The FEIS concludes that:

> [t]he low-level use of the habitat that would be impacted (based on densities of juvenile Chinook and coho salmon captured in these habitats) and the low numbers of coho spawning near the confluence of Tributary SFK 1.240 with the SFK, indicates drainage-wide or generational impacts to populations of salmon from direct habitat losses associated with the scenario would not be expected" (USACE 2020: Page 4.27-144).

As discussed earlier, the FEIS does not appear to address impacts to aquatic resources from the elevated metal concentrations, which would also affect fish populations.

The proposed mine also would likely alter water chemistry via land runoff and fugitive dust, and the FEIS likely underestimates these impacts. For example, the volume of material that would potentially leach metals to the environment is likely underestimated due to the use of a non-conservative neutralization potential/acid-generating potential ratio to characterize materials (USACE 2020: Section 3.18), as well as the application of a large temperature correction that is not representative of field conditions (USACE 2020: Appendix K3.18). The modeling of impacts from fugitive dust underreports the area affected and does not account for watershed loading or the effects of seasonal flushes to surface waters, such as during snowmelt (USACE 2020: Appendix K4.18). Watershed loading and "first flush" effects are also relevant to the transport of leached metals to surface waters. The FEIS also does not take into consideration the likely effect of sulfate loading from the treated water discharges on mercury methylation and subsequent bioaccumulation in fish and other aquatic organisms.

In addition to changes in water chemistry, the proposed mine would significantly alter water temperature. The FEIS predicts water temperatures will change by -1.6 to +2.8 degrees Celsius (°C) in the SFK, NFK, and UTC watersheds, from approximately 0.5 to 2.75 miles downstream of WTP discharge sites (USACE 2020: Section 4.18, Table 4.24-3). Proposed WTP discharge volumes are greatest in the NFK, which is also where the greatest temperature changes are predicted to occur. Summer water temperatures could be warmer or cooler (by approximately -1.6 to +1.6 °C), but during winter water temperatures would increase (by approximately +1.2 to +2.8 °C) (USACE 2020: Table 4.24-3).

The threshold between completely frozen and partially frozen streams can be a narrow one (Irons et al. 1989), especially for small streams with low winter groundwater inputs (i.e., like many of the headwater streams in the SFK, NFK, and UTC watersheds). As a result, even small increases in winter water temperatures can have large effects. These predicted increases in winter streamflow and temperature would likely reduce ice cover and increase flow velocities, resulting in substantial alteration of fish habitats (Huusko et al. 2007, Brown et al. 2011) and reduced spawning success due to the scouring of redds.

The influence of temperature on fish bioenergetics is well understood (Brannon 1987, Beacham and Murray 1990, Hendry et al. 1998, Quinn 2018), and even small increases in water temperature can affect

salmon development, growth, and timing of life-history events such as emergence and migration (Section 4.2.4.5) (e.g., Beacham and Murray 1990, McCullough 1999, Fuhrman et al. 2018, Adelfio et al. 2019, Sparks et al. 2019). The FEIS acknowledges the potential for impacts to eggs and alevins in spawning gravels due to adverse effects on egg development, hatching, and emergence timing (USACE 2020: Page 4.24-23). For example, increases in water temperatures during alevin development can increase development rates and associated yolk conversion rates (USACE 2020: Page 4.24-23), potentially leading to faster yolk depletion and earlier emergence from the gravel at overall smaller sizes (Weber-Scannell 1991). The timing of egg hatching and fry emergence is critical for survival, and fry that emerge too early could experience reduced feeding, growth, and survival due to mismatches in the timing of prey availability or increased predation on smaller-sized fry at emergence (Rooke et al. 2019). Altered water temperatures resulting from the loss of groundwater inputs also would likely change the species composition and richness of macroinvertebrates, a key food for juvenile salmonids, and alter overall macroinvertebrate abundance and productivity in the affected reaches (e.g., Campbell et al. 2020).

Water quality in the SFK, NFK, and UTC are predicted to change downstream of the mine site under the 2020 Mine Plan, due to the loss of upstream aquatic habitats, changes in surface water and groundwater flows, and the release of treated water discharges. These changes would create water quality conditions that would differ from the current baseline conditions to which fish communities (as well as other organisms) in the region are adapted. These changes would alter fish habitat and the ecological cues that influence the timing of fish migration, spawning, incubation, emergence, rearing, and outmigration with likely negative consequences. Because the FEIS does not consider these effects, it further underestimates potential impacts of the 2020 Mine Plan to the region's aquatic resources.

B.5.2 Multiple, Cumulative Effects

Under the 2020 Mine Plan, aquatic resources in the SFK, NFK, and UTC watersheds would experience a suite of co-occurring and interacting changes, including losses of headwater streams and wetlands; changes in streamflow regime due to changes in surface water and groundwater hydrology and treated water discharges; and changes in water temperature and water chemistry. However, the FEIS estimates effects of the 2020 Mine Plan by considering each impact independently—that is, by assuming each effect would act in isolation, typically without consideration of how multiple effects acting simultaneously would impact aquatic resources. Even considered in isolation, impacts on aquatic habitats documented in the FEIS constitute an unacceptable adverse effect on fishery areas (Section 4.2); a more holistic evaluation of how the full suite of changes expected to result from the 2020 Mine Plan would likely only increase the extent and magnitude of these impacts. This failure to consider multiple, cumulative effects is evident across multiple contexts, as the following examples below demonstrate.

- Effects on species, and life stages within species, are considered independently. There is no consideration of how "optimization" of water discharges for priority species and life stages at certain times of year would affect other species and life stages (USACE 2020: Section 4.24).

Similarly, there is no consideration of how the direct effects of the 2020 Mine Plan on one life stage within a species will indirectly influence subsequent life stages (Marra et al. 2015), in addition to any direct effects those life stages experience.

- Effects on fishes are considered only in terms of changes to fish habitat, despite that fact that fishes also will be affected by impacts on lower trophic levels (e.g., macroinvertebrates, algae), which may be particularly sensitive to changes in physical and chemical characteristics likely to occur under the 2020 Mine Plan.
- Effects in different sections of the stream channel are considered independently, without consideration of how changes in upstream portions may influence effects in downstream portions and vice versa (e.g., by affecting upstream movement).
- Effects of different stressors (e.g., changes in flow, temperature, water quality, and sedimentation) are considered independently, without consideration of how simultaneous exposure to multiple stressors, which also affect each other, would alter aquatic resources.

As a result, the FEIS likely underestimates how multiple, co-occurring changes associated with the 2020 Mine Plan would cumulatively affect the region's aquatic habitats and fish populations. Although all aquatic resources in and downstream of the mine site would be affected by a suite of co-occurring (and likely interacting) changes to chemical, physical, and biological conditions (Hodgson et al. 2019), the impact of each change is only evaluated as if it would be acting in isolation. The impacts reported in the FEIS likely represent a minimum estimate of how aquatic resources would be affected under the 2020 Mine Plan. This underestimation of cumulative impacts compounds the numerous underestimates of single-factor impacts throughout the FEIS. For example, based only on modeled streamflow impacts, RFI 149 concludes that there would be a loss of more than 10 percent of Chinook Salmon spawning habitat in the Koktuli River (PLP 2019f: RFI 149), a major producer of Chinook Salmon within the Nushagak River and within the state of Alaska. For reasons discussed in Sections B.3 and B.4, this value likely underestimates streamflow impacts to Chinook Salmon populations; this value also fails to account for other co-occurring contributors to Chinook Salmon population impacts that would result from the 2020 Mine Plan, such as changes in water temperature, water chemistry, and downstream transport of energy and materials from headwater streams and wetlands.

B.6 Climate Change and Potential Mine Impacts to Aquatic Habitats and Fish

The ecosystems that support Pacific salmon species, in Alaska and elsewhere, are experiencing rapid changes due to a changing climate (Markon et al. 2018, Jones et al. 2020, von Biela et al. 2022). Alaska is warming faster than any other state (Markon et al. 2018). Across the entire Bristol Bay watershed, average temperature is projected to increase by approximately 4°C by the end of the century, with winter temperatures projected to experience the highest increases (EPA 2014: Table 3-5, Figure 3-16). Similar patterns are projected in the Nushagak and Kvichak River watersheds (EPA 2014: Table 3-5). By

the end of the century, precipitation is projected to increase roughly 30 percent across the Bristol Bay watershed, for a total increase of approximately 250 mm annually (EPA 2014: Table 3-6, Figure 3-17). In the Nushagak and Kvichak River watersheds, precipitation is projected to increase roughly 30 percent as well, for a total increase of approximately 270 mm of precipitation annually (EPA 2014: Table 3-6). At both spatial scales, increases in precipitation are expected to occur in all four seasons (EPA 2014: Table 3-6). Based on evapotranspiration calculations (i.e., calculations of the total amount of water moving from the land surface to the atmosphere via evaporation and transpiration), annual water surpluses of 144 mm and 165 mm are projected for the Bristol Bay watershed and the Nushagak and Kvichak River watersheds, respectively (EPA 2014: Table 3-7, Figure 3-18).

These projected changes in temperature and precipitation are likely to have repercussions for both water management at the proposed mine and the surrounding aquatic resources. For example, increases in air temperature are likely to affect evapotranspiration and exacerbate thermal stress, increasing the probability of high severity wildfires (Lader et al. 2017). The combined effects of increased air temperature, altered timing and type of precipitation, and vegetation changes likely will lead to altered stream temperature regimes, with implications for fish metabolism and timing of key life history events. For example, if water temperatures increase and cold-water species cannot find optimal conditions of groundwater exchange, incubating eggs may fail to develop or develop too rapidly. In precipitation driven streams, Adelfio et al. (2019) reported shifts in modeled incubation timing by Coho Salmon by up to 3 months during years with warmer winters. Given that substantially warmer winters are projected to be increasingly common in Alaska in the near future (Lader et al. 2017), these life history shifts may become increasingly common. Such shifts in timing can result in egg emergence that is out of sync with the availability of food resources (Cushing 1990, McCracken 2021), as well as other asynchronizations across salmon life histories. These life history shifts may disrupt the adaptation of salmon life stages to local environmental conditions, particularly if altered timing of key life history events such as emergence, migration, or seasonal movements is no longer synched to favorable conditions for salmonid growth and survival. These changes can lead to adverse impacts on resilience of Pacific salmon populations (Crozier et al. 2008).

Such increases in temperature (and associated adverse ecological effects) can occur during the winter, and at temperatures well below the State of Alaska's critical temperature threshold for spawning or egg incubation (13°C; ADEC 2020). Thermal effects on fry size and emergence timing can interact with streamflow to adversely affect juvenile salmon survival. Increases in precipitation, as well as changes in the seasonality of precipitation, snowpack, and the timing of snowmelt, would likely affect streamflow regimes. High-intensity rainfalls, projected to increase in frequency with climate change (Lader et al. 2017), may contribute to increased scouring and sedimentation of stream channels. Increased exposure to earlier or larger peak streamflows can displace incubating eggs or newly emerged salmon fry, contributing to mortality. Stream types at the mine site are highly susceptible to scour and erosion and could be destabilized significantly by streamflow or sediment regime changes (Brekken et al. 2022).

Wobus et al. (2015) incorporated climate change scenarios into an integrated hydrologic model for the upper Nushagak and Kvichak River watersheds. These simulations projected changes in water

temperature, average winter streamflows, and dates of peak streamflows by 2100 (Wobus et al. 2015). Ultimately, these projected increases in temperature and changes in hydrology could affect salmon populations in multiple ways, such as alteration of spawning and rearing habitats, changes in fry emergence and growth patterns, and direct thermal stress (Tang et al. 1987, Beer and Anderson 2001, Bryant 2009, Wobus et al. 2015).

Despite these expected climate changes in the Bristol Bay region, many of the models used in the FEIS to evaluate potential impacts of the 2020 Mine Plan were parameterized based on past environmental conditions. For example, the mine site water-balance model included in the FEIS incorporated climate variability by using the 76-year average monthly synthetic temperature and precipitation record (USACE 2020: Section 3.16). EPA (2019) recommended that the FEIS consider how projected changes in the type (e.g., snow versus rain) and timing of precipitation could affect impacts to aquatic resources under the 2020 Mine Plan, but no future climate scenarios were included in the FEIS analysis of streamflow changes under the 2020 Mine Plan. It is not clear that past variability in temperature and precipitation will adequately capture future variability. Schindler and Hilborn (2015) stated that "…we should expect that the future is not likely to be a simple extrapolation of the recent past." Predictions of future habitat based on conditions in the recent past—or even current conditions—are of limited utility (Moore and Schindler 2022). As a result, models like those used in the FEIS may fail to adequately characterize mine impacts in ecosystems experiencing an altered future climate (Sergeant et al. 2022).

A thorough evaluation of potential impacts under the 2020 Mine Plan should consider future climate scenarios, particularly in terms of water treatment and management and potential effects on aquatic habitats and salmon populations. Even without this evaluation, the impacts on aquatic habitats documented in the FEIS constitute an unacceptable adverse effect on fishery areas (Section 4.2); consideration of how future climate conditions would affect these impacts would not change this unacceptability finding, but would give a more complete assessment of likely effects associated with the 2020 Mine Plan. A key feature of salmon populations in the Bristol Bay watershed is their genetic and life history diversity (i.e., the portfolio effect), which serves as an overall buffer for the entire population (Section 3.3.3). Different sub-populations may be more productive in different years, which affords the entire population stability under variable conditions year to year. If this variability increases over time due to changes in temperature and precipitation patterns, this portfolio effect becomes increasingly important in providing the genetic diversity to potentially allow for adaptation; thus, affecting or destroying genetically diverse populations may have a larger than expected effect on the overall Bristol Bay fishery under future climate conditions.

B.7 References

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Attachment 1

How Certain FEIS Conclusions Relate to EPA's Final Determination

A few commenters on the proposed determination cited specific conclusions in USACE's 2020 FEIS (USACE 2020a) as potentially contradicting EPA's conclusions in the final determination. In this attachment, EPA provides the FEIS conclusions (verbatim, as cited by commenters) and details why these FEIS conclusions do not contradict the conclusions underpinning EPA's final determination.

The FEIS conclusions highlighted in these comments are grouped into six general themes: (1) that the 2020 Mine Plan is expected to have no "measurable" effect on fish populations or fisheries; (2) that the appropriate scale for analyzing potential effects is at the scale of the Bristol Bay, Nushagak River, and/or Kvichak River watersheds; (3) that expected effects of the 2020 Mine Plan would not exceed the natural range of variability in the system; (4) that habitat availability is expected to increase as a result of the 2020 Mine Plan; (5) that cumulative impacts of the 2020 Mine Plan will be minimal to moderate; and (6) that mining and fisheries successfully coexist in other watersheds. Note that these themes are not discrete categories, as many of the FEIS conclusions relate to multiple themes.

1. Conclusions related to "no measurable" changes, effects, or impacts of the 2020 Mine Plan

Commenters cited several FEIS quotes stating that the mine proposed to be developed under the 2020 Mine Plan is not expected to have a "measurable" effect or impact on fish populations.

Cited FEIS Quotes

1.a "The loss of habitat is not expected to have a measurable impact on fish populations based on physical habitat characteristics and fish density estimates in the affected reaches." [USACE 2020a: Page 4.24-1]

1.b "Measurable changes to fish populations in the Nushagak watershed are not expected to occur from changes in stream productivity based on the extent and magnitude of changes in stream productivity." [USACE 2020a: Page 4.24-21]

1.c "This impact is expected to be limited to the habitats within this reach and would not be expected to have a measurable effect on Bristol Bay salmon populations due to the magnitude and extent of the effect." [USACE 2020a: Page 4.24-24]

1.d "Impacts to Bristol Bay salmon are not expected to be measurable and given the vast breadth and diversity of habitat (and salmon populations) in the Bristol Bay watershed, impacts on the Portfolio Effect are certain but not likely to be noticeable in context of the Bristol Bay watershed." [USACE 2020a: Page 4.24-47]

1.e "The duration of direct impacts of the removal of anadromous habitat would be permanent. However, considering the physical characteristics and current fish use of habitat to be removed,

the consequently low densities of juvenile Chinook and coho observed in the affected tributaries, and the few numbers of spawning coho observed (see Section 3.24, Fish Values), impacts to anadromous and resident fish populations from these direct habitat losses would not be measurable, and would be expected to fall within the range of natural variability." [USACE 2020a: Page 4.24-46]

1.f "Alternative 1a would not have measurable effects on the number of adult salmon returning to the Kvichak and Nushagak river systems as a result of project construction and operations, due the limited lineal footage of upper Koktuli River fish habitat affected by placement of fill." [USACE 2020a: Page 4.6-9]

1.g "This alternative would not be expected to have measurable effects on the number of adult salmon, and therefore would have no impact to commercial fisheries." [USACE 2020a: Page 4.6-4]

1.h "There would be no measurable change in the number of returning salmon and the historical relationship between ex-vessel values and wholesale values. In addition, there would be no changes to wholesale values or processor operations expected for Alternative 1a. Under normal operations, the Alternatives would not be expected to have a measurable effect on fish numbers and result in long-term changes to the health of the commercial fisheries in Bristol Bay." [USACE 2020a: Executive Summary Page 87]

1.i "As with Alternative 1a, Alternative 3 would not be expected to measurably affect the health or value of Bristol Bay salmon fishery, including permit holder earnings, permit holder value, crew earnings, fishery first wholesale values, processor earnings, or local fiscal contributions." [USACE 2020a: Page 4.6-18]

1.j "Overall, impacts to fish and wildlife would not be expected to impact harvest levels. Resources would continue to be available because no population-level decrease in resources would be anticipated." [USACE 2020a: Executive Summary Page 51]

1.k "The Portfolio Effect is an observation that the Bristol Bay salmon run is produced from an abundance of diverse aquatic habitat; this diversity allows for a harvestable surplus even when some systems experience low abundance (Schindler et al. 2010). The term "Portfolio Effect" is taken from the concept of investment portfolios, where adding to the diversity of investments is thought to reduce risk (or the likelihood of occurrence of losses to the overall investment portfolio, even if some individual investments do not do well). Any loss of salmon production would have an effect on the Bristol Bay "portfolio," similar to the way that financial losses by individual investments would have an effect on an investor's portfolio. In this EIS, the effect to the Bristol Bay portfolio is considered by evaluating the amount of habitat and salmon production that would be lost. No long-term measurable changes in the number of returning salmon are expected, nor is genetic diversity expected to change; therefore, the impact to the Portfolio Effect would not be discernable." [USACE 2020a: Page 4.24-47]

EPA Response

As explained in detail below, none of the FEIS conclusions quoted above contradict EPA's conclusions in the final determination. In addition, numerous experts, including those from EPA, U.S. Fish and Wildlife Service, NMFS, tribes, and academia, have noted the limitations of the baseline environmental data underpinning certain analyses in the FEIS (e.g., O'Neal 2012, Parasiewicz 2012, Stratus Consulting 2012, Woody 2012, EPA 2019)[1] and criticized both the streamflow and fish habitat modeling upon which the FEIS conclusions about fishery impacts are based (e.g., EPA 2019, Lubetkin and Reeves 2020, NMFS 2020, Reeves 2020, Reeves and Lubetkin 2020, Wobus and Prucha 2020).[2] As a result, the FEIS conclusions about the lack of effects on fish habitats and fish populations often are not supported by the available evidence or are stated without acknowledgement and evaluation of the limitations and uncertainties inherent in the analyses presented to support those conclusions. FEIS values likely represent a minimum estimate of impacts to fishery areas in the SFK, NFK, and UTC watersheds—and as discussed in Section 4 of the final determination, even these minimum estimates represent an unacceptable adverse effect.

There are several reasons that the FEIS quotes cited above to do not contradict EPA's conclusions in the final determination:

- Most, if not all, of the above FEIS conclusions either explicitly or implicitly focus on impacts to fish populations at large spatial scales (e.g., the entire Bristol Bay watershed or the entire Nushagak River watershed). As discussed in greater detail below, this larger scale is not the only or the most appropriate scale at which to assess whether adverse effects will occur (see *2. Conclusions related to scales at which effects or impacts should evaluated*). EPA has not made an unacceptable adverse effects determination at these larger scales. EPA has determined that the impacts from the discharge of dredged or fill material evaluated in the final determination will result in unacceptable adverse effects on fishery areas at the scale of the SFK, NFK, and UTC watersheds. This scale is consistent with both the scale at which the FEIS analyzed effects resulting from the construction and operation of the 2020 Mine Plan (although the results of those analyses often were presented in terms of larger spatial scales), as well as the scale at which USACE based its decision to deny the permit application for the 2020 Mine Plan (USACE 2020b).
- Similarly, the final determination does not conclude that impacts to the fish-related endpoints mentioned in the quoted passages above—e.g., "adult salmon returning to the Kvichak and Nushagak river systems," "returning salmon," "harvest levels," "health or value of the Bristol Bay fishery"—will be measurable. Rather, EPA has determined that the impacts from the discharge of

[1] EPA recognizes that the SFK, NFK, and UTC are relatively well-sampled streams, compared with other streams in the region, due to PLP's efforts to collect environmental baseline data in areas draining the Pebble deposit area; however, these data are still spatially and temporally limited and thus should be interpreted with caution (see Sections B.1 and B.2 for more detail).

[2] Multiple professional societies expressed explicit support for EPA's findings and the proposed determination, including the world's foremost society of professional fisheries biologists, the American Fisheries Society (AFS 2022), and the National Association of Wetland Managers (NAWM 2022).

dredged or fill material evaluated in the final determination will result in unacceptable adverse effects on *fishery areas*, as referenced in Section 404(c) of the Clean Water Act (CWA) (33 U.S.C. § 1344). The FEIS clearly documents "measurable" impacts to these fishery areas from the discharge of dredged or fill material associated with construction and operation of the 2020 Mine Plan, for example:

  - "Mine site development would permanently remove approximately 22 miles of fish habitat in the North Fork Koktuli and South Fork Koktuli drainages." [USACE 2020a: Page 4-24.1]
  - "The magnitude, duration, and extent of aquatic habitat loss from development of the mine site would be the removal of 99.7 miles of streambed habitat and 125 acres of riverine wetland habitat." [USACE 2020a: Page 4.24-8].
  - "The mine site would eliminate 21 miles of fish habitat in the Koktuli River watershed, 8.5 miles of which is anadromous habitat." [USACE 2020a: Page 4.24-9)]

- The FEIS indicates that the 2020 Mine Plan would result in large-scale, permanent impacts to aquatic resources at the mine site, in terms of losses of anadromous streams, losses of additional streams that support anadromous streams, losses of wetlands and other waters that support anadromous streams, and changes in streamflow in anadromous streams downstream of the mine site. The final determination is based on EPA's evaluation of these "measurable" impacts that the FEIS concludes will occur during construction and operation of the mine. For example, the FEIS states that "impacts to wetlands and other waters would be certain if the project is permitted and constructed" (USACE 2020a: Page 4.22-5), that "the duration of impacts to surface water hydrology would vary from temporary to permanent" (USACE 2020a: Page 4.16-2), and that "the extent of the impact on the NFK and SFK rivers may extend to just below the confluence of the two rivers" (USACE 2020a: Page 4.16-2). Section 3 and Appendix B of the final determination discuss the importance of the aquatic resources that would be impacted in detail. The factual record strongly supports EPA's conclusion that the aquatic resources that would be lost or damaged at the mine site (1) are productive habitats for aquatic biota, including anadromous fishes, and (2) support the productivity of downstream anadromous waters. The functional and productive capacity of the lost fishery areas would be zero, because they would no longer provide fish habitat. The functional and productive capacity of remaining downstream fishery areas also would be significantly degraded due to the loss of inputs from the lost upstream aquatic resources.

- As detailed in Section B.1.1, FEIS conclusions that the loss of stream habitats expected to result from the construction and operation of the 2020 Mine Plan would be inconsequential for fish populations appear to be based on an assumption that the relative quality of these habitats is low and that these habitats have minimal influence on downstream waters. These assumptions and, thus, the conclusions based on them are not supported by the available information about these habitats or the current science surrounding the importance of headwater systems (see Section B.1.1 for additional discussion related to this point).

- As detailed in Section 4 and Appendix B of the final determination, available evidence indicates that the levels of impacts to fishery areas documented in the FEIS would adversely affect fish habitats and populations in the SFK, NFK, and UTC watersheds, the spatial scale to which EPA's final determination applies. Indeed, even the FEIS concludes that "…impacts on the Portfolio Effect are certain…" (quote 1.d). The levels of adverse effects on aquatic resources in the SFK, NFK, and UTC watersheds associated with the construction and operation of the 2020 Mine Plan, as identified in the FEIS, lead to the finding in the Record of Decision (ROD) that mine site impacts would cause significant degradation and, thus, cannot be authorized under the CWA (USACE 2020b)—a finding that is consistent with EPA's final determination.

- The FEIS concludes that impacts on the Portfolio Effect "would not be discernable" (quote 1.k) and "are not likely to be noticeable in context of the Bristol Bay watershed" (quote 1.d), "…nor is genetic diversity expected to change…" (quote 1.k), but the FEIS provides no evidence to support these conclusions (e.g., genetic evaluation of anadromous fishes captured at sites in the SFK and NFK watersheds). Moreover, the FEIS acknowledges that "…impacts on the Portfolio Effect are certain…" (quote 1.d) and the ROD concludes that construction and operation of the 2020 Mine Plan "may have a local portfolio effect" (USACE 2020b: Page B3-21). As detailed in Section 3.3.3 of the final determination, available evidence indicates that the high genetic diversity of anadromous fish populations in this region, at relatively fine spatial scales, depends on the diversity and complexity of high-quality, intact, and connected aquatic habitats.

- Certain FEIS conclusions cited by commenters have been taken out of context or are referring to aspects of the project that are not relevant to EPA's action. For example, quote 1.g is referring to effects of the transportation corridor, which is not considered in EPA's final determination.

2. Conclusions related to the scale at which impacts or effects should be evaluated

Commenters cited several FEIS quotes that relate to the scale or scales at which impacts or effects should be evaluated. Many of the FEIS conclusions finding no "measurable" impact or effect from the construction and operation of the 2020 Mine Plan depend explicitly or implicitly on the choice of scale—that is, whether impacts or effects are presented in terms of relatively large spatial scales (i.e., the Bristol Bay, Nushagak River, and/or Kvichak River watersheds) or in terms of smaller spatial scales directly relevant to where mining would occur (i.e., the SFK, NFK, and/or UTC watersheds).

Cited FEIS Quotes

2.a "The mine site area is not connected to the Togiak, Ugashik, Naknek, and Egegik watersheds and is not expected to affect fish populations or harvests from these watersheds." [USACE 2020a: Page 4.6-4]

2.b "Impacts to Bristol Bay salmon are not expected to be measurable and given the vast breadth and diversity of habitat (and salmon populations) in the Bristol Bay watershed, impacts on the

Portfolio Effect are certain but not likely to be noticeable in context of the Bristol Bay watershed." [USACE 2020a: Page 4.24-47]

2.c "Alternative 1a would not have measurable effects on the number of adult salmon returning to the Kvichak and Nushagak river systems as a result of project construction and operations, due the limited lineal footage of upper Koktuli River fish habitat affected by placement of fill." [USACE 2020a: Page 4.6-9]

2.d "As with Alternative 1a, Alternative 3 would not be expected to measurably affect the health or value of Bristol Bay salmon fishery, including permit holder earnings, permit holder value, crew earnings, fishery first wholesale values, processor earnings, or local fiscal contributions." [USACE 2020a: Page 4.6-18]

2.e "Impacts to Bristol Bay salmon are not expected to be measurable and given the vast breadth and diversity of habitat (and salmon populations) in the Bristol Bay watershed, impacts on the Portfolio Effect are certain but not likely to be noticeable in context of the Bristol Bay watershed." [USACE 2020a: Page 4.24-47]

2.f "Overall, impacts to fish and wildlife would not be expected to impact harvest levels. Resources would continue to be available because no population-level decrease in resources would be anticipated." [USACE 2020a: Executive Summary Page 51]

2.g "The Portfolio Effect is an observation that the Bristol Bay salmon run is produced from an abundance of diverse aquatic habitat; this diversity allows for a harvestable surplus even when some systems experience low abundance (Schindler et al. 2010). The term "Portfolio Effect" is taken from the concept of investment portfolios, where adding to the diversity of investments is thought to reduce risk (or the likelihood of occurrence of losses to the overall investment portfolio, even if some individual investments do not do well). Any loss of salmon production would have an effect on the Bristol Bay "portfolio," similar to the way that financial losses by individual investments would have an effect on an investor's portfolio. In this EIS, the effect to the Bristol Bay portfolio is considered by evaluating the amount of habitat and salmon production that would be lost. No long-term measurable changes in the number of returning salmon are expected, nor is genetic diversity expected to change; therefore, the impact to the Portfolio Effect would not be discernable." [USACE 2020a: Page 4.24-47]

EPA Response

As discussed in detail in Section B.2.1, the assessment of whether "measurable" impacts or effects occur is scale dependent. If an assessment considers a large-enough spatial scale, relative to the assessed area, when evaluating impacts or effects, the relative magnitude of those impacts or effects will diminish as a function of increasing scale (although their absolute magnitude remains unchanged). FEIS statements that there will be no "measurable" effect on fish populations are typically made at the scale of the entire Bristol Bay watershed, without an evaluation of effects at smaller spatial scales. Assessment of effects should occur at the spatial and temporal scales that are most relevant to the resources being evaluated. As such, an assessment of effects of developing a mine at the Pebble deposit should include conclusions

at the spatial and temporal scales that are most biologically relevant to the species (salmon) and life stages (eggs, juveniles, adults) of concern—that is, the spatial and temporal scales that ultimately determine the reproductive success and long-term persistence of these species and their genetically distinct populations.

EPA's final determination considers impacts at the scale of the SFK, NFK, and UTC watersheds because these watersheds are the areas that would be most directly affected by mine development at the Pebble deposit and because the most extensive physical, chemical, and biological data currently available have been collected in these watersheds (e.g., PLP 2011, PLP 2018a, USACE 2020a). Streams and wetlands in each of the SFK, NFK, and UTC watersheds provide habitat for five species of Pacific salmon and numerous other fish species, including genetically distinct populations. Each of these headwater watersheds also supports fish habitats and populations in larger downstream systems via contributions of water, organisms, organic matter, and other resources.

EPA has determined that the impacts from the discharge of dredged or fill material evaluated in the final determination will result in unacceptable adverse effects on fishery areas at the scale of the SFK, NFK, and UTC watersheds (see Section 4). EPA has not made an unacceptable adverse effects determination for the entire Bristol Bay watershed or for the entire Nushagak River watershed, or in the Togiak, Ugashik, Naknek, and Egegik watersheds.[3] The scale used by EPA is consistent with both the scale at which the FEIS analyzed effects resulting from the construction and operation of the 2020 Mine Plan and the scale at which USACE based its decision to deny the permit application for the 2020 Mine Plan (USACE 2020b). FEIS conclusions based on larger spatial scales do not invalidate conclusions made by EPA or USACE (USACE 2020b) at smaller spatial scales.

A key contention of the FEIS, in considering effects at larger spatial scales, is that there is an abundance of aquatic resources throughout the Bristol Bay watershed that will compensate for any impacts to aquatic resources from construction and operation of the 2020 Mine Plan (e.g., quote 2.b). As explained above and in Section B.2.1, this contention does not invalidate conclusions made regarding lost habitats at smaller, more relevant spatial scales. This concept also does not recognize that habitats are not interchangeable across these different scales. Discharges of dredged or fill material associated with the construction and operation of the 2020 Mine Plan will result in the loss of anadromous fishery areas in the headwaters of the NFK and SFK watersheds. Salmon that are adapted to and currently spawn and rear in these headwater habitats will not by default be able to successfully spawn and rear in other watersheds draining to Bristol Bay, as they will not be well adapted to conditions in these other areas and likely will be outcompeted by salmon that are. Similarly, the presence of existing downstream habitat does not negate the loss of headwater tributaries. As detailed in Box 3-1, the habitats that would

[3] Although EPA has not made an unacceptable adverse effects determination at these larger spatial scales, EPA recognizes that the SFK, NFK, and UTC watersheds are headwaters of the larger Bristol Bay watershed and the aquatic resources of the SFK, NFK, and UTC watersheds are connected to downstream aquatic resources in the larger Bristol Bay watershed. Thus, the intact headwater-to-larger river systems found in the SFK, NFK, and UTC watersheds, with their associated streams, wetlands, lakes, and ponds, help sustain the overall productivity of fishery areas in the larger Bristol Bay watershed.

be lost or damaged as a result of the discharge of dredged or fill material associated with construction and operation of the 2020 Mine Plan represent unique combinations of habitat characteristics and arrangements to which local populations of anadromous (and other) fishes are adapted. These habitats are not simply duplicates of other habitats within the Bristol Bay watershed.

3. Conclusions related to the impacts or effects of the 2020 Mine Plan falling "within the range of natural variability"

Commenters cited several FEIS quotes suggesting that any changes in aquatic resources resulting from the 2020 Mine Plan would have minimal effects because they would fall "within the range of natural variability" for these resources.

Cited FEIS Quotes

3.a "The duration of direct impacts of the removal of anadromous habitat would be permanent. However, considering the physical characteristics and current fish use of habitat to be removed, the consequently low densities of juvenile Chinook and coho observed in the affected tributaries, and the few numbers of spawning coho observed (see Section 3.24, Fish Values), impacts to anadromous and resident fish populations from these direct habitat losses would not be measurable, and would be expected to fall within the range of natural variability." [USACE 2020a: Page 4.24-46]

3.b "Therefore, the intensity of the impacts to surface water resources would be generally expected to result in changes in water quantity, likely within the limits of historic and seasonal variation." [USACE 2020a: Executive Summary Page 63]

3.c "The duration of impacts to surface water hydrology would vary from temporary to permanent. The geographic extent of the impact on the NFK and the SFK rivers may extend just below the confluence of the two rivers. After the flows combine at the confluence of the NFK and SFK rivers, discernable changes in flow would be unlikely and are expected to be within historic and seasonal variation in the Koktuli River." [USACE 2020a: Page 4.16-2]

EPA Response

These FEIS quotes focus on changes in fish populations, surface water quantities, and streamflow patterns downstream of the mine site. In each case, the FEIS states that effects on these parameters are expected or likely to fall within the range of natural, historic, and seasonal variability. These statements do not mean that the 2020 Mine Plan would not significantly impact aquatic resources at or downstream of the mine site. As discussed in greater detail in Section B.2.2, the habitats that would be lost or degraded as a result of the discharge of dredged or fill material associated with the construction and operation of the 2020 Mine Plan are highly variable in terms of streamflow, fish densities, water

temperature, and other parameters. This variability is evident even across the relatively limited spatial and temporal scales over which baseline environmental data have been collected in the region.[4]

Because these are highly variable systems, changes associated with construction and operation of the 2020 Mine Plan could fall within the range of recorded natural variability but still represent large impacts to these systems, thereby resulting in unacceptable adverse effects (Section B.2.2). It is important to consider how aquatic resources would be affected not just by the magnitude of expected changes, but also by their disruption of natural temporal and spatial patterns of variability at biologically meaningful scales. For example, streamflow variability is critical to the structure and function of these ecosystems. As discussed in Section B.3.2, the discharge of treated water would transform the naturally varying and unregulated surface water flows in the headwaters of the NFK and SFK into less variable streamflows that at times are dramatically increased from natural conditions, due to uniform WTP discharges of regulated process-water to surface waters. The FEIS does not explain how streamflow changes associated with the construction and operation of the 2020 Mine Plan would alter natural flow patterns and variability,[5] nor consider how these changes in the natural flow regime would affect physical habitat, water quality, and the full suite of organisms adapted to these systems (Section B.3.1).

Quote 3.a states that "…impacts to anadromous and resident fish populations from these direct habitat losses would not be measurable, and would be expected to fall within the range of natural variability." As discussed above, this statement tells us very little about the severity of project impacts. The 2020 Mine Plan will permanently reduce the total area of habitat for anadromous and resident fishes. As detailed in Section 4 of the final determination, the productivity of remaining downstream fish habitat also will be permanently degraded due to alterations in streamflow, water chemistry, and water temperature and the loss of ecological subsidies from impacted upstream habitats. This permanent loss of productive capacity will reduce the ability of the habitat to support anadromous and resident fish populations and will reduce the range of variability for fish populations relative to current conditions.

Quote 3.b addresses State-permitted water withdrawals from surface waters and indicates that such withdrawals would primarily occur along the transportation corridor during the 4-year construction period. The FEIS notes only that permit requirements would likely maintain streamflows or waterbody volumes within the limits of historic and seasonal variation. Quote 3.b is not relevant to EPA's final determination because EPA's determinations of unacceptable adverse effects are not based on aquatic

[4] EPA recognizes that the SFK, NFK, and UTC are relatively well-sampled streams, compared with other streams in the region, due to PLP's efforts to collect environmental baseline data in areas draining the Pebble deposit area; however, these data are still spatially and temporally limited and, thus, should be interpreted with caution (see Sections B.1 and B.2 for more detail).

[5] The FEIS acknowledges that "[f]lood magnitude and frequency on the NFK and SFK rivers could potentially change as a result of mine development" and that "[t]he geographic extent of potential changes to flood magnitude on the NFK and SFK could extend just below the confluence of the two rivers," (USACE 2020: Page 4.16-18), but does not discuss how specific flood events, such as channel-forming flows or bankfull flows that occur every 1.5 to 2 years, would be altered; what such changes would mean for stream stability; or how such changes would affect aquatic habitats and species.

resource impacts resulting from surface water withdrawals, short-term impacts from construction, or impacts along the transportation corridor.

Quote 3.c makes two points: (1) that impacts to surface water hydrology from construction and operation of the 2020 Mine Plan would occur in all reaches of the NFK and SFK downstream of the mine site; and (2) that any changes in streamflow below the confluence of the NFK and SFK "…are expected to be within historic and seasonal variation in the Koktuli River." Regarding the first point, there are approximately 61 miles of mainstem habitat between the mine site and the confluence of the NFK and SFK—that is, there are 38 miles in the NFK and 23 miles in the SFK that support anadromous fishes and would experience impacts to surface water hydrology. Changes in natural flow patterns and variability would be most dramatic at upstream reaches closer to the mine site. For example, average streamflows in April are predicted to increase by more than 100 percent within the SFK Reach D and NFK Reaches C and D due to construction and operation of the 2020 Mine Plan. These predicted changes would constitute a significant alteration of natural flow conditions. Section 4.2.4 of the final determination addresses how EPA considered adverse effects resulting from changes in streamflow in downstream anadromous fish streams. The second point in quote 3.c is not relevant to the final determination because EPA's determination of unacceptable adverse effects is not based on predicted streamflow changes within the Koktuli River downstream of the confluence of the NFK and SFK.

4. Conclusions related to predicted habitat availability

Commenters cited two FEIS quotes related to predicted fish habitat availability that they contend contradict EPA's conclusions in the final determination.

Cited FEIS Quotes

4.a "With few exceptions, predicted changes in habitat in the modeled portion of the upper mainstem Koktuli River (upstream of the Swan River) are near zero or positive, suggesting that project effects from flow changes would not negatively impact reaches downstream of the NFK and SFK confluence, or in UTC." [USACE 2020a: Page 4.24-13]

4.b "In mainstem reaches, few changes in surface water flows are expected to result in decreased suitable habitat exceeding 2 percent. Most changes would be expected to increase suitable habitat (see Table K4.24-1), partially because of the WTP treated water discharge into the mainstem reaches (or tributaries immediately upstream of the mainstems) of the NFK, SFK, and UTC, according to the species and life-stage priorities listed in Table 4.24-2. Figure 4.24-2 shows that 81 to 90 percent of expected changes in suitable spawning habitat would be positive, or within 2 percent of pre-mine conditions, with more predicted increases in habitat than decreases, for both anadromous and resident fish species in an average water year scenario. All predicted decreases in suitable habitat exceeding 10 percent are from tributaries NK 1.190 and SK 1.190." [USACE 2020a: Page 4.24-14]

EPA Response

As detailed in Appendix B, EPA has concerns about how the PHABSIM analysis was conducted and applied in the FEIS. The FEIS assumed that PHABSIM-generated changes in depth and velocity adequately capture effects on fish habitat, despite the fact that many other parameters influence fish habitat use (see Section B.4 for a more detailed discussion of EPA's concerns). EPA considered the PHABSIM analysis included in the FEIS when developing the proposed determination, the recommended determination, and this final determination. However, EPA also recognizes the importance of natural flow regimes in maintaining habitat-forming processes and the biotic integrity of salmon ecosystems in the SFK, NFK, and UTC watersheds (EPA 2014: Chapter 7). Thus, EPA used projected streamflow changes from the natural hydrograph to evaluate effects resulting from the discharge of dredged or fill material associated with the construction and operation of the 2020 Mine Plan. Such an approach considers changes in the natural hydrograph that affect the hydrogeomorphic processes creating, shaping, and maintaining aquatic habitats, rather than focusing on an individual species, a specific guild of species (e.g., Pacific salmon), or a specific life stage (e.g., spawning adults) that may have different spatial and temporal habitat requirements than other biota in the natural system. Alteration of these hydrogeomorphic processes affects habitat-forming processes, as well as habitat conditions beyond water depth and velocity (see Section B.4).

The FEIS conclusion that most changes in fish spawning and rearing habitats predicted to result from construction and operation of the 2020 Mine Plan would be "near zero or positive" is flawed for several reasons (see Section B.4). For example, the FEIS assumes that increases in winter flows would increase fish habitat use, although this assumption is not supported by available data at the mine site. The FEIS does not include any winter fish distribution and abundance data and does not evaluate potential losses of incubating eggs due to increased winter flows. Predicting how flow changes would affect winter habitat is particularly challenging given the lack of streamflow measurements collected during winter months, lack of fish habitat use information during winter months (e.g., calibration data), and the complex interactions of groundwater and surface water that would be disrupted due to streamflow alterations with potential implications for winter ice-free habitat and water temperatures.

Aquatic biota are adapted to the natural flow regimes of their habitats, and streamflow changes occurring due to the construction and operation of the 2020 Mine plan will disrupt all components of the natural flow regime. The FEIS did not evaluate the effects of this disruption on habitat availability and use for all Pacific salmon species at all life stages. Instead, the FEIS assumes, without explanation or justification, that more water translates to more fish habitat, even when this assumption is clearly not supported by the available data. For example, field data demonstrate decreased habitat use by juvenile Coho, Sockeye, and Chinook salmon with increasing depth (Figure B-2): as water depth increased above approximately 2.1 feet, the probability that juvenile Coho and Chinook salmon would be found decreased, with no juveniles of either species found at water depths above roughly 3.7 feet. The FEIS also did not provide data on fish distribution and abundance data in overwintering areas or consider potential impacts on salmon egg incubation.

The FEIS did not provide any specific details about how treated water discharges would be managed and monitored to optimize conditions for "species and life-stage priorities" (quote 4.b), and EPA questions whether the goal of habitat optimization is attainable. Specifically, EPA questions, among other things, whether habitat optimization is possible given the limitations of the flow-habitat model development and the limitations of the planned streamflow monitoring program (see Sections B.3.2 and B.4.3 for further discussion).

Quote 4.a states that streamflow changes associated with construction and operation of the 2020 Mine Plan "would not negatively impact reaches downstream of the NFK and SFK confluence." As explained above, EPA's final determination is not based on impacts below the confluence of the NFK and SFK. EPA's final determination is based solely on the unacceptable adverse effects on fishery areas within the NFK, SFK, and UTC watersheds.

5. Conclusions related to cumulative effects

Commenters cited one FEIS quote related to cumulative effects of the Expanded Mine Scenario, which they believe contradict EPA's conclusions in the final determination.

Cited FEIS Quote

5.a. "Overall, the contribution of Alternative 1a to cumulative effects to aquatic resources, when taking other past, present, and RFFAs [Reasonably Foreseeable Future Actions] into account, would be minor to moderate in terms of magnitude, duration, and extent, given the documented habitat use by fish, existing habitat potential, and permit requirements regarding fish and aquatic habitat protection at stream crossings." [USACE 2020a: Page 4.24-70]

EPA Response

The cumulative effects of the Expanded Mine Scenario are not a basis for this final determination (see Section 4 of the final determination), and as such quote 5.a is not relevant to this final determination. Nevertheless, EPA provides the following in response to comments. The conclusion that cumulative effects to aquatic resources that would result under the Expanded Mine Scenario would be "minor to moderate" is based on "documented habitat use by fish" and estimates of "existing habitat potential." As detailed in Section B.1.1, FEIS conclusions that the loss of stream habitats would be inconsequential for fish populations appear to be based on an assumption that the relative quality of these habitats is low and that these habitats have minimal influence on downstream waters. These assumptions and, thus, the conclusions based on them, are not supported by the available information about these habitats or the current science surrounding the importance of headwater systems (see Sections B.1 and B.2 for additional discussion related to this point). Section 3 and Appendix B of the final determination discuss the importance of the aquatic resources that would be impacted by the discharge of dredged or fill material associated with the construction and operation of the 2020 Mine Plan and the Expanded Mine Scenario in detail. The factual record strongly supports EPA's conclusion that the habitats that would be lost or damaged at the mine site (1) are productive habitats for aquatic biota, including fishes, and (2) support the productivity of downstream anadromous waters.

In fact, the FEIS documents the large amounts of habitat loss that would occur under the Expanded Mine Scenario:

- "The cumulative effects of indirect impacts described above [changes in surface and groundwater flows, increased sediment, changes in water temperature] are expected to change overall productivity in the NFK and SFK drainages…" [USACE 2020a: Page 4.24-28]
- "At the mine site, an additional 35 miles of anadromous stream habitat would be lost in the SFK and UTC drainages, including the entire footprint of Frying Pan Lake, which would [sic] inundated by the south collection pond, potentially affecting sockeye, coho, chum, and Chinook salmon." [USACE 2020a: Page 4.24-64.]
- "The Pebble Project expansion scenario footprint would impact approximately 31,892 acres, compared to 9,612 acres…" [USACE 2020a: Page 4.24-65]
- "Expansion of the project would contribute to cumulative effects on wetlands and other waters through the excavation and placement of fill, fragmentation of habitat, deposition of dust, and dewatering. These actions would be expected to contribute to the permanent loss of habitat and associated reduction in habitat connectivity, ecological function, and the perceived values of wetlands and other waters." [USACE 2020a: Page 4.22-115]
- "With expansion, the duration of these impacts would be extended by an additional 58 years of mining and 20 years of additional milling, extending the intermittent impacts and increasing the likelihood of impacts from spills." [USACE 2020a: Page 4.24-65]

The discharge of dredged or fill material associated with the construction and operation of the 2020 Mine Plan will result in the permanent loss of approximately 8.5 miles of streams in the NFK watershed with documented occurrence of anadromous fishes, specifically Coho and Chinook salmon. The Expanded Mine Scenario would eliminate an additional 35 miles of streams in the SFK and UTC watersheds with documented occurrence of anadromous fishes (USACE 2020a: Section 4.24). The additional stream losses that would occur as a result of the Expanded Mine Scenario represent 25.7 percent of anadromous fish streams across the SFK and UTC watersheds combined.[6] The discharge of dredged or fill material associated with the Expanded Mine Scenario also would result in the permanent loss of an additional 295.5 miles of streams that support downstream anadromous fish streams across the SFK and UTC watersheds, most of which would be perennial streams (USACE 2020a: Table 4.22-40).

The discharge of dredged or fill material associated with the Expanded Mine Scenario would result in the permanent loss of an additional 8,756 acres of wetlands and other waters in the SFK and UTC watersheds (USACE 2020a: Table 4.22-40) and the complete loss of 544 acres of lakes and ponds with documented anadromous fish use (Giefer and Graziano 2022), including the 150-acre Frying Pan Lake in the SFK watershed. Frying Pan Lake, which would be inundated by the south collection pond, provides

[6] The SFK watershed contains 60.0 miles of anadromous waters and the UTC watershed contains 76.2 miles of anadromous waters, based on AWC and PLP stream layers (USACE 2020a: Section 3.24).

rearing habitat for Sockeye Salmon, Arctic Grayling, Northern Pike, whitefish, stickleback, and sculpin. Across the SFK, NFK, and UTC watersheds, the discharge of dredged or fill material associated with the Expanded Mine Scenario would result in losses of documented Sockeye, Coho, Chinook, and Chum salmon habitat (USACE 2020a: Section 4.24). The functional and productive capacity of these lost fishery areas—for anadromous fishes, as well as for resident fishes and other aquatic biota—would be zero, and the functional and productive capacity of remaining downstream fishery areas would be significantly damaged.

As Table 4-6 of the final determination illustrates, the discharge of dredged or fill material associated with the Expanded Mine Scenario would cumulatively result in the following losses of anadromous stream habitat in the SFK, NFK, and UTC watersheds: 32.8 miles documented to support Coho Salmon; 13.7 miles documented to support Chinook Salmon; 7.8 miles documented to support Sockeye Salmon; and 1.6 miles documented to support Chum Salmon. Sections B.1 and B.2 explain why these values likely represent minimum estimates of actual impacts, and even these minimum estimates represent extraordinary levels of anadromous habitat loss.

EPA assumes that construction and operation of the 2020 Mine Plan and the Expanded Mine Scenario would involve implementation of all required stream crossing (and other) protections. Further, any accidents or failures of these required safeguards, although likely (see Section 6 of the final determination), are not a basis for this final determination.

6. Conclusions related to the coexistence of mining and fisheries in other watersheds

Commenters cited one FEIS quote that suggests that construction and operation of the 2020 Mine Plan would not be expected to affect salmon populations at the mine site because salmon fisheries and resource extraction activities have co-existed elsewhere in Alaska.

Cited FEIS Quote

6.a “Other salmon fisheries in Alaska exist in conjunction with non-renewable resource extraction industries. For example, the Cook Inlet salmon fisheries exist in an active oil and gas basin and have developed headwaters of Anchorage and the Matanuska-Susitna areas. The Copper River salmon fishery occurs in a watershed with the remains of the historic Kennecott Copper Mine and the Trans Alaska Pipeline System in the headwaters of portions of the fishery. Both fisheries average higher prices per pound than the Bristol Bay Salmon Fishery.” [USACE 2020a: Executive Summary Page 86]

EPA Response

This quote does not address the expected impacts of the discharge of dredged or fill material associated with the construction and operation of the 2020 Mine Plan or the development of the Pebble deposit, which is the sole focus of this final determination. As explained in detail in Section 4, EPA has determined that the discharge of dredged or fill material associated with the construction and operation

of the 2020 Mine Plan will result in unacceptable adverse effects on fishery areas in the NFK, SFK, and UTC. The FEIS acknowledges that the examples cited in this quote are not relevant to assessment of impacts associated with construction and operation of the 2020 Mine Plan, stating that "…no other wild salmon fishery in the world exists in conjunction with an active mine of this size, so existing examples are limited in their usefulness as working comparisons" (USACE 2020a: Page 4.6-9). Evaluating the impacts that will result from the discharge of dredged or fill material associated with construction and operation of the 2020 Mine Plan or similar development of the Pebble deposit requires a place-based analysis that accounts for the nature and magnitude of the potential adverse effects and the ecological significance of the region's salmon populations.

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APPENDIX C

TECHNICAL EVALUATION OF POTENTIAL COMPENSATORY MITIGATION MEASURES

CONTENTS

Executive Summary **C-1**

Section 1. Compensatory Mitigation Background **C-2**

1.1 Location, Type, and Amount of Compensation C-2

1.2 Compensatory Mitigation Guidance for Alaska C-3

Section 2. Important Ecological Functions and Services Provided by Affected Streams and Wetlands **C-5**

2.1 Aquatic Resources Affected at the Proposed Mine Site C-5

2.2 Importance of Affected Aquatic Resources C-5

2.3 Identifying the Appropriate Watershed Scale for Compensatory Mitigation C-7

Section 3. Review of Additional Potential Compensatory Mitigation Measures **C-8**

3.1 Permittee-Responsible Compensatory Mitigation C-8

3.1.1 Compensation Measures Suggested within the SFK, NFK, and UTC Watersheds C-8

3.1.1.1 Increase Habitat Connectivity C-9

3.1.1.1.1 Remove Beaver Dams C-10

3.1.1.1.2 Connect Off-channel Habitats and Habitat Above Impassible Waterfalls C-11

3.1.1.2 Increase Habitat Quality C-13

3.1.1.3 Increase Habitat Quantity C-15

3.1.1.4 Manage Water Quantity C-17

3.1.1.4.1 Direct Excess On-site Water C-17

3.1.1.4.2 Augment Flows C-18

3.1.1.4.3 Pump Water Upstream C-19

3.1.1.5 Manipulate Water Quality C-19

3.1.1.5.1 Increase Levels of Alkalinity, Hardness, and Total Dissolved Solids C-20

3.1.1.5.2 Increase Levels of Nitrogen and/or Phosphorus C-21

3.1.2 Other Potential Compensation Measures Suggested within the Nushagak and Kvichak River Watersheds C-25

3.1.2.1 Remediate Old Mine Sites C-25

3.1.2.2 Remove Roads C-25

3.1.2.3 Retrofit Road Stream Crossings C-26

3.1.2.4 Construct Hatcheries C-26

3.1.2.5 Stock Fish C-27

3.2 Other Suggested Measures C-28

Section 4. Effectiveness of Compensation Measures at Offsetting Impacts on Fish Habitat C-29

Section 5. Conclusions..... C-33

Section 6. References..... C-34

6.1 Citations C-34

6.2 Additional Publications Reviewed.....C-49

Acronyms and Abbreviations

BBA	Bristol Bay Assessment
CWA	Clean Water Act
DA	Department of the Army
EBD	Environmental Baseline Document
EPA	Environmental Protection Agency
FEIS	Final Environmental Impact Statement
MOA	Memorandum of Agreement
NFK	North Fork Koktuli River
NOAA	National Oceanic and Atmospheric Administration
PLP	Pebble Limited Partnership
ROD	Record of Decision
SFK	South Fork Koktuli River
TDS	total dissolved solids
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geologic Survey
UTC	Upper Talarik Creek
WTP	wastewater treatment plant

EXECUTIVE SUMMARY

Compensatory mitigation refers to the restoration, establishment, enhancement, and/or in certain circumstances preservation of wetlands, streams, or other aquatic resources. Compensatory mitigation regulations jointly promulgated by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (USACE) state that "the fundamental objective of compensatory mitigation is to offset environmental losses resulting from unavoidable impacts to waters of the United States authorized by [Clean Water Act (CWA) Section 404 permits issued by USACE]" (40 CFR 230.93(a)(1)). Compensatory mitigation enters the analysis only after a proposed project design has incorporated all appropriate and practicable means to avoid and minimize adverse impacts on aquatic resources (40 Code of Federal Regulations [CFR] 230.91(c)).

The Pebble Limited Partnership (PLP) has proposed to develop the Pebble copper-gold-molybdenum porphyry deposit as a surface mine in the Bristol Bay watershed in southwest Alaska (i.e., the 2020 Mine Plan) (PLP 2020b). In its 2023 *Final Determination of the U.S. Environmental Protection Agency Pursuant to Section 404(c) of the Clean Water Act: Pebble Deposit Area, Southwest Alaska*, EPA finds that the estimated loss and degradation of wetlands, streams, and other aquatic resources from the discharge of dredged or fill material for the construction and routine operation of the 2020 Mine Plan will have unacceptable adverse effects on anadromous fishery areas.

During development and finalization of the Bristol Bay Assessment (BBA) (EPA 2014) between 2011 and 2014 and review of an earlier 404(c) proposed determination regarding the Pebble deposit published in 2014, PLP and other commenters suggested an array of measures as having the potential to compensate for the nature and magnitude of adverse impacts on wetlands, streams, and fish from the discharge of dredged or fill material associated with developing the Pebble deposit.

This appendix provides a detailed technical evaluation of each of these measures, for informational purposes. Available information demonstrates that known compensation measures are unlikely to adequately mitigate effects described in this final determination to an acceptable level.

SECTION 1. COMPENSATORY MITIGATION BACKGROUND

Compensatory mitigation is defined as the restoration, establishment, enhancement, and/or, in certain circumstances, preservation of wetlands, streams, or other aquatic resources conducted specifically for the purpose of offsetting unavoidable authorized impacts to these types of resources (40 Code of Federal Regulations [CFR] 230.92, Hough and Robertson 2009). According to compensatory mitigation regulations jointly promulgated by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (USACE), "the fundamental objective of compensatory mitigation is to offset environmental losses resulting from unavoidable impacts to waters of the United States authorized by [Clean Water Act (CWA) Section 404 permits issued by USACE]" (40 CFR 230.93(a)(1)).

CWA Section 404 permitting requirements for compensatory mitigation are based on what is "practicable and capable of compensating for the aquatic resource functions that will be lost as a result of the permitted activity" (40 CFR 230.93(a)(1)). In determining what type of compensatory mitigation will be "environmentally preferable," USACE "must assess the likelihood for ecological success and sustainability, the location of the compensation site relative to the impact site and their significance within the watershed, and the costs of the compensatory mitigation project" (40 CFR 230.93(a)(1)). Furthermore, compensatory mitigation requirements must be commensurate with the amount and type of impact associated with a particular CWA Section 404 permit (40 CFR 230.93(a)(1)).

1.1 Location, Type, and Amount of Compensation

Regulations regarding compensatory mitigation require the use of a watershed approach to "establish compensatory mitigation requirements in [Department of the Army] permits to the extent appropriate and practicable" (40 CFR 230.93(c)(1)). Under these regulations, the watershed approach to compensatory mitigation site selection and planning is an analytical process for making compensatory mitigation decisions that support the sustainability or improvement of aquatic resources in a watershed. It involves consideration of watershed needs and how locations and types of compensatory mitigation projects address those needs (40 CFR 230.92). The regulations specifically state that compensatory mitigation generally should occur within the same watershed as the impact site and in a location where it is most likely to successfully replace lost functions and services (40 CFR 230.93(b)(1)). The goal of this watershed approach is to "maintain and improve the quality and quantity of aquatic resources within watersheds through strategic selection of compensatory mitigation sites" (40 CFR 230.93(c)(1)).

The regulations emphasize using existing watershed plans to inform compensatory mitigation decisions when such plans are determined to be appropriate for use in this context (40 CFR 230.93(c)(1)). Where appropriate plans do not exist, the regulations describe the types of considerations and information that should be used to support a watershed approach to compensation decision-making. Central to the

watershed approach is consideration of how the types and locations of potential compensatory mitigation projects would sustain aquatic resource functions in the watershed. To achieve that goal, the regulations emphasize that mitigation projects should, where practicable, replace the suite of functions typically provided by the affected aquatic resource, rather than focus on specific individual functions (40 CFR 230.93(c)(2)). For this purpose, "watershed" means an "area that drains to a common waterway, such as a stream, lake, estuary, wetland, or ultimately the ocean" (40 CFR 230.92). Although there is flexibility in defining geographic scale, the watershed "should not be larger than is appropriate to ensure that the aquatic resources provided through compensation activities will effectively compensate for adverse environmental impacts resulting from [permitted] activities" (40 CFR 230.93(c)(4)).

With regard to type, in-kind mitigation (i.e., involving resources similar to those being impacted) is generally preferable to out-of-kind mitigation, because it is most likely to compensate for functions lost at the impact site (40 CFR 230.93(e)(1)). Furthermore, the regulations recognize that, for difficult-to-replace resources such as bogs, fens, springs, and streams, in-kind "rehabilitation, enhancement, or preservation" should be the compensation of choice, given the greater likelihood of success of those types of mitigation (40 CFR 230.93(e)(3)).

The amount of compensatory mitigation required must be, to the extent practicable, "sufficient to replace lost aquatic resource functions" (40 CFR 230.93(f)(1)), as determined through the use of a functional or condition assessment. If an applicable assessment methodology is not available, the regulations require a minimum one-to-one acreage or linear foot compensation ratio (40 CFR 230.93(f)(1)). Certain circumstances require higher ratios, even in the absence of an assessment methodology (e.g., use of preservation, lower likelihood of success, differences in functionality between the impact site and compensation project, difficulty of restoring lost functions, and the distance between the impact and compensation sites) (40 CFR 230.93(f)(2)).

1.2 Compensatory Mitigation Guidance for Alaska

In addition to the federal regulations regarding compensatory mitigation, EPA and the DA have also developed compensatory mitigation guidance applicable specifically to Alaska in a 2018 Memorandum of Agreement (MOA) (EPA and DA 2018).[1] The 2018 MOA provides guidance regarding flexibilities that exist in the mitigation requirements for CWA Section 404 permits, and how those flexibilities can be applied in Alaska given the abundance of wetlands and unique circumstances involved with CWA Section 404 permitting in the state. Accordingly, the 2018 MOA recognizes that restoring, enhancing, or establishing wetlands for compensatory mitigation may not be practicable due to limited availability of sites and/or technical or logistical limitations. It also recognizes that compensatory mitigation options

[1] This MOA updates and replaces the EPA and DA Memoranda entitled *Clarification of the Clean Water Act Section 404 Memorandum of Agreement on Mitigation*, dated January 24, 1992, and *Statements on the Mitigation Sequence and No Net Loss of Wetlands in Alaska*, dated May 13, 1994.

over a larger watershed scale may be appropriate given that compensation options are frequently limited at a smaller watershed scale.

The 2018 MOA also identifies when compensatory mitigation may be required to ensure that an activity requiring a CWA Section 404 permit complies with the CWA Section 404(b)(1) Guidelines (40 CFR Part 230.91(c)(2)). The 2018 MOA provides the following examples.

- Compensatory mitigation may be required to ensure that discharges do not cause or contribute to a violation of water quality standards or jeopardize a threatened or endangered species or result in the destruction or adverse modification of critical habitat under the Endangered Species Act (40 CFR Part 230.10(b)).
- Compensatory mitigation may be required to ensure that discharges do not cause or contribute to significant degradation (40 CFR Part 230.10(c)).
- The CWA Section 404(b)(1) Guidelines also require compensatory mitigation measures when appropriate and practicable (40 CFR Parts 230.10(d), 230.12, 230.91, and 230.93(a)(1)).

The 2018 MOA also notes that during the CWA Section 404(b)(1) Guidelines compliance analysis, USACE may determine that a CWA Section 404 permit for a proposed discharge cannot be issued because of a lack of appropriate and practicable compensatory mitigation options (40 CFR Part 230.91(c)(3)).

It is important to remember that decisions regarding the appropriate type, amount, and location of compensatory mitigation are made on a case-by-case basis and depend on a number of factors, including the type, amount, and location of aquatic resources being impacted.

SECTION 2. IMPORTANT ECOLOGICAL FUNCTIONS AND SERVICES PROVIDED BY AFFECTED STREAMS AND WETLANDS

2.1 Aquatic Resources Affected at the Proposed Mine Site

As discussed in Section 2 of the final determination, the Pebble Limited Partnership (PLP) has proposed to develop the Pebble copper-gold-molybdenum porphyry deposit as a surface mine in the Bristol Bay watershed in southwest Alaska. The project (i.e., the 2020 Mine Plan) consists of four primary components: the mine site, the port, the transportation corridor including concentrate and water return pipelines, and the natural gas pipeline and fiber optic cable (PLP 2020b).[2]

As discussed in Section 4 of the final determination, USACE's Final Environmental Impact Statement (FEIS) and Record of Decision (ROD) for the project estimate that the discharge of dredged or fill material at the mine site would result in the total loss of approximately 99.7 miles of stream habitat, representing approximately 8.5 miles of anadromous fish streams and approximately 91 miles of additional streams that support anadromous fish streams. Such discharges of dredged or fill material also would result in the total loss of approximately 2,108 acres of wetlands and other waters in the South Fork Koktuli River (SFK) and North Fork Koktuli River (NFK) watersheds that support anadromous fish streams (USACE 2020a and 2020b).[3] Section 4 of the final determination also discusses how discharges of dredged or fill material for the construction and routine operation of the 2020 Mine Plan would adversely affect approximately 29 miles of anadromous fish streams resulting from greater than 20 percent changes in average monthly streamflow. In the final determination, EPA finds that certain discharges of dredged or fill material for the construction and routine operation of the 2020 Mine Plan will have unacceptable adverse effects on anadromous fishery areas.

2.2 Importance of Affected Aquatic Resources

Section 3 of the final determination provides a detailed description of the importance of the region's ecological resources. As discussed in Section 3 of the final determination, because of its climate, geology, hydrology, pristine environment, and other characteristics, the Bristol Bay watershed is home to

[2] The final determination focuses on the adverse effects of discharges of dredged or fill material associated with the mine site(see final determination: Section 2.1.2).

[3] Anadromous fishes are those that hatch in freshwater habitats, migrate to sea for a period of relatively rapid growth, and then return to freshwater habitats to spawn. For the purposes of this final determination, "anadromous fishes" refers only to Coho or Silver salmon (*Oncorhynchus kisutch*), Chinook or King salmon (*O. tshawytscha*), Sockeye or Red salmon (*O. nerka*), Chum or Dog salmon (*O. keta*), and Pink or Humpback salmon (*O. gorbuscha*). Impact values cited here come from the ROD, which provides updates to the impact values provided in the FEIS.

abundant, diverse, and productive aquatic habitats (final determination: Figure ES-1). These streams, rivers, wetlands, lakes, and ponds support world-class commercial, subsistence, and recreational fisheries for multiple species of Pacific salmon, as well as numerous other fish species valued as subsistence and recreational resources (final determination: Section 3.3).

The productivity and diversity of the watershed's aquatic habitats are closely tied to the productivity and diversity of its fisheries. The waters of the SFK, NFK, and Upper Talarik Creek (UTC) watersheds are important for maintaining the integrity, productivity, and sustainability of the region's salmon and non-salmon fishery resources (final determination: Sections 3.2 and 3.3). The Pebble deposit overlies portions of the SFK, NFK, and UTC watersheds, and these areas would be most directly affected by mine development at the Pebble deposit.

Streams and lakes in the SFK, NFK, and UTC watersheds are ideal for maintaining high levels of fish production, with clean, cold water, gravel substrates, and abundant areas of groundwater upwelling. These conditions create preferred salmon spawning habitat and provide favorable conditions for egg incubation and survival. Figure 4-3 of the final determination illustrates reported distributions for all five species of Pacific salmon (Coho [*Oncorhynchus kisutch*], Chinook [*O. tshawytscha*], Sockeye [*O. nerka*], Chum [*O. keta*], and Pink [*O. gorbuscha*]) in these three watersheds. Streams and lakes in the SFK, NFK, and UTC watersheds also provide high-quality habitat for fishes, such as Rainbow Trout (*O. mykiss*), Dolly Varden (*Salvelinus malma*), Arctic Grayling (*Thymallus arcticus*), and Northern Pike (*Esox lucius*). Wetlands provide essential off-channel habitats that protect young Coho Salmon and other species, as well as provide spawning areas for Northern Pike. All of these species move throughout the region's freshwater habitats during their life cycles, and all are fished—commercially, for subsistence use, and recreationally—in downstream waters. Thus, the intact headwater-to-larger river systems found in the SFK, NFK, and UTC watersheds, with their associated wetlands, help sustain the overall productivity of these fishery areas (final determination: Sections 3.2 and 3.3).

Not only do the streams, wetlands, and ponds of the SFK, NFK, and UTC watersheds directly provide habitat for salmon and other fishes, they also provide critical support for downstream habitats. By contributing water, organic matter, and macroinvertebrates to downstream systems, these headwater areas help maintain downstream habitats and fuel their fish productivity. Together, these functions—direct provision of high-quality habitat and indirect provision of other resources to downstream habitats—help support the valuable fisheries of the Bristol Bay watershed (final determination: Section 3.2).

This support is vital for populations of Coho, Chinook, and Sockeye salmon in these watersheds. Chinook Salmon are the rarest of the North American Pacific salmon species but are a critical subsistence resource, particularly along the Nushagak River. The SFK, NFK, and UTC watersheds support discrete populations of Sockeye Salmon that are genetically programmed to return to specific localized reaches or habitats to spawn; they likely do the same for Coho and Chinook salmon (final determination: Section 3.3.3). This portfolio of multiple small populations is essential for maintaining the genetic diversity and,

thus, the stability and productivity of the region's overall salmon stocks (i.e., the portfolio effect) (final determination: Section 3.3.3).

2.3 Identifying the Appropriate Watershed Scale for Compensatory Mitigation

As previously noted, the regulations regarding compensatory mitigation specifically state that compensatory mitigation generally should occur within the same watershed as the impact site and in a location where it is most likely to successfully replace lost functions and services (40 CFR 230.93(b)(1)).

For the impacts of the mine site associated with the 2020 Mine Plan, ecological functions and services would be most directly affected in the SFK, NFK, and UTC watersheds. Accordingly, the most appropriate geographic scale at which to compensate for any unavoidable impacts resulting from such a project would be within these same watersheds, as these locations would offer the greatest likelihood that compensation measures would replace the "suite of functions typically provided by the affected aquatic resource" (40 CFR 230.93(c)(2), Yocom and Bernard 2013). An important consideration is that salmon populations in these watersheds possess unique adaptations to local environmental conditions, as suggested by recent research in the region (Olsen et al. 2003, Ramstad et al. 2010, Quinn et al. 2012, Dann et al. 2012, Shedd et al. 2016, Brennan et al. 2019). Accordingly, maintenance of local biocomplexity (i.e., salmon genetic, behavioral, and phenotypic variation) and the environmental template upon which biocomplexity develops will be important for sustaining resilience of these populations (Hilborn et al. 2003, Schindler et al. 2010, Griffiths et al. 2014, Brennan et al. 2019). Thus, the most appropriate spatial scale and context for compensation would be within the local watersheds where impacts on salmon populations occur.

If there are no practicable or appropriate opportunities to provide compensation in these watersheds, exploring options in adjoining watersheds may be appropriate. However, defining the watershed scale too broadly would likely fail to ensure that wetland, stream, and associated fish losses in the SFK, NFK, and UTC watersheds would be addressed, because compensation in a different watershed(s) would not reduce the severity of the impacts to aquatic resources in the affected watersheds. Similarly, compensation in different watersheds would not address impacts to the subsistence fishery where users depend on a specific temporal and spatial distribution of fish to ensure nutritional needs and cultural values are maintained (EPA 2014: Chapter 12).

SECTION 3. REVIEW OF ADDITIONAL POTENTIAL COMPENSATORY MITIGATION MEASURES

During development and finalization of the Bristol Bay Assessment (BBA) between 2011 and 2014 and during public review of an earlier 404(c) proposed determination regarding the Pebble deposit published in 2014, PLP and other commenters suggested an array of measures as having the potential to compensate for the nature and magnitude of adverse impacts on wetlands, streams, and fish from the discharge of dredged or fill material associated with developing the Pebble deposit. This section provides a technical evaluation of the likely efficacy, applicability, and sustainability of these additional measures in reducing the unavoidable aquatic resource impacts estimated for the 2020 Mine Plan to an acceptable level. Since mitigation bank and in-lieu fee program options are not available, all of these additional measures would involve permittee-responsible compensatory mitigation.[4]

Neither PLP, the State of Alaska, USACE, nor any other party suggested any additional compensation measures during (1) the initial stakeholder consultation with EPA prior to issuance of the 2022 Proposed Determination, (2) the public comment period on the 2022 Proposed Determination, or (3) final consultation on the recommended determination in December 2022.

3.1 Permittee-Responsible Compensatory Mitigation

3.1.1 Compensation Measures Suggested within the SFK, NFK, and UTC Watersheds

This section discusses specific suggestions for potential compensation measures within the SFK, NFK, and UTC watersheds that were provided in the public and peer review comments on the BBA and 2014 Proposed Determination.

[4] Mitigation banks and in-lieu fee programs are other mechanisms for satisfying compensatory mitigation requirements that rely on third-party providers (40 CFR 230.92). Should a mitigation bank or in-lieu fee sponsor pursue the establishment of mitigation bank or in-lieu fee program sites to address impacts of the nature and magnitude estimated for the 2020 Mine Plan, they would encounter the same challenges described in Section 3 of this appendix. Permittee-responsible mitigation means an aquatic resource restoration, establishment, enhancement, and/or preservation activity undertaken by the permittee to provide compensatory mitigation for which the permittee retains full responsibility (40 CFR 230.92).

3.1.1.1 Increase Habitat Connectivity

Several commenters recommended actions to increase connectivity between aquatic habitats, which are discussed in this section. Connectivity among aquatic habitats within stream networks is an important attribute influencing the ability of mobile aquatic taxa to utilize the diversity and extent of habitats within those networks. Within riverine floodplain systems, a complex array of habitats can develop that express varying degrees of surface and sub-surface water connectivity to main channels (Stanford and Ward 1993). In the study area, off-channel floodplain habitats can include side channels (both inlet and outlet connections to main channel), various types of single-connection habitats including alcoves and percolation channels, and pools and ponds with no surface connection to the main channel during certain flow conditions (PLP 2011: Appendix 15.1D). Beavers (*Castor canadensis*) can be very important modifiers and creators of habitat in these off-channel systems (Pollock et al. 2003, Rosell et al. 2005). As a result of their morphology and variable hydrology, the degree of surface-water connectivity and the ability of fish to move among floodplain habitats changes with surface water levels. Connectivity for fish movement at larger spatial scales within watersheds is influenced by barriers to longitudinal movements and migrations. Examples include dams and waterfalls.

Efforts to manage or enhance connectivity within aquatic systems have primarily focused on watersheds altered by human activities, where land uses and water utilization have led to aquatic habitat fragmentation. Specific activities to increase habitat connectivity within human-dominated stream-wetland systems may include the following.

- Improving access around real or perceived barriers to migration (including dams constructed by humans or beavers).
- Removing or retrofitting of road culverts.
- Excavating and engineering of channels to connect isolated wetlands and ponds to main channels.
- Reconnection of historic floodplains via levee removal or other channel engineering.

Within watersheds minimally affected by human activity, efforts to increase connectivity may include creation of passage around barrier waterfalls to expand the availability of habitat for species like Pacific salmon. Removal of human-created dams do not offer any opportunities for habitat improvement or expansion in the Nushagak or Kvichak River watersheds because they are absent, so they are not discussed further. As stated earlier, this is primarily a roadless area, so road stream crossing retrofits presently offer few if any opportunities for habitat improvement or expansion within the SFK, NFK, and UTC watersheds, but exist elsewhere in the larger Nushagak and Kvichak River watersheds and are discussed in Section 3.1.2. Here, beaver dam removal and engineered connections to variably connected floodplain habitats, and habitats upstream of barrier waterfalls are discussed. For each of these measures, the potential applicability, suitability, and effectiveness as mitigation tools within the SFK, NFK, and UTC watersheds are addressed.

3.1.1.1.1 Remove Beaver Dams

Two commenters suggested the removal of beaver dams as part of a potential compensation strategy that included beaver management. Presumably, the rationale for this recommendation is that beaver dams can block fish passage, limiting fish access to otherwise suitable habitat, thus, the removal of beaver dams could increase the amount of available fish habitat. This rationale is based on early research that led to the common fish management practice of removing beaver dams to protect certain fish populations like trout (Salyer 1934, Reid 1952, *in* Pollock et al. 2004). However, more recent research has documented numerous benefits of beaver ponds to fish populations and habitat (Murphy et al. 1989, Pollock et al. 2003). For example, Bustard and Narver (1975) found that a series of beaver ponds on Vancouver Island had a survival rate for overwintering juvenile Coho Salmon that was twice as high as the 35 percent estimated for the entire stream. Pollock et al. (2004) estimated a 61 percent reduction in summer habitat capacity relative to historical levels, largely due to the loss of beaver ponds, for Coho Salmon in one Washington watershed.

A recent review by Larsen et al. (2021) describes the extensive and complex ways in which beavers modify stream ecosystems. Increases in habitat complexity and availability of ponded and productive floodplain habitats associated with beaver activity can result in positive impacts on Sockeye, Coho, and Chinook salmon, as well as Dolly Varden, Rainbow Trout, and Steelhead (Kemp et al. 2012). Using meta-analysis and weight-of-evidence methodology, Kemp et al. (2012) showed that most (71.4 percent) negative effects cited, such as low dissolved oxygen and impediment to fish movement, lack supportive data and are speculative in nature, whereas the majority (51.1 percent) of positive impacts cited are quantitative in nature and well supported by data. In addition to increased invertebrate (i.e., food) production and habitat heterogeneity, the study cited the importance of beaver ponds as rearing habitat due to the increased cover and protection that higher levels of woody material and overall structural diversity provide. Other studies from the Pacific Northwest (Nickelson et al. 1992, Collen and Gibson 2001) and Alaska (Lang et al. 2006) have identified beaver ponds as excellent salmon rearing habitat because they have high macrophyte cover, low flow velocity, and increased temperatures, and they trap organic materials and nutrients. DeVries et al. (2012) describe a stream restoration approach that attempts to mimic and facilitate beaver dam creation and the numerous positive benefits for stream habitat and riparian enhancement. Studies in Oregon have shown that salmon abundance is positively related to pool size, especially during low flow conditions (Reeves et al. 2011), and beaver ponds provide particularly large pools. During winter, beaver ponds typically retain liquid water below the frozen surface, providing refugia for species that overwinter in streams and off-channel habitats (Nickelson et al. 1992, Cunjak 1996).

Beaver dams generally do not constitute significant barriers to salmonid migration, even though their semi-permeability may temporarily limit fish movement during periods of low stream flow (Rupp 1955, Gard 1961, Pollock et al. 2003). Even when beaver dams impede fish movements, the effects are typically temporary with higher flows from storm events ultimately overtopping them or blowing them out (Leidholt-Bruner et al. 1992, Kemp et al. 2012). Even the temporary effect may be limited, when seasonal rainfall is at least average (Snodgrass and Meffe 1998, Kemp et al. 2012). Adding to the body of

evidence, Pacific salmon and other migratory fish species commonly occur above beaver dams, including above beaver dams in the study area (PLP 2011: Appendix 15.1D). Other surveys have documented both adult and juvenile Sockeye Salmon, Steelhead, Cutthroat Trout, and char upstream of beaver dams (Swales et al. 1988, Murphy et al. 1989, Pollock et al. 2003).

Beavers preferentially colonize headwater streams and off-channel habitats (Collen and Gibson 2001, Pollock et al. 2003). An October 2005 aerial survey of active beaver dams in the mine site area mapped 113 active beaver colonies (PLP 2011). PLP's Environmental Baseline Document (EBD) highlights the significant role that beaver ponds are currently providing for Pacific salmon in this area:

> [W]hile beaver ponds were relatively scarce in the mainstem UT [UTC], the off-channel habitat study revealed a preponderance of beaver ponds in the off-channel habitats. As in the SFK watershed, beaver ponds accounted for more than 90 percent of the off-channel habitat surveyed. Beaver ponds in the UT provided habitat for adult spawning and juvenile overwintering for Pacific salmon. The water temperature in beaver ponds in the UT was slightly warmer than in other habitat types and thus, beaver ponds may represent a more productive habitat as compared to other mainstem channel habitat types. (PLP 2011)

The current body of literature describing the effects of beaver dams on salmonid species reports more positive associations between beaver dam activity and salmonids than negative associations (Kemp et al. 2012). Hence, removal of beaver dams as a means of compensatory mitigation could lead to a net negative impact on salmonid abundance, growth, and productivity. Moreover, because the mine footprint would eliminate or block several streams with active beaver colonies in the headwaters of the NFK, the benefits provided by those habitats would be part of the suite of functions that compensatory mitigation should aim to offset.

3.1.1.1.2 Connect Off-channel Habitats and Habitat Above Impassable Waterfalls

Off-channel habitats can provide important low-velocity rearing habitats for juvenile salmon and other native fishes. Floodplain-complex habitats including beaver ponds, side channels, oxbow channels, and alcoves can contribute significantly to juvenile salmonid rearing capacity (e.g., Beechie et al. 1994, Ogston et al. 2015). Such habitats are a common feature of unmodified alluvial river corridors. These habitats may express varying degrees of surface-water connectivity to main channels that depend on streamflow stage and natural channel dynamics in unmodified rivers. Off-channel habitats may become isolated from the main channel during certain streamflow conditions due to channel migration or avulsion, and in highly dynamic channels, connectivity may change frequently during bed-mobilizing events (Stanford and Ward 1993). This shifting mosaic of depositional and erosional habitats within the floodplain creates a diverse hydraulic and geomorphic setting, contributing to biocomplexity (Amoros and Bornette 2002). In river systems modified by human activity, isolation or elimination of off-channel habitats has had severe impacts on salmon productivity (e.g., Beechie et al. 1994), and re-connection and re-creation of off-channel habitats are now common tools for increasing juvenile salmonid habitat capacity in those systems (Morley et al. 2005, Roni et al. 2006, Ogston et al. 2015).

Waterfalls or high-gradient stream reaches can prevent fish from accessing upstream habitats, due to velocity barriers or drops that exceed passage capabilities of fish (Reiser et al. 2006). Waters upstream

of barriers may be devoid of all fish life or may contain resident fish species including genetically distinct populations (e.g., Whiteley et al. 2010). Engineered passageways for fish around waterfalls have been used to create access to upstream lakes or stream systems for fish, such as salmon. However, the response of resident fish species to barrier removal and the colonization success of species from downstream habitats may be context dependent and difficult to predict (Kiffney et al. 2009, Pess et al. 2014). Salmon population responses to a fishway in southeast Alaska depended on the species, and the ecological effects of fish passage on the upstream lake system and watershed are not fully understood (Bryant et al. 1999). Burger et al. (2000) provide a well-documented history of colonization of Sockeye Salmon in Frazer Lake, Alaska, above a historically impassable waterfall following passage installation and planting of salmon eggs, fry, and adults above the barrier. Their study documents how differing donor populations, each with different life-history characteristics, contributed differently toward the establishment of populations in the newly accessible habitats (Burger et al. 2000). This study highlights the importance of genetics and life history adaptations of source populations to colonization success.

Creating connectivity between parts of the river network that are naturally disconnected can have adverse ecological effects, including impacts on resident vertebrate and invertebrate communities, as well as disruptions to ecosystem processes. Introduction of fish to fishless areas can lead to altered predator–prey interactions, food web changes, changes in algal production, nutrient cycling, and meta-population dynamics of other vertebrate species (Section 3.1.2.5). For example, previous studies on the introduction of trout species to montane, wilderness lakes have shown that introducing fish to fishless lakes can have substantial impacts on nutrient cycles (Knapp et al. 2001). The risk of disruption to the functions of naturally fishless aquatic ecosystems should be fully evaluated before these approaches are used for the sole purpose of creating new fish habitat area.

The importance of spatial habitat configuration to stream salmonid ecology has been recognized by a wide variety of systems (reviewed by Flitcroft et al. 2019). For example, Rosenfeld and co-authors (Rosenfeld et al. 2008, Rosenfeld and Raeburn 2009) conducted a variety of experiments and monitoring activities within a re-connected river meander in coastal British Columbia to explore the relationship of salmon productivity to habitat features. Their work highlights the importance of habitat configuration. In their study, spacing of pools (foraging habitats for fish) and riffles (source areas for invertebrate prey) was an important factor influencing growth rates of juvenile Coho Salmon. Given the high diversity of channel conditions within floodplain habitats in the SFK, NFK, and UTC watersheds (PLP 2011), it is likely that fish responses to increased connectivity would be highly variable.

Rosenfeld et al. (2008) point out the importance of considering the full suite of factors that influence habitat capacity and productivity when designing restoration or enhancement projects. For instance, attempting to optimize habitat structure for one species may adversely affect species with differing habitat preferences, as demonstrated by Morley et al. (2005) who found differential responses of juvenile Steelhead and juvenile Coho Salmon to conditions in constructed and natural off-channel habitats. Predator–prey relationships also need to be considered. Increased connectivity of off-channel habitats has been proposed as a strategy for enhancing Northern Pike production in northern Canada

(Cott 2004). How increased connectivity in the project area would influence trophic relationships among Northern Pike and salmonids is unknown, although introduced Northern Pike in other areas of Alaska have the potential to reduce local abundances of salmonids via predation (Sepulveda et al. 2013). Bryant et al. (1999) in their study of the effects of improved passage at a waterfall concluded that the effects on food webs, trophic relationships, and genetics among resident and newly colonizing species were largely unknown. Rosenfeld and Raeburn (2009) emphasize the high degree of uncertainty associated with channel design for enhanced fish productivity, stating the following:

> …despite the enormous quantity of research on stream rearing salmonids and their habitat associations, stream ecologists still lack a definitive understanding of the relationship between channel structure, prey production and habitat capacity for drift-feeding fishes. (Rosenfeld and Raeburn 2009: Page 581)

Several commenters proposed that enhanced or increased connectivity of off-channel habitats or habitats above waterfalls could provide fish access to the currently underutilized or inaccessible habitat. This comment presumes that currently disconnected habitats would provide suitable mitigation sites. Based on the above, multiple criteria would have to be met, and numerous assumptions would have to be validated for these sites to qualify as effective mitigation sites. Given the examples of the challenges of connectivity management, use of fishways at waterfalls, and engineered connections to off-channel habitats there is a great deal of uncertainty regarding the efficacy and sustainability of such techniques as compensatory mitigation in the affected watersheds. Further, there also appears to be a lack of opportunities to implement such techniques. When evaluating what compensation measures could reduce the severity of the adverse effects estimated for the 2020 Mine Plan in the Koktuli River watershed,[5] PLP ruled out all other potential measures aside from preservation stating that "[r]estoration, establishment, or enhancement projects within the identified watershed are not plentiful enough in size or scale to mitigate for the identified acreage of direct and indirect impacts to be mitigated" (PLP 2020c).

3.1.1.2 Increase Habitat Quality

EPA received comments about enhancing habitat quality. Addition of large structural elements, such as wood and boulders to streams, has been a common stream habitat rehabilitation approach in locations where stream habitats have been extensively simplified by mining, logging, and associated timber transportation, or other disturbances (Roni et al. 2008). The goals of large-structure additions are typically to create increased hydraulic and structural complexity and improve local-scale habitat conditions for fish in streams that are otherwise lacking in rearing or spawning microhabitats. Properly engineered structural additions to channels can increase hydraulic diversity, habitat complexity, and retention of substrates and organic materials in channels. However, benefits for fish can be highly variable and context-dependent (Roni 2019) and can be difficult to quantify (Richer et al. 2022, Rogers et al. 2022). The unpredictability of beneficial biotic responses to stream structural enhancements is at odds with perceptions by managers whose evaluations tend to be overtly positive—but usually based on

[5] The most severe impacts of the 2020 Mine Plan are concentrated in the SFK and NFK watersheds, which are a part of the Koktuli River watershed.

qualitative opinion rather than scientific observation (Jähnig et al. 2011). In addition, improperly sited or engineered structural additions can fail to achieve desired effects or have adverse, unanticipated consequences (e.g., via structural failure or scour and fill of sensitive non-target habitats (Frissell and Nawa 1992), highlighting the need for appropriate design (Kondolf et al. 2007).

Commenters proposed that the quality of stream habitats in the project area could be enhanced by increasing habitat complexity through the addition of boulders or large wood to existing off-channel habitats. Off-channel habitats can provide important low-velocity rearing habitats for juvenile salmon and other native fishes. Floodplain-complex habitats including beaver ponds, side channels, oxbow channels, and alcoves provide hydraulic diversity that can be important for fishes in variable flows (Amoros and Bornette 2002, Rosenfeld et al. 2008). Beavers are a major player in the creation and maintenance of these habitats in the study area (PLP 2011: Appendix 15.1D), as has been noted elsewhere (Pollock et al. 2003, Rosell et al. 2005). Off-channel habitats also provide important foraging environments, and can be thermally diverse, offering opportunities for thermoregulation or enhanced bioenergetic efficiency (Giannico and Hinch 2003). Off-channel habitats are relatively frequent and locally abundant in area streams and rivers, particularly in lower-gradient, unconstrained valley settings and at tributary confluences (e.g., PLP 2011: Figure 15.1-15). PLP's EBD, Appendix 15.1D (PLP 2011) contains an assessment of the natural fluvial processes creating and maintaining off-channel habitats and their quality, quantity, and function in the SFK, NFK, and UTC watersheds, including mechanisms of connectivity to the mainstem channels. The EBD (PLP 2011) provides background information that is useful for evaluating the potential effectiveness of off-channel habitat modification.

Commenters proposed that off-channel habitats could also be improved by engineered modifications to the depth, shoreline development ratio, and configuration of off-channel habitats to create better overwintering habitat for juvenile salmon. The degree to which existing habitats could be enhanced to improve survival of juvenile salmon as proposed by commenters, will depend on several considerations, including an evaluation of factors known to influence the utilization, survival, and growth within these habitats. These considerations are discussed below.

Off-channel habitats surveyed by PLP and other investigators reveal that patterns of occupancy and density are high but variable among off-channel habitats (PLP 2011: Appendix 15.1D). Some of the highest densities observed were within off-channel habitats, such as side channels and alcoves, but some "isolated" pools held fish (PLP 2011: Appendix 15.1D). This variability could reflect variation in suitability, access, or other characteristics of individual off-channel habitats. Juvenile salmonids require a diverse suite of resources to meet habitat requirements—cover and visual isolation provided by habitat complexity is one such resource. However, other critical resources include food, space, and suitable temperatures and water chemistry (Quinn 2018). Habitat configuration within constructed side-channel habitats can also strongly influence density, size, and growth of juvenile salmonids (Rosenfeld and Raeburn 2009). Giannico and Hinch (2003) in experimental treatments in side channels in British Columbia found that wood additions were beneficial to Coho Salmon growth and survival in surface–water-fed side channels, but not in groundwater-fed channels. They attributed this effect to

differences in foraging strategy and bioenergetics of the juvenile Coho Salmon overwintering in the channels. Additions of wood had no effect, or even possibly a detrimental effect, on Coho Salmon survival in groundwater-fed side channels. These findings highlight the importance of understanding the ecology, bioenergetics, and behavior of the species and life histories present within habitats that may be quite diverse with regard to hydrology and geomorphology.

It is not clear from current data that adding complexity would address any limiting factor within existing off-channel habitats, or that additions of boulders and wood would enhance salmonid abundance or survival. Placement of structures (e.g., boulders, large wood) within stream channels could also have potential adverse consequences, including unanticipated shifts in hydraulic conditions that lead to bank erosion or loss of other desirable habitat features. Sustainability of off-channel habitat modifications is also in question. As stated in the EBD, off-channel habitats are a product of a dynamic floodplain environment and ". . . are continually being created and destroyed" (PLP 2011: Appendix 15.1D; page 2). Maintenance of engineered structures or altered morphologies of such habitats over the long term would be a challenging task (Tullos et al. 2021). Observations from the EBD suggest that beavers are already providing desired complexity:

> . . . habitat mapping from this off-channel study shows that the beaver ponds contain extensive and diverse habitats and dominate the active valley floor" and "…these off-channel habitats provide a critical habitat component of freshwater rearing of Coho Salmon, and to a lesser extent, other anadromous and resident species. (PLP 2011: Appendix 15.1D: Page 14)

3.1.1.3 Increase Habitat Quantity

EPA received comments about increasing habitat quantity. The creation of spawning channels and off-channel habitats has been proposed as a means to compensate for lost salmon spawning and rearing areas. The intent of a constructed spawning channel is to simulate a natural salmon stream by regulating flow, gravel size, and spawner density (Hilborn 1992). Off-channel habitats may be enlarged or modified to alter habitat conditions and capacities for rearing juvenile salmonids. Examples include the many spawning channels (Bonnell 1991) and off-channel habitats (Cooperman 2006) enhanced or created in British Columbia and off-channel ponds rehabilitated by the City of Seattle (Hall and Wissmar 2004).

Off-channel spawning and rearing habitats can be advantageous to salmon populations by providing diverse hydraulic and habitat characteristics. Redds constructed in these habitats may be less susceptible to scour compared to main channel habitats due to flow stability provided by their hyporheic or groundwater sources (Hall and Wissmar 2004). Moderated thermal regimes can provide benefits for growth and survival for overwintering juveniles (Giannico and Hinch 2003). Morley et al. (2005) compared 11 constructed off-channel habitats to naturally occurring paired reference side channels and found that both natural and constructed off-channel habitats supported high densities of juvenile salmonids in both winter and summer. Although numerous studies have documented short-term or localized benefits of constructed off-channel habitats, ascertaining population-level effects is much more difficult (Ogston et al. 2015). Any additional fry produced by spawning channels (if successful) would require additional suitable habitat for juvenile rearing and subsequent life stages in order to have a net positive effect on populations. In a notable study, Ogston et al. (2015) tracked

production of Coho Salmon smolts from rehabilitated floodplain habitats that had been extensively modified by logging and observed a significant population-level increase in smolts. Hilborn (1992) indicates that success, measured by increased production of adult fish from such channels, is unpredictable and generally unmonitored. A notable exception is the study by Sheng et al. (1990), which documented 2- to 8-fold increases in recruitment of Coho Salmon spawner production from groundwater-fed off-channel habitats. Sheng et al. (1990) stated that effectiveness would be greatest in systems that currently lack adequate overwinter refuges. As with any rehabilitation strategy, population responses will depend on whether factors actually limiting production are addressed (Gibeau et al. 2020). Additional research and monitoring would be important to quantify factors currently limiting production within project area watersheds.

Replacing destroyed salmon habitats with new constructed channels is also not a simple task. Factors for consideration in designing and implementing off-channel habitat development are outlined in Lister and Finnigan (1997), and include evaluation of species and life stages present, current habitat conditions, and factors limiting capacity or productivity (Roni et al. 2008). Research indicates that channels fed by hyporheic flow or groundwater may be most effective for creating suitable spawning and rearing habitats (Lister and Finnigan 1997). Near-stream excavation and compaction associated with channel construction can alter groundwater flowpaths, so designing projects to protect current function and groundwater connectivity is important.

Numerous researchers have emphasized that replacing lost habitats is not merely a process of providing habitat structure (Lake et al. 2007). Effective replacement of function also requires establishment of appropriate food web structure and productivity to support the food supply for fish—in essence, an entire ecosystem, including a full suite of organisms such as bacteria, algae, and invertebrates—needs to be in place for a constructed channel to begin to perform some of the same functions of a destroyed stream (Palmer et al. 2010, Bellmore et al. 2017). Quigley and Harper (2006b), in a review of stream rehabilitation projects, concluded "the ability to replicate ecosystem function is clearly limited."

There is some history of using constructed spawning channels to mitigate for the impacts of various development projects on fish, based on the premise that they would provide additional spawning habitat and produce more fry, which would presumably result in more adult fish returning (Hilborn 1992). Off-channel rearing habitats have also been used to create additional overwintering habitats in Pacific Northwest rivers (Roni et al. 2006), and spawning channels have also been shown to provide suitable overwintering habitats for juvenile Coho Salmon (Sheng et al. 1990). Reliance on spawning channels for fishery enhancement may also introduce unintended adverse consequences. Enhancement of Sockeye Salmon via use of spawning channels in British Columbia's Skeena River has been accompanied by the erosion of local diversity and homogenization of life history traits, leading to possible losses in the spatial availability of salmon harvests to indigenous fisheries and local ecosystems (Price et al. 2021). Constructed spawning channels, particularly those dependent on surface flow, may also require annual maintenance and cleaning (Hilborn 1992), and salmon using them can be prone to disease outbreaks (Mulcahy et al. 1982). Off-channel habitats to mainstems are also extremely difficult

to engineer in a way that can self-sustain in the face of a dynamic fluvial environment. Alluvial channels frequently shift (Amoros and Bornette 2002), and beavers are highly effective ecosystem engineers whose activities are constantly re-arranging floodplain channels and creating new dams (Pollock et al. 2003), including within engineered channels and culverts (Cooperman 2006).

In light of their uncertain track record, it does not appear that constructed spawning channels and engineered connections of off-channel habitats would provide reliable and sustainable fish habitat in the Bristol Bay region.

3.1.1.4 Manage Water Quantity

Two commenters suggested a variety of techniques to manipulate water quantities within the SFK, NFK, and UTC watersheds to improve fish productivity. Possible techniques for accomplishing this include flow management, flow augmentation, and flow pump-back.

3.1.1.4.1 Direct Excess On-site Water

Commenters suggested that fish habitat productivity could be improved through careful water management at the mine site, including the storage and strategic delivery of excess water to streams and aquifers to maintain or enhance flow and/or thermal regimes in the receiving streams. Delivering such flows via groundwater (i.e., by using wastewater treatment plant (WTP) discharges to "recharge and surcharge groundwater aquifers") was identified as a preferred approach; commenters argued doing so would both render the measure less prone to operational anomalies at the WTP and better mimic current natural flow patterns, thereby attenuating potential adverse effects related to discharge volume and temperature. Ideally, flow, temperature, and habitat modeling would inform the design and operation of flow management to optimize species and habitat benefits, for example, by providing water at specific times to locations where low flow currently limits fish productivity.

Manipulation of surface flows at another mine in Alaska—Red Dog, in the northwest part of the state—has resulted in an increase in fish (Arctic Grayling and Dolly Varden) use of the downstream creek (Weber-Scannell 2005, Ott 2004). The circumstances at Red Dog, however, differ from those in the SFK, NFK, and UTC area. As described in Weber-Scannell (2005), the near complete absence of fish in Red Dog Creek prior to implementation of the water management techniques was the direct result of water quality, not quantity, as the stream periodically experienced toxic levels of metals that occurred naturally as it flowed through and downslope of the exposed ore body. Furthermore, the Red Dog water management system primarily involves point-to-point diversion or transfer of surface, rather than groundwater, both around the ore body and from tributaries upstream of the mine. Utilization of managed aquifer surcharge or recharge to manage streamflows (e.g., Van Kirk et al. 2020) involves significant complexities that may require spatially distributed numerical modeling and would still be subject to considerable uncertainty (Ronayne et al. 2017), particularly in hydrologically complex areas like the Pebble deposit site.

Given that most streams in the area support multiple salmonid species and life stages, with differing habitat needs at different times, designing and managing a water delivery system to overcome limiting factors for one or more species without adversely affecting others would be a significant challenge. Given the complexity of the surface-groundwater connectivity in the watersheds draining the Pebble deposit, ensuring that discharges to groundwater actually reached the target habitat at the intended time would, perhaps, be the most difficult task. Quigley and Harper (2006b), in a review of stream rehabilitation projects, concluded "the ability to replicate ecosystem function is clearly limited."

This challenge could be easier to overcome where habitat limitations occurred only as a result of mine development, assuming pre-project modeling and verification accurately identified groundwater flow paths to those areas. It is important to note, however, that even if such actions appeared to be feasible, they likely would be required to avoid or minimize the adverse impacts of flow reduction due to mine development, rather than to compensate for unavoidable habitat losses.

If it were an overall enhancement to pre-existing habitat, using WTP discharges to groundwater to address natural limitation factors could be a form of compensatory mitigation. For example, PLP (2011) points out that productivity may be limited by the existence of "losing" reaches along the SFK mainstem and intermittent or ephemeral tributaries to both the SFK and NFK. Altering the natural flow regimes at such sites, however, could have unintended consequences on the local ecosystem and species assemblages (Poff et al. 1997). Moreover, "enhancing" these habitats through a WTP-sourced groundwater flow delivery system would be even more challenging than managing flow to avoid or minimize impacts to already productive habitat, because it would require "improving" the natural flow delivery system that currently results in the periodic drying or low flows. Given that aquifer recharge for streamflow management is a highly experimental approach to enhancing fish productivity, particularly in a natural stream system there is a great deal of uncertainty regarding the efficacy and sustainability of this technique as compensatory mitigation in the affected watersheds.

3.1.1.4.2 Augment Flows

Another means suggested for maintaining or increasing habitat productivity downstream of the mine site is to increase flow volume into specific streams by creating new sources of surface flow or groundwater recharge, specifically from impoundments or ice fields. EPA is unaware of any documented successful compensatory mitigation efforts to create impoundments or ice fields for the benefit of salmonids. If there were potential locations for impoundments to manage flow in stream reaches identified as having "sub-optimal" flow, logistical and environmental issues decrease the likely efficacy and sustainability of such an approach. Manipulating streamflows in particular watersheds would require diverting water from other basins or capturing water during peak flows for subsequent release at other times, with the concomitant engineering, construction, and maintenance challenges. Doing so would create additional adverse impacts from the construction of infrastructure and would be subject to modeling and perpetual management sufficient to ensure that water withdrawals from the "donor" watershed or from other times of the year would not adversely affect fish habitat and populations in the donor watershed or the watershed's downstream waters. These concerns are in addition to those

commonly associated with impoundments, such as alteration of flow, thermal, and sediment transport regimes.

Creating ice fields to increase the total volume of water available to a stream would also require water diversion, with the same challenges and concerns related to building and maintaining system infrastructure and reducing water volumes in the source watershed. Using ice fields to change the timing of water availability would create issues related to managing the melt to produce stream flow at the intended time (i.e., late summer or late winter low-flow periods). Moreover, because aquatic organisms supported by a particular waterbody typically have evolved specific life history, behavioral, and morphological traits consistent with the characteristics of that waterbody's natural flow regime, local populations are inherently vulnerable to flow modification (Lytle and Poff 2004). Any use of ice fields would face the potentially substantial challenges of the effects of climate change on ice production and preservation. Given the logistical and environmental issues associated with this technique and the lack of evidence of its use to benefit salmonids, it does not appear to be an effective or sustainable approach to compensatory mitigation in the affected watersheds.

3.1.1.4.3 Pump Water Upstream

Another option suggested for making flow in some stream reaches more persistent is to pump groundwater or surface water from a down-gradient site upstream to either a direct release point or a recharge area. This technique has been used for fish habitat restoration at sites in the continental United States, for example, the Umatilla River in Oregon (Bronson and Duke 2005), the Lower Owens River in California (LADWP 2013), and Muddy Creek in Colorado (AECOM et al. 2012). However, EPA is unaware of any documentation addressing its efficacy in increasing salmonid productivity.

Even if potential source sites with sufficient water could be identified, this technique would require substantial disturbance and additional environmental impacts associated with the construction of tens of kilometers of water pipeline, power infrastructure, and access, along with maintenance of those facilities in perpetuity. It would also entail active management to ensure that releases occur at appropriate times to increase the persistence of flow in target streams without otherwise adversely affecting their hydrographs or habitat. Such management would be another aspect of the approach that would be perpetual. In total, this technique would involve a great deal of uncertainty with regard to both efficacy and sustainability, making it a questionable mechanism for providing compensatory mitigation.

3.1.1.5 Manipulate Water Quality

Two commenters suggested that alteration of stream water chemistry would improve fish production in the SFK, NFK, and UTC. They suggested increasing two groups of water chemistry parameters: basic parameters such as alkalinity, hardness, and total dissolved solids, and nutrients such as nitrogen (N) and phosphorous (P). This argument suggests that low concentrations of basic parameters or nutrients limit algae production, thus, limiting aquatic macroinvertebrate production and habitat complexity. This, in turn, can reduce overall fish production, reduce individual fish growth rates, or result in fish movements away from low production areas.

3.1.1.5.1 Increase Levels of Alkalinity, Hardness, and Total Dissolved Solids

PLP suggested in its 2014 comments that current levels of alkalinity, hardness, and total dissolved solids (TDS) in the SFK, NFK, and UTC are suboptimal for fish production and could be manipulated to improve fish production. PLP proposes "that streams with higher concentrations of total alkalinity, hardness, and total dissolved solids, assuming no nutrient limitations due to low concentration of nitrogen or phosphorus, produce a higher biomass per unit area than areas with lower concentrations" (PLP 2014, Exhibit 6). However, PLP does not propose any actual mechanisms for fish habitat compensation via increases in alkalinity, hardness, or TDS nor does it state its basis for assuming that N and P are not limiting.

PLP proposed increasing levels of alkalinity, hardness, and TDS in streams as a compensation proposal in its comments on the draft BBA (NDM 2013, Attachment D). In these comments, PLP refers to a number of field studies of streams. The cited studies of stream manipulations that raise alkalinity, hardness, or TDS are studies of the mitigation of acid mine drainage or of streams acidified by acid deposition (Gunn and Keller 1984, Hasselrot and Hultberg 1984, Rosseland and Skogheim 1984, Zurbuch 1984, Gagen et al. 1989, Lacroix 1992, Clayton et al. 1998, McClurg et al. 2007). The addition of limestone or dolomite often increases the production of acidic streams, and alkalinity, hardness, and TDS also increase, but the coincidence is not necessarily causal. It is more likely that the improvement is due to reduced acidity or reduced dissolved metal concentrations, not to increased alkalinity, hardness, or TDS per se. Other studies address the differences in the natural ability of streams to buffer natural or anthropogenic acids. Streams with acidic inputs and high buffering capacity may have higher productivity, as well as high alkalinity, hardness, and TDS. Other studies cited were not explicitly acidified sites, but it was not clear what role, if any, alkalinity, hardness, or TDS played in reported differences in productivity among those streams. Some of the studies are confounded by differences in habitat, macronutrients, or other factors. Others suffer from pseudo-replication or low replication.

Further, PLP's comments (NDM 2013, Attachment D) do not support that such measures would be effective. For example, it cites Scarnecchia and Bergersen (1987) as supporting the importance of alkalinity, hardness, and TDS at the Pebble site (NDM 2013, Attachment D, Section 3.4.2.1). However, Scarnecchia and Bergersen concluded the opposite. They found that most of the variance in productivity and biomass was associated with elevation and the three chemical parameters were correlated with elevation: "The overall weakness (despite statistical significance) of the correlations of chemical factors with production suggested to us that physical factors strongly influence production in these streams. Elevation, percentage of zero-velocity stations, and substrate diversity were the three most effective combinations of variables for explaining variation in production."

Given the lack of a mechanism by which any of the three aggregated parameters would increase productivity in the absence of acidity or high metal concentrations and inherent problems in the studies, the causal nature of the reported field relationships is questionable. In any case, their relevance to compensatory mitigation of the Pebble site has not been demonstrated.

The potential for unintended adverse consequences if alkalinity, hardness, or TDS are raised without an understanding of the mechanisms of action and of the chemistry and biology of the receiving streams is illustrated by studies that show impairment of stream communities in response to elevating one or more of those parameters. In particular, the addition of limestone or dolomite to streams to mitigate acid drainage and the filling of valleys with carbonaceous rock from mining have raised hardness, alkalinity and TDS/conductivity, which have been shown to cause adverse and persistent effects on stream invertebrate and fish communities (Weber-Scannell and Duffy 2007, Pond et al. 2008, Bernhardt and Palmer 2011, Cormier et al. 2013a, Cormier et al. 2013b, Hopkins et al. 2013, Hitt and Chambers 2014, Morris et al. 2019).

3.1.1.5.2 Increase Levels of Nitrogen and/or Phosphorus

Commenters have also suggested that water quality could be manipulated by altering stream water chemistry to increase levels of N and P where they are individually or co-limiting.

The commenters make recommendations about how to consider these factors when developing mitigation in the SFK, NFK, and UTC. They suggest that the spatial distribution could focus on existing or newly created side channels, sloughs, beaver ponds, alcoves, or, if necessary, the main channels at 10-km intervals. They suggest several possible temporal distribution options, such as adding the nutrients only during the growing season, potentially earlier, or all winter in open-water locations where biological production continues year-round. They further indicate that the key considerations are access cost and maintenance requirements. The commenters note that there are several types of nutrient delivery methods: liquid fertilizer, slow-release fertilizer, and nutrient analogs (which are essentially slow-release pellets of processed fish).

As support for their conclusion that lake and stream fertilization represent "demonstrably successful mitigation techniques" for the SFK, NFK, and UTC, the commenters cite papers summarizing experiments and case studies, as well as references to several management programs in the United States, Canada, and northern Europe. These studies have examined the use of increased levels of inorganic N and P, or fish carcasses, to improve ecosystem productivity and/or fish production.

The commenters assert that current levels of N and P in the SFK, NFK, and UTC are suboptimal for fish production stating that benefits of fertilizing oligotrophic waters to stimulate fish production have been demonstrated in many venues. Although numerous studies show an effect at one or more trophic levels in response to fertilization, these studies are insufficient for drawing conclusions regarding the long-term effectiveness of nutrient application to streams in the SFK, NFK, and UTC watersheds because they lack scientific controls or have not been replicated, do not account for potential confounding factors, were conducted in very different ecosystems, and/or only evaluated short-term effects. These differences are discussed in the following paragraphs.

Commenters provided examples of experiments and studies aimed at increasing primary productivity and theoretically salmon productivity. These studies assume that nutrients are the limiting factor preventing increased salmon productivity, but that is not necessarily the case (Collins et al 2015).

Paleolimnetic studies in Alaska indicate nutrient inputs are not always tied to higher primary productivity or salmon productivity (Chen et al. 2011). Wipfli and Baxter (2010) found that most fish consume food from external or very distant sources, including from marine systems borne by adult salmon, from fishless headwaters that transport prey to downstream fish, and from riparian vegetation and associated habitats. An increase in food via nutrients may not overcome other limiting factors, such as habitat availability or interspecies competition.

Most studies on stream and lake fertilization to increase productivity are short term in duration and conducted in ecosystems with important differences from Bristol Bay (e.g., Perrin et al. 1987, Raastad et al. 1993, Wipfli et al. 1998, Slaney et al. 2003). Many of the studies have been conducted in lakes (e.g., Bradford et al. 2000, Kyle 1994), which have different ecosystem dynamics from streams. Furthermore, factors that limit populations in one habitat or time period may be different than in another (Collins et al. 2015). Almost all of the stream studies are conducted in locations where salmon populations have been negatively affected; therefore, the increased production is aimed at restoration, not enhancement, of an existing healthy population.

Most studies are conducted between one and five years in duration, and a spike in productivity has been seen in a number of these short-term studies. For example, the studies conducted at the Keogh and Salmon Rivers (Ward et al. 2003, Slaney et al. 2003) examined the effect of nutrient supplement in the form of salmon carcasses and inorganic N and P, respectively, in two coastal river systems for a period of three years. Additionally, most studies quantify responses at the individual level, which may not translate to an increase at the population level (Collins et al. 2015).

While a short-term spike in productivity is common, long-term studies call into question whether the trend will be sustained over longer periods. Several papers cite results from the early years of the longest-running study on stream fertilization located in the pristine Kuparuk River on the North Slope of Alaska. This study raises concerns about using fertilization other than as an interim restorative measure. While commenters cite a study capturing the increased size and growth rates of Arctic Grayling during the first seven years of the study (Deegan and Peterson 1992), a subsequent paper documenting conditions after 16 years found that persistent increased levels of N and P can result in dramatic ecosystem shifts (Slavik et al. 2004). This long-term ecological research on the North Slope of Alaska examined the effect of P input into P-limited streams, finding an increase in production for some species at all trophic levels over the first few years. These results are similar to the studies finding improved fish productivity in predominantly degraded systems cited extensively by commenters. However, after approximately eight years of fertilization, a dramatic rise in moss (photos A and B) changed ecosystem structure, affecting food and shelter availability (Slavik et al. 2004). Despite higher insect biomass in the fertilized area during this period, there were no significant differences in fish growth rates between the fertilized reach and the reference reach. The decrease in fish productivity was thought to result from the effects of moss on preferred insect prey (Slavik et al. 2004, Gough et al. 2016). Following cessation of nutrient enrichment, it took eight years of recovery to approach reference levels, after storms had

scoured most remnant moss in the recovering reach, demonstrating that even at low concentrations, sustained nutrient enrichment can have "dramatic and persistent consequences" (Benstead et al. 2007).

Photos showing the difference in bottom coverage between the diatom state (Photo A, left) and the fertilized moss state (Photo B, right). Used with permission (Slavik et al. 2004).

Slavik et al. (2004) conclude that "[a]dditional long-term whole stream fertilization studies are needed to better understand the delayed stream ecosystem responses to nutrient enrichment. Even studies of two to eight years in duration may be poor predictors of the long-term responses to added nutrients." This conclusion is echoed in the most recent (2019) *Long Term Ecological Research Network Decadal Review Self Study* (Groffman et al. 2019), which is a collection of papers reflecting study and experimentation at diverse sites ranging from arctic and alpine tundra to grasslands, forests, streams, wetlands, and lakes. In the paper addressing nutrient supply effects on ecosystems, the authors state, "Long term observations and experiments at LTER sites have shown that short term patterns may have little bearing on the ultimate direction and magnitude of nutrient effects, which can play out over many decades" (Groffman et al. 2019: Page 23). The risks of long-term fertilization would also play out in the context of global climate change, which is predicted to cause a release of phosphorous into streams from melting permafrost (Hobbie et al. 1999), adding yet another layer to the unknowns.

In another study, long-term nutrient enrichment produced an unanticipated trophic decoupling whereby enrichment continued to stimulate primary consumer production without a similar increase in predator fish (Davis et al. 2010). The majority of the increased ecosystem productivity was confined to lower trophic levels because the long-term enrichment primarily stimulated primary consumers that were relatively resistant to predation. Based on these results, the authors concluded that "even in ecosystems where energy flow is predicted to be relatively efficient, nutrient enrichment may still increase the production of non-target taxa (e.g., predator or grazer resistant prey), decrease the production of higher trophic levels, or lead to unintended consequences that may compromise the productivity of freshwater ecosystems" (Davis et al. 2010).

These unanticipated results raise important questions about the potential consequences of long-term nutrient supplementations. They also underscore the unpredictability of nutrient additions on the food web, and the greater likelihood of unintended consequences as the effects ripple through complex interactions between species. These implications are relevant considerations for potential long-term

mitigation, which would be necessary for the SFK, NFK, and UTC. If long-term nutrient addition were to cause an ecosystem shift at lower trophic levels in the SFK, NFK, and UTC, effects on higher trophic levels including the productivity of salmon and other target fish species are unknown.

Studies examining the relationship between salmon carcasses and productivity at various trophic levels are another active area of investigation. Some research provides evidence that carcasses are superior to inorganic nutrient amendments for sustaining and restoring stream productivity, including fish production, potentially because inorganic nutrients lack biochemicals and macromolecules that are utilized directly by consumers (Wipfli et al. 2010, Martin et al. 2010, Heintz et al. 2010). Others have found the effects of carcasses can be transient, localized, and variable with no increase in fish growth (Cram et al. 2011). Few studies have documented the long-term impacts of carcass addition, and there are many remaining gaps in understanding the efficacy of this method of potentially improving salmon productivity. In addition, a number of authors express concern about the potential for the spread of toxins and pathogens when carcasses are used as the supplemental nutrient source (Compton et al. 2006).

Authors of many of these studies state that the application of their results are relevant and appropriate for salmonid restoration in streams or lakes with depressed numbers (e.g., Larkin and Slaney 2011). The authors do not describe their results as informing methods to manipulate existing unaltered wild systems to further augment salmon production. Although some commenters draw heavily from Ashley and Stockner (2003) to support their recommendation to use this as a method of mitigation in the SFK, NFK, and UTC watersheds, the authors of that study state the following:

> The goal of stream and lake enrichment is to rebuild salmonid escapement to historical levels via temporary supplementations of limiting nutrients using organic and/or inorganic formulations. Stream and lake enrichment should not be used as a 'techno-fix' to perpetuate the existing mismanagement of salmonids when there is any possibility of re-establishing self-sustaining wild populations through harvest reductions and restoration of salmonid habitat. Therefore, fertilization should be viewed as an interim restorative measure that is most effective if all components of ecosystem recovery and key external factors (e.g. overfishing) are cooperatively achieved and coordinated. This paper reviews some of the technical and more applied aspects of stream, river, and lake enrichment as currently practiced in British Columbia and elsewhere. As a caveat, the discussion assumes that salmonid stock status of candidate lakes and streams has been quantified and classified as significantly depressed and that additional limiting factors (e.g. habitat/water quality and quantity) have been addressed and/or incorporated into an integrated basin or lake restoration plan. (Ashley and Stockner 2003: Page 246)

There are still many gaps in understanding the role of nutrients in fish productivity, so there is much that is not known about whether nutrient addition can be a successful method to increase fish productivity especially in the long term. Furthermore, much of the existing literature on which commenters base their assertions rests on several untested assumptions (Collins et al. 2015).

Setting aside questions of scientific efficacy and applicability, there are also numerous practical challenges inherent in nutrient addition as a potential mitigation method. Conducting a long-term management protocol in remote waterways subject to extreme weather changes necessarily requires careful monitoring of water chemistry, as well as other ecosystem parameters and precise application of

nutrients, which calls into question the sustainability of altering stream water chemistry to improve the fish production.

At this time, there are no scientific studies showing how an increase in nutrients resulting in increased salmon productivity can be reliably achieved on a long-term basis in the SFK, NFK, and UTC watersheds or the larger Bristol Bay ecosystem without risk to the region's existing robust populations. Just as for the addition of non-nutrients, such as limestone, manipulating stream chemistry in this largely unaltered ecosystem through the addition of N and P would be a challenging and difficult experiment with many negative outcomes being possible.

3.1.2 Other Potential Compensation Measures Suggested within the Nushagak and Kvichak River Watersheds

As noted above, if practicable or appropriate opportunities to provide compensation within the SFK, NFK, or UTC watersheds are non-existent or limited, it may be appropriate in certain circumstances to explore options in adjoining watersheds. For example, there are a few scattered degraded sites in more distant portions of the Nushagak and Kvichak River watersheds that could potentially benefit from restoration or enhancement. This section discusses specific suggestions for other potential compensation measures within the Nushagak and Kvichak River watersheds that were provided in the public and peer review comments on the BBA and in response to the 2014 Proposed Determination.

3.1.2.1 Remediate Old Mine Sites

The U.S. Geological Survey identifies four small mine sites within the Nushagak and Kvichak River watersheds: Red Top (in the Wood River drainage), Bonanza Creek (a Mulchatna River tributary), Synneva or Scynneva Creek (a Bonanza Creek tributary), and Portage Creek (in the Lake Clark drainage) (USGS 2008, 2012). These sites could provide opportunities for performing ecological restoration or enhancement. However, due to their relatively small size and distant location, it is unlikely that these sites could provide sufficient restored or enhanced acreage or ecological function to reduce the adverse effects of the 2020 Mine Plan to an acceptable level. Further, some mitigation measures have already occurred at these mines; for example, Alaska Department of Environmental Conservation (ADEC) determined the cleanup of the Red Top mercury retort site to be complete in 2012 (ADEC 2012). Resolution of liability and contamination issues at these old mines would be necessary before they could serve as compensatory mitigation sites for other projects. In its comments on the 2014 Proposed Determination, PLP rejected this as a potential compensation measure, in part, due to concerns regarding the resolution of these kinds of liability issues (PLP 2014: Exhibit 2).

3.1.2.2 Remove Roads

Another potential type of restoration within the Nushagak and Kvichak River watersheds is the removal of existing or abandoned roads. As described in detail in EPA 2014, Appendix G, roads have persistent, multifaceted impacts on ecosystems and can strongly affect water quality and fish habitat. Common long-term impacts from roads include (1) permanent loss of natural habitat; (2) increased surface runoff

and reduced groundwater flow; (3) channelization or structural simplification of streams and hydrologic connectivity; (4) persistent changes in the chemical composition of water and soil; (5) disruption of movements of animals, including fishes and other freshwater species; (6) aerial transport of pollutants via road dust; and (7) disruption of near-surface groundwater processes, including interception or re-routing of hyporheic flows, and conversion of subsurface slope groundwater to surface flows (Trombulak and Frissell 2000, Forman 2004). Road removal, thus, could facilitate not only the reestablishment of former wetlands and stream channels, but also the enhancement of nearby aquatic resources currently degraded by the road(s).

Commenters did not offer specific suggestions for potential road-removal sites. As EPA 2014 Appendix G highlights, the Nushagak and Kvichak River watersheds are almost entirely roadless areas (EPA 2014, Appendix G, Figure 1). Further, it is unlikely that local communities would support removal of any segments of the few existing roads in the watersheds. Thus, it appears there are very few, if any, viable opportunities to provide environmental benefits through road removal.

3.1.2.3 Retrofit Road Stream Crossings

Another potential type of enhancement within the Nushagak and Kvichak River watersheds is to retrofit existing road stream crossings to improve fish passage through these human-made features. Stream crossings can adversely affect spawning, rearing (Sheer and Steel 2006, Davis and Davis 2011), and refuge habitats (Price et al. 2010), as well as reduce genetic diversity (Wofford et al. 2005, Neville et al. 2009). These changes can, in turn, reduce long-term sustainability of salmon populations (Hilborn et al. 2003, Schindler et al. 2010). Blockage or inhibition of fish passage is a well-documented problem commonly associated with declines in salmon and other fish populations in many regions of the United States (Nehlsen et al. 1991, Bates et al. 2003), including Alaska (ADF&G 2022).

Removing and replacing crossings that serve as barriers to fishes could improve fish passage and re-open currently inaccessible habitat. However, as noted in Section 3.1.2.2, the Nushagak and Kvichak River watersheds are almost entirely roadless areas and, thus, likely offer few, if any, viable opportunities to provide the extent of environmental benefits necessary to reduce the adverse effects of the 2020 Mine Plan to an acceptable level. Further, prior to concluding that any effort to retrofit existing stream crossings would be appropriate compensatory mitigation, it would first be necessary to determine that no other party has responsibility for the maintenance of fish passage at those stream crossings (e.g., through the terms or conditions of a CWA Section 404 permit that authorized the crossing). After initially proposing this as a potential compensation measure, in its comments on the 2014 Proposed Determination, PLP rejected this measure due to "the long term liability involved as PLP would be responsible for effectiveness in perpetuity, possible requiring monitoring and maintenance (including repair and replacement)" (PLP 2014: Exhibit 2).

3.1.2.4 Construct Hatcheries

One commenter referenced the potential use of hatcheries as a compensation measure. Such a proposal could be very problematic, particularly in the Bristol Bay watershed, where the current salmon

population is entirely wild. There are several concerns over the introduction of hatchery-produced salmon to the Bristol Bay watershed.

Many of the potential risks associated with fish hatcheries concern reductions in fitness, growth, health, and productivity that result from decreases in genetic diversity when hatchery-reared stocks hybridize with wild salmon populations. Hatchery-raised salmon have lower genetic diversity than wild salmon (Christie et al. 2011, Yu et al. 2012). Consequently, when hatchery-raised salmon hybridize with wild salmon, the result can be a more genetically homogenous population, leading to decreases in genetic fitness (Waples 1991). In some cases, wild populations can become genetically swamped by hatchery stocks. Zhivitovsky et al. (2012) found evidence of such swamping in a wild Chum Salmon population in Kurilskiy Bay, Russia, during a two-year period of high rates of escaped hatchery fish. This genetic homogenization is of concern because hatchery-raised fish stocks are considered less genetically "fit" and, therefore, could increase the risk of collapse of salmon fisheries. This concern is supported by Araki et al. (2008); a review of 14 studies that suggests that nonlocal hatchery stocks reproduce very poorly in the wild. The authors of this review also found that wild stocks reproduce better than both hatchery stocks and wild, local fish spawned and reared in hatcheries.

Hatchery fish can also compete directly for food and resources with wild salmon populations in both freshwater and marine environments (Rand et al. 2012a). Ruggerone et al. (2012) examined the effect that Asian hatchery Chum Salmon have had on wild Chum Salmon in Norton Sound, Alaska, since the early 1980s. They found that an increase in adult hatchery Chum Salmon abundance from 10 million to 80 million adult fish led to a 72 percent reduction in the abundance of the wild Chum Salmon population. They also found smaller adult length-at-age, delayed age-at-maturation, and reduced productivity were all associated with greater production of Asian hatchery Chum since 1965 (Ruggerone et al. 2012). In addition to this competition for resources, hatchery-raised subyearling salmon can also prey upon wild subyearling salmon, which tend to be smaller in size (Naman and Sharpe 2012).

Despite extensive efforts to restore federally listed Pacific Northwest salmon populations, these salmon remain imperiled, and hatchery fish stocks may be a contributing stressor (Kostow 2009). Given the exceptional productivity of the wild Bristol Bay salmon population, hatcheries would likely pose greater ecological risks than benefits to this unique and valuable wild salmon population.

3.1.2.5 Stock Fish

Comments also mentioned stocking fish. Because many of the fish used in fish stocking originate in hatcheries, fish stocking raises many of the same concerns as hatcheries and, thus, would also be a problematic form of compensatory mitigation for the Bristol Bay region. Although stocking has been a common practice in other regions, even in previously fishless habitats (e.g., Red Dog Mine, Alaska), a large body of literature describes widespread adverse impacts of such management decisions. Fish stocking throughout western North America and worldwide has affected other fish (Knapp et al. 2001, Townsend 2003), nutrient cycling (Schindler et al. 2001, Eby et al. 2006, Johnson et al. 2010), primary production (Townsend 2003, Cucherousset and Olden 2011), aquatic macroinvertebrates (Dunham et

al. 2004, Pope et al. 2009, Cucherousset and Olden 2011), amphibians (Pilliod and Peterson 2001, Finlay and Vredenberg 2007), and terrestrial species (Epanchin et al. 2010). Although fish stocking has provided limited benefits in certain circumstances, it would appear from the growing body of literature that the ecological costs of fish stocking far outweigh any potential benefits.

3.2 Other Suggested Measures

Commenters also suggested that payments to organizations that support salmon sustainability or investing in various public education, outreach, or research activities designed to promote salmon sustainability could constitute potential compensatory mitigation for impacts on fish and other aquatic resources. Although these initiatives can provide benefits in other contexts, compensatory mitigation for impacts authorized under Section 404 of the CWA can only be provided through purchasing credits from an approved mitigation bank or in-lieu fee program or conducting permittee-responsible compensatory mitigation projects (40 CFR 230.92). One commenter also suggested reducing commercial fishery harvests to compensate for fish losses due to large-scale mining; however, such a measure would also be inconsistent with the definition of compensatory mitigation (40 CFR 230.92).

In its comments on the 2014 Proposed Determination, PLP (2014, Exhibit 2) provides a list of compensation measures that it was not recommending, specifically culvert replacement, contaminated site clean-up, landfill rehabilitation or replacement, and clean-up and restoration of legacy wells. In deciding not to recommend these measures in 2014, PLP notes that "[t]he task to evaluate mitigation actions in the Bristol Bay region included all opportunities available" and that the feasibility of these opportunities was identified as "very expensive, high-risk, low compensatory credit return" and that "[g]enerally, the main limitation to these permittee-responsible mitigation projects is a lack of opportunity for restoration, establishment, and/or enhancement of wetlands within the Bristol Bay region." PLP goes on to state that "[o]ther limitations to these permittee-responsible mitigation projects include liability, cost, monitoring responsibilities in perpetuity, and the lack of infrastructure within the Bristol Bay region to access existing opportunities" (PLP 2014: Exhibit 2).

SECTION 4. EFFECTIVENESS OF COMPENSATION MEASURES AT OFFSETTING IMPACTS ON FISH HABITAT

In North America, 73 percent of fish extinctions are linked to habitat alterations (Miller et al. 1989). Although extensive efforts have been undertaken to create or improve salmon habitat and prevent fishery losses, all U.S. Atlantic salmon populations are endangered (NOAA 2022), 40 percent of Pacific salmon in the lower 48 states are extirpated from historical habitats (NRC 1996), and one-third of remaining populations are threatened or endangered with extinction (Nehlsen et al. 1991, Slaney et al. 1996, Gustafson et al. 2007). Coho and Chinook salmon are the two rarest of North America's five species of Pacific salmon (Healey 1991) and have the greatest number of population extinctions among the five species of Pacific salmon (Nehlsen et al. 1991, Augerot 2005). Approximately one-third of Sockeye Salmon population diversity assessed by Rand et al. (2012b) was considered at risk of extinction or extinct. Of remaining populations categorized as of "least concern," Bristol Bay Sockeye Salmon likely represent the most abundant, diverse Sockeye Salmon populations left in the United States.

Since 1990, a billion dollars has been spent annually on stream and watershed restoration in the United States (Bernhardt et al. 2005). More than 60 percent of the projects completed during this period were associated with salmon and trout habitat restoration efforts in the Pacific Northwest and California (Katz et al. 2007). Despite the proliferation of projects and the significant funds being expended on these efforts, debate continues over the effectiveness of various fish habitat restoration techniques and the cumulative impact of multiple, poorly coordinated restoration actions at watershed or regional scales (Reeves et al. 1991, Chapman 1996, Roni et al. 2002, Kondolf et al. 2008). However, in the Columbia River Basin where billions of dollars have been spent on salmon and steelhead recovery efforts, a 2013 report indicates that some stream rehabilitation techniques, such as fish passage improvements, in-stream wood and rock structures, livestock grazing controls, connection or construction of off-channel habitat, and flow augmentation appear to be leading to fish habitat improvements in this basin where logging, grazing, channelization, irrigation, development of urban areas, and construction and operation of dams have led to extensive historic fish habitat loss and degradation (BPA 2013).

A 2014 review of 434 stream restoration, enhancement, and creation projects conducted to offset impacts to Appalachian streams from surface coal mining authorized by CWA Section 404 permits highlights the uncertain outcomes of stream mitigation projects (Palmer and Hondula 2014). Palmer and Hondula (2014) found that even after five years of monitoring, 97 percent of projects reported suboptimal or marginal habitat; they conclude that stream mitigation projects "are not meeting the objectives of the Clean Water Act to replace lost or degraded streams ecosystems and their functions."

In general, independent evaluations of the effectiveness of fish habitat compensation projects are rare (Harper and Quigley[6] 2005b, Quigley and Harper 2006a, Quigley and Harper 2006b), and consequently the long-term success rates and efficacy of such projects are not well known (DFO 1997, Lister and Bengeyfield 1998, Lange et al. 2001, Quigley and Harper 2006a). A 2008 review of stream habitat rehabilitation studies published worldwide found that "[d]espite locating 345 studies on effectiveness of stream rehabilitation, firm conclusions about many specific techniques were difficult to make because of the limited information provided on physical habitat, water quality, and biota and because of the short duration and limited scope of most published evaluations" (Roni et al. 2005, Roni et al. 2008). Despite these shortcomings, Roni et al. (2008) did find that some techniques, specifically, reconnection of isolated habitats, floodplain rehabilitation, and instream habitat improvement, were proven to be effective under numerous circumstances for improving habitat and increasing local fish abundance.

In its 2014 comments, PLP relies heavily on the findings of Roni et al. (2008) and BPA (2013) to support the following positions.

- The effectiveness of the stream rehabilitation techniques PLP had proposed at that time for use at the Pebble site is unequivocal and "settled science."
- These stream rehabilitation techniques should be expected to effectively rehabilitate streams permanently lost or degraded by mining at the Pebble deposit.
- These stream rehabilitation techniques should also be expected to result in demonstrable improvements in fish habitats in unaltered/undegraded streams that are currently part of an ecosystem that supports some of the world's most productive wild salmon runs.

While PLP ultimately did not propose any of these measures during the CWA Section 404 permit review process (PLP 2020a, 2020c), its application of the findings of Roni et al. (2008) and BPA (2013) is inaccurate or oversimplified for the following reasons.

- **Type of restoration is different.** The effectiveness of the stream rehabilitation techniques reviewed in these papers is not settled science, and the success of these approaches is highly variable and context-dependent (Roni 2019); can be difficult to quantify (Richer et al. 2022, Rogers et al. 2022); and must address the suite of factors influencing fish populations (water quality, connectivity, hydrology, sediment, etc.).
- **Impact is different.** A large majority of the stream rehabilitation studies reviewed in these papers were conducted in moderate climates, for streams that had been impacted by forestry, agriculture,

[6] Dr. Jason Quigley, a scientist employed in 2014 by a company working to advance a mine at the Pebble deposit, sent EPA Region 10 a letter dated April 28, 2014, indicating his concern that the BBA cited his work in a manner that is "not fully accurate." EPA notes that the findings and conclusions of Dr. Quigley's earlier studies referenced by the BBA are taken directly from Dr. Quigley's studies. Further, EPA clearly notes in this section that Quigley's earlier studies highlight the need for improvements in compensation science, as well as institutional approaches, such as better project planning, monitoring, and maintenance. Dr. Quigley's letter also notes that compensation success has improved since his earlier studies; however, no examples of such documented success are included in his letter.

roads, or human activities other than mining. The papers were not a review of rehabilitation of streams impacted by mining. Where reviews of mined stream mitigation success have occurred in Appalachia, monitoring revealed that 97 percent of the projects reported suboptimal or marginal habitat (Palmer and Hondula 2014). These papers do not support use of these techniques to rehabilitate streams permanently lost or degraded by mining at the Pebble deposit.

- **Magnitude of restoration is likely not enough.** There is little evidence that unaltered and high-functioning habitats such as those in the affected watersheds can be made substantially better. Roni and Beechie (2012) observed that when and where positive responses to restoration have been observed, it has primarily been in systems where habitat had been greatly simplified due to land clearing, road building, channelization, or other human activities (e.g., Ogston et al. 2015). Furthermore, with the exception of downstream barrier removal (e.g., Pess et al. 2012) or barrier modification, EPA is aware of no instances where restoration approaches yielded significant improvements in fish populations in highly functional watersheds with minimal human modification. These papers do not support the position that existing unaltered/undegraded fish habitats could somehow be improved by use of these techniques.

- **Population response is not demonstrated.** Even in watersheds where significant habitat rehabilitation efforts have been undertaken, a corresponding salmon response at the population scale has been elusive (Bennett et al. 2016).

- **It is preferable to protect than to restore.** Many authors have stated that based on lessons learned regarding the difficulty of restoring fish habitat once it has been degraded, priority should always be given to protecting existing high-quality habitat because it is much more effective and efficient to protect than to restore (Beechie et al. 2008).

In Canada, the Department of Fisheries and Oceans evaluated the efficacy of fish habitat compensation projects in achieving the conservation goal of no net loss (Harper and Quigley 2005a, Harper and Quigley 2005b, Quigley and Harper 2006a, Quigley and Harper 2006b). Quigley and Harper (2006a) showed that 67 percent of compensation projects resulted in net losses to fish habitat, 2 percent resulted in no net loss, and only 31 percent achieved a net gain in habitat area. Quigley and Harper (2006a) concluded that habitat compensation in Canada was, at best, only slowing the rate of fish habitat loss. Quigley and Harper (2006b) showed that 63 percent of projects resulted in net losses to aquatic habitat productivity, 25 percent achieved no net loss, and only 12 percent provided net gains in aquatic habitat productivity. Quigley and Harper (2006b) concluded "the ability to replicate ecosystem function is clearly limited."

Quigley and Harper (2006b) and Quigley et al. (2006) highlight the need for improvements in compensation science, as well as institutional approaches, such as better project planning, monitoring, and maintenance. Findings from Quigley and Harper (2006a and 2006b) are echoed in a 2016 study of marsh and riparian habitat compensation projects constructed within the Fraser River Estuary from

1983 to 2011; this study found that only 33 percent of compensation sites were meeting biological and functional goals, even after many decades (Lievesley et al. 2016).

Although there are clearly opportunities to improve the performance of fish habitat compensation projects, Quigley and Harper (2006b) caution the following:

> It is important to acknowledge that it is simply not possible to compensate for some habitats. Therefore, the option to compensate for HADDs [*harmful alteration, disruption or destruction to fish habitat*] may not be viable for some development proposals demanding careful exploration of alternative options including redesign, relocation, or rejection.

SECTION 5. CONCLUSIONS

PLP and other commenters suggested an array of measures over the past decade as having the potential to compensate for adverse impacts on wetlands, streams, and fishes from the discharge of dredged or fill material associated with developing the Pebble deposit. EPA evaluated these measures for informational purposes. Available information demonstrates that known compensation measures are unlikely to adequately mitigate effects described in this final determination to an acceptable level.

SECTION 6. REFERENCES

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