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Proposed Determination of the U.S. Environmental Protection Agency Region 10 Pursuant to Section 404(c) of the Clean Water Act

Pebble Deposit Area, Southwest Alaska

Region 10, Seattle, WA
www.epa.gov/bristolbay

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U.S. Environmental Protection Agency
Region 10
Seattle, WA

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Acronyms and Abbreviations

ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ANCSA	Alaska Native Claims Settlement Act
AWC	Anadromous Waters Catalog
BBA	Bristol Bay Assessment
BBAP	Bristol Bay Area Plan for State Lands
BBMA	Bristol Bay Sport Fish Management Area
BLM	biotic ligand model
CEAA	Canadian Environmental Assessment Agency
CFR	Code of Federal Regulations
CWA	Clean Water Act
EPA	U.S. Environmental Protection Agency
FR	Federal Register
IGTT	Intergovernmental Technical Team
MCO	Mineral Closing Order
MDN	marine-derived nutrients
NA	not applicable
NAG	non-acid-generating
NDM	Northern Dynasty Minerals Ltd.
NEPA	National Environmental Policy Act
NFK	North Fork Koktuli River
NFP	no or low floodplain potential
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
SEC	U.S. Securities and Exchange Commission
Secretary	Secretary of the Army
SFK	South Fork Koktuli River
TSF	tailings storage facility
USACE	U.S. Army Corps of Engineers
U.S.C.	U.S. Government Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTC	Upper Talarik Creek
WWTP	wastewater treatment plant

EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) Region 10 is requesting public comment on a proposed determination to restrict the use of certain waters in the Bristol Bay watershed for disposal of dredged or fill material associated with mining the Pebble deposit, a large ore body in southwest Alaska. EPA Region 10 is taking this step because of the high ecological and economic value of the Bristol Bay watershed and the assessed unacceptable environmental effects that would result from such mining. This proposed determination relies on clear EPA authorities under the Clean Water Act (CWA), and is based on peer-reviewed scientific and technical information. Its scope is geographically narrow and it does not affect other deposits or mine claim holders outside of those affiliated with the Pebble deposit. EPA Region 10 is taking this step pursuant to Section 404(c) of the CWA and its implementing regulations at 40 Code of Federal Regulations (CFR) Part 231.

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. As a result, the region is a globally significant resource with outstanding value. 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, maintain the productivity of the entire ecosystem, including numerous other fish and wildlife species.

The Bristol Bay watershed's streams, wetlands, and other aquatic resources support world-class, economically important commercial and sport fisheries for salmon and other fishes, as well as a more than 4,000-year-old subsistence-based way of life for Alaska Natives. Each year Bristol Bay 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 frequently at or near the world's largest, and the region also supports significant coho, chum, and pink salmon populations. Because no hatchery fish are raised or released in the watershed, Bristol Bay's salmon populations are entirely wild. 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 this fishery is the fact that its aquatic habitats are untouched and pristine, unlike the waters that support many other fisheries.

Nearly 70% of the sockeye and large numbers of the coho, Chinook, pink, and chum salmon are harvested in commercial, subsistence, and recreational fisheries before they can return to their natal lakes and streams to spawn. Thus, these salmon resources have significant economic, nutritional, cultural, and recreational value, both within and beyond the Bristol Bay region. The Bristol Bay watershed's ecological resources generated nearly $480 million in direct economic expenditures and sales and provided employment for over 14,000 full- and part-time workers in 2009. The Bristol Bay commercial salmon fishery generates the largest component of this economic activity, with an estimated value of $300 million (sales from fishers to processors) and employment for over 11,000 full- and part-time workers (EPA 2014: Chapter 5).

In February 2011, Northern Dynasty Minerals Ltd. (NDM) formally submitted information to the U.S. Securities and Exchange Commission (SEC) that put forth plans for the development of a large-scale mine at the headwaters of this pristine ecosystem (Figure ES-2). Their proposal outlines several stages of mine development, the smallest being a 2.0-billion-ton mine[1] and the largest being a 6.5-billion-ton mine[2] (Ghaffari et al. 2011, SEC 2011), both of which are larger than 90% of the known ore deposits of this type in the world (EPA 2014: Chapter 4).

The Pebble deposit is a large, low-grade, porphyry copper deposit (containing copper-, gold-, and molybdenum-bearing minerals) that underlies portions of the South Fork Koktuli River (SFK), North Fork Koktuli River (NFK), and Upper Talarik Creek (UTC) watersheds. Based on information provided by NDM to the SEC (Ghaffari et al. 2011, SEC 2011), mining the Pebble deposit is likely to involve excavation of the largest open pit ever constructed in North America, covering up to 6.9 square miles (17.8 km^2) and reaching a depth of as much as 0.77 mile (1.24 km) (EPA 2014: Chapter 6); for reference, the maximum depth of the Grand Canyon is approximately 1 mile. Disposal of resulting waste material would require construction of up to three mine tailings impoundments covering an additional 18.8 square miles (48.6 km^2) and waste rock piles covering up to 8.7 square miles (22.6 km^2) (EPA 2014: Chapter 6) in an area that contains highly productive streams and wetlands. The volume of mine tailings and waste rock produced from the smallest mine proposed by NDM to the SEC (Ghaffari et al. 2011, SEC 2011) would be enough to fill a professional football stadium more than 880 times, whereas the largest mine would do so more than 3,900 times.

In total, these three mine components (mine pit, tailings impoundments, and waste rock piles) would cover an area larger than Manhattan. Mine construction and operation would also require the construction of support facilities, including a major transportation corridor, pipelines, a power-generating station, wastewater treatment plants, housing and support services for workers, administrative offices, and other infrastructure. Such facilities would greatly expand the "footprint" of the mine and affect additional aquatic resources beyond the scope of this proposed determination. Although NDM's preliminary plans (Ghaffari et al. 2011, SEC 2011) could change, any mining of this deposit would, by necessity, require similar mine components, support facilities, and operational features.

Given the extent of streams, wetlands, lakes, and ponds both overlying the Pebble deposit and within adjacent watersheds, excavation of a massive mine pit and construction of large tailings impoundments and waste rock piles would result in discharge of dredged or fill material into these waters. This discharge would result in complete loss of fish habitat due to elimination, dewatering, and

[1] Ghaffari et al. (2011) call the 2.0 stage mine the "Investment Decision Case," which describes an initial 25-year open pit mine life upon which a decision to initiate permitting, construction, and operations may be based.
[2] Ghaffari et al. (2011) call the 6.5 stage mine the "Resource Case," which is based on 78 years of open pit production and seeks to assess the long-term value of the project in current dollars.

fragmentation of streams, wetlands, and other aquatic resources. In addition, water withdrawal and capture, storage, treatment, and release of wastewater associated with the mine would significantly impair the fish habitat functions of other streams, wetlands, and aquatic resources. All of these losses would be irreversible.

Based upon information known to EPA about the proposed mine at the Pebble deposit and its potential impacts on fishery resources, and as a result of multiple inquiries, concerns, and petitions to EPA to use its authorities to protect these fishery resources, EPA decided to conduct an ecological risk assessment before considering any additional steps. 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) (EPA 2014) in January 2014. The Bristol Bay Assessment established that the extraction, storage, treatment, and transportation activities associated with building, operating, and maintaining one of the largest mines ever built would pose significant risks to the unparalleled ecosystem that produces one of the greatest wild salmon fisheries left in the world. In simple terms, the infrastructure necessary to mine the Pebble deposit jeopardizes the long-term health and sustainability of the Bristol Bay ecosystem.

The Bristol Bay Assessment characterizes the significant ecological resources of the region and describes potential impacts on salmon and other fish from large-scale porphyry copper mining at the Pebble deposit. The Bristol Bay Assessment evaluated these impacts using three mine scenarios that represent different stages of mining at the Pebble deposit, based on the amount of ore processed.

- Pebble 0.25 stage mine (approximately 0.25 billion tons of ore over 20 years)
- Pebble 2.0 stage mine (approximately 2.0 billion tons of ore over 25 years)
- Pebble 6.5 stage mine (approximately 6.5 billion tons of ore over 78 years)

Ghaffari et al. (2011) indicate that the total mineral resources at the Pebble deposit are now believed to be approximately 12 billion tons of ore. Thus, it is expected that development of a mine at the Pebble deposit would ultimately be much larger than the 0.25 stage mine and could exceed the 6.5 stage mine. NDM has stated to the public that "the Pebble deposit supports open pit mining utilizing conventional drill, blast and truck-haul methods, with an initial mine life of 25 years and potential for mine extensions to 78 years and beyond" (NDM 2011). This statement, along with others to investors, indicates that NDM is actively considering a mine size between 2.0 and 6.5 billion tons.

Nevertheless, EPA also assessed the impacts of a much smaller mine footprint in the Bristol Bay Assessment. The 0.25 stage mine is based on the worldwide median size porphyry copper deposit (Singer et al. 2008). Although this smaller size is dwarfed by the mine sizes that NDM put forward to the SEC (Ghaffari et al. 2011, SEC 2011), its impacts would still be significant.

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

In total, the Bristol Bay Assessment estimates that habitat losses associated with the 0.25 stage mine would include nearly 24 miles (38 km) of streams, representing approximately 5 miles (8 km) of streams with documented anadromous fish occurrence and 19 miles (30 km) of tributaries of those streams (EPA 2014: Chapter 7). Total habitat losses would also include more than 1,200 acres (4.9 km^2) of wetlands, lakes, and ponds, of which approximately 1,100 acres (4.4 km^2) are contiguous with either streams with documented anadromous fish occurrence or tributaries of those streams. For the largest mine that NDM put forward to the SEC (the 6.5 stage mine), stream losses would expand to 94 miles (151 km), representing over 22 miles (36 km) of streams with documented anadromous fish occurrence and 72 miles (115 km) of tributaries of those streams (EPA 2014: Chapter 7). Total habitat losses for the 6.5 stage mine would also include more than 4,900 acres (19.8 km^2) of wetlands, lakes, and ponds, of which approximately 4,100 acres (16.6 km^2) are contiguous with either streams with documented anadromous fish occurrence or tributaries of those streams.

To put these numbers in perspective, stream losses for just the 0.25 stage mine would equal a length of more than 350 football fields and the 0.25 stage mine wetland losses would equal an area of more than 900 football fields. Although Alaska has many streams and wetlands that support salmon, individual streams, stream reaches, wetlands, lakes, and ponds play a critical role in protecting the genetic diversity of Bristol Bay's salmon populations. Individual waters can support local, unique populations (Quinn et al. 2001, Olsen et al. 2003, Ramstad et al. 2010, Quinn et al. 2012). Thus, losing these populations would erode the genetic diversity that is crucial to the stability of the overall Bristol Bay salmon fisheries (Hilborn et al. 2003, Schindler et al. 2010, EPA 2014: Appendix A).

These stream, wetland, and other aquatic resource losses also would reverberate downstream, depriving downstream fish habitats of nutrients, groundwater inputs, and other subsidies from lost upstream aquatic resources. In addition, water withdrawal, capture, storage, treatment, and release at even the 0.25 stage mine would result in streamflow alterations in excess of 20% in more than 9 miles (nearly 15 km) of streams with documented anadromous fish occurrence. These streamflow changes would result in major changes in ecosystem structure and function and would reduce both the extent and quality of fish habitat downstream of the mine to a significant degree. The impacts from the larger mine sizes NDM has forecasted would be significantly higher. The 2.0 and 6.5 stage mines would result in streamflow alterations in excess of 20% in more than 17 miles (27 km) and 33 miles (53 km), respectively, of streams with documented anadromous fish occurrence (EPA 2014: Chapter 7).

The CWA is a law essential for EPA's mission, which is to protect and restore the environment and public health for current and future generations. Section 404(c) of the CWA authorizes EPA to prohibit, restrict, or deny the use of any defined area in waters of the United States for specification as a disposal site whenever it determines, after notice and opportunity for public hearing, that the discharge of dredged or fill material into the area will have an unacceptable adverse effect on fishery areas (including spawning and breeding areas). EPA has used its Section 404(c) authority judiciously and sparingly, having completed only 13 Section 404(c) actions in the 42-year history of the CWA.

As a first step in the regulatory process pursuant to Section 404(c), EPA Region 10 coordinated with NDM, the Pebble Limited Partnership (PLP),[4] and the State of Alaska to provide them an opportunity to submit information that demonstrated either that no unacceptable adverse effects would result from discharges associated with mining the Pebble deposit or that actions could be taken to prevent unacceptable adverse effects on fishery areas. EPA Region 10 met with both NDM/PLP and the State of Alaska and extended the time period for both to submit this information.

Both NDM/PLP and the State of Alaska submitted information that raised scientific and technical issues, most of which had been previously raised in public comments on the Bristol Bay Assessment. However, this information did not demonstrate to the satisfaction of EPA Region 10 that no unacceptable adverse effects on fishery areas will occur should the disposal of dredged or fill material associated with mining the Pebble deposit proceed.

Therefore, EPA Region 10 has decided to take the next step in the Section 404(c) review process, publication of this proposed determination. As part of a Section 404(c) proposed determination, the EPA Regional Administrator must identify a defined area, known as the disposal site, where its prohibitions or restrictions would apply. In this case, the proposed geographic boundaries of the potential disposal site are the waters within the mine claims held by NDM subsidiaries, including PLP, that fall within the SFK, NFK, and UTC watersheds (Figure ES-3). EPA Region 10 focused on this area because it determined that it best represents the smallest geographical area where the discharge of dredged or fill material associated with mining the Pebble deposit is most likely to occur.

To protect important fishery areas in the SFK, NFK, and UTC watersheds from unacceptable adverse effects, EPA Region 10 recognizes that losses of streams, wetlands, lakes, and ponds and alterations of streamflow each provide a basis to issue this Section 404(c) proposed determination.

Given the proposals made by NDM to develop 2.0- and 6.5-billion-ton mines at the Pebble deposit (Ghaffari et al. 2011, SEC 2011) and EPA's evaluation of the 0.25-billion-ton mine (EPA 2014), the Regional Administrator has reason to believe that mining of the Pebble deposit at any of these sizes, even the smallest, could result in significant and unacceptable adverse effects on ecologically important streams, wetlands, lakes, and ponds and the fishery areas they support.

Accordingly, the Regional Administrator proposes that EPA restrict the discharge of dredged or fill material related to mining the Pebble deposit into waters of the United States within the potential disposal site that would, individually or collectively, result in any of the following.

[4] 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). Anglo American PLC withdrew from the partnership in late 2013; since 2013, NDM has been the sole partner in PLP.

1. **Loss of streams**

   a. The loss of 5 or more linear miles of streams with documented anadromous fish[5] occurrence; **or**

   b. The loss of 19 or more linear miles of streams where anadromous fish are not currently documented, but that are tributaries of streams with documented anadromous fish occurrence; **or**

2. **Loss of wetlands, lakes, and ponds.** The loss of 1,100 or more acres of wetlands, lakes, and ponds contiguous with either streams with documented anadromous fish occurrence or tributaries of those streams; **or**

3. **Streamflow alterations.** Streamflow alterations greater than 20% of daily flow in 9 or more linear miles of streams with documented anadromous fish occurrence.

These restrictions derive from the estimated impacts resulting from the discharge of dredged or fill material associated with construction and routine operation of a 0.25 stage mine at the Pebble deposit, as evaluated in the Bristol Bay Assessment (EPA 2014).

EPA Region 10's evaluation of relevant portions of the Section 404(b)(1) Guidelines (40 CFR Part 230) further demonstrates that discharge of dredged or fill material resulting in the level of adverse effects identified in the proposed restrictions could result in unacceptable adverse effects on fishery areas. Degradation of these aquatic resources would be even more pronounced given extensive cumulative impacts at successive stages of mine expansion (i.e., 2.0 and 6.5 stage mines or larger) at the Pebble deposit, including elevated instream copper concentrations sufficient to cause direct toxicity to fish. Toxic effects on fish would include fish kills; reduced survival, growth, and/or reproduction; and reduced sensory acuity, which is important to salmon for locating natal streams, finding food, and avoiding predators.

EPA Region 10 recognizes it has underestimated potential adverse effects on resources within the SFK, NFK, and UTC watersheds from mining the Pebble deposit for several reasons. This evaluation does not include footprint impacts associated with all of the components necessary to construct and operate such a mine (e.g., a major transportation corridor, pipelines, a power-generating station, wastewater treatment plants, housing and support services for workers, administrative offices, and other infrastructure). It also does not rely upon impacts resulting from potential accidents and failures as a basis for its findings. There is a high likelihood that wastewater treatment plant failures would occur, given the long management horizon expected for the mine (i.e., decades). There is also real uncertainty as to whether severe accidents or failures, such as a complete wastewater treatment plant failure or a tailings dam failure, could be adequately prevented over a management horizon of centuries, or even in perpetuity, particularly in such a geographically remote area subject to climate extremes. If such events

[5] Anadromous fish 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 these restrictions, anadromous fish 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*).

were to occur, they would have profound ecological ramifications. By not relying on potential accidents and failures, EPA Region 10 has employed a conservative analysis of adverse effects.

Known compensatory mitigation techniques are unlikely to offset impacts of the nature and magnitude described in the proposed restrictions. Compensatory mitigation is the concept of improving stream or wetland health in other parts of the watershed to compensate for stream or wetland destruction or degradation in a separate area. Compensatory mitigation efforts typically involve restoration and enhancement of waters that have potential for improvement in ecological services. However, the waters of the Bristol Bay watershed are already among the most productive in the world. EPA Region 10 sees little likelihood that human activity could improve upon the high-quality natural environment in the Bristol Bay watershed that nature has created and that has thus far been preserved. Compensation methods proposed by PLP, including placement of instream structures, stream fertilization, and construction of spawning channels, have typically had only variable, local, or temporary effects, were designed for use in degraded watersheds, or resulted in adverse, unintended consequences (EPA 2014: Appendix J).

Mine alternatives with lower environmental impacts at the Pebble deposit are not evaluated in either the Bristol Bay Assessment or this Section 404(c) proposed determination. If these proposed restrictions are finalized, proposals to mine the Pebble deposit that have impacts below each of these restrictions would proceed to the Section 404 permitting process with the U.S. Army Corps of Engineers. Any such proposals would have to meet the statutory and regulatory requirements for permitting under Section 404.

After evaluating available information, EPA Region 10 has reason to believe that unacceptable adverse effects on fishery areas (including spawning and breeding areas) could result from the discharge of dredge or fill material associated with mining the Pebble deposit. Further, it has not been demonstrated to the satisfaction of EPA Region 10 that no unacceptable adverse effect(s) will occur.

EPA Region 10 is soliciting public comment on all issues discussed in this proposed determination, including likely adverse impacts on fishery resources, mitigation measures to potentially address these impacts, and other options to restrict or prohibit potentially harmful discharges of dredged or fill material associated with mining the Pebble deposit. All comments will be fully considered as EPA Region 10 decides whether to withdraw the proposed determination or forward to EPA Headquarters a recommended determination to restrict the use of certain waters in the SFK, NFK, and UTC watersheds in southwest Alaska as disposal sites for the discharge of dredged or fill material associated with mining the Pebble deposit. Should EPA Region 10 make a recommended determination, EPA Headquarters will then determine, based on the recommended determination, public comments received on the proposed determination, and all other available, relevant information, whether to issue a final determination under Section 404(c).

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.

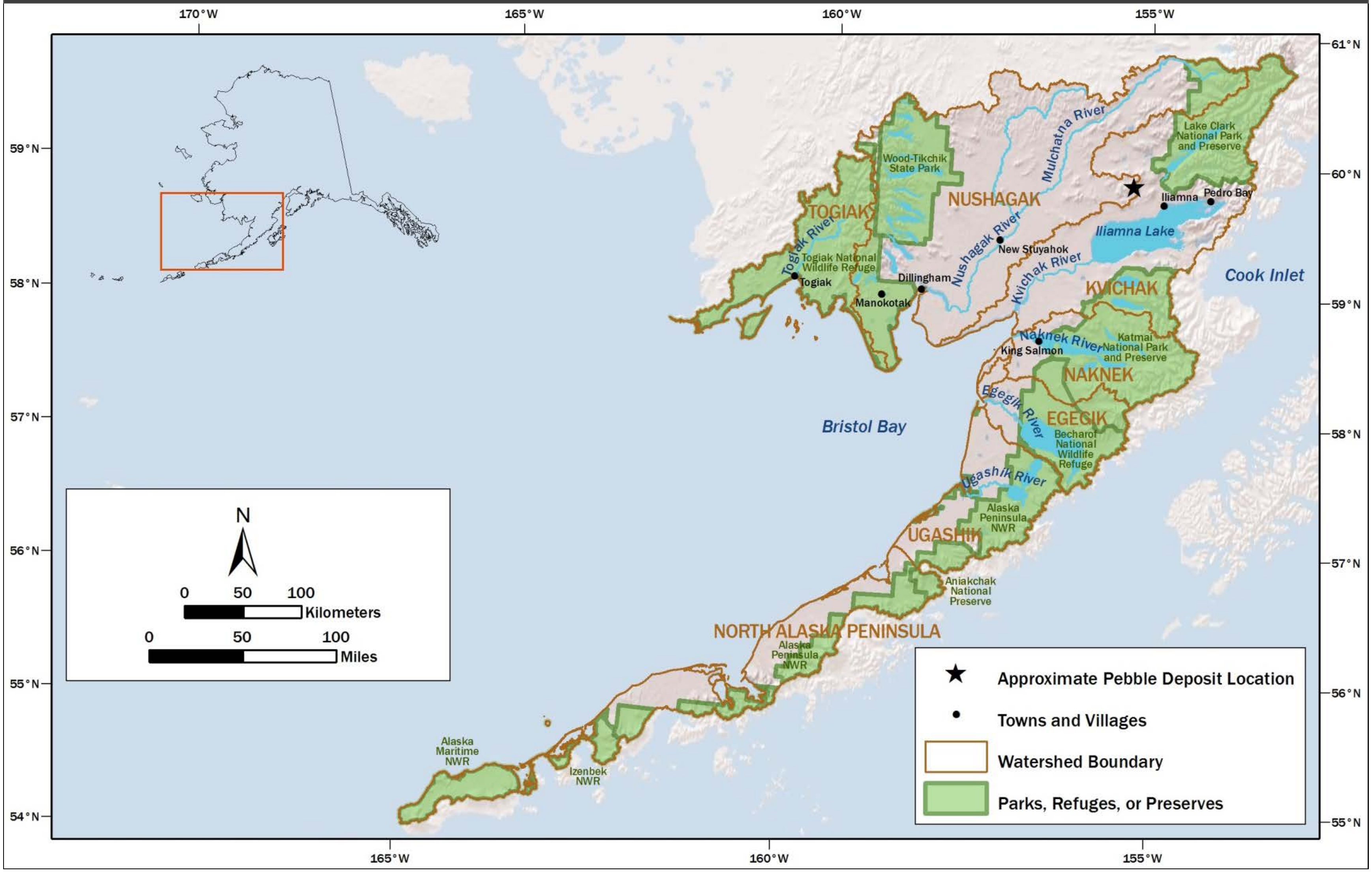


Figure ES-2. The Nushagak and Kvichak River watersheds.

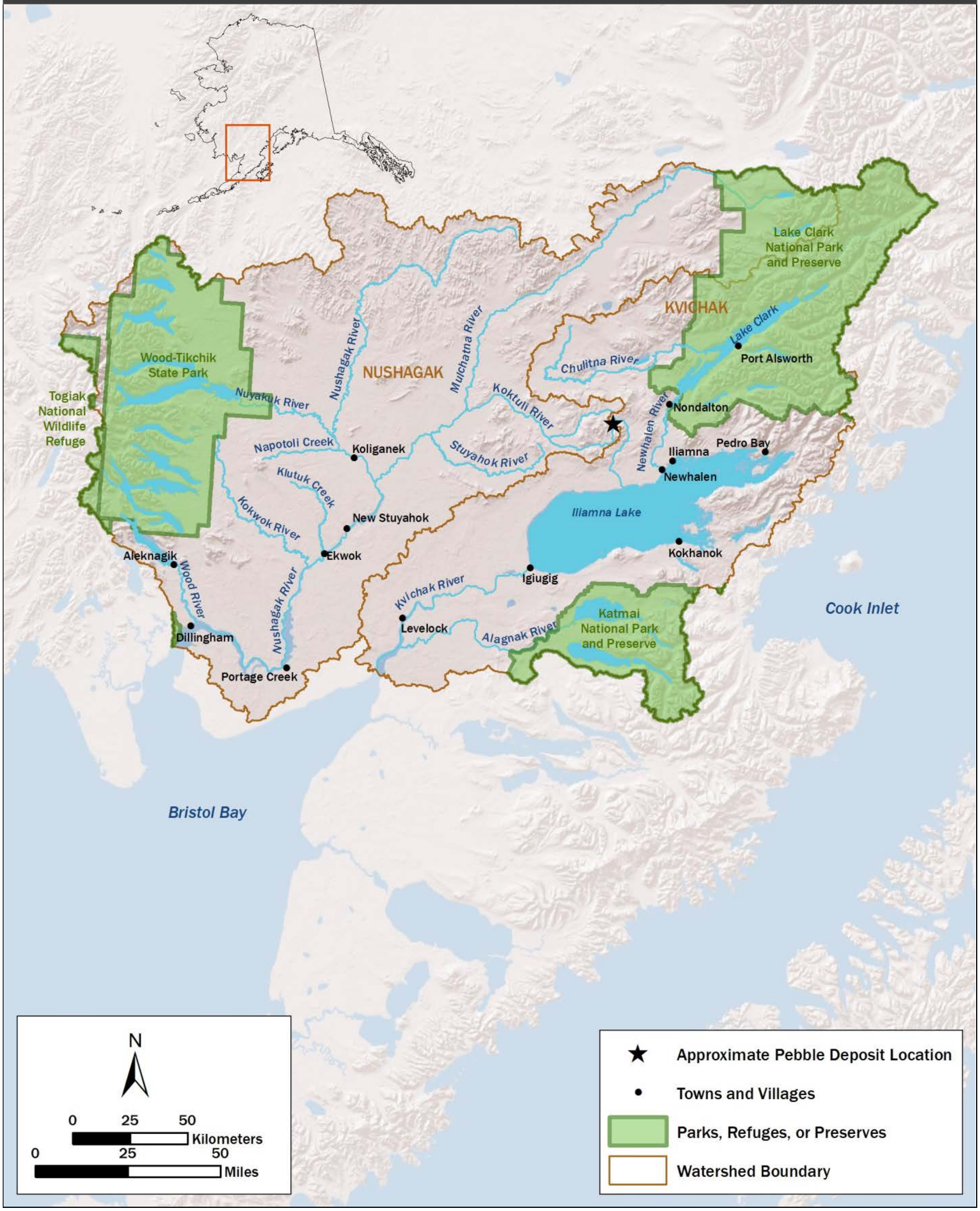
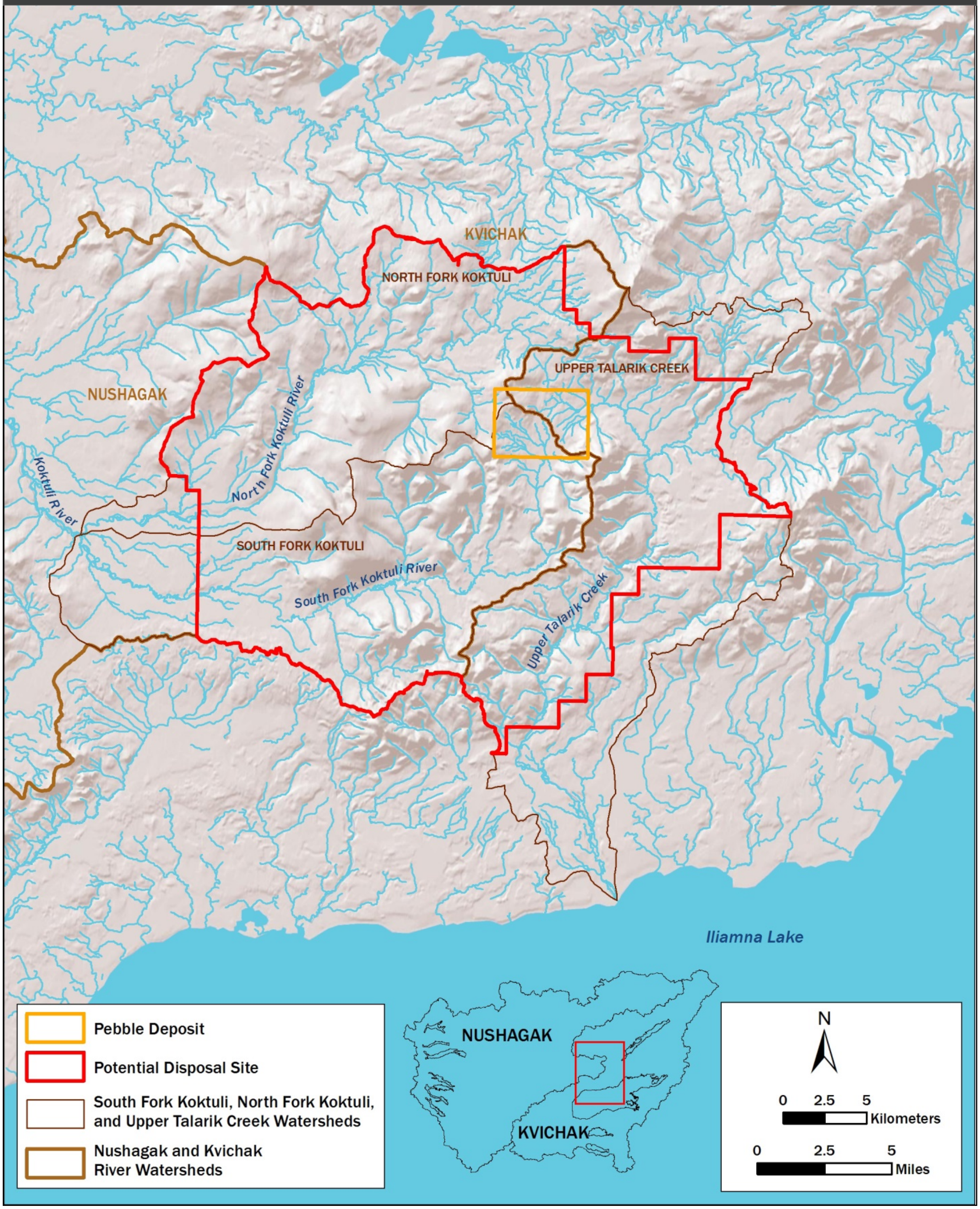


Figure ES-3. The potential disposal site delineated in the proposed determination.



SECTION 1. INTRODUCTION

The Clean Water Act (CWA), 33 U.S. Code (U.S.C.) Section 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. Section 1344. Section 404(a) 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 Section 404(c) are set forth in Title 40 of the Code of Federal Regulations (CFR) Part 231 and establish a four-step Section 404(c) review process.

- **Step 1: Initial Notification.** If the EPA Regional Administrator has reason to believe, after evaluating the available information, that use of a site for the discharge of dredged or fill material could have an unacceptable adverse effect on one or more of the aforementioned resources, the Regional Administrator may initiate the Section 404(c) process by notifying USACE, the applicant (if any), and the site owner that he intends to issue a proposed determination. Each of those parties then has 15 days to demonstrate to the satisfaction of the Regional Administrator that no unacceptable adverse effects will occur, or that corrective action to prevent an unacceptable adverse effect will be taken.
- **Step 2: Proposed Determination.** If no such information is provided to the Regional Administrator, or if the Regional Administrator is not satisfied that no unacceptable adverse effect will occur, the Regional Administrator will publish a notice of the proposed determination in the *Federal Register*, soliciting public comment and offering an opportunity for public hearing.
- **Step 3: Recommended Determination.** Following public hearing and close of the comment period, the Regional Administrator will decide whether to withdraw the proposed determination or prepare a recommended determination. A decision to withdraw may be reviewed at the discretion of the Assistant Administrator for Water at EPA Headquarters. If the Regional Administrator prepares a recommended determination, the Regional Administrator then forwards it and the complete administrative record compiled in the Regional Office to the Assistant Administrator for Water.

- **Step 4: Final Determination.** The Assistant Administrator for Water will consider the recommended determination of the Regional Administrator and the information in the administrative record, and also consult again with USACE, the applicant (if any), and the site owner. Following consultation and consideration of all available information, the Assistant Administrator for Water makes the final determination affirming, modifying, or rescinding the recommended determination.[6]

This document represents Step 2 in the above process. In this proposed determination, EPA Region 10 is proposing to restrict the use of a defined area for specification as a disposal site because it has reason to believe that discharge of dredged or fill material into the area could result in unacceptable adverse effects on fishery areas. EPA Region 10 is soliciting public comment on all issues discussed in this proposed determination. All comments will be fully considered in reaching a decision to either withdraw the proposed determination or forward to EPA Headquarters a recommended determination to restrict use of certain waters in the South Fork Koktuli River (SFK), North Fork Koktuli River (NFK), and Upper Talarik Creek (UTC) watersheds in southwest Alaska as disposal sites for dredged or fill material associated with mining the Pebble deposit.

This proposed determination is organized as follows.

- **Section 2** provides background material on the history of exploration and mine planning at the Pebble deposit as well as pre-application consultation with regulatory agencies. It also describes key aspects of the development of EPA's ecological risk assessment, *Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*[7] (Bristol Bay Assessment or BBA), final release of the BBA in January 2014, and EPA Region 10's initiation of its Section 404(c) review regarding mining the Pebble deposit.
- **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 commercial, subsistence, 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.
- **Section 4** describes how the direct and secondary effects of the discharge of dredged or fill material associated with construction and routine operation of a 0.25-billion-ton mine into certain streams, wetlands, and other aquatic resources of the SFK, NFK, and UTC watersheds could result in significant loss of or damage to important fishery areas.

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[6] In 1984, the EPA Administrator delegated the authority to make final determinations under Section 404(c) to EPA's national CWA Section 404 program manager, who is the Assistant Administrator for Water. That delegation remains in effect.

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

- **Section 5** presents a set of proposed restrictions designed to protect important fishery areas in the SFK, NFK, and UTC watersheds from unacceptable adverse effects that could result from the discharge of dredged or fill material associated with mining the Pebble deposit. These adverse effects include destruction and degradation of streams, wetlands, lakes, and ponds and significant alteration of streamflows.
- **Section 6** identifies other considerations that could further inform EPA Region 10's deliberations regarding this proposed determination, such as the potential for discharge of dredged or fill material associated with mining the Pebble deposit to result in adverse effects on wildlife, recreation, or public water supplies. It also includes considerations of other concerns such as potential impacts on subsistence resources, environmental justice issues, and tribal consultation responsibilities.
- **Section 7** highlights a set of specific issue areas upon which EPA Region 10 is seeking public comment.
- **Section 8** lists references cited in the proposed determination.

SECTION 2. BACKGROUND AND PROJECT DESCRIPTION

2.1 Background

2.1.1 Prior to the Bristol Bay Assessment (1984–2011)

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). In 1984, the Alaska Department of Natural Resources (ADNR) also closed the channel plus 100 feet on either side of anadromous reaches of 64 streams in the Bristol Bay region to new mineral entry, stating 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). The SFK, NFK, and UTC, the headwaters of which overlie the Pebble deposit, were included in the 1984 closure. The BBAP was revised in 2005; it is not clear in the 2005 BBAP if the closure still applies to the SFK, NFK, and UTC (Box 2-1).

2.1.1.1 Clean Water Act Section 404 Pre-Application and Technical Working Group Meetings

The Pebble deposit was first explored by Cominco America Incorporated between 1985 and 1997. Drilling on the Pebble deposit began in 1988 and continued through 1997, with 117 holes totaling 62,930 feet completed (Ghaffari et al. 2011). During this time, baseline environmental, engineering, and preliminary economic studies were initiated (Ghaffari et al. 2011). The prospect subsequently changed hands and was explored by Northern Dynasty Minerals Ltd. (NDM) between 2001 and 2007 and by the Pebble Limited Partnership (PLP) between 2007 and the present. 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) (Anglo American PLC withdrew from the partnership in late 2013). Mineral exploration of the Nushagak and Kvichak River watersheds accelerated after the Pebble deposit was located, and several additional mineral deposits have been discovered in the two watersheds.

Between 2001 and 2011, NDM/PLP staked additional claims, conducted further geochemical and geophysical surveys, completed 698,296 feet of drilling to delineate the Pebble deposit, and completed 169,151 feet of drilling elsewhere on the property. This work resulted in significant expansion of the western delineation of the Pebble deposit, and the discovery of a higher-grade zone to the east. Extensive engineering, baseline environmental studies, and stakeholder engagement work also occurred during this time (Ghaffari et al. 2011).

BOX 2-1. STATE LAND USE PLANNING IN THE BRISTOL BAY WATERSHED

In September 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." The plan stated "Through implementation of the plan (including plan guidelines), fish and wildlife resources and the income and employment generated from the harvest of fish and wildlife resources can be expected to continue indefinitely, thereby providing a sound economic base for Alaska and the Bristol Bay area" (ADNR 1984a).

The State of Alaska also determined in 1984 that mining in much of the Nushagak and Kvichak River watersheds would be incompatible with the production of salmon. Alaska Statute 38.05.185 requires that the Commissioner of the Alaska Department of Natural Resources (ADNR) must determine that mining would be incompatible with significant surface uses to close state-owned areas to mineral entry (ADNR 1984a). The 1984 BBAP made that determination for 64 streams in the Bristol Bay area. On September 13, 1984, ADNR Commissioner Esther Wunnicke signed Mineral Closing Order (MCO) 393, which closed the channel plus 100 feet on either side of anadromous reaches of 64 streams to new mineral entry, stating 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). MCO 393 states several times that mineral development is incompatible with fisheries and considers existing state and federal water quality regulations and standards inadequate to guarantee the continued propagation and production of salmon and other fish resources in stream waters in the Bristol Bay area (ADNR 1984b).

In 2005, the State of Alaska revised the BBAP. The 2005 BBAP was most notably different from the 1984 plan in that it no longer explicitly placed fish and wildlife habitat and harvest as a primary use throughout the Bristol Bay study area (ADNR 2005). Although MCO 393 was retained in the 2005 BBAP, the finding that mineral development is incompatible with salmon propagation and production was not retained. The Pebble deposit extends beneath waters that are closed by MCO 393, but the 2005 BBAP states that mineral development in the area of the Pebble deposit is expected to be authorized (ADNR 2005). It also states that "mineral development must be performed in such a manner as to ensure that impacts on the anadromous and high value resident fish streams are avoided or reduced to levels deemed appropriate in the state/federal permitting processes related to mineral deposit development" (ADNR 2005).

The 1984 BBAP identifies primary designated uses for the lands surrounding the Pebble deposit as Fish & Wildlife, Recreation, and Minerals, except for lands within a 200-foot corridor along anadromous fish streams that explicitly include the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek. The 2005 BBAP identifies the primary land use designation for that same area as Minerals, with a note that MCO 393 applies where appropriate; however, the anadromous waters in this area are not explicitly identified.

On May 5, 2009, six Bristol Bay tribes filed suit against ADNR in Alaska Superior Court (Third Judicial District) over ADNR's 2005 changes to the BBAP (Nondalton Tribal Council et al. v. ADNR). The suit challenged the validity of the 2005 BBAP. Among other issues, the plaintiffs challenged that a 90% reduction in Habitat as a primary designated land use was unlawful. In 2013, ADNR released revisions to the 2005 BBAP in response to an agreement with the plaintiffs, which dismissed the litigation in exchange for ADNR's agreement to address the issues raised in the lawsuit through the existing administrative process for amending area land use plans and reclassifying state land (ADNR 2014a).

The 2013 BBAP revisions increase the amount of lands across the Bristol Bay planning area classified as Wildlife Habitat and Public Recreation and, to a lesser extent, lands co-designated as Habitat and Minerals. Increases in these land use classifications were primarily at the expense of lands designated as General Use in the 2005 BBAP. Smaller decreases also occurred in lands designated as Settlement and Minerals (or Minerals and Habitat) in the 2005 BBAP (ADNR 2013[8]). The designation of a particular area as Wildlife Habitat does not mean that the land is unavailable for other uses such as resource extraction, although the classification could trigger more stringent environmental requirements.

[8]ADNR has indicated that it is working to resolve management area acreage errors in the published 2013 revised BBAP and those revisions may change these statements (Phelps pers. comm.).

Beginning in 2004, NDM/PLP engaged with USACE in pre-application meetings. Through these meetings, NDM/PLP has been informed that development of a mine at the Pebble deposit would require a permit under Section 404 of the CWA (Lestochi pers. comm.). Further, NDM/PLP was informed that the process would include a public interest review, development of an environmental document in accordance with the National Environmental Policy Act (NEPA), and a review for compliance with the CWA Section 404(b)(1) Guidelines (Lestochi pers. comm.).[9]

Starting in 2004, EPA Region 10 met numerous times with NDM/PLP to discuss mine development at the Pebble deposit, the ore body resources they were pursuing, potential environmental impacts associated with mine development, early environmental baseline study plans, and preparation for review of the mine project pursuant to NEPA and CWA Section 404. During this time, EPA Region 10 staff reviewed the draft Environmental Baseline Studies, the 2004 Study Plan, and the Analytical Quality Assurance Plan.

In 2004, NDM established and began coordinating a Baseline Environmental Team of federal and state agency technical staff, including EPA Region 10, to continue the work of reviewing the draft Environmental Baseline Study Plan, Field Sampling Plan, Progress Reports, and the Analytical Quality Assurance Plan. NDM also provided periodic updates on the mine development process, as well as findings about the region and potentially affected natural and cultural resources from the baseline studies.

In 2005, EPA Region 10 formed an internal interdisciplinary team to engage in the consultation and review process, and participated in several Pebble deposit site visits with NDM. EPA Region 10 also participated in NDM's community leaders meeting.

In 2006, NDM submitted water rights applications to ADNR (NDM 2006). NDM applied for water rights permits to Upper Talarik Creek and the Koktuli River for use in mining operations. In total, NDM applied for rights to approximately 35 billion gallons of groundwater and surface water per year (ADNR 2014c).

Between 2007 and 2010, multiple technical working groups operated under the umbrella Pebble Project Technical Working Group to facilitate coordinated agency review of important environmental studies for NEPA and subsequent permitting (ADNR 2014b). Nine 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 10 technical working groups. These groups met regularly and EPA Region 10 staffed them from its interdisciplinary team. EPA Region 10 participated in the Geochemistry, Surface and Groundwater Quality, Surface and Groundwater Hydrology, Wildlife, Baseline Multi-Media Trace Elements, Freshwater Fish Studies, Freshwater Aquatic Organisms, Marine Organisms, Marine Wildlife, and Instream Flow Habitat Modeling Subgroup Technical Working Groups. Concurrently, EPA Region 10, along with several state agencies, reviewed NDM/PLP's geotechnical drilling water management plan.

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[9] There have been 10 pre-application meetings between PLP and USACE, not including meetings for Nationwide Permit 6 permit actions, since January 12, 2009 (Kochenbach pers. comm.).

During this same period, NDM/PLP held open meetings with tribal leaders in the Bristol Bay area. EPA Region 10 attended those meetings and also met separately with Bristol Bay tribes at their request.

In 2007, PLP hired the Keystone Center (Keystone) to facilitate a dialogue on mining the Pebble deposit. The stated purpose of the dialogue was to help stakeholders make better-informed decisions about the project (Keystone 2014a). As one of the principal products of that dialogue, Keystone held a series of science panels to evaluate PLP's draft environmental and socioeconomic baseline studies with the aim of helping stakeholders determine if the studies were credible and sufficient for their intended purpose.[10]

In February 2011, NDM submitted its preliminary plans for mining the Pebble deposit to the U.S. Securities and Exchange Commission (SEC) (SEC 2011). This submission included NDM's report titled *Preliminary Assessment of the Pebble Project, Southwest Alaska* (Ghaffari et al. 2011). Ghaffari et al. (2011) describe 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. Ghaffari et al. (2011) also indicate that the total Pebble mineral resource may approach 12 billion tons of ore.

In December 2011, PLP provided EPA Region 10 with an advance, embargoed copy of its more than 25,000-page environmental baseline document (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 along the proposed mine's transportation corridor that would link the mine site to a proposed port site on Cook Inlet. The environmental baseline document primarily presents results of the baseline studies conducted by NDM/PLP from 2004 through 2008.

2.1.1.2 Petitions to U.S. Environmental Protection Agency

On May 2, 2010, EPA Administrator Lisa P. Jackson and Regional Administrator Dennis McLerran (EPA Region 10) received a letter from six federally recognized Bristol Bay tribal governments who requested that EPA initiate a process under Section 404(c) of the CWA to protect waters, wetlands, fish, 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. Their co-counsels also provided a separate letter dated May 7, 2010, regarding secondary effects on subsistence and recreational use from a potential Pebble mine in the context of Section 404(c) regulations. Subsequently, three additional federally recognized Bristol Bay tribal governments signed on to this letter: Native Village of Ekuk, Village of Clark's Point, and Twin Hills Village Council.

[10] These sessions occurred over a 2-year period that began with a panel in December 2010 titled "Responsible Large-scale Mining: Global Perspectives" and concluded with a panel in May 2013 titled "Wetlands, Vegetation, Wildlife, and Threatened & Endangered Species." The final listed panel, titled "Evaluating Choices – A Panel Discussion Designed to Help Stakeholders Examine a Mine Plan and Its Potential Influence on the Region's Ecological, Social, and Economic Base," has not yet been scheduled (Keystone 2014b). To date, Keystone has not published any of its findings.

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

Also in 2010, EPA received requests to refrain from taking action under Section 404(c). These requests included those that asked for more time to understand potential implications of mine development in the Bristol Bay watershed, and others that requested EPA wait until formal mine permit applications had been submitted and an environmental impact statement 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, Governor Parnell of Alaska, and attorneys representing PLP.

In 2010, EPA met, at their request, with stakeholders who support and stakeholders who oppose 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, Anchorage, Seattle, and Washington, D.C.

EPA Administrator Jackson and 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 for all local and regional entities.

2.1.2 Development of the Bristol Bay Assessment (2011–2014)

On February 7, 2011, 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 (see Table 2-1 for a timeline of BBA development).[11] EPA initiated the BBA in response to the competing requests described in the previous section.

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

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 Seattle, Anchorage, and multiple villages in the Bristol Bay watershed 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 public 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.

EPA Region 10 notified 31 Bristol Bay tribes, the Alaska Department of Environmental Conservation (ADEC), ADF&G, ADNR, the Bureau of Land Management, NMFS, NPS, USACE, USFWS, and the U.S. Geological Survey (USGS) of its intent by letter. The same week it was announced, EPA Region 10 met with Nuna Resources (which represents several Alaska Native Claims Settlement Act [ANCSA] Village Corporations) and had meetings with other stakeholders. Many of these tribes and agencies participated in the Intergovernmental Technical Team (IGTT) (Section 2.1.2.2). NFMS, USFWS, and USGS worked closely with EPA on development of the BBA, including authoring appendices to the BBA.

2.1.2.1 Summary of the Bristol Bay Assessment Process

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, in terms of both day-to-day operations and potential accidents and failures, on the region's fish resources; 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 available information to identify and evaluate potential risks of future large-scale mining development on the Bristol Bay watershed's fish habitats and populations and consequent indirect effects on the region's wildlife and Alaska Native cultures.

Ecological Risk Assessment Framework and Process

EPA developed the BBA following EPA's guidelines for ecological risk assessment (EPA 1998). EPA began by reviewing existing literature to synthesize background information on the Bristol Bay region, particularly the Nushagak and Kvichak River watersheds. This information focused on several topics, including the ecology of Pacific salmon and other fishes; the ecology of relevant wildlife species; mining and mitigation, particularly in terms of porphyry copper mining; potential risks to aquatic systems due to road and pipeline crossings; fishery economics; and Alaska Native culture. These detailed background characterizations are included as appendices to the BBA (EPA 2014a).

In accordance with the different phases of an ecological risk assessment, the BBA document itself is organized into two main sections: problem formulation and risk analysis and characterization. Problem formulation is the first phase of an ecological risk assessment, during which the purpose and scope of the assessment are defined. Risk assessors, decision makers, and stakeholders determine the topical, spatial, and temporal scope needed to effectively address whatever decision process the assessment is meant to inform. Assessment endpoints, or explicit expressions of the environmental entities of interest, are identified (EPA 1998). Conceptual models illustrating potential linkages among sources, stressors, and endpoints considered in the assessment, as well as a plan for analyzing and characterizing risks, are developed.

The risk analysis and characterization phases follow problem formulation (EPA 1998). During the risk analysis phase, available data are used to assess potential exposures to stressors and exposure-response relationships for those exposures and endpoint effects. In the risk characterization phase, information on exposures and effects is integrated, and the uncertainties and limitations associated with the assessment's analyses are identified.

Data Used

An ecological risk assessment requires data of sufficient quantity and quality, from a variety of sources. Throughout the problem formulation, risk analysis, and risk characterization phases, relevant data are identified and acquired. These data may result from different kinds of studies, including field studies at the site of interest, field studies at other sites somehow relevant to the site or issue of interest, laboratory tests, and modeling applications.

EPA prioritized peer-reviewed, publicly accessible sources of information for use in the BBA, to ensure that incorporated information and data were of sufficient quality. In many cases, however, peer-reviewed data—particularly those directly relevant to potential mining in the Bristol Bay region—were not available. Thus, information and data from other credible, non-peer-reviewed sources were also used in the BBA. These sources included NDM/PLP reports (e.g., Ghaffari et al. 2011, PLP 2011); reports from the State of Alaska, the U.S. government, and other governments; State of Alaska datasets (e.g., ADF&G 2012, Johnson and Blanche 2012); U.S. government datasets (e.g., USFWS 2012, USGS 2012); other datasets (e.g., ICOLD 2001, RAP 2011); mine industry publications (e.g., mine company reports, conference proceedings); reports from non-governmental organizations (e.g., Zamzow 2011, Levit and Chambers 2012); and personal communications with qualified experts. In all cases, sources of information and data included in the BBA are appropriately cited and listed in BBA Chapter 15 (EPA 2014a).

2.1.2.2 Public and Stakeholder Involvement

Meaningful engagement with 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. To ensure transparency, EPA involved and informed stakeholders throughout the BBA process. Community involvement efforts included a project webpage and listserv to share BBA-related information with the public. Additional ways in which stakeholders and tribal governments were involved in the BBA process are summarized below.

- **Public and stakeholder meetings.** Throughout development of the BBA, EPA visited many Bristol Bay communities, including Ekwok, Dillingham, Kokhanok, New Stuyahok, Koliganek, Iliamna, Newhalen, Nondalton, Naknek, King Salmon, Igiugig, and Levelock. EPA also met with representatives from Bristol Bay tribal governments and corporations, as well as organizations representing the mining industry, commercial fishers, seafood processors, hunters and anglers, chefs and restaurant owners, jewelry companies, conservation interests, members of the faith community, and elected officials from Alaska and other states. EPA heard from hundreds of people at these meetings and from thousands more via phone and email. EPA was also invited to numerous conferences and meetings to discuss the BBA. The following stakeholder and public meetings are of particular note.
    - **June 2011.** EPA Senior Policy Counsel Robert Sussman, EPA Acting Assistant Administrator for Water Nancy Stoner, and Regional Administrator McLerran met with PLP, toured the Pebble deposit site, and visited five Alaska Native villages. They held public meetings in the villages of Newhalen, Ekwok, New Stuyahok, and Dillingham. In Koliganek, they met with members of the Village Council.
    - **June 2012.** EPA held eight public meetings seeking public comment on the May 2012 draft of the BBA (see "public comments" bullet below).
    - **August 2013.** EPA Administrator Gina McCarthy and Regional Administrator McLerran met with PLP, toured the Pebble deposit site, and held public meetings in the villages of Iliamna and Dillingham.
- **IGTT.** In August 2011, EPA met with the IGTT, which was established to provide EPA with input on the structure of the BBA and to identify potential data sources. IGTT participants included tribal representatives from Ekwok, Newhalen, Iliamna, South Naknek, New Koliganek, Curyung, Nondalton, and Levelock and agency representatives from the Alaska Department of Public Health, ADF&G, ADNR, NPS, USFWS, NMFS, and the Bureau of Land Management. Feedback from this workshop was used to inform the early stages of problem formulation. EPA also updated the IGTT on BBA progress in January 2012 via webinar.
- **Tribal consultation.** 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. Consultation is a process of meaningful communication and coordination between EPA and tribal

officials. In February 2011, EPA invited all 31 federally recognized tribal governments of the Bristol Bay region to enter formal consultation on the BBA, to ensure their involvement and to include their concerns and relevant information in the BBA. Throughout development of the BBA there have been numerous opportunities for tribes to participate in the tribal consultation process. Not all tribes elected to participate in consultation. EPA met with representatives from 20 of the 31 tribes (including all 13 tribes with federally recognized tribal governments in the Nushagak and Kvichak River watersheds), either in person or on the phone, during the consultation process.

- **ANCSA engagement.** EPA provided multiple engagement opportunities for ANCSA Village and Regional Corporations throughout development of the BBA, consistent with Public Law 108-199, Division H, Section 161, and Public Law 108-447, Division H, Title V, Section 518. EPA representatives traveled to King Salmon, Iliamna/Newhalen, and Anchorage for meetings at the request of multiple ANCSA Corporations, to share information about and receive input on the BBA. Additionally, ANCSA Corporation representatives were invited to participate in a webinar following release of the April 2013 draft of the BBA. Throughout BBA development, ANCSA Corporations have traveled numerous times to meet with EPA officials in Anchorage, Seattle, and Washington, D.C. Seventeen of the 26 ANCSA Corporations within the Bristol Bay region were engaged through these mechanisms.

- **Public comments.** 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 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. In March 2014, EPA released the Response to Public Comments documents for both the May 2012 and April 2013 drafts of the BBA.

- **Public involvement in peer review.** EPA provided multiple opportunities for stakeholder involvement in the peer review process. In February 2012, the public was invited to nominate qualified scientists as potential peer reviewers; these nominations were submitted to the peer review contractor for consideration. In March 2012, EPA requested public comments on the charge questions to be given to peer reviewers, and these questions were revised in response to comments received. In August 2012, the public was invited to participate in the first 2 days of the peer review meeting in Anchorage, to provide oral comments to and observe discussions among the peer reviewers.

2.1.2.3 Peer Review Process

The peer review process is designed to provide a documented, independent, and critical review of a draft product. Its purpose is to identify any problems, errors, or necessary improvements to a draft product prior to it being released as a final product. To this end, EPA tasked Versar, an independent contractor, with coordinating an external peer review of the May 2012 draft of the BBA. Versar assembled 12 independent experts to serve as peer reviewers. These reviewers were selected from a pool of qualified candidates, with particular attention to the public nominees. In assembling the peer reviewers, Versar evaluated the qualifications of each peer review candidate and conducted thorough conflict of interest screenings.

The peer reviewers were asked to evaluate the May 2012 draft of the BBA (the main report and its appendices) and provide a written review responding to 14 questions developed by EPA with input from public commenters. Peer reviewers were charged only with evaluating the quality of the science included in the draft BBA and were not charged with making any regulatory recommendations, commenting on any policy implications of EPA's role in mine development in the region, or reaching consensus in either their deliberations (during the peer review meeting, see below) or their written comments. Peer reviewers were provided with a summary of public comments submitted during the 60-day public comment period for the May 2012 draft and were given access to the public comments themselves.

A 3-day peer review meeting, coordinated by Versar, was held in Anchorage on August 7 through 9, 2012. On the first day of the meeting, peer reviewers heard testimony from approximately 100 members of the public. Peer reviewers deliberated among themselves on the second and third days of the meeting; these deliberations were open to the public on the second but not the third day. EPA staff were present at all 3 days of the peer review meeting and were available to the peer reviewers to answer clarifying questions on the second and third days.

Following the public peer review meeting, peer reviewers were given additional time to complete their individual written reviews. Versar provided these final written comments to EPA in the *Final Peer Review Meeting Summary Report* for the May 2012 draft, which EPA released to the public in November 2012 (EPA 2012). EPA considered these peer review comments, as well as comments received during the 60-day public comment period, as it revised the May 2012 draft of the BBA.

In April 2013, EPA released a revised draft of the BBA. The same 12 peer reviewers were asked to conduct a follow-on peer review to evaluate whether the April 2013 draft of the BBA was responsive to their original comments. EPA provided reviewers with a draft response to comments document, in which EPA responses to peer review comments on the May 2012 draft of the BBA were added to the *Final Peer Review Meeting Summary Report* (EPA 2012).

In the follow-on review, peer reviewers were asked to go through their comments on the May 2012 draft, review EPA's draft responses to their original comments, and evaluate whether their original review comments had been addressed sufficiently and appropriate changes had been incorporated into the April 2013 draft. EPA received these follow-on peer review comments directly from the 12 peer reviewers in August and September 2013. Again, EPA considered these peer review comments, as well as comments received during the 60-day public comment period, as it revised the April 2013 draft of the BBA.

In January 2014, EPA released both the final BBA and the final response to peer review comments document.

2.1.3 Initiation of the Clean Water Act Section 404(c) Review Process (2014–Present)

After careful consideration of available information, including the BBA and extensive information provided by NDM/PLP, EPA Region 10 announced on February 28, 2014, its decision to proceed under CWA Section 404(c) regulations, 40 CFR Part 231, to review potential adverse environmental effects of discharges of dredged or fill material associated with mining the Pebble deposit. Pursuant to these regulations, Regional Administrator McLerran sent letters to the Alaska District USACE, the State of Alaska, and PLP, notifying them of the decision to initiate this process and providing them an opportunity to submit information, for the record, to demonstrate either that no unacceptable adverse effects on aquatic resources would result from discharges associated with mining the Pebble deposit or that actions could be taken to prevent such unacceptable adverse effects.

Section 404(c) regulations provide 15 days for responding to this request. In response to requests for additional time, EPA Region 10 sent letters to PLP and to the Alaska Attorney General on March 13, 2014, granting a 45-day extension (until April 29, 2014) to respond to the Section 404(c) initiation letter.

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 Section 404(c) consultation period. These submittals raised a number of legal, policy, scientific, and technical issues, including questions regarding EPA's authority to initiate a Section 404(c) review at this time, the scientific credibility of the BBA, and whether the BBA should be used to inform decision-making under Section 404(c). Most of the scientific and technical issues detailed in these documents had been raised before; EPA has 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. Examples of these scientific and technical issues and EPA's responses are provided below.

- In its April 29, 2014, submittal, PLP continued to assert that streams and other aquatic habitats most likely to be affected by the mine's footprint are "either not utilized by fish or support low to very low densities of fish" and that these streams and associated wetlands have low habitat value for fish. However, EPA has highlighted concerns regarding the methods PLP used to analyze its data and reach these conclusions. For example, sampling fish in the area near the Pebble deposit can be very difficult and costly. Information on fish distribution and abundance in the region must rely on intermittent site visits during periods when the area and streams are accessible and suitable for effective sampling. It is reasonable to conclude that the current databases provide an incomplete description of the full distribution and abundance of fish in the region, and likely represent underestimates of actual fish distribution, fish abundance, and habitat importance, for several reasons.

  - Counts of fish reported in PLP's environmental baseline document (PLP 2011) do not always include estimates of observer efficiency, sampling efficiency, or other factors that affect the proportion of fish present that are actually observed. Thus, counts may often underestimate true abundance.
  - Some habitats are seasonally important. Fish may be absent from a site during portions of the year, but present in high abundances at other times. Low abundance at one point in time does not necessarily equate to low abundance at another point in time, nor does it mean that the habitat is not ecologically important.
  - Sites with low abundances during years with low adult escapement may have high abundances during years with higher survival or escapement, allowing populations to respond to favorable conditions.
  - Sites with low apparent abundances of target species (e.g., salmon) may provide habitat for other fish species, macroinvertebrates, or other components essential for ecosystem function.
  - Sites with low abundances may provide important services to downstream waters, including regulation of water quality or streamflows or supplies of materials.
- Given these factors, it is not valid to conclude that streams with low abundances observed under a particular sampling regime are somehow unimportant. They can in fact be very important, as is well-known and documented within the ecological and fisheries literature detailed in the BBA (EPA 2014a: Chapter 7, EPA 2014b).
- PLP's April 29, 2014, submittal also dismisses the stream, wetland, and other aquatic resources losses associated with the mine footprint as "inconsequential when put into context of the overall Nushagak/Kvichak drainages and Bristol Bay region." PLP notes that stream and wetland losses associated with the 0.25 stage mine would be 0.05% and 0.004%, respectively, of the streams and wetlands in the Bristol Bay watershed. EPA has pointed out that this perspective is flawed because it assumes that these habitats are less ecologically valuable than streams, wetlands, and other aquatic habitats elsewhere in the watershed and ignores the important role that individual streams or stream reaches, wetlands, lakes, ponds, and other aquatic habitats can play in protecting the genetic diversity of Bristol Bay's salmon populations. In the Bristol Bay region, hydrologically diverse riverine and wetland landscapes provide a variety of salmon spawning and rearing habitats. Environmental conditions can differ among habitats in close proximity, and recent research has highlighted the potential for local adaptations and fine-scale population structuring in the Bristol Bay and neighboring watersheds (Quinn et al. 2001, Olsen et al. 2003, Ramstad et al. 2010, Quinn et al. 2012). Losses that eliminate local, unique populations would erode the genetic diversity that is crucial to the stability of the overall Bristol Bay salmon fisheries (Hilborn et al. 2003, Schindler et al. 2010, EPA 2014a: Appendix A, EPA 2014b). PLP's approach is also problematic because it is inconsistent with USACE guidance in effect since 1989. In this 1989 guidance, USACE Headquarters specifically criticizes New Orleans District USACE's assertion that wetland losses associated with a

project under review were “inconsequential” because “…project alterations of wetlands represents a very small portion of similar habitat within the project vicinity and coastal Louisiana…only 2.39% of the saline marsh on Grand Isle and only 0.005% of the saline marsh in coastal Louisiana....” The 1989 guidance finds that this approach ignores the fact that the cumulative effects of many projects could add up to very significant wetlands loss and notes that the proposed destruction of 22 acres of special aquatic sites in the case under review by New Orleans District could not simply be “dismissed as unimportant” (USACE 1989). EPA has also concluded, based on NDM’s submissions to the SEC as well as more recent statements (Ghaffari et al. 2011, SEC 2011, NDM 2014), that the development of a mine at the Pebble deposit will be much larger than the 0.25 stage mine, likely as much as 25 times larger under the resource case presented in Ghaffari et al. (2011).

- PLP’s submittal claims that the BBA underestimated by more than 80% the surplus water volumes available for treatment and release to mitigate potential effects on downstream aquatic habitats. PLP has made similar claims in the past, but has not provided any supporting information to substantiate this claim.
- PLP’s submittal is critical of the surplus water release strategy used in the BBA and claims it has a “more strategic and science-based” strategy to manage surplus water flows that will prevent negative effects on fish and possibly provide beneficial effects on four species of salmon and three other fish species. PLP has made similar claims in the past, but has not provided any supporting information to substantiate this claim. Tables 1 and 2 in PLP’s submittal purport to evaluate the surplus water release strategy used in the BBA and a second theoretical strategy identified by PLP. However, these tables provide a skewed analysis by showing streamflow changes at the scale of the entire river or Bristol Bay, rather than at the scale of the stream reach as shown in the BBA. Finally, Appendix J of the BBA (EPA 2014a) discusses the challenges associated with actually implementing the kind of sophisticated water quantity management strategy proposed by PLP; these challenges are not addressed by PLP’s submittal.
- In its comments on the May 2012 and April 2013 drafts of the BBA, PLP identified an array of compensatory mitigation measures that it felt could offset the kinds of unavoidable impacts on streams, wetlands, and fish expected to occur during mining of the Pebble deposit. Appendix J of the BBA evaluated these potential compensation measures (EPA 2014a). EPA concluded that there are significant challenges regarding the potential efficacy, applicability, and sustainability of compensation measures proposed by PLP for use in the Bristol Bay region, and raised questions as to whether sufficient compensation measures exist to address impacts of the expected nature and magnitude. Compensatory mitigation efforts typically involve restoration and enhancement of waters that have potential for improvement in ecological services. However, the waters of the Bristol Bay watershed are already among the most productive in the world. EPA Region 10 sees little likelihood that human activity could improve upon the high-quality natural environment in the Bristol Bay watershed that nature has created and that has thus far been preserved. PLP’s April 29, 2014, submittal included additional information regarding compensatory mitigation. EPA reviewed this material but determined that it did not change the conclusions drawn in Appendix J of the BBA

(EPA 2014a). Nearly all of the existing peer-reviewed literature reviews evaluating the effectiveness of stream restoration and rehabilitation projects, including reviews referenced in PLP's submittal, conclude that the majority of restoration projects either are never measured for effectiveness or do not meet their restoration objectives. PLP points to the millions of dollars spent on salmon recovery projects in the Pacific Northwest and British Columbia, with the implication that there is a connection between financial investment and salmon productivity. However, despite the millions spent, Pacific salmon remain at a fraction of their historical levels in the lower 48 states. As discussed in detail in Appendix J of the BBA, compensation methods proposed by PLP, including placement of instream structures, stream fertilization, and construction of spawning channels, have typically had only variable, local, or temporary effects; were designed for use in degraded watersheds; or resulted in adverse, unintended consequences (Peterman 1982, Giannico and Hinch 2003, Walters et al. 2008, Whiteway et al. 2010, Jones et al. 2014, EPA 2014a: Appendix J).

On June 23, 2014, EPA Region 10 sent letters to four companies that are controlled by or subsidiaries of NDM and that have mineral claims near the Pebble deposit. These letters provide a copy of the original February 28, 2014, CWA Section 404(c) initiation letter and an opportunity for those entities to send any additional information or response. On July 8, 2014, PLP responded on behalf of the four companies and informed EPA Region 10 that each company adopts the response submitted by PLP on April 29, 2014.

After fully considering the April 29, 2014, submittals from PLP and the Alaska Attorney General, the Regional Administrator was not satisfied that no unacceptable adverse effect could occur, or that adequate corrective action could be taken to prevent an unacceptable adverse effect. Thus, EPA Region 10 has decided to take the next step in the Section 404(c) process, publication of this proposed determination.

2.2 Project Description

2.2.1 Overview of the Pebble Deposit

The Pebble deposit, located in the headwaters of tributaries of the Nushagak and Kvichak River watersheds (Figure ES-2), is the largest known porphyry copper deposit in southwest Alaska and represents the most likely site for near-term, large-scale mine development in the Bristol Bay watershed (EPA 2014a: Chapter 6). It is a large, low-grade deposit containing copper-, gold-, and molybdenum-bearing minerals. Extraction would involve the creation of a large open pit and the production of large amounts of waste rock and mine tailings (EPA 2014a: Chapter 6).

PLP holds the largest mine claim block in the Nushagak and Kvichak River watersheds. Although PLP has not yet submitted a Section 404 individual permit application for development of a mine, preliminary mine plans have been developed and submitted to the federal government (i.e., SEC 2011). Publicly available information strongly suggests that a mine at the Pebble deposit has the potential to become one of the largest mining developments in the world (EPA 2014a: Chapter 6).

The Pebble deposit covers an area of at least 1.9 by 2.8 miles and consists of two contiguous segments, Pebble West and Pebble East. The approximate center of the prospect 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.[12] The full extent of the Pebble deposit is not yet defined (NDM 2014), but Ghaffari et al. (2011) indicate that the Pebble mineral resource may approach 12 billion tons of ore.

For the purposes of this proposed determination, EPA Region 10 is describing the surficial boundary of the Pebble deposit as a rectangular area encompassing the currently known Pebble deposit and measuring 2.5 miles north-south by 3.5 miles east-west. As illustrated in Figure ES-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.*

2.2.2 Overview of the Bristol Bay Assessment Mine Scenarios

The BBA evaluated three mine scenarios for the Pebble deposit that draw on preliminary plans submitted by NDM to the SEC (Ghaffari et al. 2011, SEC 2011), consultation with experts, and baseline data collected by NDM/PLP. The two larger scenarios reflect NDM's preliminary plans for mining the deposit. All three scenarios include the use of modern conventional mining technologies and practices, the scale of mining activity required for economic development of the resource, and the infrastructure needed to support large-scale porphyry copper mining.

The three mine scenarios evaluated in the BBA represent different stages of mining at the Pebble deposit, based on the amount of ore processed (Table 2-2).

- Pebble 0.25 stage mine (approximately 0.25 billion tons of ore over 20 years)
- Pebble 2.0 stage mine (approximately 2.0 billion tons of ore over 25 years)
- Pebble 6.5 stage mine (approximately 6.5 billion tons of ore over 78 years)

The Pebble 0.25 stage mine is based on the worldwide median size porphyry copper deposit (Singer et al. 2008).[13] The Pebble 2.0 stage mine[14] and Pebble 6.5 stage mine[15] are based on the smallest and

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[12] 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 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 2014d).

[13] The 0.25 stage mine was added to the BBA to address a comment by peer reviewers who noted that both the 2.0 and 6.5 stage mines were larger than the 90th percentile of all porphyry copper deposits in the world and recommended that a smaller mine scenario on the order of the 50th percentile of worldwide porphyry copper deposits should be evaluated.

largest mine sizes, respectively, that NDM described in its submittal to the SEC (Ghaffari et al. 2011, SEC 2011). Ghaffari et al. (2011) indicate that the total mineral resources at the Pebble deposit are now believed to be approximately 12 billion tons of ore; thus, it is expected that development of a mine at the Pebble deposit would ultimately be much larger than the 0.25 stage. In its February 23, 2011, press statement announcing the release of Ghaffari et al. (2011), NDM stated "As presented in the Preliminary Assessment, project economics are robust and support a mine development that is both technically feasible and permittable under existing regulatory standards in Alaska." Listed in the press release as a "Preliminary Assessment Key Finding" is the following statement: "The Pebble deposit supports open pit mining utilizing conventional drill, blast and truck-haul methods, with an initial mine life of 25 years and potential for mine extensions to 78 years and beyond" (NDM 2011).

Table 2-2. Mine stage parameters.

Parameter	Mine Stage		
	Pebble 0.25	Pebble 2.0	Pebble 6.5
Amount of ore mined (billion metric tons)	0.23	1.8	5.9
Approximate duration of mining (years)	20	25	78
Ore processing rate (metric tons/day)	31,100	198,000	208,000
Mine Pit			
Surface area (km²)	1.5	5.5	17.8
Depth (km)	0.30	0.76	1.24
Waste Rock Pile			
Surface area (km²)	2.3	13.0	22.6
PAG waste rock (million metric tons)	86	580	4,700
NAG waste rock (million metric tons)	320	2,200	11,000
TSF 1[a]			
Capacity, dry weight (billion metric tons)	0.25	1.97	1.97
Surface area, exterior (km²)	6.8	16.1	16.1
Maximum dam height (m)	92	209	209
TSF 2[a]			
Capacity, dry weight (billion metric tons)	NA	NA	3.69
Surface area, exterior (km²)	NA	NA	22.7
TSF 3[a]			
Capacity, dry weight (billion metric tons)	NA	NA	0.96
Surface area, exterior (km²)	NA	NA	9.82
TOTAL TSF surface area, exterior (km²)	**6.8**	**16.1**	**48.6**

Notes:
[a] Final value, when TSF is full.
PAG = potentially acid-generating; NAG = non-acid-generating; TSF = tailings storage facility; NA = not applicable.

The major components of each mine would be an open mine pit, waste rock piles, and one or more tailings storage facilities (TSFs). Mine construction and operation would also require the construction of

[14] Ghaffari et al. (2011) call the 2.0 stage mine the "Investment Decision Case," which describes an initial 25-year open pit mine life upon which a decision to initiate permitting, construction, and operations may be based.
[15] Ghaffari et al. (2011) call the 6.5 stage mine the "Resource Case," which is based on 78 years of open pit production and seeks to assess the long-term value of the project in current dollars.

support facilities, including a major transportation corridor, pipelines, a power-generating station, wastewater treatment plants, housing and support services for workers, administrative offices, and other infrastructure. Such facilities would greatly expand the "footprint" of the mine and affect additional aquatic resources beyond the scope of this proposed determination. Although NDM's preliminary plans (Ghaffari et al. 2011, SEC 2011) could change, any mining of the Pebble deposit would, by necessity, require similar mine components, support facilities, and operational features. By only considering the footprint impacts associated with the mine pit, TSFs, and waste rock piles, EPA Region 10 recognizes that it has underestimated potential adverse effects on resources within the SFK, NFK, and UTC watersheds from the construction of all of the additional support facilities necessary to construct and operate a mine at the Pebble deposit.[16] Given the extent of streams, wetlands, lakes, and ponds both overlying the Pebble deposit and within adjacent watersheds, excavation of a massive mine pit and construction of large TSFs and waste rock piles would result in discharges of dredged or fill material into these waters. As USACE has already determined, it is clear that mining the Pebble deposit will entail discharge of dredged or fill material into waters of the United States regulated under the CWA (Lestochi pers. comm.).

Although the BBA and this proposed determination evaluate potential effects associated with all three mine stages, EPA Region 10 has determined that the direct and secondary effects associated with the discharge of dredged or fill material for construction and routine operation of the 0.25 stage mine could result in unacceptable adverse effects on fishery areas. Thus, the primary focus and basis for this proposed determination are the environmental effects associated with the 0.25 stage mine and their potential to cause unacceptable adverse effects on fishery areas. However, EPA Region 10 has also determined that it is highly likely, based on representations from NDM (Ghaffari et al. 2011, SEC 2011, NDM 2014), that ultimate development of the Pebble deposit will be much larger than the 0.25 stage mine and will therefore likely result in much greater impacts than those identified for the 0.25 stage mine.

2.2.3 Potential Disposal Site

Section 404(c) authorizes EPA to prohibit, deny, or restrict the use of "any defined area" for specification as a disposal site for the discharge of dredged or fill material after determining 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 recreation areas."

EPA Region 10 is exercising its discretion to define the potential disposal site as narrowly as possible to encompass the area where discharges associated with mining the Pebble deposit will likely occur, while simultaneously protecting fishery areas from unacceptable adverse effects related to such mining.

[16] An underground extension of the mine, which could increase the size of the mine to more than 6.5 billion tons of ore, was not included in the BBA.

EPA Region 10 first considered the location of the Pebble deposit at the headwaters of the SFK, the NFK, and UTC. Given this location, EPA Region 10 determined that the mine itself, the discharge of dredged or fill material associated with mining the Pebble deposit, and the unacceptable adverse effects on fishery areas that could result from discharge of this material are most likely to occur within these three watersheds. Therefore, EPA Region 10 concluded that it is reasonable to use the boundaries of the three watersheds to initially define the potential disposal site for dredged or fill material associated with mining the Pebble deposit.

EPA Region 10 then narrowed its focus to mine claims in the three watersheds that are in and around the Pebble deposit, because these are the areas where discharge of dredged or fill material is most likely. Alaska state law specifically recognizes the opportunity for mineral claim owners to use the state's surface land above their mineral claims for mining activity.[17]

In this instance, NDM subsidiaries own mine claims for the Pebble deposit and nearby areas within the SFK, NFK, and UTC watersheds.[18] Given the parent-subsidiary relationship of these companies, it is reasonable to conclude that NDM would consider the mine claims of its subsidiaries within the three watersheds when deciding where to conduct mining activities, including the placement of dredged or fill material associated with construction and operation of a mine at the Pebble deposit. Therefore, a potential disposal site that includes all mine claims owned by NDM subsidiaries in the three watersheds best represents locations where the discharge of dredged or fill material associated with mining the Pebble deposit, and any resulting unacceptable adverse effects on fishery areas, are most likely to occur.

EPA Region 10 has determined that the scope of the potential disposal site subject to EPA Region 10's proposed restrictions, although narrowly tailored to include only those areas where discharge of dredged or fill material associated with mining the Pebble deposit is most likely, will protect important fishery areas from unacceptable adverse effects.

The size of the potential disposal site is approximately 268 square miles (693 km^2). The description of the potential disposal site (Figure ES-3) is as follows.

> *Beginning in the northeast, at latitude 59.994 degrees north (59.994 N) and longitude 155.262 degrees west (155.262 W), it travels generally westward, 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*

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[17] 11 Alaska Administrative Code 86.600: Millsite permit (a) The director may grant the owner of a mining interest on federal, state, or private land a millsite permit for use of the state's surface estate for a millsite, tailings disposal, or another use necessary for the mineral development. The surface estate subject to the millsite permit must be on or near the owner's mining interest. The director will set the term of the millsite permit for a duration that is appropriate to the permittee's use of the site, and will condition the millsite permit upon payment of fair market rental value for the term of the permit. (b) This section does not require an owner of a mineral location under AS 38.05.185 - 38.05.275 to obtain a millsite permit for use of the state's surface estate within the boundaries of the location.

[18] According to filings with the SEC, Pebble West Claims Corporation and Pebble East Claims Corporation own mine claims for the Pebble deposit itself. Both of these companies are owned by PLP, which itself is a subsidiary of NDM. In addition, PLP and NDM own Kaskanak Copper LLC and U5 Resources Inc., respectively. Both Kaskanak Copper LLC and U5 Resources Inc. own mine claims within the SFK, NFK, and UTC watersheds.

River and mainstem Koktuli River watersheds, until reaching the north boundary of Section 5, Township 4 South, Range 37 West, Seward Meridian (S004S037W05), at approximately latitude 59.866 N and longitude 155.681 W; then east along the north section line approximately 0.64 mile to the west boundary of S004S037W04, at approximately latitude 59.866 N and longitude 155.663 W; then south along the west section line 0.5 mile to the east-west half-section line, at approximately latitude 59.859 N and longitude 155.663 W; then east along the half-section line 0.5 mile to the north-south half-section line, at approximately latitude 59.859 N and longitude 155.648 W; then south along the north-south half-section line approximately 5.4 miles to the boundary between the Koktuli River and Kaskanak Creek watersheds, at approximately latitude 59.781 N and longitude 155.648 W; then generally eastward, along the watershed boundary to approximately latitude 59.767 N and longitude 155.541 W; then generally eastward, along the boundary between the Koktuli River and Lower Talarik Creek watersheds to approximately latitude 59.762 N and longitude 155.363 W; then generally southeastward, along the boundary between the Upper Talarik Creek and Lower Talarik Creek 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, 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 along the east section line 1.0 mile to the south boundary of S005S035W09, at approximately latitude 59.751 N and longitude 155.259 W; then east along the south section line 1.0 mile to the east section line, at approximately latitude 59.751 N and longitude 155.230 W; then north along the east section line 1.0 mile to the south boundary of S005S035W03, at approximately latitude 59.765 N and longitude 155.230 W; then east along the south section line 1.0 mile to the east section line, at approximately latitude 59.765 N and longitude 155.201 W; then north along the east section line 1.0 mile to the south boundary of S004ST034W31, at approximately latitude 59.779 N and longitude 155.201 W; then west along the south section line 0.09 mile to the west section line, at approximately latitude 59.779 N and longitude 155.204 W; then north along the west section line 2.0 miles, to the south boundary of S004S034W19, at approximately latitude 59.808 N and longitude 155.204 W; then east along the south section line 1.0 mile to the east section line, at approximately latitude 59.808 N and longitude 155.176 W; then north along the east section line 1.0 mile to the south boundary of section S004S034W17, at approximately latitude 59.823 N and longitude 155.176 W; then east along the south section line 3.0 miles to the east boundary of S004S034W15, at approximately latitude 59.823 N and longitude 155.090 W; then north along the east section line 2.0 miles to the south boundary of S004S034W02, at approximately latitude 59.852 N and longitude 155.090 W; then east along the south section line, approximately 2.64 miles, 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 to the south boundary of S003ST034W12, at approximately latitude 59. 924 N and longitude 155.059 W; then west along the south section line approximately 2.06 miles to the west boundary of S003S034W10, at approximately latitude 29.924 N and longitude 155.119 W; then north, along the west section line 1.5 miles to the east-west half section line of S003S034W04, at approximately latitude 59.946 N and longitude 155.119 W; then west along the half-section line 1.0 mile to the west section line, at approximately latitude 59.946 N and longitude 155.295 W; then south along the section line 0.5 mile to the south boundary of S003S034W05, at *approximately latitude 59.935 N and longitude 155.295 W; then west 1.5 miles to the north-south half-section line of S003S034W06, at approximately latitude 59.935 N and longitude 155.191 W; then north along the half-section line 0.5 mile to the north section line, at approximately latitude 59.946 N and longitude 155.191 W; then west 1.5 miles to the west boundary of S003S035W01, at approximately latitude 59.946 N and longitude 155.233 W; then north along the west section line 0.5 mile to the south boundary of S002S035W35, at approximately latitude 59.953 N and longitude 155.233 W; then west along the south section line 0.5 mile to the north-south half-section line, at approximately latitude 59.953 N and longitude 155.247 W; then north along the half-section line 0.5 mile to the east-west half section line, at approximately latitude 59.960 N and longitude 155.247 W; then west along the half-section line 0.5 mile to the west section line, at approximately latitude 59.960 N and longitude 155.262 W; then north along the west section line to the starting point, on the boundary between the Upper Talarik Creek and Chulitna River watersheds (coordinates above).*

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. This ecological wealth supports a number of sustainable economies that are of vital importance to the region, including commercial, subsistence, and sport fishing; subsistence and sport hunting; and non-consumptive recreation. In 2009 alone, these activities generated approximately $480 million in direct economic expenditures and provided employment for over 14,000 full- and part-time workers (EPA 2014: Chapter 1, Appendix E).

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. These topics are considered at multiple geographic scales. The Pebble deposit is located 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.[19] The SFK, NFK, and UTC watersheds are the areas that would be most directly affected by mine development at the Pebble deposit. However, these streams help support fish habitats and populations in larger downstream systems via contributions of water, organisms, organic matter, and other resources. Thus, ecological resources across broader geographic scales (e.g., throughout the Nushagak and Kvichak River watersheds) also must be considered.

3.1 Physical Setting

Bristol Bay is a large gulf of the Bering Sea located in southwestern Alaska. The land area draining to Bristol Bay consists of six major watersheds—from west to east, the Togiak, Nushagak, Kvichak, Naknek, Egegik, and Ugashik River watersheds—and a series of smaller watersheds draining the North 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 more than half the land area in the Bristol Bay watershed (EPA 2014: Chapter 3).

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

[19] 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 190303021104 (located immediately west of the Pebble deposit). UTC represents one 10-digit HUC (1903020607).

to Bristol Bay provide intact, connected habitats from headwaters to ocean. Unlike most other areas supporting Pacific salmon populations, 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 undeveloped lake in the United States.

The primary human manipulation of the Bristol Bay ecosystem is the marine harvest of approximately 70% of salmon returning to spawn (EPA 2014: Chapter 5). However, commercial salmon harvests are ADF&G's second priority for fish management; its first priority is to ensure that sufficient fish migrate into rivers to maintain a sustainable fishery and, thus, sustainable salmon-based ecosystems. No hatchery fish are reared or released in the Bristol Bay watershed, whereas approximately 5 billion hatchery-reared juvenile salmon are released annually across the North Pacific (Irvine et al. 2009). This lack of hatchery fish in the Bristol Bay region is notable, given the economic investment that rearing and releasing hatchery fish requires and the fact that its benefits are highly variable and difficult to quantify (Naish et al. 2007). Hatchery fish also can have significant adverse effects on wild fish populations (e.g., Hilborn and Eggers 2000, Levin et al. 2001, Mobrand et al. 2005, Araki et al. 2009, Rand et al. 2012).

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 that contributes to the environmental integrity and resilience of the watershed's ecosystems (Section 3.3.6) (Schindler et al. 2010, Ruff et al. 2011, Lisi et al. 2013).

This section presents key aspects of these 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.

3.2.1 Quantity and Diversity of Aquatic Habitats

In general, conditions in the Bristol Bay watershed are highly favorable for Pacific salmon. The Nushagak and Kvichak River watersheds encompass an abundant and diverse array of aquatic habitats that support a diverse salmonid assemblage (Section 3.3). Freshwater habitats range from headwater streams to braided rivers, small ponds to large lakes, 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 that includes 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% lake cover for the Bristol Bay watershed and 13.7% lake cover for the Kvichak River 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%) (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 2005). 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 2005). 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 gravels 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 likely the dominant source of flow in streams draining the Pebble deposit area (PLP 2011, Rains 2011). 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).

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), 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, Woody and Higman 2011).

These groundwater–surface water interactions and their influence on water temperature are extremely important for fish, particularly salmon. Water temperature controls the metabolism and behavior of salmon and, if temperatures are stressful, fish 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 2012). 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 2005). Groundwater moderates winter temperatures, which strongly control egg development, egg hatching, and emergence timing (Brannon 1987, Hendry et al. 1998), and groundwater contributions that maintain water temperatures above 0^{0}C are critical for maintaining winter refugia in streams that might otherwise freeze (Power et al. 1999). Thus, winter groundwater connectivity may be critical for fish 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 fish and their environments that adversely affect survival (Angilletta et al. 2008).

In terms of water quality, streams draining the Pebble deposit area tend to be neutral to slightly acidic, with low conductivity, hardness, dissolved solids, suspended solids, and dissolved organic carbon (EPA 2014: Chapter 8). 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. PLP (2011) found that copper levels in some samples from the SFK exceeded Alaska's chronic water quality standard. However, most of the exceedances were in or close to the deposit area and the number and magnitude of exceedances decreased with distance downstream (PLP 2011: Figure 9.1-35, 60, 61, 65, and 66).

In summary, the Bristol Bay watershed in general, and the SFK, NFK, and UTC watersheds specifically, provide diverse, high-quality 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 diverse 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 670 miles (1,085 km) of which are in the SFK, NFK, and UTC watersheds. These streams provide abundant, high-quality habitat and other resources, supporting a robust assemblage of fishes (Section 3.3).

Stream and river habitats of the SFK, NFK, and UTC watersheds can be characterized in terms of attributes that represent fundamental aspects of the physical and geomorphic settings in streams, and thus provide context for stream and river habitat development and subsequent fish habitat suitability (Burnett et al. 2007, Shallin Busch et al. 2011). The BBA 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).[20] 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.[21]

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% 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 frequently met in stream channels with gradients less than 3% (Montgomery et al. 1999). In low-gradient channels, the channel's capacity to transport fine sediments will be low and substrates may be dominated by fines, providing suboptimal salmon spawning habitat. At gradients above 3%, the size, stability, and frequency of pockets of suitable spawning substrates decrease substantially (Montgomery and Buffington 1997). In the SFK, NFK, and UTC watersheds, low-gradient (<3%) channels account for 87% of the stream network.

[20] Note that the NHD underestimates total stream length, because it does not capture all stream courses and may underestimate channel sinuosity.

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

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% 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 and other deposits. Larger-bodied Chinook salmon adults are less likely to access smaller streams for spawning (Quinn 2005), but juvenile Chinook salmon are observed in small tributaries where spawning has not been documented. In the SFK, NFK, and UTC watersheds, small streams account for 65% of the stream network.

Streams in the larger valleys of the SFK, NFK, and UTC watersheds generally 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 a diversity of 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. In addition, smaller, steeper streams in the watersheds provide seasonal (and some year-round) habitat for other fish species, and provide important provisioning services to downstream waters (Section 3.2.4).

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.

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

Notes:

[a] 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).

[b] 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.

[c] 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.

[d] >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.

FP = high floodplain potential (≥5% flatland in lowland); NFP = no or low floodplain potential (<5% flatland in lowland).

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 2012) has data for approximately 83% of the area encompassed by the SFK, NFK, and UTC watersheds. By extrapolating these data to the entire area of the three watersheds, a rough estimate of total wetland acreage, as well as the acreage of different wetland types, can be calculated (Table 3-2).

Table 3-2. Acreage of wetland habitats in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds.

Wetland Type	Description	Area (acres)[a]	% of Total Area[b]
Freshwater emergent wetland	Non-tidal wetlands dominated by erect, rooted herbaceous hydrophytes	12,980	6
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)	21,150	9
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% vegetative cover or a plant community dominated by species that principally grow on or below water surface, and have at least 25% of substrates less than 2.75 inches in size	3,710	2
Lake	Wetlands and deep-water (deeper than 6.6 feet) habitats that are situated in topographic depressions, have less than 30% vegetative cover, and are greater than 20 acres in size	1,746	1
Riverine	Wetlands and deep-water (deeper than 6.6 feet) habitats in natural or artificial channels that contain flowing water at least periodically	542	<1
TOTAL		**40,130**	**18**

Notes:

[a] Total area of wetland types in three watersheds, assuming 83% National Wetlands Inventory (NWI) coverage accurately represents wetland coverage in 17% of area with no NWI coverage.

[b] Total area of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds = 228,700 acres.

Source: USFWS 2012.

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, PLP (2011) used multiple sources of high resolution remote imaging and ground-truthing to map wetlands in their mine mapping area, which focused on the proposed mine working area and major stream valleys. They reported wetland densities of approximately 29% for the mapping area (PLP 2011: Table 14.1-3), whereas preliminary NWI mapping identified approximately 20% of this same area as wetland (PLP 2011: Table 14.1-1).

3.2.4 Importance of Headwater Stream and Wetland Habitats to Fish

Small headwater streams make up 65% of assessed stream length in the SFK, NFK, and UTC watersheds (Table 3-1). Thus, these headwater streams—and their associated headwater wetlands—are key habitat features in this region. These headwater systems provide high-quality habitat for numerous fish species and supply water, invertebrates, organic matter, and other resources to larger downstream waters. Because of their crucial influence on downstream water flow, chemistry, and biota, the importance of headwater systems reverberates throughout entire watersheds downstream (Freeman et al. 2007, Meyer et al. 2007).

Headwater streams and spring (headwater) wetland habitats are particularly important in establishing and maintaining fish diversity. These habitats support assemblages that include both resident and migrant fish, and 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 2005). 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). For example, headwater streams in southeastern Alaska can be an important source area for downstream Dolly Varden populations (Bryant et al. 2004). In the Nushagak and Kvichak River watersheds, 96% of 108 surveyed headwater streams contained fish, 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).

Fish distribution in southwestern Alaska headwater systems is likely most extensive in late summer and early fall (Elliott and Finn 1983). This coincides with maximum growth periods for rearing juvenile salmon, as both stream temperatures and food availability increase (Quinn 2005). 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 main stream 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 fish in the SFK, NFK, and UTC watersheds given the relatively cold temperatures and long winters in the region. 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, which makes them 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, 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.

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%—because of their shallow depths and narrow widths (Collen and Gibson 2001, Pollock et al. 2003). Beaver ponds provide important and relatively 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).

The lateral expansion of floodplain wetland habitats during flooding greatly influences habitat connectivity by determining whether and how long fish 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 fish 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 fish 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). 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 (e.g., 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). This is particularly true in dendritic stream networks like the SFK, NFK, and UTC systems, which have a high density of headwater streams. Because of their narrow width, headwater streams receive proportionally greater inputs of organic material from the surrounding terrestrial vegetation than larger stream channels (Vannote et al. 1980). This material is either used locally (Tank et al. 2010) or transported downstream to larger streams in the network (Wipfli et al. 2007).

Invertebrates and detritus are exported from headwater streams to downstream reaches, providing 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).

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; 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 summary, headwater streams and wetlands play a vital role in maintaining diverse, abundant fish populations—both by providing high-quality fish habitat themselves and by supplying energy and other resources needed to support fish in connected downstream habitats. Headwater streams and wetlands are abundant in the Pebble deposit area and likely 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 importance of commercial, subsistence, and recreational fisheries in the region; and the ecological importance of these fish populations, in terms of providing nutrient subsidies and maintaining biological complexity and diversity at both local and global scales. As this section illustrates, this region supports a robust, diverse fish assemblage of considerable ecological, economic, and cultural value, and loss of these fisheries 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 (at least 17 of which have been documented to occur in the SFK, NFK, and UTC watersheds[22]), as well as information

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[22] Fish surveys typically have captured juvenile lampreys and there is no simple morphological method to distinguish juvenile Arctic and Alaskan brook lampreys, so the Alaska Freshwater Fish Inventory (AFFI) (ADF&G

on their migratory patterns and general abundance, habitat types, and predator-prey relationships, are listed in Table 3-3. 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 Schwanke 2009). These resources generate significant benefit for commercial fishers (Section 3.3.3), provide nutritional and cultural sustenance for Alaska Native populations and other residents (Section 3.3.4), and support valued recreational fisheries (Section 3.3.5).

Five species of Pacific salmon spawn and rear in the Bristol Bay watershed's freshwater habitats: coho or silver (*Oncorhynchus kisutch*), Chinook or king (*O. tshawytscha*), sockeye or red (*O. nerka*), chum or dog (*O. keta*), and pink or humpback (*O. gorbuscha*). Because no hatchery fish are raised or released in the watershed, Bristol Bay's salmon populations are entirely wild.

All five salmon species share a trio of 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 return to their natal freshwater habitats to spawn. This homing behavior fosters reproductive isolation, thereby enabling populations to adapt to the particular environmental conditions of their natal habitats (Blair et al. 1993, Dittman and Quinn 1996, Ramstad et al. 2010, Eliason et al. 2011) (Section 3.3.6.2). Finally, each species is semelparous: adults die after spawning a single time, thereby depositing the nutrients incorporated into their bodies in their spawning habitats (Section 3.3.6.1).

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. 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, ponds, and lakes (Table 3-4). 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 2005). Sockeye are unique among the species, in that most populations rely on lakes as the primary freshwater rearing habitat (Table 3-4).

2012) records observations collectively as "Arctic-Alaskan brook lamprey paired species." The species total for the SFK, NFK, and UTC watersheds reflects this pairing.

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 commercial, subsistence, or recreational fisheries. This list does not include primarily marine species that periodically venture into the lower reaches of coastal streams. See Appendix B, Table 1 in EPA (2014) for references and additional information on the abundance and life history of each species.

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 fish (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 fish (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 fish (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	-

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 commercial, subsistence, or recreational fisheries. This list does not include primarily marine species that periodically venture into the lower reaches of coastal streams. See Appendix B, Table 1 in EPA (2014) for references and additional information on the abundance and life history of each species.

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 fish; 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 fish (threespine stickleback, sculpin) Eaten by other fish (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 fish (least cisco, salmon, Arctic grayling, many others) when large Eaten by other fish (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	

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 commercial, subsistence, or recreational fisheries. This list does not include primarily marine species that periodically venture into the lower reaches of coastal streams. See Appendix B, Table 1 in EPA (2014) for references and additional information on the abundance and life history of each species.

Family	Species	Migratory Pattern(s)[a]	Relative Abundance	Predator–Prey Relationships[b]
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 fish when large (salmon, Arctic char, lake trout, many others)
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 fish (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 fish (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 fish when large (least cisco, lake trout, sculpin, round whitefish) Eaten by other fish (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 fish (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 fish (salmon fry, burbot, humpback whitefish, northern pike, others)
	Slimy sculpin *(C. cognatus)*	N		

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 commercial, subsistence, or recreational fisheries. This list does not include primarily marine species that periodically venture into the lower reaches of coastal streams. See Appendix B, Table 1 in EPA (2014) for references and additional information on the abundance and life history of each species.

Family	Species	Migratory Pattern(s)[a]	Relative Abundance	Predator–Prey Relationships[b]

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 time in fresh water is limited (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 for these two species, which are the most commonly encountered life stages in these watersheds, are indistinguishable. We note that both species are present in the watershed, but it is possible that all documented occurrences are for one of this 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.

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 are more dependent on upstream freshwater resources than chum and pink salmon.

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	3,670
Chinook	1+	Headwater streams to large-sized mainstem rivers	2–4	Moderate-sized streams to large rivers	2,980
Sockeye	0–3	Lakes, rivers	2–3	Beaches of lakes, streams connected to lakes, larger braided rivers	2,860
Chum	0	Limited	2–4	Moderate-sized streams and rivers	2,110
Pink	0	Limited	1+	Moderate-sized streams and rivers	1,370

Notes:
Data compiled from EPA 2014: Appendix A.

In addition to the five Pacific salmon species, the Bristol Bay region is home to at least 24 other 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 (*O. mykiss*)[23], Dolly Varden (*Salvelinus malma*), Arctic char (*S. alpinus*), Arctic grayling (*Thymallus arcticus*), humpback whitefish (*Coregonus pidschian*), northern pike (*Esox lucius*), and lake trout (*S. namaycush*), 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, from headwater streams to rivers and lakes.

Given the importance of rainbow trout, Dolly Varden, and northern pike to both subsistence and sport fisheries (Sections 3.3.4 and 3.3.5), 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, versus summer and early fall for salmon. Juveniles emerge from spawning gravels in summer (Johnson et al. 1994, ADF&G 2012), and immature fish may remain in their natal streams for several years before migrating to other habitats (Russell 1977).

[23] 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.

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 fish 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 water bodies (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). 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 2012). Because Dolly Varden occur in headwater lakes and high-gradient headwater streams (ADF&G 2012)—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.

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; they 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 to occur 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 are well-known predators of salmon eggs and emergent fry, and northern pike can be effective predators of juvenile salmon and other fish species (Russell 1980, Sepulveda et al. 2013). Insectivorous and planktivorous fishes may compete with juvenile salmonids for food (e.g., Hartman and Burgner 1972). Thus, significant impacts on any one fish species could affect the entire assemblage.

3.3.2 Distribution and Abundance

As the preceding section 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 commercial, subsistence, and recreational fisheries (Sections 3.3.3 through 3.3.5). These fishes use a diversity of freshwater habitats throughout their life cycles. Fish populations across the Bristol Bay watershed have not been sampled comprehensively; thus, estimates of total distribution and abundance across the region are not available. However, available data[24] provide at least minimum estimates of where key species are found and how many individuals of those species have been caught.[25] More information on the distribution and abundance of key fish species can be found in Appendices A and B of the BBA (EPA 2014).

3.3.2.1 Nushagak and Kvichak River Watersheds

Most (63%) 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, and 12% are documented to contain all five species (Figure 3-1). Reported distributions for each salmon species in the Nushagak and Kvichak River watersheds are shown in Figures 3-2 through 3-6.

Coho salmon spawn and rear in many stream reaches throughout the Nushagak and Kvichak River watersheds (Figure 3-2). 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 (Figure 3-3). Although Chinook is the least common salmon species across the Bristol Bay region, the Nushagak River watershed supports a large Chinook salmon fishery (Section 3.3.3). Chinook salmon returns to the Nushagak River are consistently greater than 100,000 fish per year and

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[24] Notable sources of data include the Anadromous Waters Catalog (AWC) (Johnson and Blanche 2012), the Alaska Freshwater Fish Inventory (AFFI) (ADF&G 2012), 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).

[25] AWC stream reach designations and AFFI observation points should be interpreted with care, because not all streams could be sampled and there are potential errors associated with fish identification and mapping. See Section 7.2.5 of the BBA (EPA 2014) for additional information on the interpretation of available fish distribution data.

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 runs.

Sockeye is by far the most abundant salmon species in the Bristol Bay watershed (Salomone et al. 2011).[26] Sockeye returns to the Kvichak River, including the Alagnak River, averaged 12.1 million fish between 1963 and 2011 (Cunningham et al. 2012). Kvichak River sockeye runs have exceeded 30 million fish three times since 1956 (Cunningham et al. 2012). Tributaries to Iliamna Lake, Lake Clark, and, in the Nushagak River watershed, the Wood-Tikchik Lakes are major sockeye spawning areas, and juveniles rear in each of these lakes (Figure 3-4). Iliamna Lake provides the majority of sockeye 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 (Figure 3-4).

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 (Figures 3-5 and 3-6), but do not have extended freshwater rearing stages.

Extensive sampling for rainbow trout, Dolly Varden, northern pike, and other fish has not been conducted throughout the Bristol Bay region, so total distributions and abundances are unknown. Figure 3-7 shows the reported occurrence of rainbow trout and Dolly Varden throughout the Nushagak and Kvichak River watersheds and provides minimum estimates of their extents.

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

Summer fish distributions in the SFK, NFK, and UTC watersheds have been sampled over several years. The catalogued distributions of the five Pacific salmon species (coho, Chinook, sockeye, chum, and pink), resident rainbow trout, and Dolly Varden (both anadromous and non-anadromous forms are present) in these watersheds are shown in Figures 3-8 through 3-13. In addition, Arctic-Alaskan brook lamprey, northern pike, humpback whitefish, least cisco, round whitefish, Arctic grayling, burbot, threespine stickleback, ninespine stickleback, and slimy sculpin occur in these watersheds (Table 3-5) (ADF&G 2013). 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 the BBA (EPA 2014).

Of the 674 miles (1,085 km) of stream that have been mapped in the SFK, NFK, and UTC watersheds, 200 miles (322 km) or 30% have been documented to contain anadromous fish (Table 3-6). 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 3-8). Chinook and sockeye salmon have been documented throughout mainstem reaches of the three watersheds, as

[26] Bristol Bay is home to the largest sockeye salmon fishery in the world, with 46% of the average global abundance of wild sockeye salmon between 1956 and 2005 (Ruggerone et al. 2010, EPA 2014: Figure 5-9A). Between 1990 and 2009, the average annual inshore run of sockeye salmon in Bristol Bay was approximately 37.5 million fish (ranging from a low of 16.8 million in 2002 to a high of 60.7 million in 1995) (Salomone et al. 2011).

well as several tributaries (Figures 3-9 and 3-10). 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 3-11 and 3-12). Rainbow trout have been collected at many mainstem and several tributary locations, especially in UTC (Figure 3-13). Dolly Varden are found throughout the three watersheds, and fish surveys indicate that they are commonly found in the smallest streams (i.e., first-order tributaries) (Figure 3-13).

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	184
Sockeye salmon	102
Chum salmon	7
Rainbow trout	111
Dolly Varden[c]	682
Arctic grayling	201
Arctic-Alaskan brook lamprey[d]	4
Northern pike	74
Burbot	2
Threespine stickleback	32
Ninespine stickleback	67
Slimy sculpin	533

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, since it based only on the Alaska Freshwater Fish Inventory; for example, pink salmon are only listed in the Anadromous Waters Catalog (Johnson and Blanche 2012).

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

[c] Listed as Arctic char in some cases, but assumed to be Dolly Varden (EPA 2014: Appendix B).

[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.

Source: Alaska Freshwater Fish Inventory (ADF&G 2013).

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]	196	213	265	674
Total anadromous fish streams[b]	59	64	76	200
By species				
Chinook salmon	37	38	39	114
Chum salmon	23	19	28	70
Coho salmon	58	64	76	198
Pink salmon	0	0	4	4
Sockeye salmon	40	29	50	119
Dolly Varden[c]	30	0	16	47

Notes:
[a] From the National Hydrography Dataset (USGS 2012).
[b] From the Anadromous Waters Catalog (Johnson and Blanche 2012).
[c] Listed as Arctic char in some cases, but assumed to be Dolly Varden (EPA 2014: Appendix B).

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 (Johnson and Blanche 2012), are summed by 12 digit hydrologic unit codes.

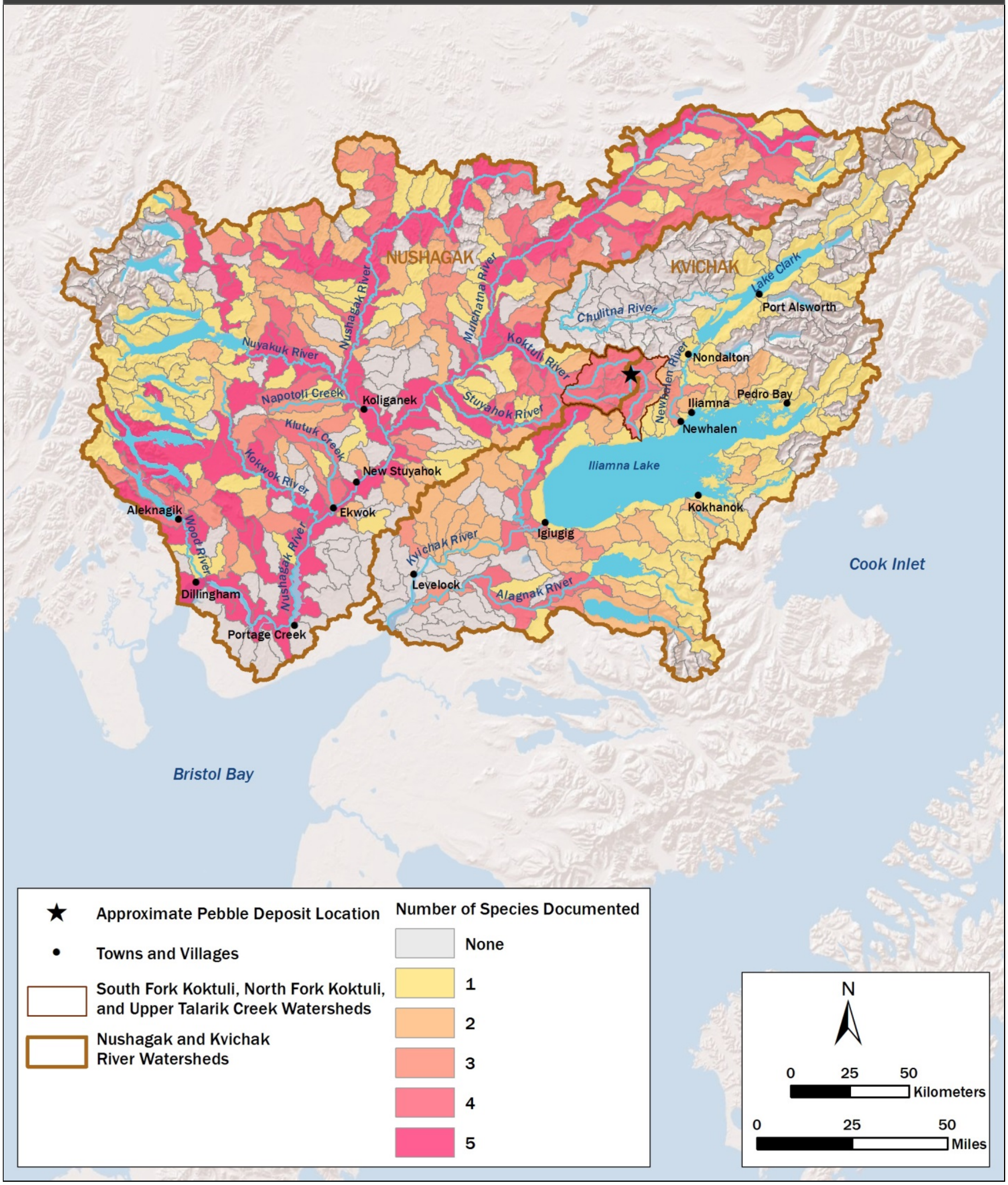


Figure 3 2. Reported coho salmon distribution in the Nushagak and Kvichak River watersheds. "Present" indicates species was present but life stage use was not determined; "spawning" indicates spawning adults were observed; "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Life stage specific reach designations are likely underestimates, given the challenges inherent in surveying all streams that may support life stage use throughout the year.

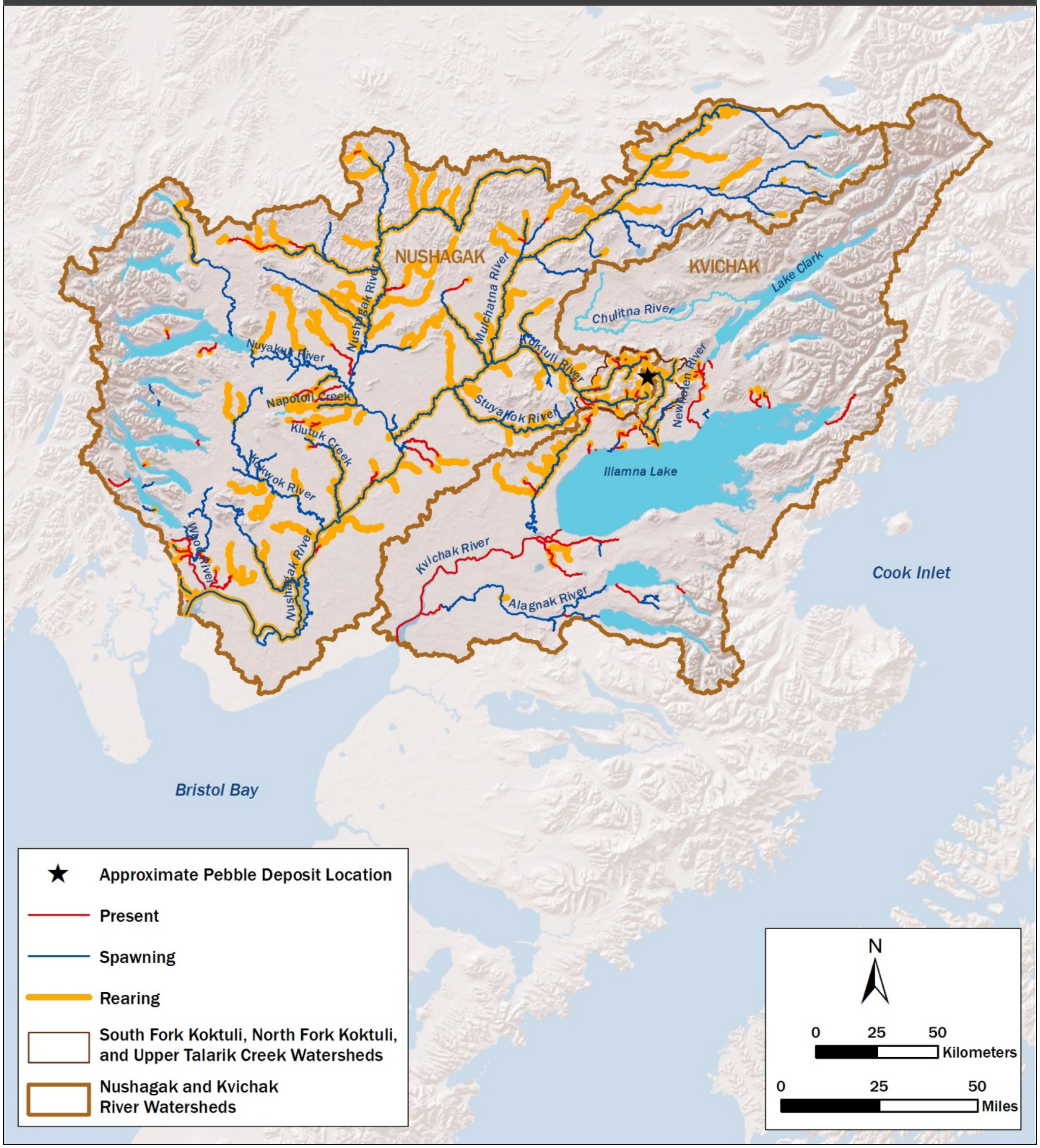


Figure 3 3. Reported Chinook salmon distribution in the Nushagak and Kvichak River watersheds. "Present" indicates species was present but life stage use was not determined; "spawning" indicates spawning adults were observed; "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Life stage specific reach designations are likely underestimates, given the challenges inherent in surveying all streams that may support life stage use throughout the year.

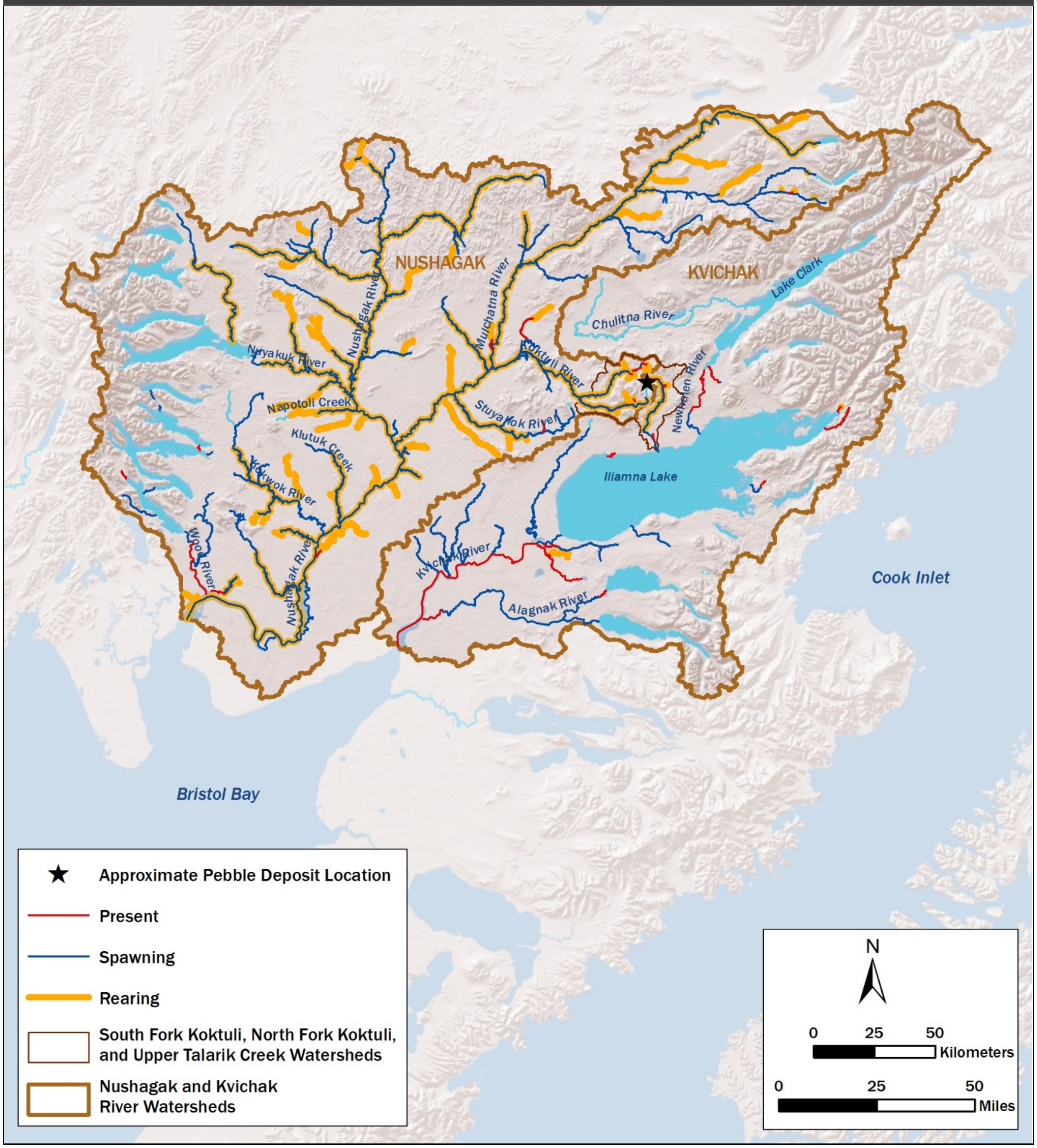


Figure 3 4. Reported sockeye salmon distribution in the Nushagak and Kvichak River watersheds. "Present" indicates species was present but life stage use was not determined; "spawning" indicates spawning adults were observed; "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Life stage specific reach designations are likely underestimates, given the challenges inherent in surveying all streams that may support life stage use throughout the year.

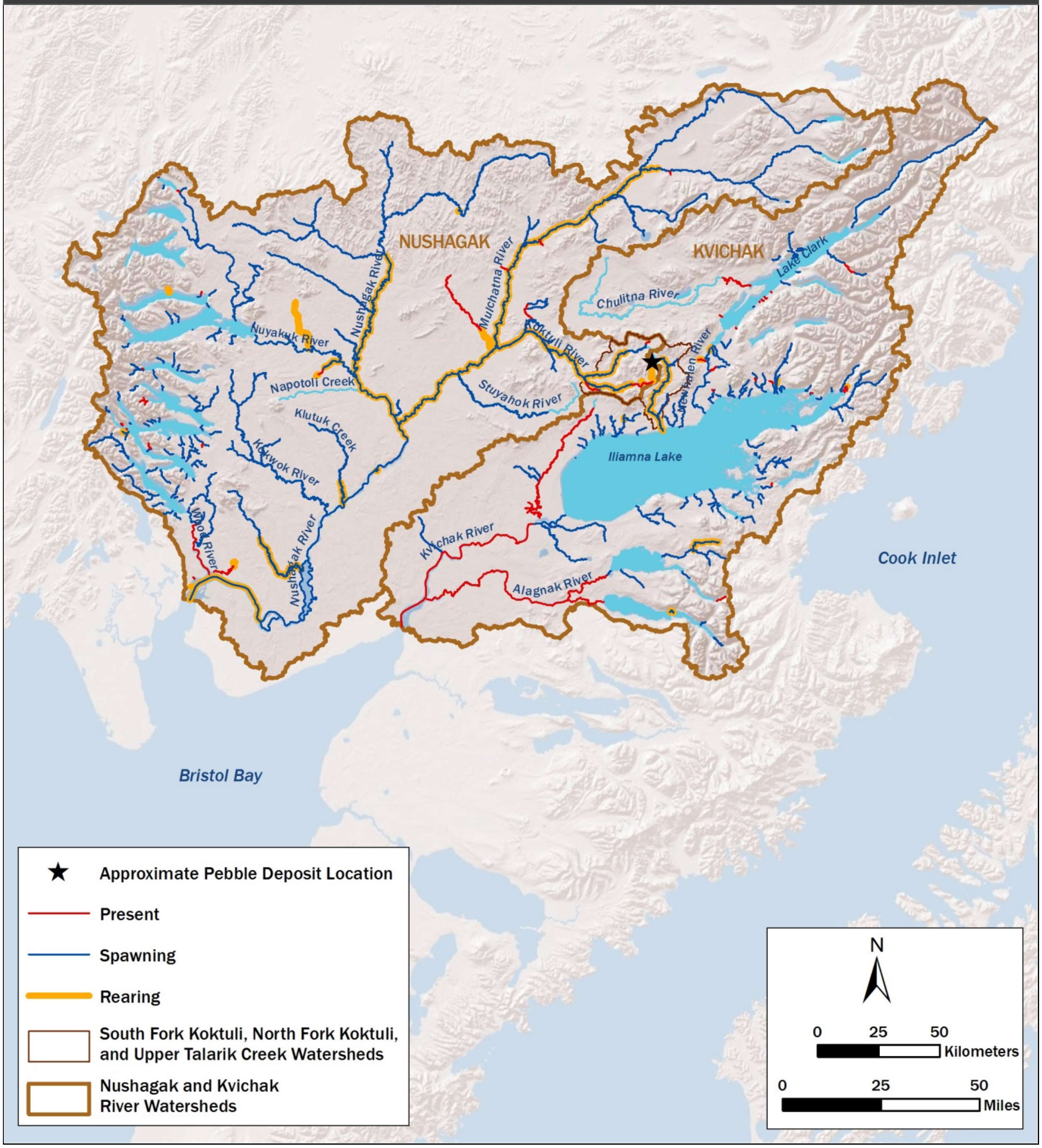


Figure 3 5. Reported chum salmon distribution in the Nushagak and Kvichak River watersheds. "Present" indicates species was present but life stage use was not determined; "spawning" indicates spawning adults were observed; "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Life stage specific reach designations are likely underestimates, given the challenges inherent in surveying all streams that may support life stage use throughout the year.

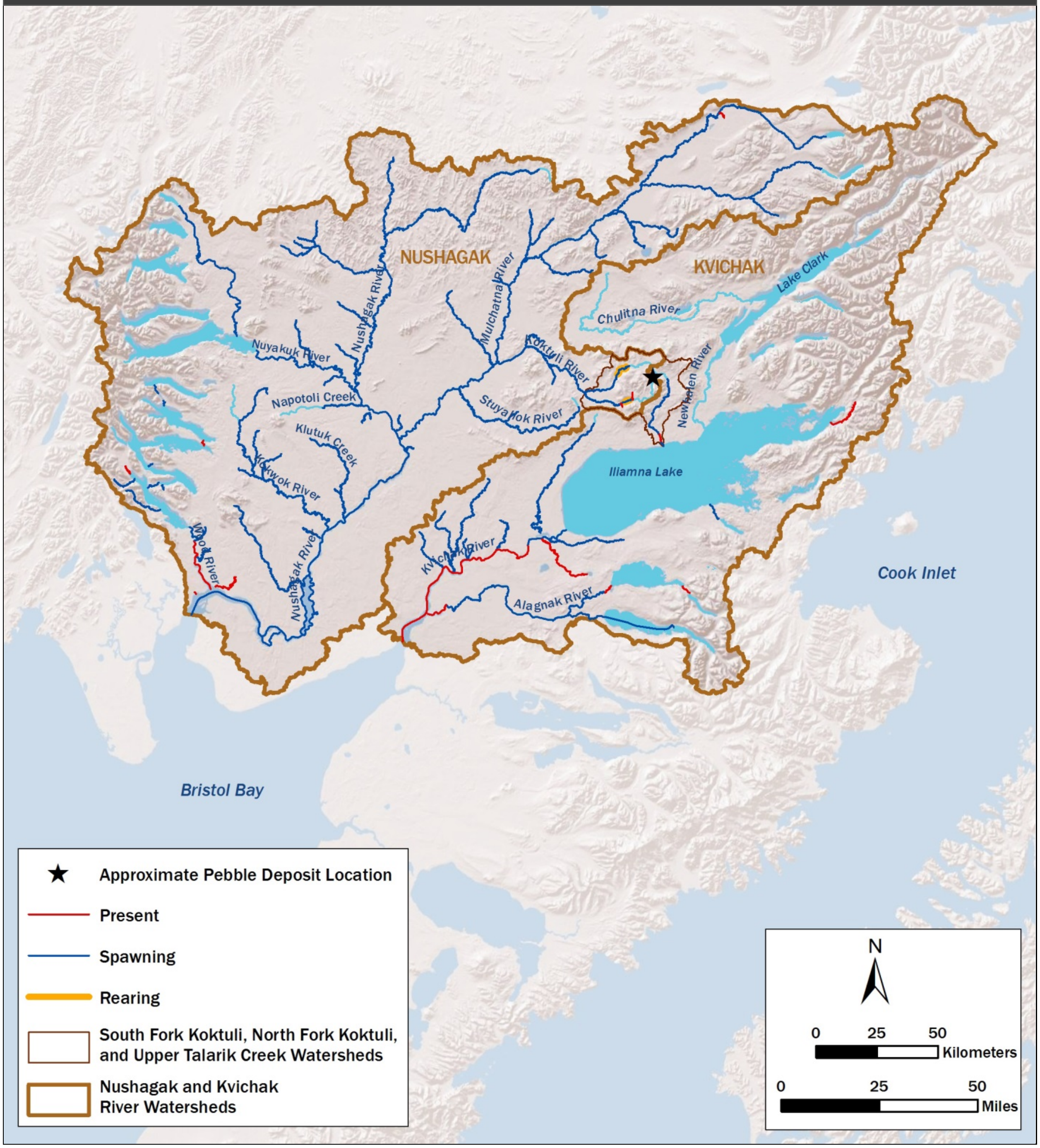


Figure 3 6. Reported pink salmon distribution in the Nushagak and Kvichak River watersheds. "Present" indicates species was present but life stage use was not determined; "spawning" indicates spawning adults were observed. Present and spawning designations are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Life stage specific reach designations are likely underestimates, given the challenges inherent in surveying all streams that may support life stage use throughout the year.

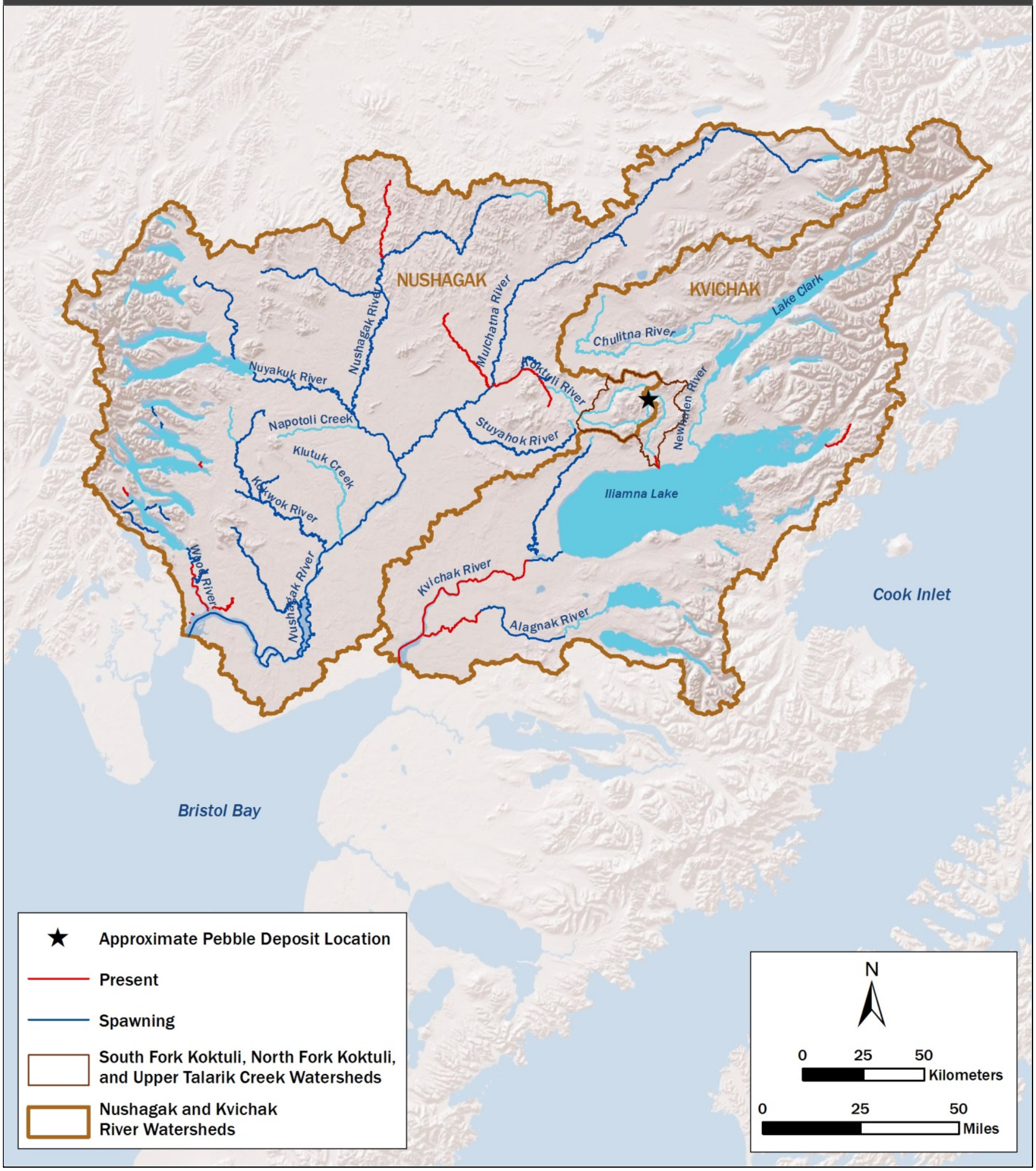


Figure 3 7. Reported rainbow trout and Dolly Varden occurrence in the Nushagak and Kvichak River watersheds. Designation of species presence is based on the Alaska Freshwater Fish Inventory (point data, ADF&G 2012) and the Anadromous Waters Catalog (line data, Johnson and Blanche 2012). Note that points shown on land actually occur in smaller streams not shown on this map, and that species absence cannot be inferred from this map.

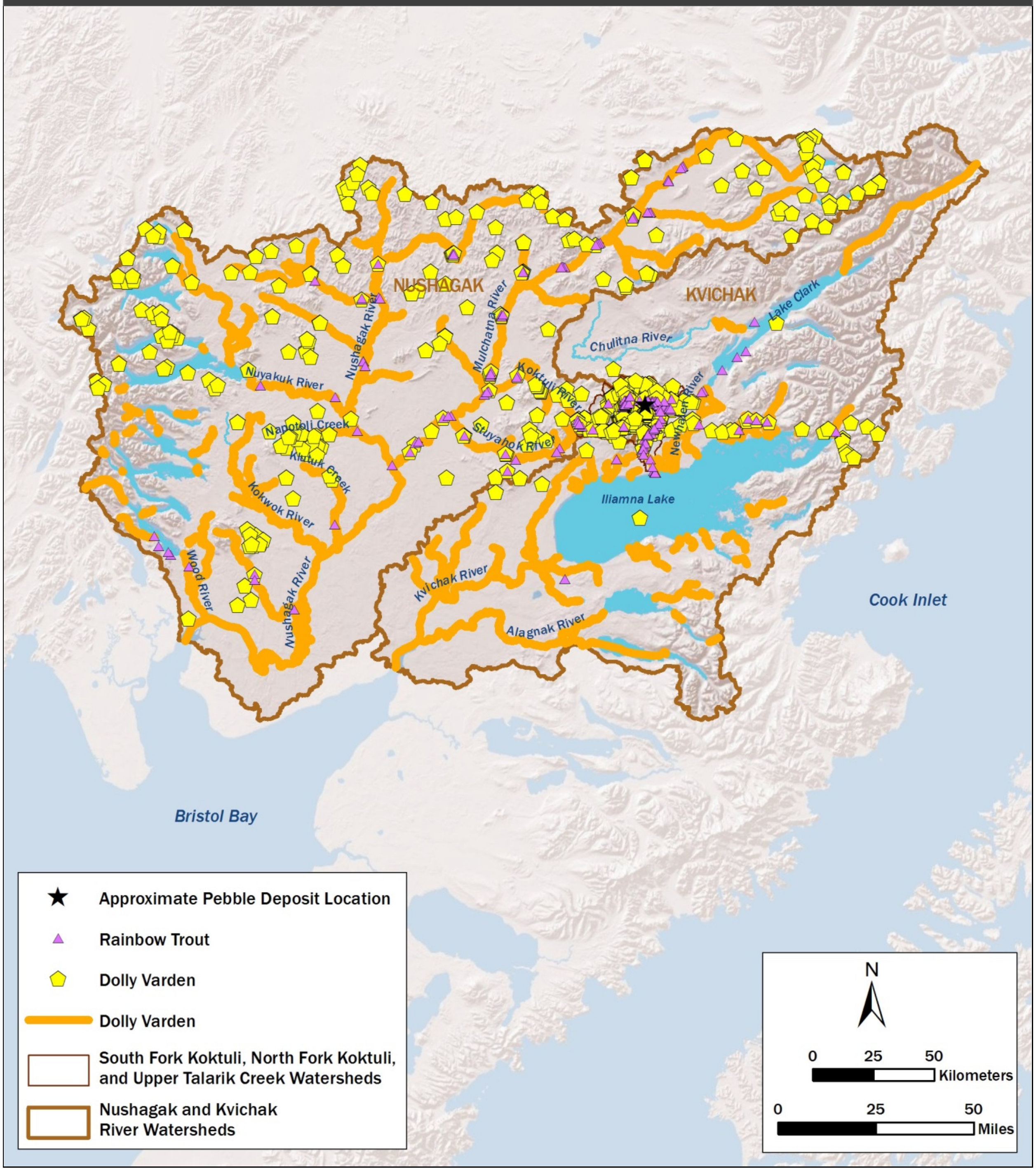


Figure 3 8. Reported coho salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. "Present" indicates species was present but life stage use was not determined; "spawning" indicates spawning adults were observed; "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Life stage specific reach designations are likely underestimates, given the challenges inherent in surveying all streams that may support life stage use throughout the year.

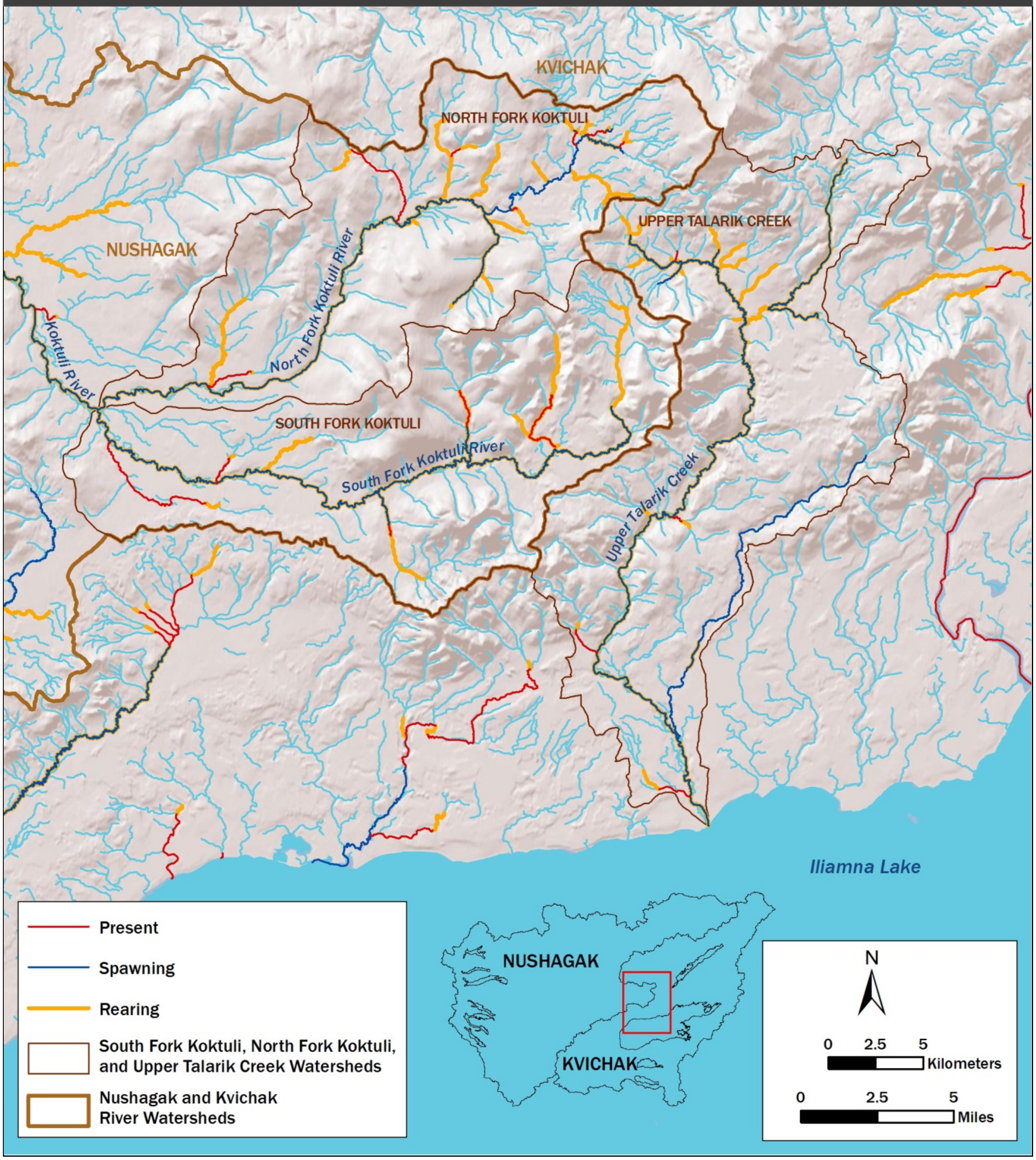


Figure 3 9. Reported Chinook salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. "Present" indicates species was present but life stage use was not determined; "spawning" indicates spawning adults were observed; "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Life stage specific reach designations are likely underestimates, given the challenges inherent in surveying all streams that may support life stage use throughout the year.

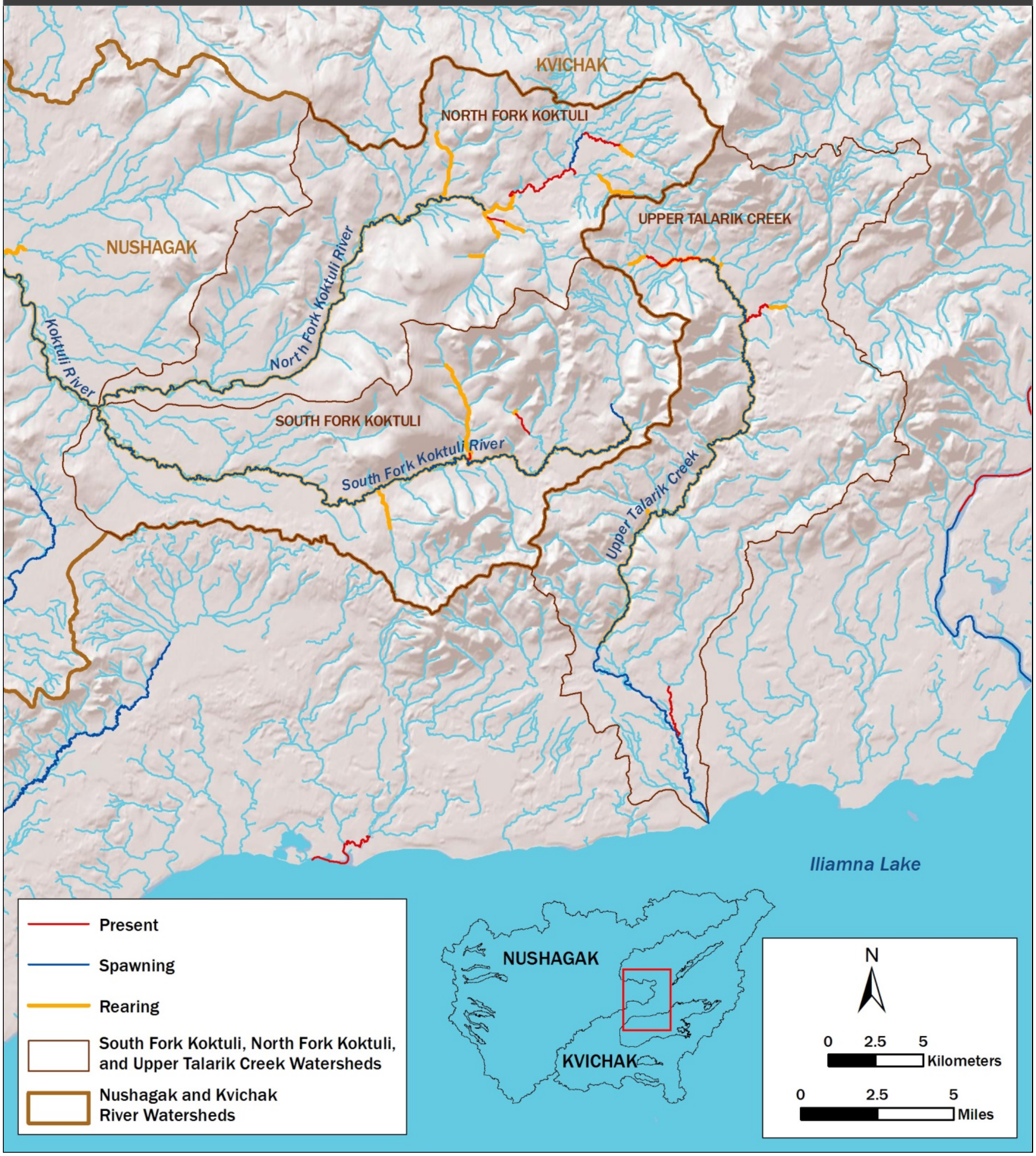


Figure 3 10. Reported sockeye salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. "Present" indicates species was present but life stage use was not determined; "spawning" indicates spawning adults were observed; "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Life stage specific reach designations are likely underestimates, given the challenges inherent in surveying all streams that may support life stage use throughout the year.

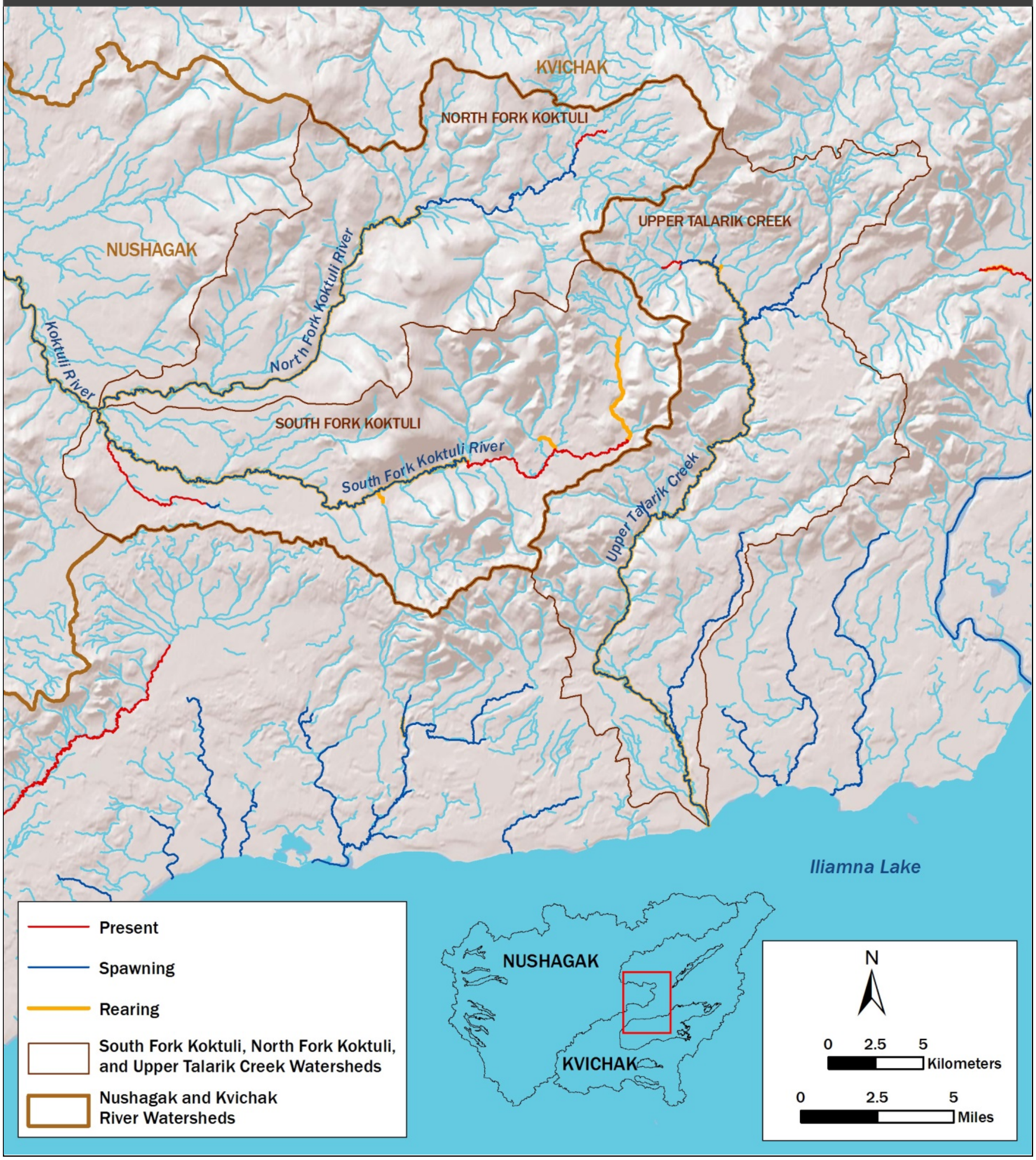


Figure 3 11. Reported chum salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. "Present" indicates species was present but life stage use was not determined; "spawning" indicates spawning adults were observed; "rearing" indicates juveniles were observed. Present, spawning, and rearing designations are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Life stage specific reach designations are likely underestimates, given the challenges inherent in surveying all streams that may support life stage use throughout the year.

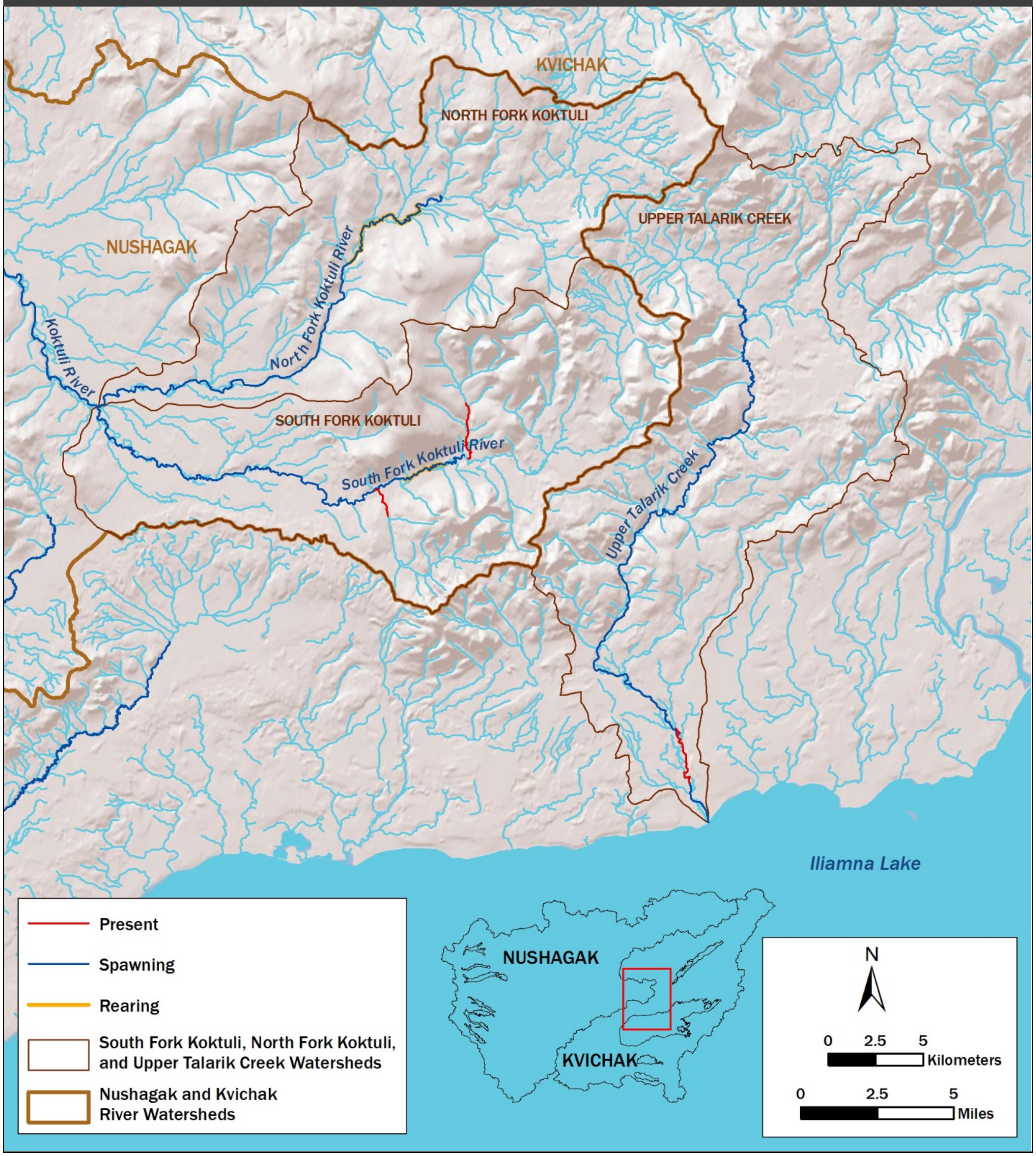


Figure 3 12. Reported pink salmon distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. "Present" indicates species was present but life stage use was not determined; "spawning" indicates spawning adults were observed. Present and spawning designations are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Life stage specific reach designations are likely underestimates, given the challenges inherent in surveying all streams that may support life stage use throughout the year.

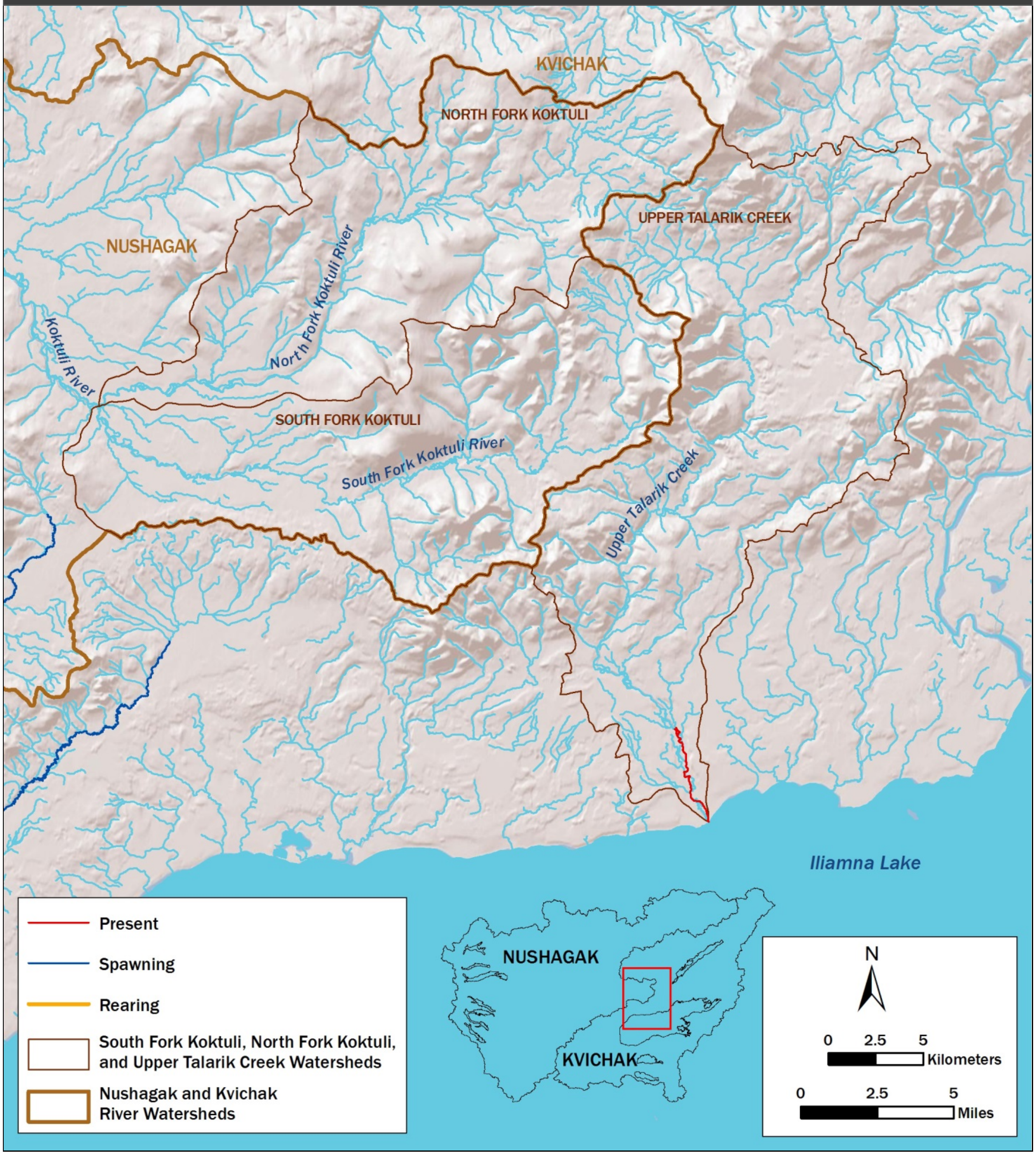
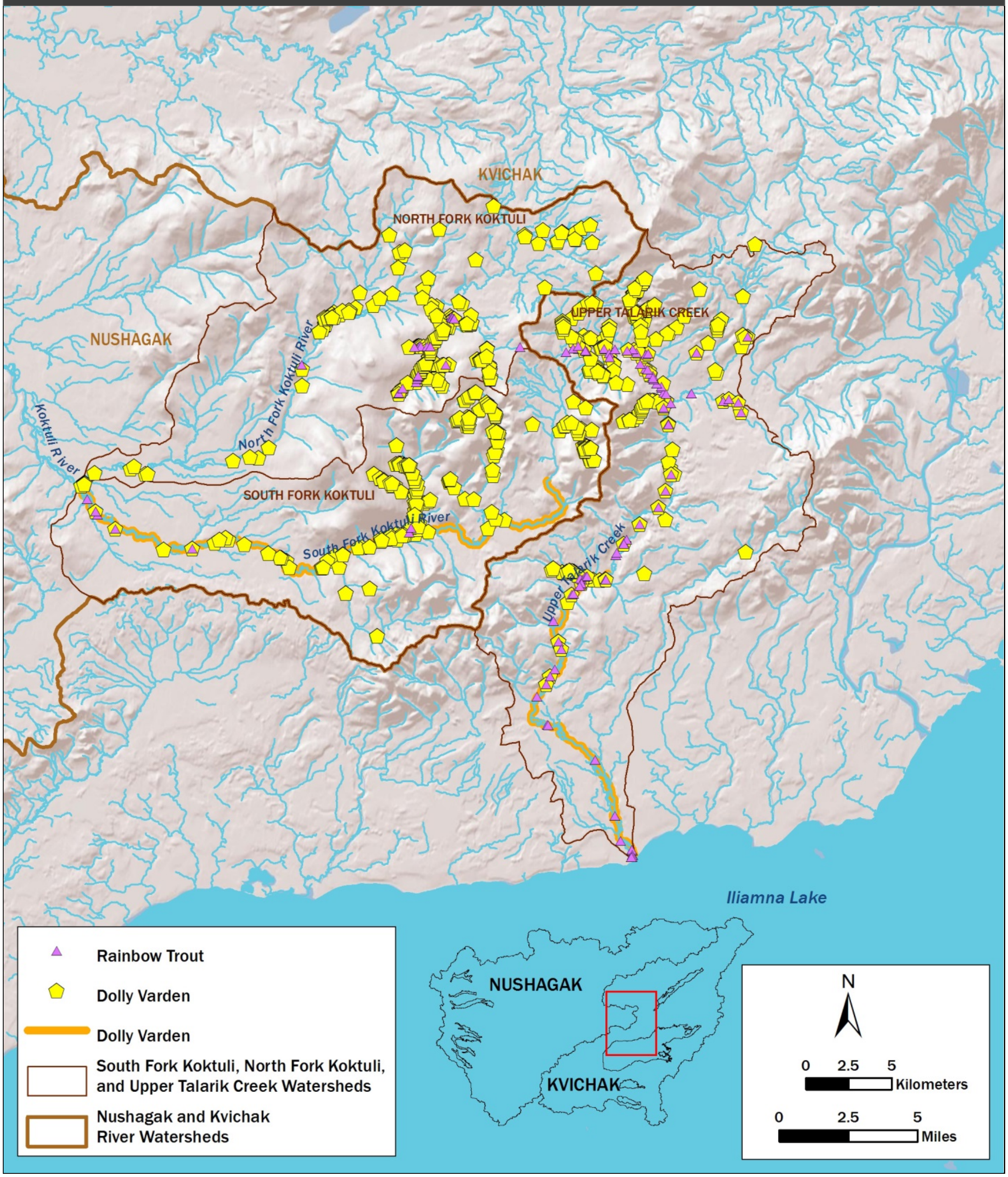


Figure 3 13. Reported rainbow trout and Dolly Varden occurrence in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds. Designation of species presence is based on the Alaska Freshwater Fish Inventory (point data, ADF&G 2012) and the Anadromous Waters Catalog (line data, Johnson and Blanche 2012). Note that species absence cannot be inferred from this map.



Index estimates of relative spawning salmon abundance in the SFK, NFK, and UTC watersheds are available for sockeye, coho, Chinook, and chum salmon. Aerial index counts of spawning salmon are available from ADF&G and PLP. This type of survey is used primarily to track variation in run size over time. Survey values tend to underestimate true abundance for several reasons. An observer in an aircraft is not able to count all fish in dense aggregations or those concealed under overhanging vegetation or undercut banks, and only a fraction of the fish that spawn at a given site are present at any one time (Bue et al. 1988, 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% of the pink salmon counted by surveyors walking the same Prince William Sound spawning streams (Bue et al. 1988). Peak aerial counts of pink salmon in southeastern Alaska are routinely multiplied by 2.5 to represent more accurately the number of fish 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% of the fish 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).

PLP (2011) 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 highest of each year's index counts for each population, approximated from figures in PLP (2011: Chapter 15). 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. 1988), but the spawning season can extend for weeks to months in the SFK, NFK, and UTC watersheds (PLP 2011). 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 and Tributary 1.60 in 2008, when approximately 82,000 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 watersheds for each year, 2004 to 2008.

Watershed	Salmon Species	Highest Index Spawner Count Per Year (Number Of Counts)[a]				
		2004	2005	2006	2007	2008
South Fork Koktuli River	Chinook	2,750 (3)	1,500 (4)	250 (5)	300 (8)	500 (9)
	Chum	(0)	350 (4)	850 (7)	200 (11)	950 (7)
	Coho	250 (2)	550 (4)	1,375 (3)	250 (10)	1,875 (20)
	Sockeye	1,400 (2)	2,000 (5)	2,700 (8)	4,000 (11)	6,000 (13)
North Fork Koktuli River	Chinook	2,800 (3)	2,900 (4)	750 (4)	600 (8)	500 (8)
	Chum	400 (1)	350 (4)	750 (4)	800 (9)	1,400 (7)
	Coho	300 (3)	350 (1)	1,050 (4)	125 (8)	1,700 (15)
	Sockeye	550 (2)	1,100 (5)	1,400 (7)	2,200 (10)	2,000 (12)
Upper Talarik Creek	Chinook	275 (2)	100 (3)	80 (3)	150 (9)	100 (8)
	Chum	(0)	3 (1)	13 (2)	8 (8)	18 (5)
	Coho	3,000 (4)	(0)	6,300 (3)	4,400 (9)	6,300 (14)[b]
	Sockeye	33,000 (2)	15,000 (4)	10,000 (6)	10,000 (14)	82,000 (14)[b]

Notes:
[a] Values likely underestimate true spawner abundance (see EPA 2014: Chapter 7 for additional details).
[b] Tributary 1.60, a major tributary of Upper Talarik Creek, was observed to support high densities of coho and sockeye salmon in 2008 (PLP 2011) and was included in this count.
Source: PLP 2011.

PLP (2011) reports counts of juvenile salmon and other salmonids in the SFK, NFK, and UTC based on extensive sampling efforts from 2004 through 2008.[27] Reported fish densities summarized over the 5-year period vary widely by stream, sample reach, and habitat type (PLP 2011: Figures 15.1-23, 15.1-52, and 15.1-82). Species that attain densities of several hundred per 328-foot (100-m) reach in one setting were often absent or sparse in other habitat types or reaches in the same stream, which is typical for fish in heterogeneous stream environments. Table 3-8 presents maximum fish densities in the mainstem SFK, NFK, and UTC, approximated from figures in PLP (2011), for species that rear for extended periods in the surveyed streams and for which data are available (Chinook and coho salmon, Arctic grayling, and Dolly Varden). Maximum density is reported to give a sense of the magnitude attained in the surveyed streams, but it should be stressed that abundance varied widely by stream reach and habitat type within a given stream (PLP 2011: Figures 15.1-23, 15.1-52, and 15.1-82). Highest reported densities were approximately 1,600 coho salmon and 2,500 Arctic grayling per 100 m from adjacent reaches in UTC, and 1,400 coho salmon per 100 m from a reach on the NFK.

[27] Snorkel surveys were the primary data collection method, but electrofishing, minnow traps, beach seines, gill nets, angling, and dip netting were used in certain situations. Raw field counts were frequently expressed as densities (count per 100-m reach was the only unit reported for all three streams). These counts should not be viewed as quantitative abundance estimates, as they are very likely underestimates because of the extreme difficulty of observing or capturing all fish in complex habitats (Hillman et al. 1992).

Table 3-8. Highest index counts of selected stream rearing fish species from mainstem habitats of the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek.

	Highest Reported Density (count per 100 m)[a]				
Stream	Chinook Salmon	Coho Salmon	Arctic Grayling	Dolly Varden	Source
South Fork Koktuli River	450	600	275	55	Figure 15.1-52 (PLP 2011)
North Fork Koktuli River	500	1,400	40	40	Figure 15.1-23 (PLP 2011)
Upper Talarik Creek	400	1,600	2,500	10	Figure 15.1-82 (PLP 2011)

Notes:
[a] Values were approximated from figures listed in the source column.

3.3.3 Commercial Fisheries

All five species of Pacific salmon are commercially harvested in Bristol Bay, in five fishing districts identified by specific rivers draining to the bay (Table 3-9). Sockeye salmon dominate the region's salmon runs and harvest by a large margin (Table 3-9) (Salomone et al. 2011). Bristol Bay is home to the largest sockeye salmon fishery in the world, with 46% of the average global abundance of wild sockeye salmon between 1956 and 2005 (Ruggerone et al. 2010). Between 1990 and 2009, annual commercial harvest of sockeye over this period averaged 25.7 million fish (Table 3-9) (Salomone et al. 2011). More than half of the Bristol Bay watershed's sockeye salmon harvest comes from the Nushagak and Kvichak River watersheds (EPA 2014: Figure 5-9B).

Although Chinook is the least common salmon species across the Bristol Bay region, the Nushagak River watershed supports a large Chinook salmon fishery and its commercial harvests are greater than those of all other Bristol Bay river systems combined (Table 3-9). Between 1990 and 2009, on average 80% of Bristol Bay's commercial Chinook salmon harvest came from the Nushagak fishing district (Table 3-9). Chinook 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 at or near the size of the world's largest Chinook runs, which is notable given the Nushagak River's small watershed area compared to other Chinook-producing rivers (EPA 2014: Chapter 5). The Nushagak River watershed also supports 33% of commercial coho harvests in the region (Table 3-9), more than any other Bristol Bay fishing district except the Egegik (Table 3-9).

Table 3-9. Mean annual commercial harvest (number of fish) by Pacific salmon species and Bristol Bay fishing district, 1990 to 2009. 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	8,238,895 (32)	8,835,094 (34)	2,664,738 (11)	5,478,820 (21)	514,970 (2)	25,732,517
Chinook	2,816 (4)	849 (1)	1,402 (2)	52,624 (80)	8,803 (13)	66,494
Coho	4,436 (5)	27,433 (33)	10,425 (12)	27,754 (33)	14,234 (17)	84,282
Chum	184,399 (19)	78,183 (8)	70,240 (7)	493,574 (50)	158,879 (16)	985,275
Pink[b]	73,661 (43)	1,489 (1)	138 (<1)	50,448 (30)	43,446 (26)	169,182

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; harvest is negligible during odd-year runs.
Source: EPA 2014: Appendix A, Table 1.

The commercial salmon fishery currently provides the region's greatest source of economic activity. From 2000 through 2010, the annual commercial salmon catch averaged 23 million fish (170 million pounds). The average annual commercial value of all Bristol Bay salmon fisheries from 1990 to 2010 totaled $116.7 million, $114.7 million of which resulted from the sockeye harvest (Salomone et al. 2011).

In 2009, fishers received $144 million for their catch and fish processors received approximately $300 million (EPA 2014: Table 5-4, Appendix E). The commercial salmon fishery, which is largely centered in the region's salt waters rather than its freshwater streams and rivers, is closely managed for sustainability using a permit system. Approximately 26% of permit holders are Bristol Bay residents. The commercial fishery also provides significant employment opportunities, directly employing over 11,000 full- and part-time workers at the season's peak (EPA 2014: Chapter 5).

Historically, fishes other than the Pacific salmon species also have been harvested commercially in the area near the Pebble deposit. In the mid-1960s, Iliamna Lake and Lake Clark supported a commercial humpback whitefish fishery as well as a commercial winter lake trout fishery (Metsker 1967). In 1966 and 1967, humpback whitefish comprised 62% of the total number of fish harvested in a freshwater commercial fishery on Tikchik Lake (Yanagawa 1967). Tikchik Lake also supported an experimental commercial freshwater fishery during these years, in which approximately 1,500 lake trout were harvested (Yanagawa 1967).

3.3.4 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 6.2 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 4,337 in 2010 (U.S. Census Bureau 2010). Dillingham (population 2,329) is the largest community; other communities range in size from two (year-round) residents (Portage Creek) to 510 residents (New Stuyahok). Because population in some communities is seasonal, these numbers increase 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 2010. 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.

This section discusses the use of subsistence fisheries in the region and the nutritional, cultural, and spiritual importance of that use. Subsistence related to foods other than fish is discussed in Section 6.2.1.

3.3.4.1 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 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. A study that included the nearby Yukon-Kuskokwim region found that approximately 23% of calories came from subsistence foods (Johnson et al. 2009). 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).[28]

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 3-10). Salmon and other fishes provide the largest portion of subsistence harvests of Bristol Bay communities, and are harvested throughout the Nushagak and Kvichak River watersheds (Figure 3-14). On average, about 50% of the subsistence harvest by local community residents (measured in pounds usable weight) is Pacific salmon, and about 10% is other fishes (Fall et al. 2009). Since 1975, the average annual subsistence harvest has

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

been approximately 152,371 salmon (Fall et al. 2009). The percentage of salmon harvest in relation to all subsistence resources ranges from 29 to 82% in the villages (EPA 2014: Appendix D, Table 11).

Table 3 10. Harvest of subsistence fisheries resources in the Bristol Bay watershed.[a]

			Estimated Per Capita Harvest (pounds)				Households Using Salmon (%)		
Community	Year	Total Harvest (pounds)[b]	All Salmon	Sockeye Salmon	Chinook Salmon	Non-Salmon Fish	Used	Gave	Received
Aleknagik	2008	64,800	140	40	72	26	100	59	59
Dillingham	1984	564,000	140	39	53	18	88	35	44
Ekwok	1987	91,700	460	160	180	69	90	48	52
Igiugig	2005	27,100	210	170	5	59	100	83	83
Iliamna	2004	51,121	370	370	0	34	100	31	39
Kokhanok	2005	116,000	510	480	3	36	97	63	60
Koliganek	2005	188,000	560	190	190	90	100	61	54
Levelock	2005	36,400	150	86	43	40	93	36	79
New Stuyahok	2005	198,000	190	36	110	28	90	55	63
Newhalen	2004	131,000	500	490	10	32	100	64	32
Nondalton	2004	58,700	220	220	0	34	92	55	63
Pedro Bay	2004	12,900	250	250	0	15	100	72	78
Port Alsworth	2004	21,100	89	88	1	12	100	46	55

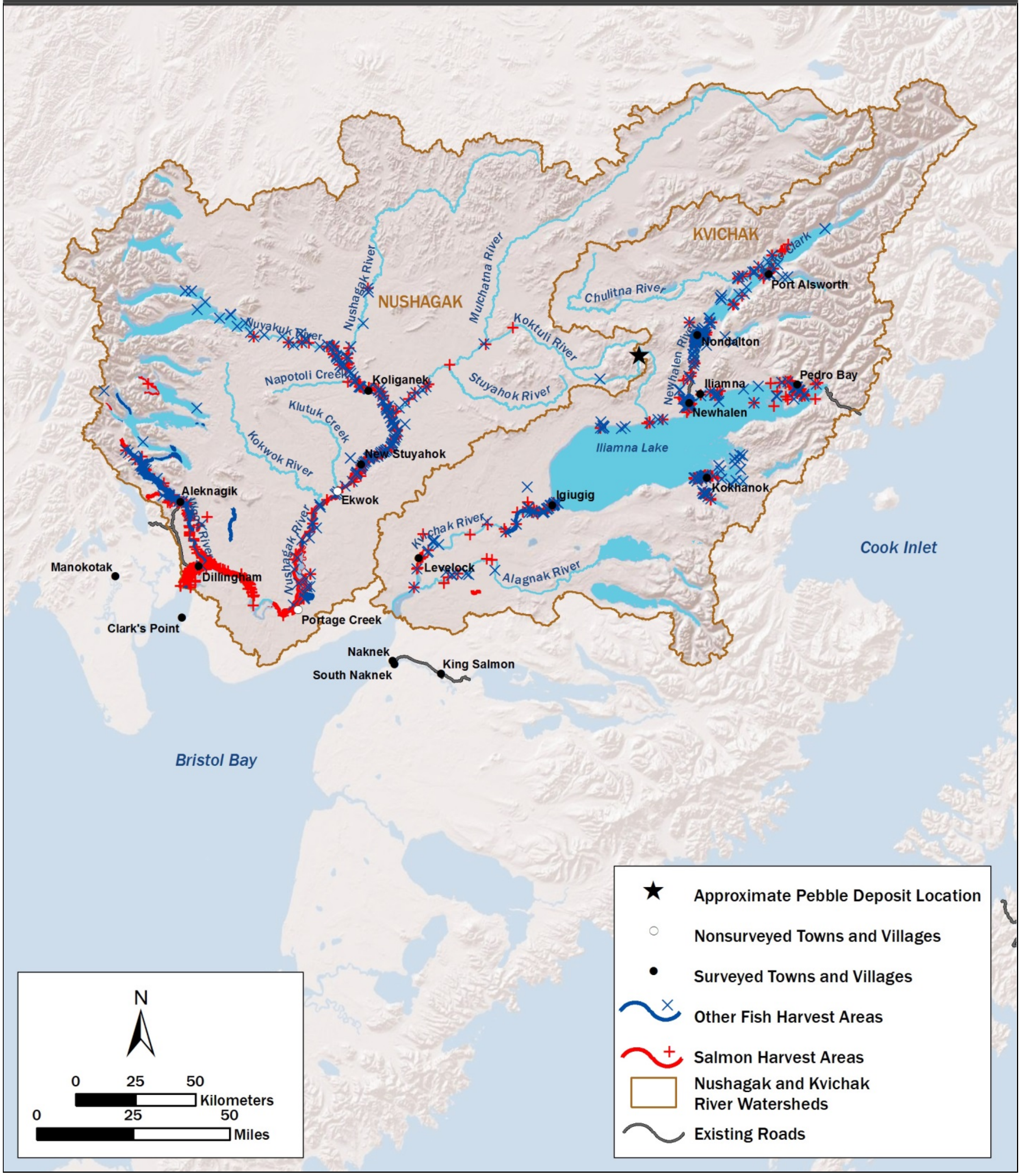
Notes:

[a] Summarized from Tables 12 and 14 in Appendix D and Table 21 in Appendix E of the BBA (EPA 2014). Data are from Fall et al. 1986, Schichnes and Chythlook 1991, Fall et al. 2006, Fall et al. 2009, Krieg et al. 2009, and Holen et al. 2012.

[b] Total harvest values include fishes, land mammals, freshwater seals, beluga, other marine mammals, plant-based foods, birds or eggs, and marine invertebrates. See Section 6.2.1 for additional information on non-fish subsistence resources.

Subsistence salmon harvests in the Nushagak and Kvichak River watersheds are similar in terms of overall harvest levels. In 2007, for example, communities in the Nushagak River watershed harvested 44,944 salmon, compared to 47,538 salmon in the Kvichak River watershed, based on permit returns (Fall et al. 2009). However, there are differences in the relative importance of different subsistence fisheries between the two watersheds (Table 3-10). For example, the 2007 subsistence salmon harvest in the Kvichak River watershed was almost all sockeye salmon (47,473 out of 47,538); in contrast, salmon harvest in the Nushagak River watershed was more varied, with larger harvests of Chinook, coho, and chum salmon (Fall et al. 2009). Villages along the Nushagak River (e.g., Ekwok, New Stuyahok) are particularly dependent on Chinook salmon as a subsistence resource (Table 3-10), in part because Chinook salmon are the first spawners to return each spring (EPA 2014: Appendix D).

Figure 3 14. Subsistence harvest and harvest effort areas for salmon and other fishes within 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 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).



All communities also rely on non-salmon fishes, including northern pike, whitefish, 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 (Fall et al. 2009). 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 fish 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%, 10 to 14%, and 7 to 10% 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). Market economy income funds goods and services purchased by households and used for subsistence activities (e.g., boats, rifles, nets, snow mobiles, and fuel). When Alaskan households spend money on subsistence-related supplies, the subsistence harvest of fish generates regional economic benefits. In total, individuals in Bristol Bay communities harvest about 2.6 million pounds of subsistence foods per year. 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). However, it is important to note that these estimates reflect only the annual economic activity generated by these activities and not the value of the subsistence resources harvested.

3.3.4.2 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% of protein, 83% of vitamin D, 37% of iron, 35% of zinc, 34% of polyunsaturated fat, 90% of eicosapentaenoic acid, and 93% 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, Alaska Department of Health and Social Services 2005, Chan et al. 2006, Ebbesson and Tejero 2007) and provision of essential micronutrients and omega-3 fatty acids (Murphy et al. 1995, Nobmann et al. 2005, Bersamin et al. 2007, Ebbesson and Tejero 2007).

However, for Alaska Natives today, 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. 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 (Table 3-10).

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.

3.3.5 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 fish such as Pacific salmon, rainbow trout, Arctic grayling, Arctic char, and Dolly Varden, since the 1930s (Dye and Schwanke 2012). 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.

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

Sport fishing in the Bristol Bay watershed accounts for approximately $60.5 million in annual spending (EPA 2014: Table 5-4), $58 million of which is spent in the Bristol Bay region. 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 (EPA 2014: Appendix A, Table 4).

Between 1997 and 2008, angler-days of effort within the BBMA ranged from 83,994 to 111,838, with total annual sport harvest for the same period ranging from 39,362 to 71,539 fish (Dye and Schwanke 2009). From 2006 to 2011, sport-fishing effort averaged 88,200 angler-days annually (Dye and Schwanke 2012). Guided sport-fishing effort during this same period averaged 33,800 angler-days across the BBMA, approximately 6,800 angler-days of which were spent in the Nushagak River watershed (Dye and Schwanke 2012).

The majority of sport fish 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 3-11) (Dye and Schwanke 2009, 2012). The Nushagak and Kvichak River watersheds support several popular recreational fisheries, particularly for sockeye salmon, Chinook salmon, and rainbow trout (Figure 3-15). The Nushagak River watershed accounted for more than 50% of the annual average sport harvest (1997–2011) of Chinook salmon in the BBMA, with an estimated harvest of 5,695 fish (Dye and Schwanke 2012); estimated recreational Chinook salmon catches are much higher (Table 3-12). In the Kvichak River, recreational harvests are dominated by sockeye salmon, whereas recreational catches are dominated by rainbow trout.

Table 3 11. Estimated sport harvest by species in the Bristol Bay Sport Fish Management Area (BBMA). Values are mean annual sport harvests from 2000 to 2008, 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	Range
Sockeye salmon	13,693	8,153 [2002] – 18,975 [2000]
Chinook salmon	12,062	6,826 [2002] – 18,489 [2008]
Coho salmon	14,219	11,590 [2001] – 20,152 [2008]
Chum salmon	1,857	501 [2007] – 3,273 [2000]
Pink salmon	1,142	469 [2003] – 3,138 [2004]
Rainbow trout	1,645	1,108 [2006] – 2,411 [2007]
Dolly Varden/Arctic char[a]	3,373	1,930 [2008] – 6,268 [2004]
Arctic grayling	1,970	839 [2005] – 3,010 [2004]
Lake trout	873	435 [2006] – 1,309 [2005]
Northern pike	1,264	812 [2008] – 1,751 [2004]

Notes:
[a] Listed as Arctic char in some cases, but assumed to be Dolly Varden (EPA 2014: Appendix B).
Source: Dye and Schwanke 2009.

Figure 3 15. Approximate extents of popular Chinook and sockeye salmon recreational fisheries in the vicinity of the Nushagak and Kvichak River watersheds. Areas were digitized from previously published maps (Dye et al. 2006). Recreational rainbow trout fisheries are also distributed throughout the watersheds.

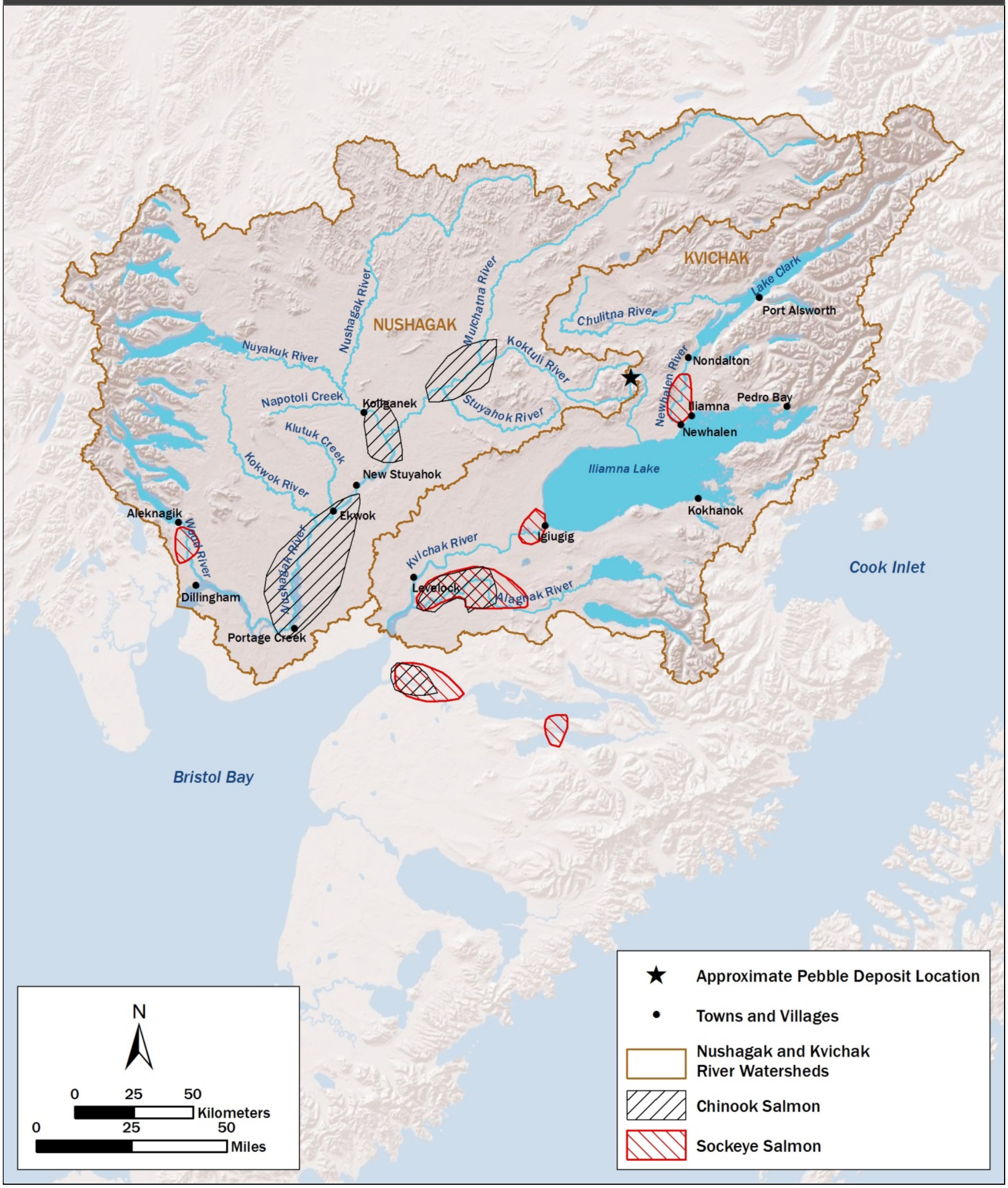


Table 3 12. Estimated annual sport harvest and catch of fishes in the Kvichak River watershed and the Nushagak, Wood, and Togiak River watersheds, 2000 to 2010. Estimated annual sport harvest is presented as the range between the minimum and maximum estimated annual harvest over the 2000 2010 period; estimated sport catch is shown for 2010.

Watershed	Fish	Estimated Annual Sport Harvest (Range, 2000–2010)	Estimated 2010 Sport Catch
Kvichak River	Pacific salmon[a]	6,036–13,576	69,328
	Sockeye	2,815–9,580	26,103
	Chinook	300–1,440	4,364
	Coho	1,141–3,082	5,971
	Chum	50–1,138	17,623
	Pink	12–1,041	15,267
	Rainbow trout	48–962	128,218
	Dolly Varden/Arctic char	108–663	8,585
	Arctic grayling	341–1,509	17,560
	Lake trout	116–789	4,933
	Northern pike	31–575	2,338
	Whitefish	0–827	554
Nushagak, Wood, and Togiak River	Pacific salmon[a]	10,295–22,440	71,517
	Sockeye	1,195–4,279	8,959
	Chinook	1,587–4,062	23,973
	Coho	3,496–10,495	18,812
	Chum	800–1,931	8,687
	Pink	23–1,365	11,086
	Rainbow trout	176–973	16,303
	Dolly Varden/Arctic char	1,300–4,898	32,945
	Arctic grayling	422–2,154	18,754
	Lake trout	21–783	2,857
	Northern pike	261–1,144	3,177
	Whitefish	0–514	391

Notes:
[a] Total for all five Pacific salmon species (coho, Chinook, sockeye, chum, pink).
Source: Jennings et al. 2011.

3.3.6 Ecological Importance of Region's Fisheries

As discussed in previous sections, the Bristol Bay watershed's aquatic habitats support world-class commercial, subsistence, and recreational salmon fisheries. These fisheries are also ecologically important, in terms of the nutrient subsidies they provide to the region's ecosystems and the maintenance of genetic diversity and Pacific salmon populations both within and beyond the region.

3.3.6.1 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). Adult salmon returning to their natal freshwater habitats to spawn import nutrients that they obtained during their ocean feeding period—marine-derived nutrients or

MDN—back into these freshwater habitats (Cederholm et al. 1999, Gende et al. 2002). 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). Because approximately 95 to 99% of the carbon, nitrogen, and phosphorus in an adult salmon's body is derived from the marine environment (Larkin and Slaney 1997, Schindler et al. 2005), MDN from salmon account for a significant portion of nutrient budgets in the Bristol Bay watershed (Kline et al. 1993). For example, sockeye salmon are 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).

Given that these systems 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 will be highest in areas of high spawning density and where carcasses accumulate. In contrast, MDN influences on aquatic foodwebs may be negligible in headwater streams above the upstream limit of anadromous fish distributions. In these systems, other sources of energy, such as terrestrial inputs and benthic production, will be important (Wipfli and Baxter 2010).

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 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) report that upon arrival of spawning salmon in the Wood River basin, rainbow trout shifted from consuming aquatic insects to primarily 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 to benefit from these MDN subsidies. Research in Iliamna Lake suggests that between 29 and 71% 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).

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, 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). 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). 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.

3.3.6.2 Biological Complexity 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 biological complexity, which greatly increases the region's ecological productivity and stability. This biological complexity operates at multiple scales and across multiple species, but it is especially evident in the watershed's Pacific salmon populations. 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 biological complexity.

The five Pacific salmon species found in the Bristol Bay watershed vary in many 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 life-history variability allows these species to fully exploit the range of habitats available throughout the Bristol Bay watershed, where many populations of each of the five Pacific salmon 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, and environmental conditions can differ among habitats in close proximity. 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).

The Pacific salmon species also exhibit homing behavior, meaning that they return to their natal streams to spawn. This homing behavior, in combination with life-history variability, results in discrete populations within each species that are adapted to their own specific spawning and rearing habitats (Hilborn et al. 2003, Ramstad et al. 2010). Spawning adults 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. In the Bristol Bay region, phenotypic variation with apparent adaptive significance has been illustrated for sockeye salmon body size and gravel size (Quinn et al. 1995), and for sockeye salmon body size and shape and spawning habitat (Quinn et al. 2001). Olsen et al. (2003) proposed that the fine-scale genetic differentiation they observed in Alaskan coho salmon may be associated with adaptation to locally diverse freshwater selective pressures, but they did not examine phenotypic variation.

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. As a result, these discrete populations can occur at fine spatial scales. For example, sockeye salmon that use spring-fed ponds and streams approximately 1 km apart exhibit differences in spawn timing, spawn site fidelity, productivity, and other traits that are consistent with discrete populations (Quinn et al. 2012). Multiple beach-spawning populations of sockeye are found in Iliamna Lake (Stewart et al. 2003). Genetically distinct river-type and lake-type populations can co-occur within watersheds (Dann et al. 2013), and inlet and outlet spawners with distinct migration patterns can occur within the same lake (Burger et al. 1997).

This life-history complexity is superimposed on localized adaptations, resulting in a high degree of biological complexity organized into discrete, locally distinct fish populations. For example, the Bristol Bay watershed's sockeye salmon "population" is actually a complex of different sockeye salmon populations—that is, a combination of hundreds of genetically distinct populations, each adapted to specific, localized environmental conditions (Hilborn et al. 2003, Schindler et al. 2010). This complex structure 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): under any given set of conditions, some assets (here, discrete sockeye salmon populations) will perform well while others perform poorly, but maintenance of a diversified portfolio stabilizes returns over time. Across the entire watershed, overall salmon productivity is stabilized as the relative contribution of sockeye with different life-history characteristics, from different regions of the Bristol Bay watershed, changes 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 the local scale—that is, across individual tributaries—and at the regional scale—that is, across the Bristol Bay watershed's major river systems (Rogers and Schindler 2008). 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). For example, small sockeye 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).

The high level of system-wide biological complexity inherent in the overall population complex structure reduces year-to-year variability in salmon run sizes, making the fishery much more reliable than it would be otherwise. 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 (Schindler et al. 2010). In other watersheds with previously robust salmon fisheries, such as the Sacramento River's Chinook fishery, losses of biological complexity have contributed to overall salmon population declines (Lindley et al. 2009).

It is likely that other Bristol Bay fisheries, in addition to sockeye salmon, are also stabilized by the portfolio effect. In particular, 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) in this region, and the loss of coho populations may be more likely to translate to loss of significant amounts of overall genetic variability (Olsen et al. 2003). Radio telemetry, tagging, and genetic studies also indicate that multiple rainbow trout populations are found within the Bristol Bay watershed (Gwartney 1985, Burger and Gwartney 1986, Minard et al. 1992, Krueger et al. 1999, Meka et al. 2003).

The potential for fine-scale population structuring of salmon fisheries, particularly in terms of sockeye and coho salmon, exists throughout the Bristol Bay watershed. Small habitat areas can maintain unique, genetically distinct populations, each of which helps to maintain the integrity of overall salmon stocks and contributes to the overall resilience of these stocks to perturbation. The ability of Bristol Bay to produce and sustain salmon production is therefore dependent on maintaining the viability of the vast network of unique habitats at small spatial scales. 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 associated decreases in biological complexity.

3.3.6.3 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. 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% of their historical breeding ranges in the western United States, and populations tend to be significantly reduced or dominated by hatchery fish where they do remain (NRC 1996). In contrast, Bristol Bay's salmon fisheries are robust and entirely wild, with no hatchery fish released in the watershed (Section 3.1).

For example, 214 salmon and steelhead 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). Species with extended freshwater rearing periods—species such as coho, Chinook, and sockeye—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). The Bristol Bay watershed contains intact, connected 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). Because the region's salmon resources have supported Alaska Native cultures in the region for at least 4,000 years and continue to support one of the last intact wild salmon-based cultures in the world (EPA 2014: Appendix D), the watershed also has global cultural significance.

3.4 Summary

Because of its climate, geology, hydrology, pristine 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 commercial, subsistence, and recreational fisheries for multiple species of Pacific salmon, as well as numerous other fish species valued as subsistence and recreational resources.

The productivity and diversity of the watershed's aquatic habitats are closely tied to the productivity and diversity of its 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. Streams and lakes in the three 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. They also provide high-quality habitat for fishes such as rainbow trout, Dolly Varden, Arctic grayling, and northern pike. 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.

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.

This support is particularly important in terms of coho, Chinook, and sockeye salmon fisheries. Chinook 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 what are likely small, discrete populations of coho, Chinook, and sockeye salmon that are genetically programmed to return to specific, localized reaches or habitats to spawn. 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.

SECTION 4. BASIS FOR PROPOSED DETERMINATION

4.1 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, 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. Section 404(c) provides:

> 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. [emphasis added]

Importantly, 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. The statute's broad reference to fishery areas and to breeding and spawning areas includes aquatic areas that support and provide fish habitat, as well as aquatic areas where fish breed or spawn.

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:

> Impact on an aquatic or wetland ecosystem which is likely to result in significant degradation of municipal water supplies 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 230). [emphasis added]

In addition, 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" (44 *Federal Register* [FR] 58076, 58078). EPA also discussed that, for example, an unacceptable adverse effect "is a large impact" and "one that the aquatic and wetland ecosystem cannot afford" (44 FR 58078).

Section 404(c) and EPA's implementing regulations at 40 CFR Part 231 make clear that EPA may exercise its discretionary authority at any time, whether or not a Section 404 permit application has been submitted or such a permit has been issued (40 CFR 231.1(a), (c); 44 FR 58076–77). In the preamble to the final rule promulgating Part 231, EPA also specifically recognized that there could be unique instances where it may exercise its discretion under Section 404(c) without a permit application because "a site may be so sensitive and valuable that it is possible to say that *any* filing of more than X acres will have unacceptable adverse effects" (44 FR 58077). In such unique circumstances, EPA may choose to exercise its discretion to act before a permit application has been filed for several reasons, which include facilitating "planning by developers and industry" and eliminating "frustrating situations in which someone spends time and money developing a project for an inappropriate site and learns at an advanced stage that he must start over" (44 FR 58077).

The ecological and mineral resources of the Bristol Bay watershed create one of the unique instances anticipated in EPA's final preamble. As discussed in Section 3, the Bristol Bay watershed, including the SFK, NFK, and UTC watersheds, is an outstanding global resource, providing pristine, intact, connected habitats from headwaters to ocean that provide extensive spawning and rearing areas for and support genetically diverse populations of wild salmon. As discussed in the BBA (EPA 2014), discharges associated with mining the Pebble deposit likely would involve the creation of a large open pit and the production of large amounts of waste rock and mine tailings. Given the extent of streams, wetlands, lakes, and ponds overlying the Pebble deposit, the construction and operation of a mine at the Pebble deposit would result in the discharge of dredged or fill material into waters of the United States.[29]

In accordance with 40 CFR 231.3(a), EPA Region 10 has prepared this proposed determination because it "has reason to believe" that unacceptable adverse effects on fishery areas "could result" from the discharge of dredged or fill material associated with construction and routine operation of the Pebble 0.25 stage mine[30] into waters of the United States within the potential disposal site (Figure ES-3 and Section 2.2.3).

Although the focus of this proposed determination is unacceptable adverse effects on fishery areas, other potential Section 404(c) resources such as wildlife habitat and recreation may also be affected and are discussed in Section 6.1.

4.2 Effects on Fishery Areas from Construction and Routine Operation of the Pebble 0.25 Stage Mine

Multiple components of a mine at the Pebble deposit would likely involve or require the discharge of dredged or fill material into waters of the United States. For example, waste rock would constitute dredged material when excavated from waters of the United States, and the sheer volume of material (255 million cubic yards [195 million m^3]), coupled with the density of aquatic resources in the vicinity, would make it highly likely that its disposal would include discharges into aquatic resources.[31] A key

[29] USACE notified the mineral rights owners and project proponents (i.e., NDM/PLP) that a Section 404 permit would be required, and pre-application meetings with USACE regarding the project have been ongoing since 2004.
[30] Equivalent to the median-sized porphyry copper deposit in the world, based on Singer et al. 2008.
[31] Material not excavated from waters of the United States would be fill.

component of the TSF, the dam that creates the impoundment, likely would require the discharge of dredged or fill material for its construction. Finally, creation of the mine pit would depend on a number of different discharges of dredged or fill material, including dams to block or divert inflow from streams, pads to support excavation equipment, stockpiles of cleared or excavated material, and fallback that is more than incidental (40 CFR 232.2).

This section considers both the direct and secondary effects of such discharges on fishery areas. Direct effects are impacts on aquatic resources within the footprint of the discharge of dredged or fill material. Direct effects of the Pebble 0.25 stage mine would include stream and other aquatic resource losses within the footprints of the tailings dam, the waste rock pile, and the mine pit. Secondary effects are associated with the discharge of dredged or fill material, but do not result from actual placement of this material. Examples of secondary effects evaluated as part of this proposed determination include the following.

- Elimination of streams and wetlands due to drowning by the tailings impoundment.
- Dewatering of streams and other aquatic resources due to pumping of groundwater from the mine pit.[32]
- Fragmentation of aquatic resources due to the placement of the mine pit, waste rock pile, or TSF.[33]
- Degradation of downstream fish habitat due to streamflow alterations resulting from water capture, withdrawal, storage, treatment, or release at the mine site.
- Degradation of downstream fish habitat due to the loss of important inputs such as nutrients and groundwater from upstream aquatic resources.

The elimination of aquatic resources includes a combination of direct effects (losses within the footprint of dredged or fill material discharged for the mine pit, waste rock pile, or TSF) and secondary effects (losses due to excavation or inundation facilitated by the discharge of dredged or fill material). Similarly, aquatic resource losses—due to elimination, dewatering, or fragmentation—would result in both the

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[32] The BBA characterizes as “dewatered” all aquatic resources not otherwise eliminated that fall within the estimated drawdown zone resulting from the pumping of water from the mine pit (EPA 2014: Box 7-1). At the Pebble 0.25 stage mine pit, the drawdown would be more than 900 feet (0.3 km) below ground surface (EPA 2014: Table 6-2 and Figure 6-5). Groundwater would be at pre-mine levels at the outer edge of the drawdown zone. The extent of dewatering of aquatic resources at the outer edge of the drawdown zone would depend on factors such as stream channel depth, pond shoreline slope, and, for wetlands, pre-mine depth to soil saturation. It is possible that dewatering would not be complete in the aquatic resources at the outermost parts of the drawdown zone. At the same time, given the proximity of those waters to one or more major mine components, it is likely that some portion of the streams and other aquatic resources described herein as “dewatered” actually would be eliminated outright by the discharge of dredged or fill material for a mine feature not assessed in the BBA. For example, it is more likely that the streams, wetlands, and ponds located in the 0.25- to 0.5-mile (400- to 800-m) wide swath between the Pebble 0.25 stage mine pit and waste rock pile would be converted to a transportation corridor for moving rock from the pit to the disposal pile rather than be dewatered (EPA 2014: Table 7-10).

[33] Characterized as “blocked” in the BBA, fragmented habitat is a stream or other aquatic resource that has a surface connection to the SFK, NFK, or UTC tributary system pre-mine that a major mine component (mine pit, TSF, or waste rock pile) would eliminate (EPA 2014: Box 7-1). Fragmentation would block customary fish migration routes, making the upstream habitat no longer accessible to anadromous and migratory resident fish.

outright loss of fish habitat, including spawning and breeding areas, and the degradation of downstream waters. The following sections evaluate effects on fishery areas resulting from losses of anadromous fish streams (Section 4.2.1), losses of tributaries of anadromous fish streams (Section 4.2.2), losses of wetlands, lakes, and ponds (Section 4.2.3), and streamflow alterations (Section 4.2.4).[34]

4.2.1 Effects of Loss of Anadromous Fish Streams

The Pebble 0.25 stage mine would eliminate or dewater nearly 5 miles (8 km) of streams with documented occurrence of anadromous fish, specifically coho and Chinook salmon (Johnson and Blanche 2012) (Table 4-1, Figure 4-1).[35] Dewatered streams would no longer have sufficient water to support previously existing uses by the fish species and life stages that were present, either continually or seasonally, pre-mine. The greatest impacts would be at the TSF location in the NFK watershed. Coho salmon spawn or rear in nearly 50% of the stream length within the TSF footprint (Table 4-2). These streams include the third-order NFK tributary that drains the TSF site, as well as two second-order tributaries of that third-order stream and three first-order tributaries of those second-order streams.[36] Coho salmon also would lose rearing habitat to the Pebble 0.25 stage mine pit drawdown zone, specifically at least 0.7 mile (1.1 km) in two second-order tributaries at the headwaters of the SFK and 0.2 mile (0.3 km) in a first-order tributary of UTC.

Table 4-1. Length of documented anadromous fish streams lost (eliminated, dewatered, or fragmented) under the Pebble 0.25 stage mine, and the anadromous fish species documented to occur in those streams.

Type of Loss	AWC Streams	
	Stream Length (miles)[a]	Anadromous Fish Documented in Streams[b]
Eliminated	3.8	Coho, Chinook
Dewatered	0.9	Coho, Chinook
Fragmented	0.0	-
TOTAL LOSS	4.7	

Notes:
[a] From the National Hydrography Dataset (USGS 2012) and the Anadromous Waters Catalog (Johnson and Blanche 2012).
[b] From the Anadromous Waters Catalog (Johnson and Blanche 2012). Individual species do not necessarily occupy the entire affected length.
AWC = Anadromous Waters Catalog.

[34] This proposed determination focuses on effects of the discharge of dredged or fill material associated with the construction and routine operation of the Pebble 0.25 stage mine. Section 4.3.1.2 discusses cumulative effects associated with mine expansion at the Pebble deposit, and Section 4.4 addresses effects associated with accidents and failures.

[35] It is important to note that the spatial extent of habitat loss and the salmon species directly affected by such loss are entirely dependent on the placement of major mine components within the SFK, NFK, and UTC watersheds. For example, as seen in Figure 4-1, placement of TSF 1 in the stream valley to the south of its location in the BBA (EPA 2014) would result in greater habitat losses for Chinook salmon and possibly losses for chum salmon as well. Similarly, slightly shifting the waste rock pile from its location in the BBA would cause habitat loss for sockeye as well as coho salmon, and far greater loss of wetlands, lakes, and ponds.

[36] The stream orders described herein are based on NHD mapping (USGS 2012), viewed at 1 inch:0.3 mile scale; any mapping that identified additional tributaries could change these orders.

Figure 4 1. Reported salmon distributions under the Pebble 0.25 stage mine. Species distributions are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Light blue areas indicate streams and rivers from the National Hydrography Dataset (USGS 2012) and lakes and ponds from the National Wetlands Inventory (USFWS 2012); dark blue areas indicate wetlands from the National Wetlands Inventory (USFWS 2012).

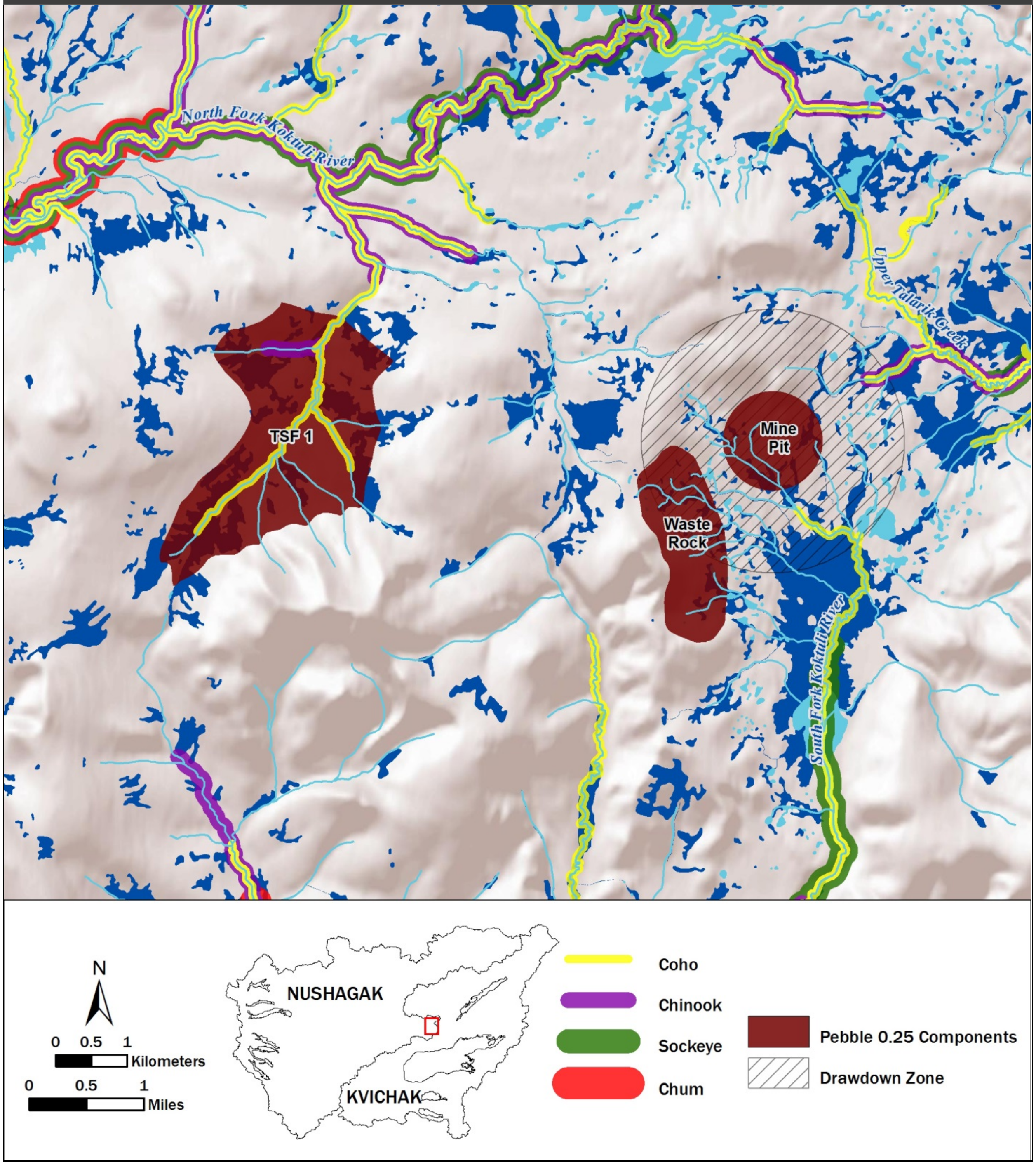


Table 4-2. Coho and Chinook salmon stream habitat lost (eliminated, dewatered, or fragmented) in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds under the Pebble 0.25 stage mine.

Species	Length of Stream (miles) by Watershed[a]			
	SFK	NFK	UTC	TOTAL[b]
Coho salmon	0.7	3.4	0.2	4.3
Chinook salmon	0.0	0.5	0.2	0.6

Note:
[a] From the National Hydrography Dataset (USGS 2012) and the Anadromous Waters Catalog (Johnson and Blanche 2012).
[b] The overall total of 4.9 miles is greater than reported in Table 4-1 because there is some overlap between coho and Chinook salmon habitat, which this table reports separately but Table 4-1 does not. The apparent discrepancy between the total length of Chinook salmon habitat and the sum of the NFK and UTC lengths is due to rounding.

As described in Section 3.2.4, the anadromous fish streams that the Pebble 0.25 stage mine would eliminate or dewater are of high quality, particularly for juvenile salmonids. These streams likely provide abundant and nutrient-rich food sources for fish, due to the dominance of deciduous shrubs in their riparian zones that produce abundant leaf litter and help fuel the production of macroinvertebrates, a key food for salmonids (Table 3-3). The third-order NFK tributary and all three of the dewatered coho salmon streams in the SFK and UTC watersheds possess contiguous ponds or seasonally to permanently inundated wetlands resulting from beaver activity (USFWS 2012). 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). Indeed, research shows that fish distribution in southwest Alaska headwater systems may be most extensive in late summer and early fall (Elliott and Finn 1983, Quinn 2005), coinciding with the period of increased food availability and maximum growth for juvenile salmon (Quinn 2005). Thus, the coho salmon streams that the Pebble 0.25 stage mine would eliminate or dewater likely play an important role in the life cycle of that species in all three watersheds.

Although their losses would not be as extensive as losses for coho salmon, Chinook salmon also would lose habitat in the NFK and UTC watersheds. Chinook salmon rear in the third-order beaver-modified stream that the TSF would eliminate, along with a different first-order tributary than those documented to support coho.[37] This currently documented Chinook salmon rearing habitat covers 0.5 mile (0.8 km) of streams. Chinook salmon also rear in the aforementioned 0.2-mile (0.3-km) beaver-modified UTC tributary used by juvenile coho salmon. Overall, the Pebble 0.25 stage mine would eliminate or dewater at least 0.6 mile (1.0 km) of habitat for Chinook salmon.

Altogether, the Pebble 0.25 stage mine would eliminate or dewater at least 4.7 miles (7.6 km) of streams with documented occurrence of coho and Chinook salmon. This large impact on anadromous fish streams is unprecedented in the context of the CWA Section 404 regulatory program in Alaska. The eliminated and dewatered habitat would permanently lose the ability to support salmon, because it either would no longer exist or would likely undergo irreversible changes in key components such as its physical structure and substrate (Beechie et al. 1994). As described in Appendix J of the BBA (EPA

[37] Fish surveys have documented coho salmon juveniles in a short (260-foot) reach at the downstream end of this tributary.

2014), areas that do not support salmon for many years are not likely to become productive again (Reeves et al. 1991a, Reeves et al. 1991b, Paulsen and Fisher 2005, Katz et al. 2007). Both the 20-year life of the Pebble 0.25 stage mine and the 40 years or more during which dewatering would persist are many times longer than the 2- to 5-year life span of coho and Chinook salmon. Thus, as successive year classes of salmon return and are unable to reach their natal spawning grounds and produce fry, the cycle of spawning would be interrupted. Displaced spawners that attempt to return to lost habitat for the first few generations after the loss and that do not die without spawning may stray elsewhere to spawn, but success will depend on availability of suitable spawning habitat and its capacity to support additional fish. The substantial spatial and temporal extent of stream habitat losses to the Pebble 0.25 stage mine suggest that these losses would reduce the overall capacity and productivity of Chinook, and particularly coho, salmon in the SFK, NFK, and UTC watersheds.

Coho salmon would lose at least 4.3 miles (7.0 km) of habitat to the Pebble 0.25 stage mine, representing more than 2% of the total documented coho salmon habitat in the three watersheds and more than 5% of documented coho habitat in the NFK watershed (Table 3-6). Habitat losses for Chinook salmon would be less than 1% of documented habitat. However, compounding the spatial and temporal magnitude of these effects is the fact that these losses likely would affect multiple, distinct populations of coho and Chinook salmon. Effects would occur in multiple streams spanning all three watersheds, each with diverse spawning and rearing conditions that create a mosaic of habitats and attendant life-history variability (Section 3.3.6.2). Adaptation to the spatially and temporally unique conditions of their natal streams can result in reproductive isolation and genetic variation that salmon homing behavior maintains or enhances (Section 3.3.1), resulting in the development of discrete, genetically distinct populations. Chinook salmon populations 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). Olsen et al. (2003) similarly describe coho populations as generally small and isolated, exhibiting local adaptation to diverse habitats. Research has shown that such distinct populations can occur at very fine spatial scales (Section 3.3.6.2). For example, 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, spawn site fidelity, and productivity) that suggest they may comprise discrete populations (Rand et al. 2007, Ramstad et al. 2010, Quinn et al. 2012). In coho salmon, genetic population structure also occurs at a fine geographic scale, with many populations found in small first- and second-order headwater streams (Olsen et al. 2003).

The fine-scale population structuring that results from the diversity of aquatic habitats in the watersheds helps to maintain the integrity of overall Bristol Bay salmon stocks and contributes to their resilience to perturbation. As described by Olsen et al. (2003):

> 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.

Lindley et al. (2009) voice similar concerns for Chinook salmon, noting that degradation of habitats in the Central Valley of California "changed the Chinook salmon complex from a highly diverse collection of numerous wild populations to one dominated by fall Chinook from four large hatcheries." The loss of such diversity defeated what Healey (1991) described as "a strategy for spreading mortality risks in uncertain environments." Lindley et al. (2009) equate this strategy to managing a financial portfolio—hence the term "portfolio effect" (Section 3.3.6.2)—and conclude that the buffering capacity of such life-history diversity manifests itself as greater resilience in the face of environmental variation.

It is not known how many different populations of coho and Chinook salmon may exist within the SFK, NFK, and UTC watersheds. However, the findings described above and in Section 3.3.6.2 indicate that the headwater and beaver-modified habitats eliminated or dewatered by the Pebble 0.25 stage mine could support populations that are distinct from those using habitats farther downstream in each watershed. Besides destroying the intact, headwater-to-larger river networks of the SFK, NFK, and UTC watersheds, stream losses that eliminate local, unique populations could translate into a substantial loss of genetic variability with impacts extending well beyond the footprints of the lost habitats. As Lindley et al. (2009) found for Central Valley Chinook salmon, these losses could erode the genetic diversity that is crucial to the stability of the overall Bristol Bay salmon fisheries (Hilborn et al. 2003, Schindler et al. 2010, EPA 2014: Appendix A). Thus, loss of the SFK, NFK, and UTC watersheds' discrete fish populations could have significant repercussions well beyond that suggested by their absolute proportion within the larger watersheds. Coho and Chinook, the two rarest of North America's five species of Pacific salmon (Healey 1991), seem particularly vulnerable to losses of small, discrete populations. These species 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 freshwater rearing. For example, Chinook salmon populations that rear for 1 to 3 years in freshwater—the dominant type in 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). Thus, the elimination or dewatering of nearly 5 miles (8 km) of salmon streams caused or facilitated by the discharge of dredged or fill material for the Pebble 0.25 stage mine could reduce the overall productivity of the SFK, NFK, and UTC watersheds for both species, at a level that the aquatic ecosystem may not be able to afford.

Adverse impacts on coho or Chinook salmon populations could, in turn, threaten the sustainability of downstream commercial, subsistence, or recreational fisheries (Sections 3.3.3 through 3.3.5). Coho and Chinook salmon are the two smallest components of the Bristol Bay commercial fishery. However, overall Nushagak River stocks are the largest for the Bristol Bay district (Table 3-9), and the Nushagak River Chinook salmon run is frequently one of the world's largest (EPA 2014: Appendix A).[38] Although sockeye salmon represent the bulk of subsistence food harvests for Alaska Natives in the region,

[38] The Nushagak River Chinook stock represents 80% of Chinook commercial harvest in the Bristol Bay district; the coho stock represents 33% of the harvest, which is approximately equal to the Egegik River stock (Table 3-9).

Chinook salmon are a large subsistence component for villages on the Nushagak River (Aleknagik, Dillingham, Ekwok, Koliganek, and especially New Stuyahok) (Table 3-10). The importance of Chinook as a subsistence resource is reflected in Alaska Native cultural practices: as the first of the Pacific salmon to return each year, Chinook salmon are the subject of a regional ritual known as the First Salmon celebration that emphasizes traditional values (EPA 2014: Appendix D). Losses that threaten the subsistence Chinook fishery could undermine this strong, centuries-old cultural connection that, in turn, serves a wide range of economic, social, and cultural functions (Section 3.3.4).

Coho, Chinook, and sockeye salmon support significant recreational fisheries as well, with the three representing the most harvested species in the region (Table 3-11). In fact, the Nushagak River—to which the SFK and NFK flow—supports the largest Chinook 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 2014).

The elimination and dewatering of anadromous fish streams would also adversely affect downstream habitat for salmon and other fish species. As described in Section 3.2.4, headwater streams such as those within the mine footprint 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 waters (Vannote et al. 1980, Wipfli and Gregovich 2002, Meyer et al. 2007, Wipfli et al. 2007) (Figures 4-2 through 4-4). Where they provide spawning grounds for coho or Chinook salmon, the lost streams are also a source of MDN for downstream waters (Section 3.3.6.1). 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). Elimination or dewatering of nearly 5 miles (8 km) of streams by the Pebble 0.25 stage mine would fundamentally alter surface 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 (Section 4.2.4). These lost streams also would no longer support or export macroinvertebrates, which are a critical food source for developing alevins, juvenile salmon, juvenile northern pike, and all life stages of other salmonids and forage fish.

Figure 4 2. Reported salmon distributions in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 0.25 stage mine. Species distributions are based on the Anadromous Waters Catalog (Johnson and Blanche 2012).

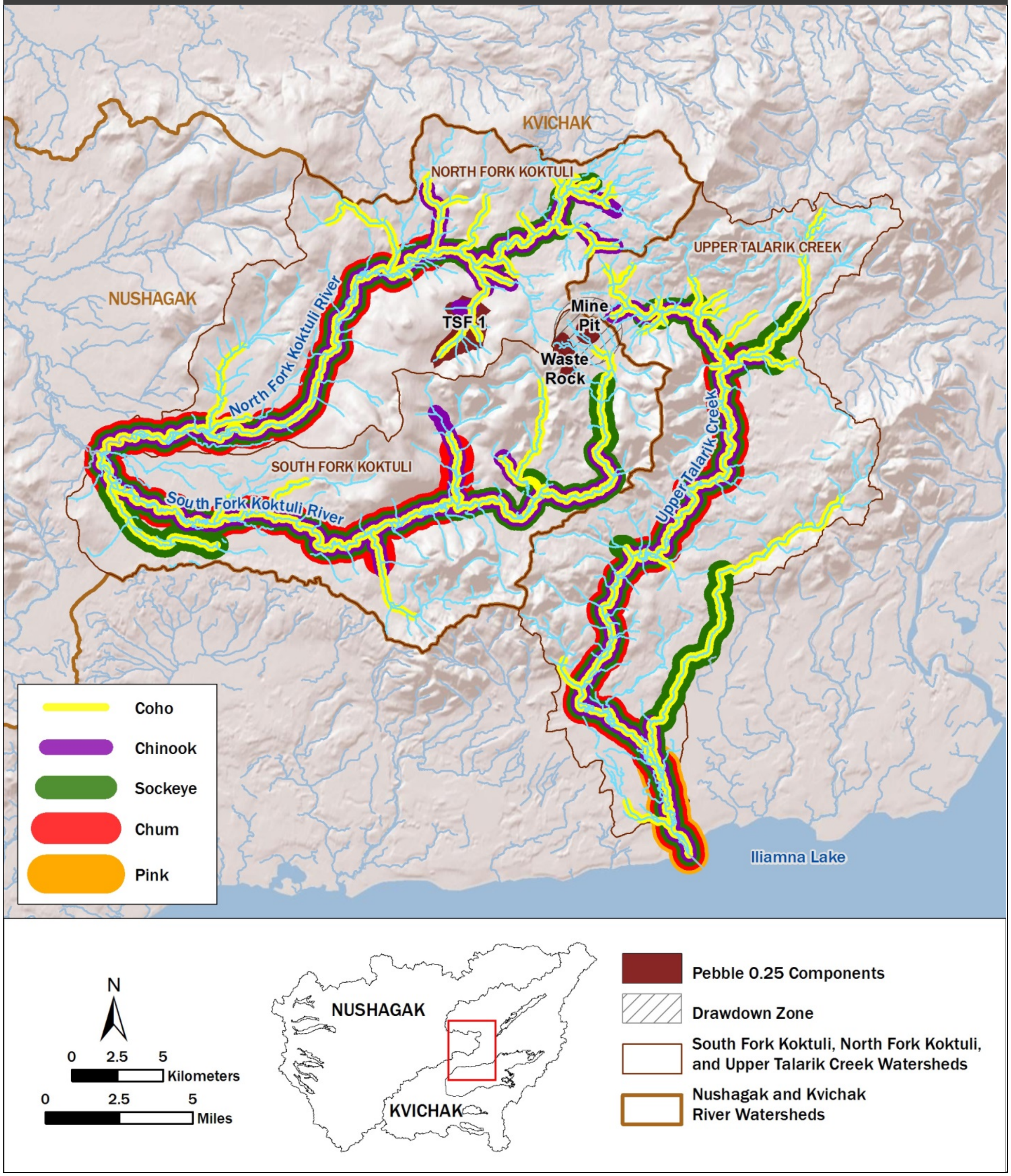


Figure 4 3. Reported rainbow trout and Dolly Varden distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 0.25 stage mine. Species distributions are based on the Alaska Freshwater Fish Inventory (point data, ADF&G 2012) and the Anadromous Waters Catalog (line data, Johnson and Blanche 2012).

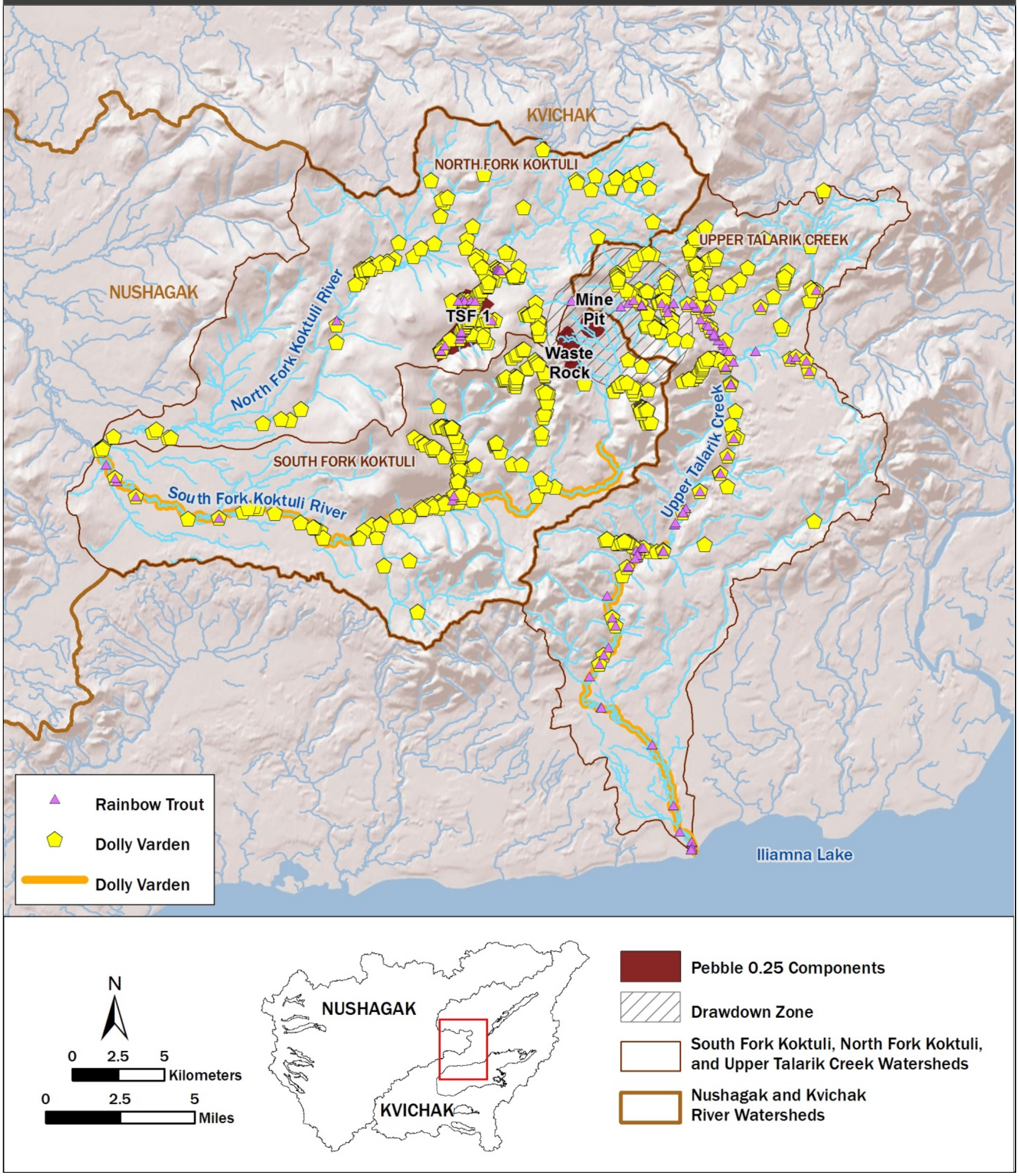
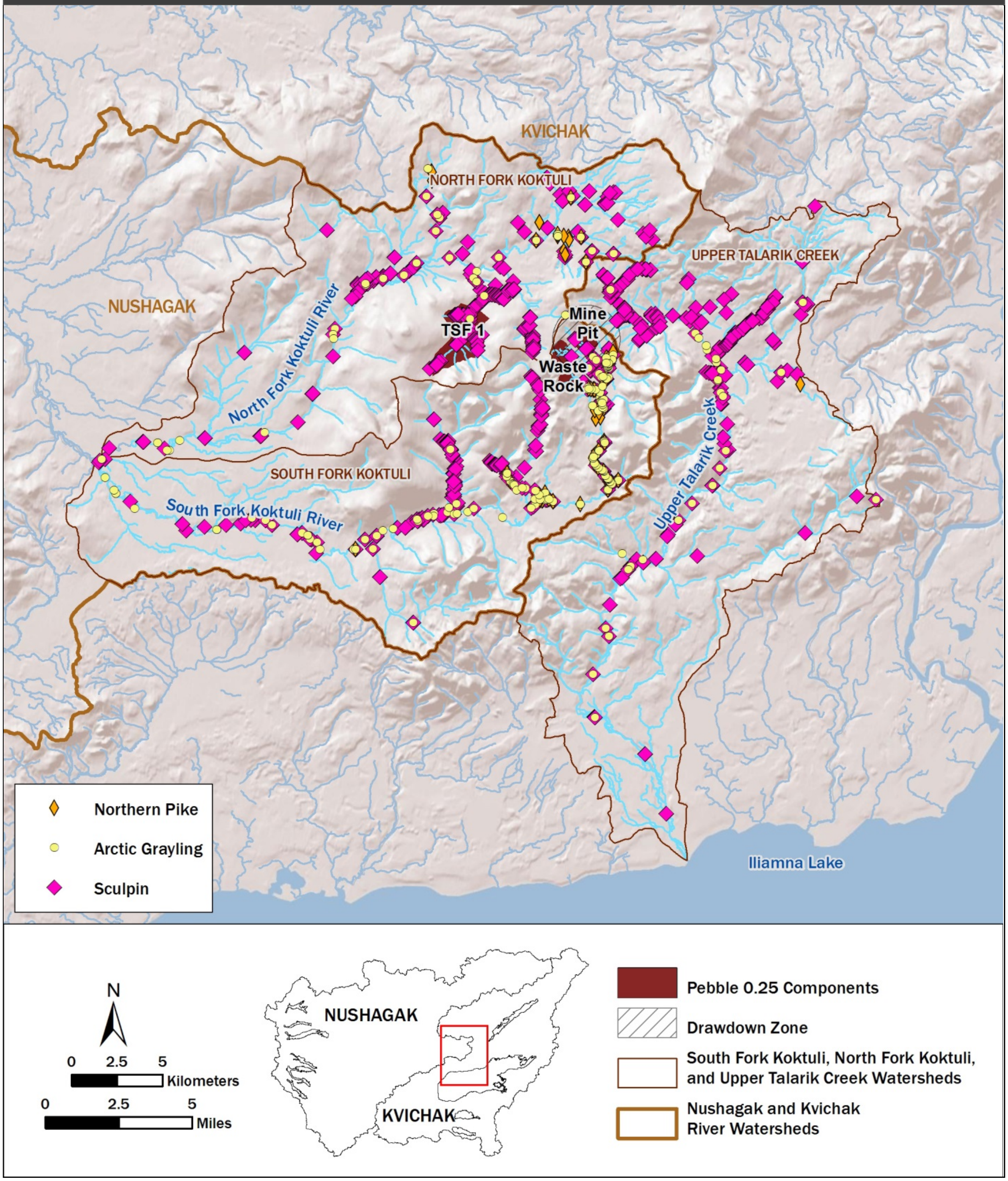


Figure 4 4. Reported distribution of other non salmon fish species in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 0.25 stage mine. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2012).



Upstream energy subsidies may be most important above the point where spawning salmon provide large seasonal influxes of MDN to the system. Based on current mapping (Johnson and Blanche 2012), Frying Pan Lake and the upper SFK, which support rearing sockeye and coho salmon, Arctic grayling and northern pike, are above documented salmon spawning grounds (Figures 4-2 and 4-4; also EPA 2014: Figures 7-2 through 7-4). The UTC tributary used by juvenile coho and Chinook salmon and rainbow trout also does not receive MDN from spawning salmon.

EPA Region 10 believes that the discharge of dredged or fill material associated with the Pebble 0.25 stage mine could have unacceptable adverse effects on fishery areas in the SFK, NFK, and UTC watersheds, as well as downstream fishery areas. This conclusion is based on several factors, including the outright loss of nearly 5 miles (8 km) of habitat under the Pebble 0.25 stage mine; the particular importance of that habitat to juvenile salmon; the degradation of additional downstream salmon rearing habitat (as well as spawning areas); the resulting erosion of the genetic diversity that is key to the uniquely abundant wild Bristol Bay salmon stocks; the economic and cultural importance of the fisheries that rely on those stocks; and the strong connection between the near total absence of current perturbation in the SFK, NFK, and UTC watersheds and the health of Bristol Bay's salmon stocks. Placement of the TSF or waste rock pile in different locations from those assessed in the BBA (EPA 2014) likely would result in even greater impacts, in terms of spatial extent and/or the number of salmon species affected (Figures 4-1 and 4-2). Although EPA Region 10 cannot be certain of the full extent of the implications of these losses, it is apparent that impacts of this magnitude could compromise the sustainability of fish populations within the SFK, NFK, and UTC watersheds, as well as downstream fishery areas.

Risks to salmon from the Pebble 0.25 stage mine are particularly compelling when the status of other North American and global salmon stocks are considered. These stocks have already experienced significant declines and extinctions (Section 3.3.6.3 and EPA 2014: Appendix A). In fact, Pacific salmon are no longer found in 40% of their historical breeding ranges in the western United States, and where they do remain, populations tend to be significantly reduced or dominated by hatchery fish (NRC 1996). The status of Pacific salmon elsewhere further highlights the health and abundance of salmon stocks within the Bristol Bay watershed and the value of the Bristol Bay watershed as a "salmon sanctuary or refuge" (Rahr et al. 1998, Pinsky et al. 2009). The uniquely pristine conditions in which intact, diverse, and connected habitats extend from headwaters such as those of the SFK, NFK, and UTC watersheds to the ocean, with minimal human influence, are in stark contrast to the effects of human development in the aforementioned watersheds with extinct or severely depleted salmon runs.

Adding further support to EPA Region 10's proposed determination is the fact that the stream losses associated with the Pebble 0.25 stage mine would adversely affect other fisheries, as well. Based on currently available fish survey data, the eliminated or dewatered anadromous fish streams also support three non-anadromous salmonid species (rainbow trout, Dolly Varden, and Arctic grayling) and three other fish species (northern pike, ninespine stickleback, and slimy sculpin) (Figures 4-5 and 4-6).[39] The three salmonid species, along with northern pike, all support subsistence and recreational fisheries in downstream waters (Fall et al. 2006, Krieg et al. 2009). Rainbow trout, in fact, are the species for which this widely acclaimed sport-fishing area is best known (Dye and Schwanke 2012, EPA 2014: Appendix A), particularly in the Kvichak River watershed, to which UTC flows. ADF&G (1990) describes rainbow trout as the "cornerstone" of the area's sport-fishing industry.

All four of these species may migrate substantial distances (120 miles [200 km] to 200 miles [320 km]) within their freshwater habitats (Section 3.3.1). Research shows that there may be multiple populations of at least one of these species—rainbow trout—within the Bristol Bay watershed (Gwartney 1985, Burger and Gwartney 1986, Minard et al. 1992, Krueger et al. 1999, Meka et al. 2003), suggesting that the portfolio effect may be important to that fishery's sustainability as well. Most of the individuals observed in fish surveys in the Pebble 0.25 stage mine footprint were sub-adults (Table 4-3) (ADF&G 2012), indicating that fish that rear in the headwater tributaries may contribute to downstream harvests. In fact, researchers have concluded that headwater streams may be important source areas for downstream populations of Dolly Varden in southeast Alaska (Bryant et al. 2004). Thus, the loss of headwater rearing habitat for those fish species due to stream losses under the Pebble 0.25 stage mine could adversely affect the productivity of downstream subsistence and recreational fisheries. Ninespine stickleback and slimy sculpin, which are ubiquitous in the three watersheds, also contribute to these fisheries, because they are prey for species such as rainbow trout, Dolly Varden, Arctic grayling, and northern pike (Table 3-3; EPA 2014: Appendix B).

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[39] The AWC documents anadromous "Arctic char" in the SFK mainstem, downstream of Frying Pan Lake. As described in Appendix B of the BBA (EPA 2014), taxonomic distinctions between Arctic char and Dolly Varden have been inconsistent in the past and recent field work suggests that fish in the Koktuli River likely are Dolly Varden. The AWC does not document any anadromous Dolly Varden (or Arctic char) habitat within or above the mine footprint. A few AFFI surveys identify the observed fish as resident, but most characterize the life history as "unknown."

Figure 4 5. Reported rainbow trout and Dolly Varden distribution under the Pebble 0.25 stage mine. Species distributions are based on the Alaska Freshwater Fish Inventory (point data, ADF&G 2012). Light blue areas indicate streams and rivers from the National Hydrography Dataset (USGS 2012) and lakes and ponds from the National Wetlands Inventory (USFWS 2012); dark blue areas indicate wetlands from the National Wetlands Inventory (USFWS 2012).

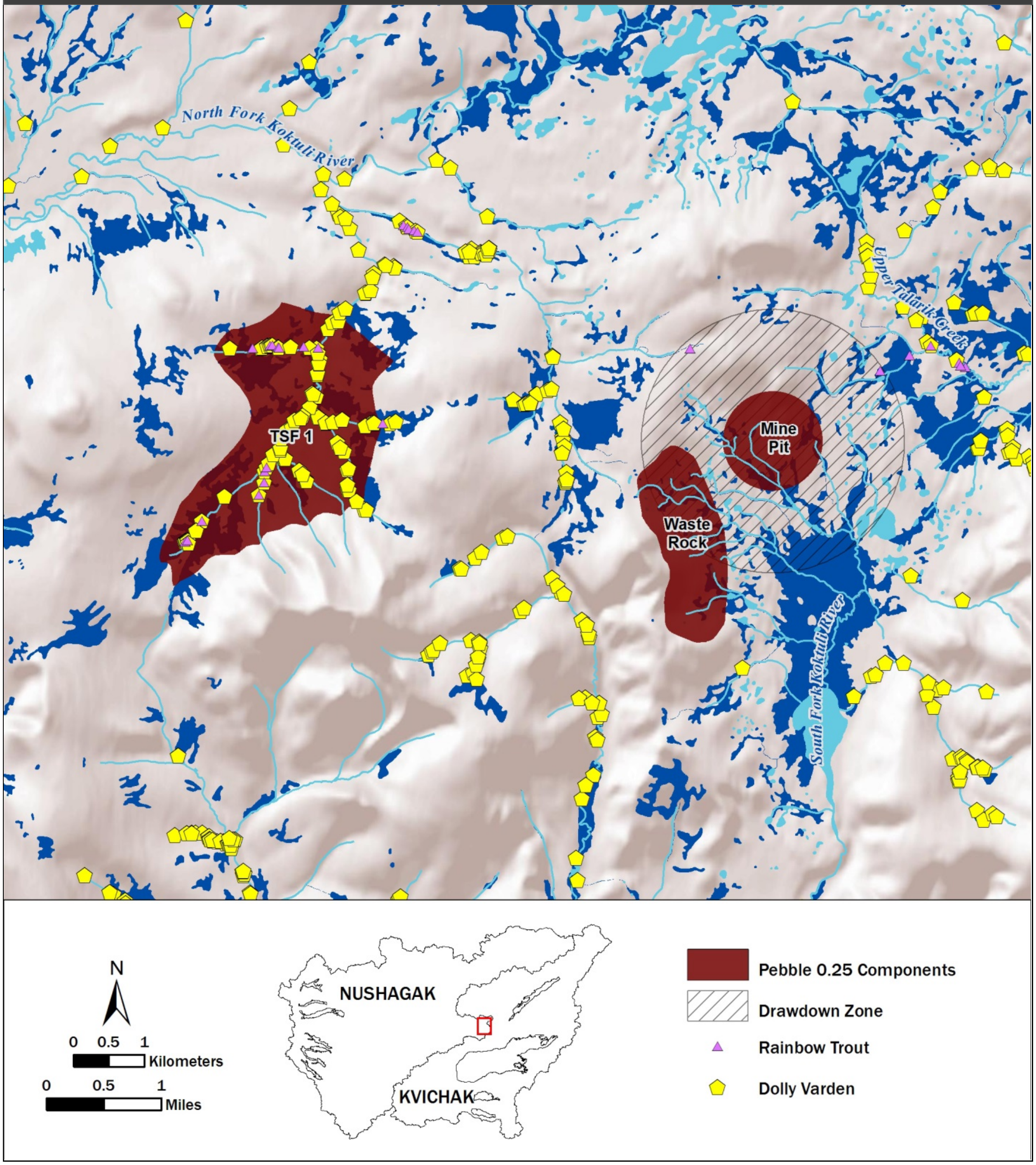


Figure 4 6. Reported distribution of other non salmon fish species under the Pebble 0.25 stage mine. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2012). Light blue areas indicate streams and rivers from the National Hydrography Dataset (USGS 2012) and lakes and ponds from the National Wetlands Inventory (USFWS 2012); dark blue areas indicate wetlands from the National Wetlands Inventory (USFWS 2012).

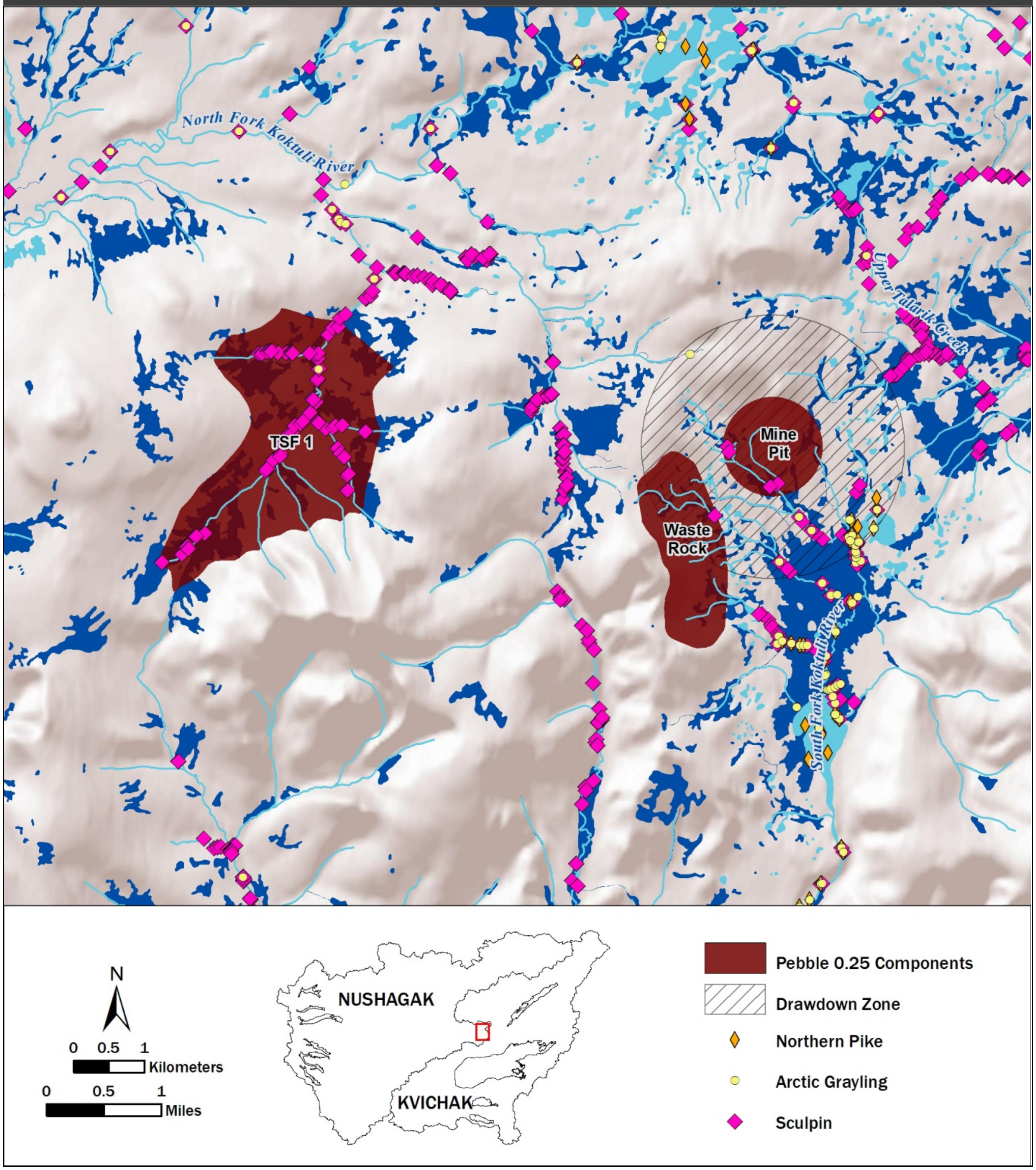


Table 4-3. Documented prevalence of different life stages of non anadromous fish species in stream habitats lost (eliminated, dewatered, or fragmented) under the Pebble 0.25 stage mine.

Species	Prevalence of Life Stage[a]			
	Juvenile	Other Sub-Adult	Adult	Not Recorded[b]
Rainbow trout	100%			
Dolly Varden	25%	55%	2%	18%
Arctic grayling	50%	6%	17%	28%
Northern pike	29%	50%	21%	

Notes:
[a] The figures in this table represent all of the fish-bearing streams within the Pebble 0.25 stage mine footprint (i.e., both anadromous and non-anadromous). If the data reflected only the non-anadromous streams higher in the watersheds, it would show an even greater proportion of the sub-adult life stages (ADF&G 2012).
[b] The fish survey did not record life stage.

4.2.2 Effects of Loss of Tributaries of Anadromous Fish Streams

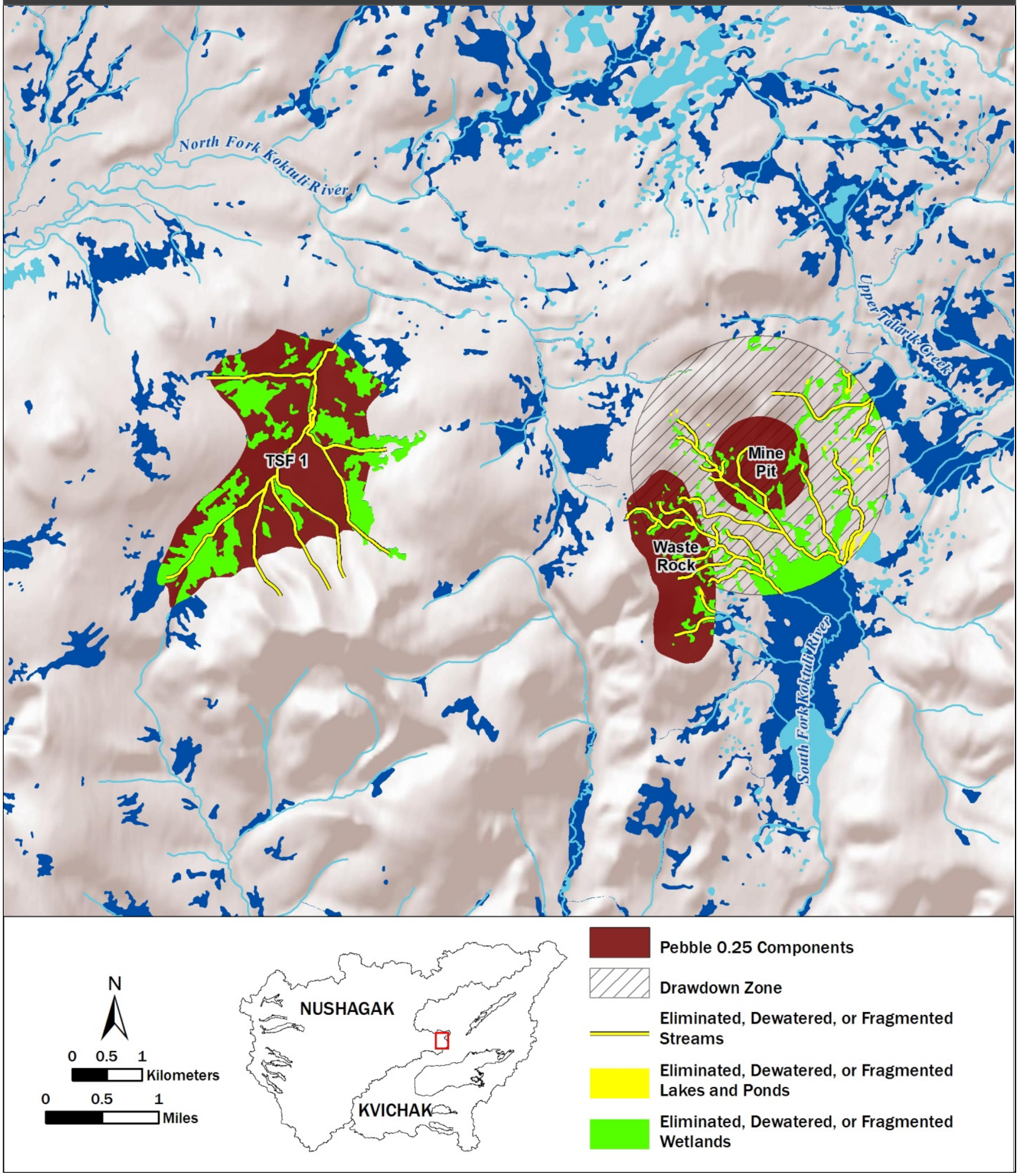
In addition to eliminating or dewatering nearly 5 miles (8 km) of documented anadromous fish streams, the Pebble 0.25 stage mine assessed by the BBA (EPA 2014) would also eliminate, dewater, or fragment nearly 19 miles (30 km) of streams that are tributaries of anadromous waters but that are not identified in the AWC themselves (Johnson and Blanche 2012) (Table 4-4, Figure 4-7). The vast majority of these tributaries are small headwater streams that provide crucial provisioning services to anadromous fish streams (Section 3.2.4). As described in Section 4.2.1, the eliminated or dewatered tributaries likely would be permanently lost. It is also likely that the support functions of tributaries that the mine would fragment would be severely compromised, since flow diversion from such tributaries likely would pass through either the wastewater treatment plant (WWTP) or diversions or pipes, the discharges from which would be unlikely to successfully mimic pre-mine tributary conditions.

Table 4-4. Length of tributaries of anadromous fish streams lost (eliminated, dewatered, or fragmented) under the Pebble 0.25 stage mine.

Type of Loss	Tributary Length (miles)[a]
Eliminated	8.9
Dewatered	8.3
Fragmented	1.7
TOTAL LOSS	**18.9**

Notes:
[a] From the National Hydrography Dataset (USGS 2012).

Figure 4 7. Streams and wetlands lost (eliminated, dewatered, or fragmented) under the Pebble 0.25 stage mine. Light blue areas indicate streams and rivers from the National Hydrography Dataset (USGS 2012) and lakes and ponds from the National Wetlands Inventory (USFWS 2012); dark blue areas indicate wetlands from the National Wetlands Inventory (USFWS 2012).



The elimination, dewatering, and fragmentation of tributaries of documented anadromous fish streams would adversely affect downstream habitat for salmon (and other fish species) (Sections 3.2.4 and 4.2.1, as well as Figures 4-2 through 4-4). These downstream waters currently provide spawning or rearing habitat for coho, Chinook, sockeye, and chum salmon in the SFK, NFK, and UTC watersheds (Figures 4-1 and 4-2); pink salmon are also present in the lower part of UTC.

Adverse impacts on salmon fishery areas would occur as the Pebble 0.25 stage mine eliminated or prevented the flow of water and food subsidies from these tributaries to downstream habitats.[40] The elimination, dewatering, or fragmentation of headwater tributaries would also eliminate or reduce groundwater inputs to downstream waters, along with their positive influence on flow, temperature moderation, and thermal habitat diversity (Section 3.2.4). The loss of the temperature moderation via groundwater-influenced flows to downstream waters would exacerbate the potentially substantial changes in stream temperature caused by WWTP discharges (EPA 2014: Chapter 8). Finally, since the narrower width of these tributaries results in proportionally greater inputs of terrestrial organic matter (Vannote et al. 1980), these habitats provide a disproportionate volume of detritus, nutrients, and macroinvertebrates to downstream waters; thus, the loss of energy subsidies may be magnified accordingly.

By itself, the elimination, dewatering, or fragmenting of approximately 19 miles (30 km) of tributaries of anadromous fish streams as the result of a CWA Section 404 permit would be an unprecedented impact in Alaska. These tributary losses represent nearly 3% of mapped streams in the SFK, NFK, and UTC watersheds, but effects of their loss would reverberate to downstream habitats and affect species such as coho, Chinook, sockeye, and chum salmon, all of which support important commercial, subsistence, or recreational fisheries. This magnification of impacts would arise from the vital role headwater streams play in maintaining diverse, abundant fish populations, via the provision of surface and groundwater inputs and food sources critical to the survival, growth, and spawning success of downstream fishes (Section 3.2.4). The loss of these subsidies could degrade downstream salmon habitat, local salmon populations, and fisheries well beyond the Pebble 0.25 stage mine footprint, compromising the overall diversity and productivity of the SFK, NFK, and UTC watersheds (Section 4.2.1).

EPA Region 10 believes that discharge of dredged or fill material for construction of the Pebble 0.25 stage mine that would result in the loss of 19 miles (30 km) of tributaries of documented anadromous fish streams could have unacceptable adverse effects on fishery areas. This finding is based on the crucial role that headwater tributary streams play in providing water and food subsidies to downstream salmon fishery areas in the SFK, NFK, UTC and elsewhere; the importance of affected salmon species in the region's commercial, subsistence, and recreational fisheries; and the likelihood of high genetic diversity among localized populations of coho, Chinook, and sockeye salmon, which, along with the

[40] The export of subsidies and losses thereof would not be uniform for all eliminated, dewatered, or fragmented tributaries. For example, the dewatered streams that drain the surficial ore body and have background copper concentrations toxic to invertebrates may contribute fewer or less diverse energy subsidies to downstream waters than other tributaries. Also, if the Pebble 0.25 stage mine incorporates diversions of the 1.7 miles (2.8 km) of fragmented streams, the downstream export of water or food subsidies from them may continue.

intact, connected tributary habitats, is a key component of the abundance of Bristol Bay salmon stocks. As shown in Figures 4-1 and 4-2, placement of major mine components (mine pit, TSF, and waste rock pile) in different locations from those assessed in the BBA (EPA 2014) could affect even more tributaries of anadromous fish streams. Adding further to EPA Region 10's concern about the loss of tributaries of anadromous fish streams is the fact that available data indicate that at least 4.9 miles (7.9 km) of these tributaries, spanning all three watersheds, support non-anadromous fish species such as rainbow trout, Dolly Varden, Arctic grayling, ninespine stickleback, and slimy sculpin (Figures 4-5 and 4-6). As described in Section 4.2.1, rainbow trout, Dolly Varden, and Arctic grayling are targets of downstream subsistence and recreational fisheries, which the stickleback and sculpin support as forage fish. Thus, not only do these 19 miles (30 km) of tributaries provide critical support to downstream salmon populations, they also directly support other non-anadromous fish species important to subsistence and recreational fisheries and aquatic foodwebs.

4.2.3 Effects of Loss of Wetlands, Lakes, and Ponds Contiguous with Anadromous Fish Streams or Their Tributaries

In addition to anadromous fish streams and their tributaries, habitat losses from the Pebble 0.25 stage mine would also include elimination, dewatering, or fragmentation of more than 1,200 acres (4.9 km^2) of wetlands, lakes, and ponds, of which approximately 1,100 acres (4.4 km^2) are contiguous with documented anadromous streams or their tributaries (Table 4-5).[41] More than 90% of these waters are contiguous with documented anadromous fish streams, and the vast majority are wetlands. These waters likely play a crucial role in the life cycles of anadromous fish in the SFK, NFK, and UTC watersheds (Section 3.2.3, PLP 2011: Appendix 15.1.D).

Table 4-5. Area of wetlands, lakes, and ponds lost (eliminated, dewatered, or fragmented) under the Pebble 0.25 stage mine.

Type of Loss	Area (acres)
Eliminated	734
Dewatered	410
Fragmented	77
TOTAL AREA LOST	**1,218**
TOTAL CONTIGUOUS AREA LOST[a]	**1,081**

Notes:
[a] Area contiguous with anadromous streams and their tributaries, based on Johnson and Blanche (2012) and USGS (2012).
Source: National Wetlands Inventory (USFWS 2012).

As described in Section 4.2.1, the contiguous waters that the Pebble 0.25 mine would eliminate, dewater, or fragment include beaver ponds and wetlands inundated as a result of beaver activity (USFWS 2012).

[41] Although the word is plural for improved readability of the sentence, there is only one lake in the drawdown zone assessed by the BBA. The NWI (USFWS 2012) classifies only water bodies of 20 acres (0.08 km^2) or more as lakes. The impacted lake is not contiguous with a mapped stream. To be conservative, the BBA reports only the acreage within the footprint of the projected drawdown zone. In reality, the drawdown zone would lower water levels in the entirety of any pond or lake it intersected. This fact would add another 10 acres (0.04 km^2) to the reported acreage of ponds and lakes impacted by "dewatering."

Coho and Chinook salmon rear in many of the beaver-modified waters or the streams they abut (Johnson and Blanche 2012). Beaver-modified waters provide excellent rearing habitat and important overwintering and flow-velocity refugia for salmonids (Sections 3.2.4 and 4.2.1). Because overwintering habitat may be limiting in the SFK, NFK, and UTC watersheds, these beaver-modified waters may be especially important in maintaining salmon productivity (Nickelson et al. 1992, Solazzi et al. 2000, Pollock et al. 2004).

There likely is also undocumented anadromous fish habitat in the form of small, unmapped tributaries in wetlands contiguous with mapped anadromous fish streams. Such channels 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 rearing and foraging conditions that may be unavailable in the main stream channel (Sommer et al. 2001, Henning et al. 2006), thereby increasing capacity for juvenile salmon rearing (Nickelson et al. 1992).

Contiguous wetlands indirectly support anadromous fish habitat by providing cover, moderating temperatures and streamflows, maintaining baseflows, serving as groundwater recharge zones, and supplying nutrients, organic material, macroinvertebrates, algae, and other materials to abutting streams and others 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). Abundant wetlands and small ponds, for example, contribute disproportionately to groundwater recharge (Rains 2011). Given the importance of groundwater–surface water exchange in this region, groundwater inputs are likely a significant determinant of surface water quantity and quality. Moreover, leaf litter from the deciduous shrubs dominant in the riparian wetlands in the area of the Pebble deposit is an important source of food in stream foodwebs and helps fuel the production of macroinvertebrates, a key food for salmonids (Section 4.2.1).

As with the habitat losses described previously, the elimination, dewatering, or fragmenting of approximately 1,100 acres (4.4 km^2) of wetlands, lakes, and ponds contiguous with anadromous fish streams and their tributaries would be a very large and unprecedented impact under the CWA Section 404 regulatory program in Alaska. The loss of such waters 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, such supplying nutrient and detrital inputs and maintaining baseflows, for both abutting and downstream waters (Section 3.2.3). In addition to the coho and Chinook salmon present within the Pebble 0.25 stage mine footprint, downstream waters also support sockeye (all three watersheds), chum (all three watersheds), and pink salmon (UTC) (Figure 4-2). As described in Section 4.2.1, the loss of food resources and overwintering habitat could reduce overall salmonid rearing capacity in the SFK, NFK, and UTC watersheds and adversely affect the valuable commercial, subsistence, and recreational fisheries downstream of the Pebble 0.25 stage mine.

In more developed regions, wetland losses have been associated with reductions in habitat quality and salmon abundance, particularly for coho salmon (Beechie et al. 1994, Pess et al. 2002).

The extent of wetland, lake, and pond losses under the Pebble 0.25 stage mine could be at a level that the SFK, NFK, and UTC watersheds may not be able to afford. The significance of these losses results from the importance of contiguous wetlands, lakes, and ponds to salmon populations, both as habitat and as sources of groundwater inputs, nutrients, and other subsidies crucial to salmon productivity (Section 3.2.3); the vulnerability of localized populations of coho, Chinook, and sockeye salmon (Section 4.2.1) in streams flowing through the lost wetlands or downstream of them; and the importance of such localized populations to the resilience of the Bristol Bay salmon fisheries. Shifting a mine component such as the waste rock pile to a slightly different location from that assessed in the BBA (EPA 2014) would likely result in even greater loss of wetlands, lakes, and ponds, with similarly greater impacts on fishery areas. Thus, loss of wetlands, lakes, and ponds due to the discharge of dredged or fill material associated with the Pebble 0.25 stage mine could have unacceptable adverse effects on fishery areas both within and downstream of the SFK, NFK, and UTC watersheds.

Compounding this concern is the fact that salmon are not the only fish species that the loss of wetlands, lakes, and ponds would adversely affect. Rainbow trout, Dolly Varden, Arctic grayling, and northern pike rear in many of the same beaver-modified habitats as coho and Chinook salmon, and Arctic grayling rear in two ponds that are contiguous with the headwaters of the SFK (Figures 4-5 and 4-6). Subsistence or recreational fisheries target all four of these species downstream of the Pebble 0.25 mine site. Given that these species move across large distances throughout their life cycles (EPA 2014: Appendix B), fish that rear in or along wetlands and ponds contiguous with anadromous fish streams likely contribute to the abundance of downstream fisheries. Thus, the loss of headwater rearing habitat could adversely affect those fisheries as well.

4.2.4 Effects of Downstream Flow Alteration

Sections 4.2.1 through 4.2.3 discuss adverse impacts on downstream waters resulting from the loss of upstream subsidies. These losses would result from the elimination, dewatering, or fragmentation of streams, wetlands, and other aquatic resources due, either directly or indirectly, to the discharge of dredged or fill material into such waters. This section addresses one particularly important subsidy in greater detail—specifically, the contribution of surface water and groundwater to streams downstream of the Pebble 0.25 stage mine.

The Pebble 0.25 stage mine would consume large volumes of water drawn from surface water and/or groundwater sources, which would change the volume, distribution, and flowpaths of surface water and groundwater flows in and beyond the mine footprint (EPA 2014: Chapter 7). Dewatering of the mine pit would significantly lower groundwater levels in the surrounding area (i.e., the drawdown zone), reducing groundwater-influenced contributions to streamflows (EPA 2014: Figure 6-5 and Box 7-1). At the same time, discharges from the WWTP would substantially increase flows in receiving streams. Although approximately 76% of captured water could be returned to the watersheds, the distribution of flows between streams and the relative contributions of surface water versus groundwater flows likely would differ substantially from pre-mine conditions (EPA 2014: Chapter 7).

A natural streamflow regime comprises multiple components—magnitude, frequency, duration, timing, and rate of change of flows—that all can have important implications for fish and other aquatic life (Poff et al. 1997). 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). 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).

Groundwater is likely the dominant source of flow in streams draining the Pebble deposit area (Section 3.2.1). Winter observations of ice-free conditions support this conclusion and suggest the presence of upwelling groundwater in strongly gaining reaches of the SFK, NFK, and UTC in the area of the Pebble deposit (PLP 2011, Woody and Higman 2011). Groundwater is one of the most important determinants of high-quality salmon habitat. Groundwater contributions result in moderated peak flows and higher baseflows than observed in streams with less groundwater influence (EPA 2014: Figure 3-10), contributing to both channel and substrate stability (Rosgen 1996, Newson and Large 2006). Groundwater exchange also moderates stream temperature extremes, resulting in cooler summer and warmer winter temperatures (Brannon 1987, Hendry et al. 1998). This function likely is essential to spawning habitat and overwintering habitat for developing eggs, through the maintenance of ice-free stream bottoms. Ultimately, these influences create high-quality salmon habitat (EPA 2014: Appendix A).

Recognizing the importance of natural flow regimes to habitat-forming processes and the biotic integrity of salmon ecosystems in the Bristol Bay region, the BBA evaluated projected streamflow changes in terms of percent change in natural flow regime, versus a more simplistic consideration based on changes in high- or low-streamflow events (EPA 2014: Chapter 7). Such an approach targets the entire aquatic ecosystem, rather than focusing on a specific species or set of species, such as salmon, that may have very different habitat requirements than other biota in the natural system.

The BBA calculated that operation of the Pebble 0.25 stage mine would reduce flow in more than 45 miles (nearly 75 km) of streams and increase flow in more than 12 miles (20 km) of streams (EPA 2014: Table 7-19).[42] Table 4-6 lists stream reaches that would experience greater than 10% streamflow alteration. Most notable among the affected reaches are the 1.2-mile (1.9-km) reach of the SFK mainstem

[42] As is true for other impacts associated with the BBA mine scenarios (and as described in Section 7.2.5 of the BBA), estimates of streamflow changes are based on certain assumptions. These include assumptions about water allocation through mine processes, an assumption that the mine would route captured water that required treatment through the WWTP, and that reduced streamflows would follow the same spatial patterns of gaining or losing groundwater reaches as pre-mine conditions. As with other impacts, actual flow modifications could vary substantially in magnitude, nature, and location from streamflows based on the BBA's assumptions. Modeling built on robust baseline data and confirmed with post-construction monitoring would be necessary for more precise determination of streamflow changes.

immediately downstream of the mine pit drawdown zone, in which flows would decrease by 54%, and the 4.7 miles (7.6 km) of SFK tributary that would receive WWTP discharges, which would increase its flows by approximately 30% (EPA 2014: Figure 7-14). In total, the BBA estimates that the Pebble 0.25 stage mine would alter streamflow by 26% or more in approximately 9.3 miles (14.9 km) of streams and that another 9.6 miles (15.6 km) of streams would experience 13% to 17% alterations. The majority of the affected streams (77%) would be in the SFK watershed, with the remainder in the NFK.

Fish surveys confirm that three salmon species—coho, Chinook, and sockeye—use the stream reaches in which the Pebble 0.25 stage mine would change streamflows by more than 20% (Table 4-6, Figure 4-8). All six affected reaches currently provide coho salmon rearing habitat; there is also documented coho spawning habitat in some affected streams. This coho salmon spawning and rearing habitat spans both the SFK and NFK watersheds. As described in Section 4.2.1, it is likely that the affected habitat supports discrete populations of coho salmon. Streamflow alterations would also adversely affect Chinook salmon rearing habitat in both watersheds, as well as Chinook spawning and sockeye rearing habitats in the SFK watershed. These Chinook and sockeye salmon populations also may be genetically distinct.

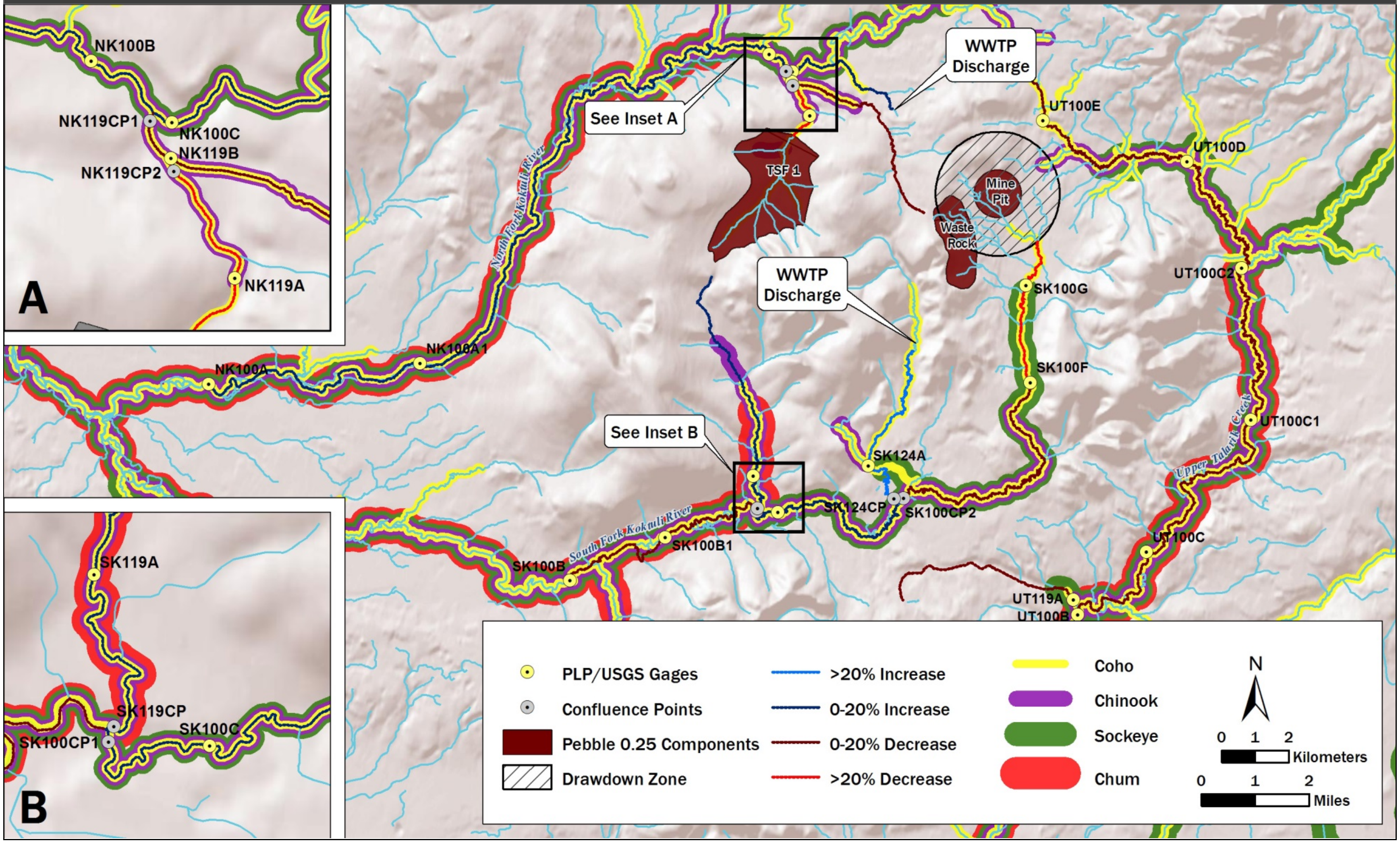
Table 4-6. Salmon species documented to occur in stream reaches experiencing greater than 10% streamflow alterations due to the Pebble 0.25 stage mine.

Stream Reach			% Streamflow Alteration	Salmon Species and Life Stages Present[b]		
Stream	Reach[a]	Length (miles)		Coho	Chinook	Sockeye
SFK mainstem	Upstream of SK100G	1.2	-54	J		J
	SK100G to SK100F	2.1	-26	J		J
	SK100F to SK100CP2	6.6	-15	A,J	A,J	J
SFK tributary	Upstream of SK124A	3.1	+32	J	J	J
	SK124A to SK124CP	1.6	+30	J	J	J
NFK tributaries	Upstream of NK119A	0.5	-29	A,J	J	
	NK119A to NK119CP2	0.8	-26	A,J	J	
	NK119CP2 to NK119CP1	0.2	-17	J	J	
	Upstream of NK100C	2.8	+13	J	J	

Notes:
[a] Reaches defined by stream gages, as shown in Figure 4-8.
[b] From the Anadramous Waters Catalog (Johnson and Blanche 2012).
A = adult; J= juvenile.

A compilation of research from around the world indicates that, regardless of geographic location, daily streamflow alterations of greater than 20% can cause major changes in the structure and function of streams (Richter et al. 2012). Richter et al. (2012) further concluded that streamflow alterations between 11 and 20% typically cause measurable changes in ecosystem structure, with minor impacts on ecosystem function. In contrast to the SFK, NFK, and UTC, the riverine systems evaluated by Richter et al. (2012) exhibited sustained levels of impact, and the authors acknowledged that restricting streamflow alterations to 20% may be insufficient to protect all ecological values, particularly in smaller streams or systems with at-risk species. Because Pacific salmon are finely attuned to small variations in multiple parameters such as temperature and velocity, it is possible that a lower threshold of streamflow modification would be necessary to adequately protect these species.

Figure 4 8. Reported salmon distributions in stream segments experiencing streamflow changes associated with the Pebble 0.25 stage mine. Species distributions are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Streamflow modification class is shown for each stream segment to indicate degree and direction of change. Classes are assigned at a gage and extend upstream to the next gage, confluence point, or mine footprint (see Chapter 7 in EPA [2014] for a more detailed discussion of methodology).



Changes in surface water and groundwater contributions to streams would reduce both the extent and quality of fish habitat downstream of the Pebble 0.25 stage mine. Reductions in streamflow of the magnitude predicted by the BBA (26 to 54%) could reduce instream habitat availability, particularly during periods of natural low flows; fragment stream habitats; and preclude normal seasonal movements by anadromous and migratory resident fish (West et al. 1992, Cunjak 1996, EPA 2014: Chapter 7). Diminished streamflows also likely would 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 (Quinn 2005).

Taken together, streamflow changes could alter channel geometry and destabilize channel structure, with effects propagating long distances downstream. Reduced streamflows likely would change sediment transport dynamics, resulting in the deposition of more or finer sediment and ultimately smothering eggs or rendering stream substrate less suitable for spawning. Streambed aggradation from increased sedimentation could lead to further hydrologic modification, loss of habitat complexity such as riffle-pool complexes, and outright loss or fragmentation of habitat. Lower streamflows can also result in reduced dissolved oxygen levels.

As described at the beginning of this section, the groundwater drawdown zone associated with the mine pit would be responsible for much of the reduction in streamflows. The loss of groundwater inputs in affected reaches would not only reduce the sheer volume of streamflow, but could also reduce baseflows in receiving waters and have profound adverse impacts on stream thermal regimes (EPA 2014: Chapter 7). Warmer summer water temperatures could limit summer habitat for salmon, whereas colder winter water temperatures could adversely affect egg development and hatching and emergence timing (Brannon 1987, Beacham and Murray 1990, Hendry et al. 1998, Quinn 2005). Since the threshold between completely frozen and partially frozen streams can be a narrow one (Irons et al. 1989), particularly for small streams with low winter discharge such as many of the headwater streams in the Pebble deposit area, these reductions in flow could substantially alter fish habitat, particularly the extent of critical unfrozen overwintering habitat (Huusko et al. 2007, Brown et al. 2011).

Warmer summer and colder winter temperatures resulting from the loss of groundwater inputs also would likely change the species composition and richness of macroinvertebrates, a key food for juvenile salmon, and reduce overall macroinvertebrate abundance and productivity in the affected reaches. At the same time, reduced hydrologic connectivity between streams and riparian wetlands would also reduce or eliminate the export of detritus, macroinvertebrates, and other energy subsidies from wetlands to streams.

At the other extreme, streamflow increases greater than 20% likely would lead to greater scour and mobilization of sediments, increasing turbidity and degrading habitat suitability for salmon (EPA 2014: Chapter 7). Increased streamflow velocities could impede salmon migration, particularly for juveniles.

Increased streamflows could also eliminate off-channel habitat through the destruction of beaver dams or erosion of stream banks, and reduce invertebrate populations as a result of streambed scour and erosion. WWTP discharges could not only increase streamflows, but also significantly change stream temperatures; the extent and duration of temperature changes would depend on the temperature, quantity, and timing of discharges, as well as the influence of other inputs such as groundwater and tributary inflows (EPA 2014: Chapter 8).

Since the timing of salmon migration, spawning, and incubation is closely tied to seasonal water temperatures, any loss of thermal heterogeneity could disrupt life-history timing cues and result in mismatches between fish and their environments that adversely affect survival (Angilletta et al. 2008). Thus, streamflow reductions resulting from the loss of temperature-moderating groundwater inputs or streamflow increases resulting from temperature-altering WWTP 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 the portfolio effect (Section 3.3.6.2). Although fish populations may be adapted to periodic disturbances associated with natural temporal flow 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 could have longer-term impacts on fish populations (Jensen and Johnsen 1999, Lytle and Poff 2004). Overall, the adverse effects of flow modification on stream and off-channel habitats could substantially reduce spawning success for coho salmon, survival of overwintering coho, Chinook, and sockeye salmon, and ultimately coho, Chinook, and sockeye productivity in the SFK and NFK watersheds. Many of the effects of substantially altered 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. Because the streamflow modifications associated with the Pebble 0.25 stage mine would affect many of the parameters that establish high-quality salmon habitat, the results of overlapping impacts on multiple parameters could be very different from impacts considered individually.

As with the habitat losses described in Sections 4.2.1 through 4.2.3, the adverse impacts of streamflow modification could result in the loss of distinct populations of coho, Chinook, and sockeye salmon. Such losses could influence evolutionary processes by restricting gene flow, causing loss in local adaptation and population resilience to environmental change (Fullerton et al. 2010, Lapointe et al. 2014). Ultimately, these changes could contribute to erosion of the population diversity that is key to the stability of the overall Bristol Bay salmon fisheries (Schindler et al. 2010). As described in Section 4.2.1, Chinook and sockeye salmon are important subsistence fisheries in the Nushagak and Kvichak River watersheds, and, with coho salmon, are by far the three most harvested sport fishes in the Nushagak and Kvichak River watersheds (Table 3-12). The adverse impacts described herein could jeopardize the long-term sustainability of these fisheries.

Following cessation of mining (EPA 2014: Table 6-2), the pit would gradually refill with water, which would begin to restore the balance of groundwater inputs to downstream flows (EPA 2014: Table 6-2). Given that refilling of the pit would take approximately 20 years for the Pebble 0.25 stage mine and that it would be necessary to divert any water leaving the pit to the WWTP for as long as treatment was necessary to meet water quality standards, mine-related alteration of the surface water–groundwater balance would persist for at least 40 years (EPA 2014: Chapter 6).[43] These time periods far exceed the 2- to 5-year life spans of coho, Chinook, and sockeye salmon. Thus, the long-term severe degradation of spawning or rearing habitat for these species could be sustained for many generations.

The BBA assumes that mine operation would include active management of water captured, diverted, detained, and/or retained on site to attempt to match seasonal stream hydrographs (EPA 2014: Chapter 7). For instance, flow regulation through the WWTP could be designed to somewhat approximate natural hydrologic regimes when sufficient water and storage capacity were available (EPA 2014: Chapter 7). The seasonal timing and magnitude of streamflow alterations would depend on water storage and management systems and strategies, and would be constrained by the fundamental needs for water at specific times and locations in the mining process (EPA 2014: Chapter 7). Moreover, the complexity inherent in surface water–groundwater interactions makes prediction, regulation, and control of such interactions during large-scale landscape development very difficult (Hancock 2002). In fact, adequately protecting the critical services that groundwater provides to fish, via its influence on surface waters, is complicated by the fact that flowpaths vary at multiple scales and connections between distant recharge areas and local groundwater discharge areas are difficult to predict (Power et al. 1999).

EPA Region 10 believes that the discharge of dredged or fill material associated with construction of the Pebble 0.25 stage mine would alter streamflows by more than 20% in approximately 9 miles (14 km) of stream, and thus could have unacceptable adverse impacts on the coho, Chinook, or sockeye fisheries of the SFK and NFK, as well as downstream fishery areas. This finding is based on the outright loss of salmon habitat due to streamflow alterations; the loss of access to crucial off-channel habitats; the loss of thermal habitat diversity, life-history timing cues, and macroinvertebrate productivity due to reduced groundwater contributions to streamflows or increased surface flows resulting from WWTP discharges; and the potential erosion of genetic diversity among local salmon populations,

In addition, such streamflow alterations would have similarly adverse effects on four additional fish species: Dolly Varden (in the SFK tributary that would receive WWTP discharges and the NFK tributary below the Pebble 0.25 stage TSF), Arctic grayling and northern pike (in the SFK mainstem), and slimy sculpin (in the SFK mainstem and one tributary) (Figures 4-9 and 4-10). As with coho, Chinook, and sockeye salmon, Dolly Varden, northern pike, and Arctic grayling also are harvested in downstream subsistence and recreational fisheries (Section 4.2.1).

[43] The duration of flow alterations would be substantially longer for the Pebble 2.0 or 6.5 stage mines (Section 4.3.1.2).

Figure 4 9. Reported rainbow trout and Dolly Varden distributions in stream segments experiencing streamflow changes associated with the Pebble 0.25 stage mine. Species distributions are based on the Alaska Freshwater Fish Inventory (point data, ADF&G 2012) and the Anadromous Waters Catalog (line data, Johnson and Blanche 2012). Streamflow modification class is shown for each stream segment to indicate degree and direction of change. Classes are assigned at a gage and extend upstream to the next gage, confluence point, or mine footprint (see Chapter 7 in EPA [2014] for a more detailed discussion of methodology).

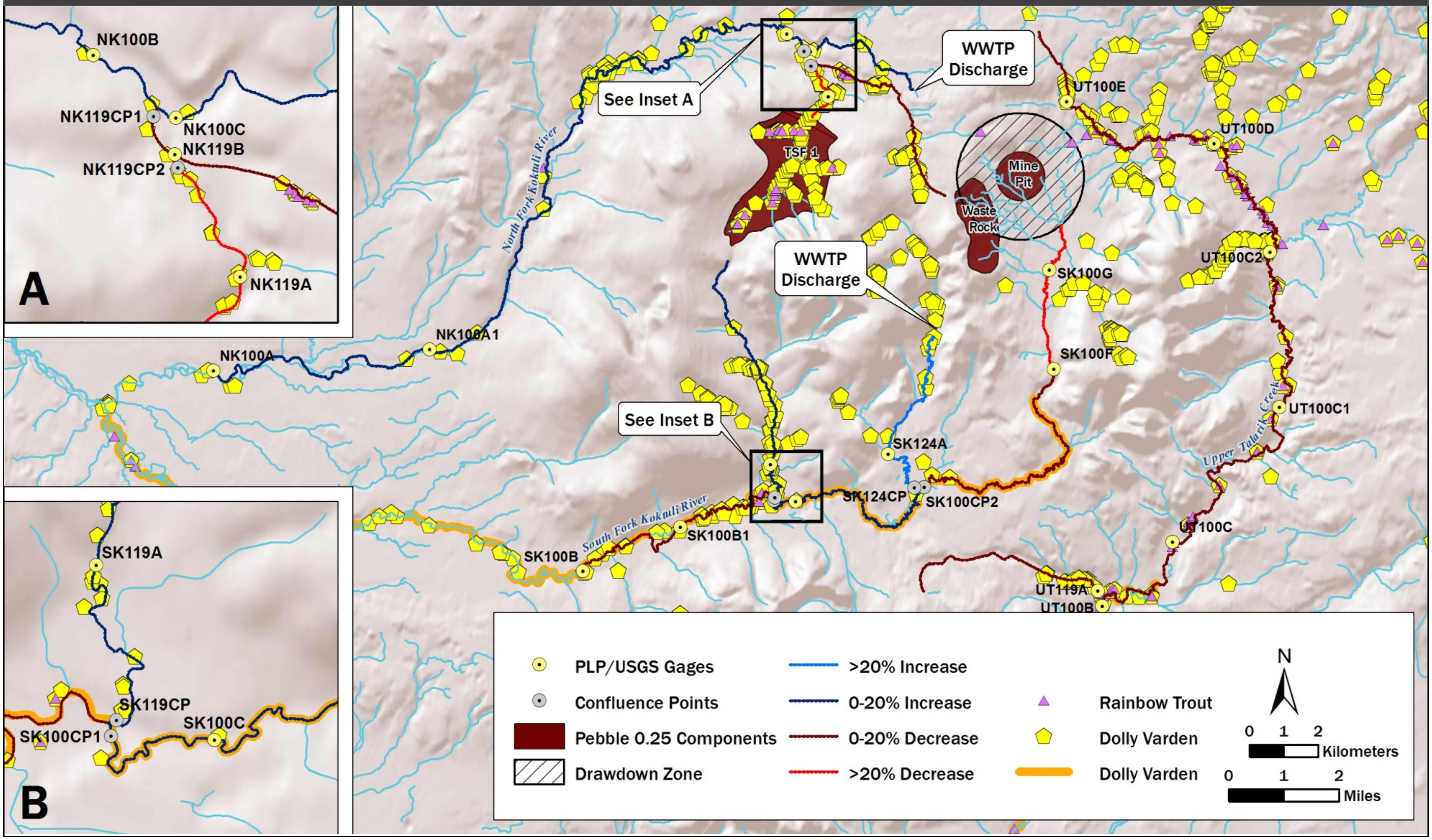
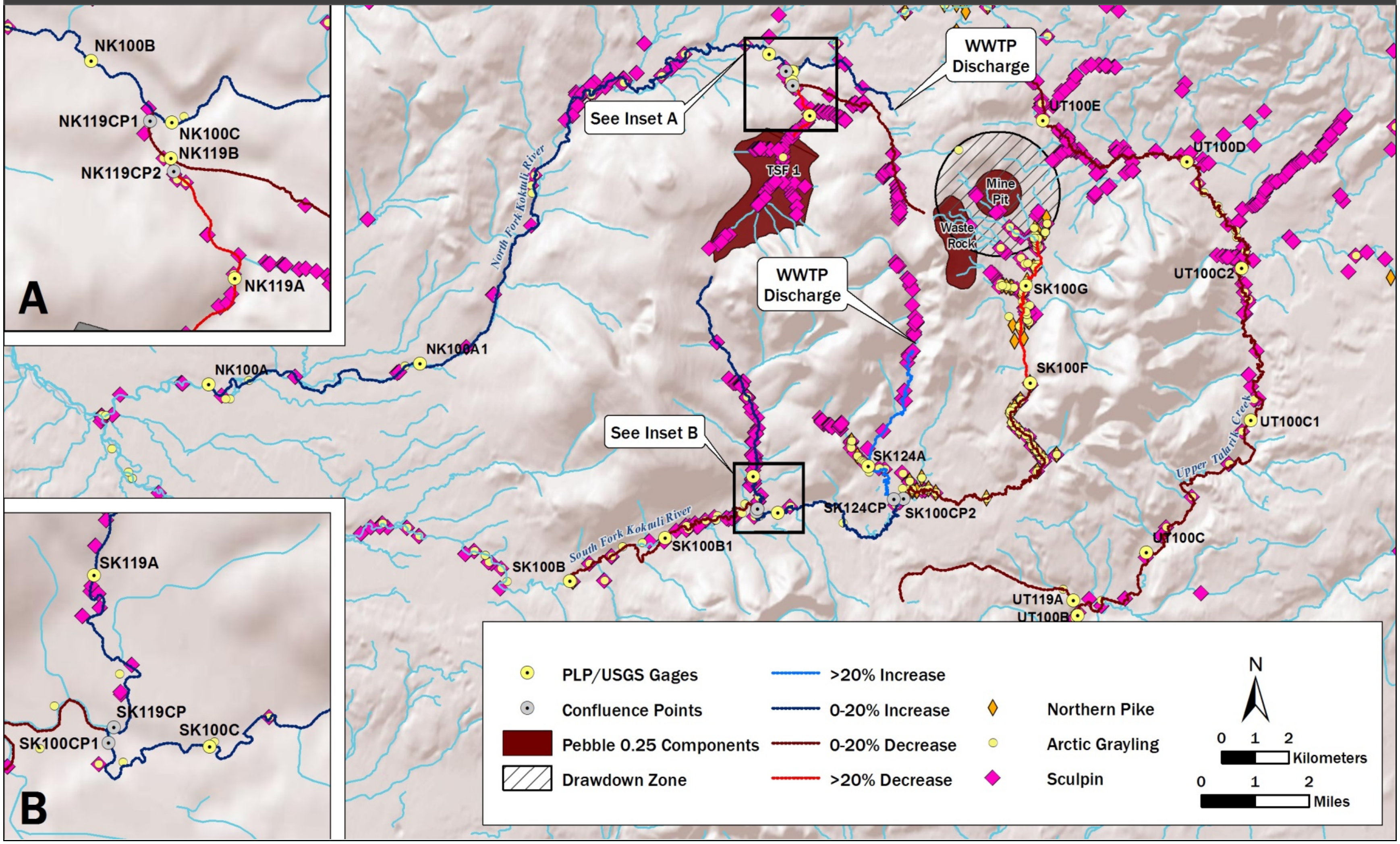


Figure 4 10. Reported distribution of other non salmon fish species in stream segments experiencing streamflow changes associated with the Pebble 0.25 stage mine. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2012). Streamflow modification class is shown for each stream segment to indicate degree and direction of change. Classes are assigned at a gage and extend upstream to the next gage, confluence point, or mine footprint (see Chapter 7 in EPA [2014] for a more detailed discussion of methodology).



4.3 Compliance with Relevant Portions of the Section 404(b)(1) Guidelines

EPA has broad discretion under CWA Section 404(c) in evaluating and determining whether a discharge will result in "unacceptable adverse effects" on fishery areas, including breeding and spawning areas. In this case, EPA Region 10 has concluded that effects within the potential disposal site could have an unacceptable adverse effect on fishery areas, as described in Sections 4.2.1 through 4.2.4.

In addition, EPA's Section 404(c) regulations at 40 CFR 231.2(e) provide that in evaluating the "unacceptability" of impacts, consideration should be given to the "relevant portions of the Section 404(b)(1) Guidelines." EPA Region 10 has identified a number of ways in which impacts of this nature and magnitude would be inconsistent with the requirements of the Section 404(b)(1) Guidelines. In Section 4.2, EPA Region 10 determined that there could be unacceptable adverse impacts on fishery areas associated with these kinds of effects. As detailed below, evaluation of compliance with relevant portions of the guidelines provides support and confirmation of the preliminary conclusion that these impacts could be unacceptable.

For the purposes of mining the Pebble deposit, the relevant portions of the Section 404(b)(1) Guidelines that are particularly important for assessing the unacceptability of environmental impacts include the following.

- 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 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:

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; and
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.

4.3.1.1 Direct and Secondary Effects of the Pebble 0.25 Stage Mine

As discussed in Section 3, the Bristol Bay watershed is home to abundant, diverse, high-quality aquatic habitats. These streams, wetlands, and other aquatic resources 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. The productivity and diversity of the watershed's aquatic habitats are closely tied to the productivity and diversity of its 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.

Section 4.2 describes in detail the extensive direct and secondary effects on valuable fishery areas resulting from the discharge of dredged or fill material associated with the Pebble 0.25 stage mine. These adverse effects would include the loss of nearly 24 miles (38 km) of streams, including approximately 5 miles (8 km) of streams with documented anadromous fish occurrence and 19 miles (30 km) of tributaries of those streams. Total habitat losses would also include more than 1,200 acres (4.9 km^2) of wetlands, lakes, and ponds, of which approximately 1,100 acres (4.4 km^2) are contiguous with either streams with documented anadromous fish occurrence or tributaries of those streams. These stream, wetland, and other aquatic resource losses would also reverberate downstream, by depriving downstream fish habitats of nutrients, groundwater inputs, and other subsidies from lost upstream aquatic resources.

In addition, water withdrawal, capture, storage, treatment, and release at the Pebble 0.25 stage mine would result in streamflow alterations in excess of 20% in more than 9 miles (nearly 15 km) of streams with documented anadromous fish occurrence. These changes in streamflow could result in major changes in ecosystem structure and function (Richter et al. 2012), and would significantly reduce both the extent and quality of fish habitats downstream of the mine (EPA 2014: Chapter 7). Streamflow reductions can reduce habitat availability for salmon and other stream 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 above background levels could result in increased scour and transport of gravels, affecting important salmon spawning areas. Increased streamflows also could be associated with altered distributions of water velocities favorable for various fish life stages (EPA 2014: Chapter 7).

Streams, wetlands, and other aquatic resources that would be destroyed or degraded by these direct and secondary effects currently provide habitat for coho, Chinook, and sockeye salmon, rainbow trout, Dolly Varden, Arctic grayling, and other fishes. This kind of extensive fish habitat destruction and degradation, particularly to spawning and rearing areas, could have significant adverse effects on these fish species and the commercial, subsistence, and recreational fisheries they support. Impacts of this nature and magnitude, including the potential to eliminate or threaten discrete populations of coho, Chinook, and sockeye salmon, could also have significant adverse effects by causing reductions of aquatic ecosystem diversity, productivity, and stability. Thus, impacts on streams, wetlands, and other aquatic resources from the discharge of dredged or fill material associated with the Pebble 0.25 stage mine could cause or contribute to significant degradation (40 CFR 230.10(c)) of fishery areas. EPA Region 10 recognizes that degradation of these aquatic resources could be even more pronounced when the extensive cumulative impacts on the aquatic ecosystem expected to occur with successive stages of mine expansion are considered (Section 4.3.1.2).

4.3.1.2 Cumulative Effects of Mine Expansion

At 40 CFR 230.1(c), 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." In light of this principle, the guidelines require making a "reasonable" prediction of these "cumulative effects," defined 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)).

The Section 404(b)(1) Guidelines require consideration of these reasonably foreseeable cumulative impacts in determining whether a project complies with the significant degradation prohibition of 40 CFR 230.10(c)).

Based on the preliminary plans NDM has already submitted to the SEC, it is reasonable to predict that a mine at the Pebble deposit would expand over time to at least 2.0 billion tons and eventually to 6.5 billion tons (Ghaffari et al. 2011, SEC 2011). It is also reasonable to consider potential impacts of the 2.0- and 6.5-billion-ton mines, as evaluated in the BBA (EPA 2014).

This section discusses the predicted impacts of the Pebble 2.0 and 6.5 stage mines. It is important to note, however, that the largest scenario considered in the BBA (6.5 billion tons) does not represent complete extraction of the Pebble deposit, which Ghaffari et al. (2011) estimates at nearly 12 billion tons. A mine that fully extracted this amount of ore would have significantly greater cumulative effects than those estimated in the BBA or evaluated here.

Pebble 2.0 and Pebble 6.5 Stage Mine Footprints

Figures 4-11 and 4-12 depict mine footprints for the Pebble 2.0 and 6.5 stage mines, respectively; specific sizes of each of these components can be found in the BBA (EPA 2014: Chapter 6). The Pebble 2.0 stage mine would entail enlargement of the Pebble 0.25 stage mine components, whereas the Pebble 6.5 stage mine would entail further enlargement and the creation of two additional TSFs. The BBA estimates total mine footprints of approximately 11,000 and 25,000 acres (45 and 103 km^2) for the Pebble 2.0 and 6.5 stage mines, respectively (EPA 2014: Chapter 6).

Figure 4 11. Streams and wetlands lost (eliminated, dewatered, or fragmented) under the Pebble 2.0 stage mine. Light blue areas indicate streams and rivers from the National Hydrography Dataset (USGS 2012) and lakes and ponds from the National Wetlands Inventory (USFWS 2012); dark blue areas indicate wetlands from the National Wetlands Inventory (USFWS 2012).

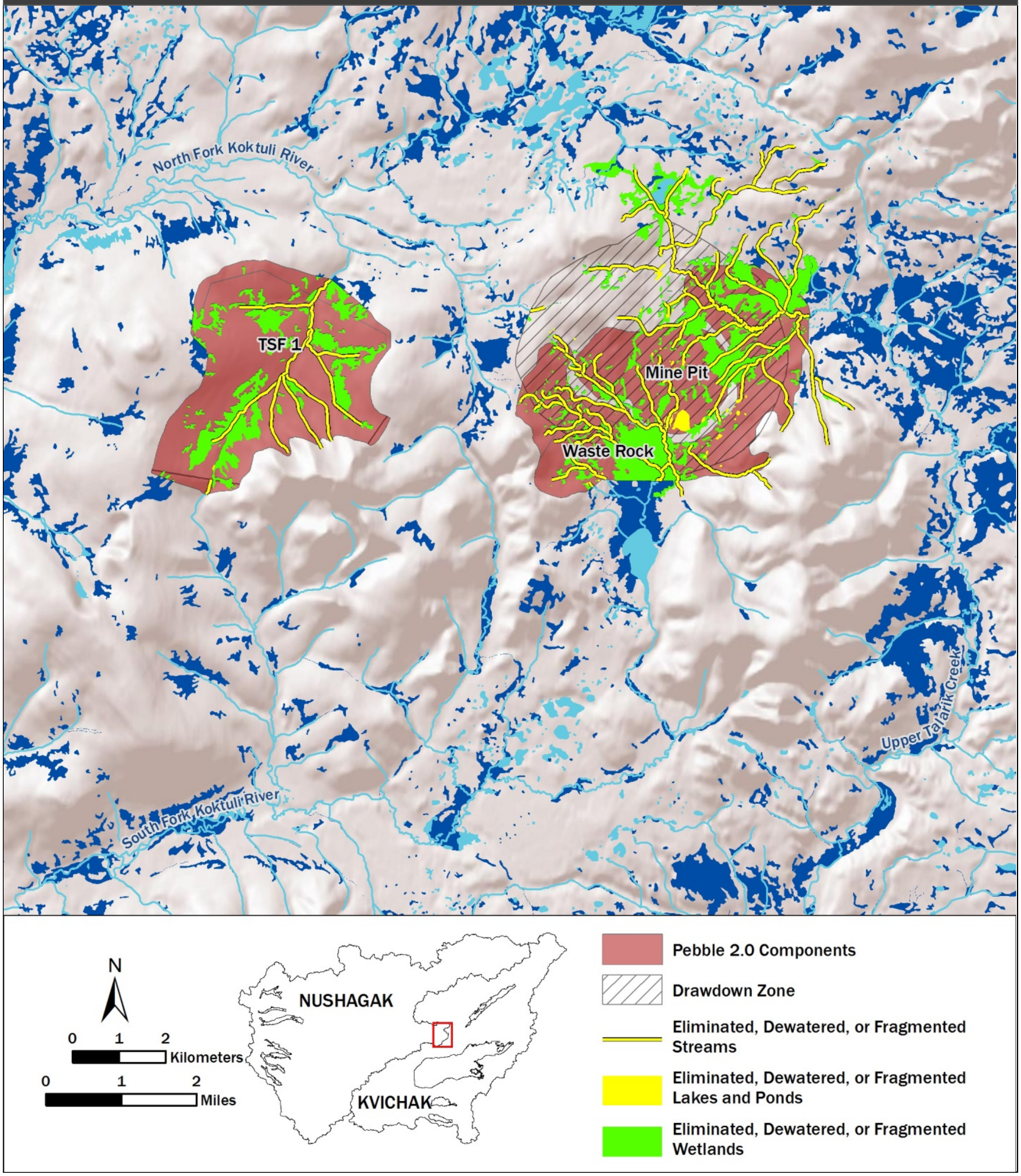
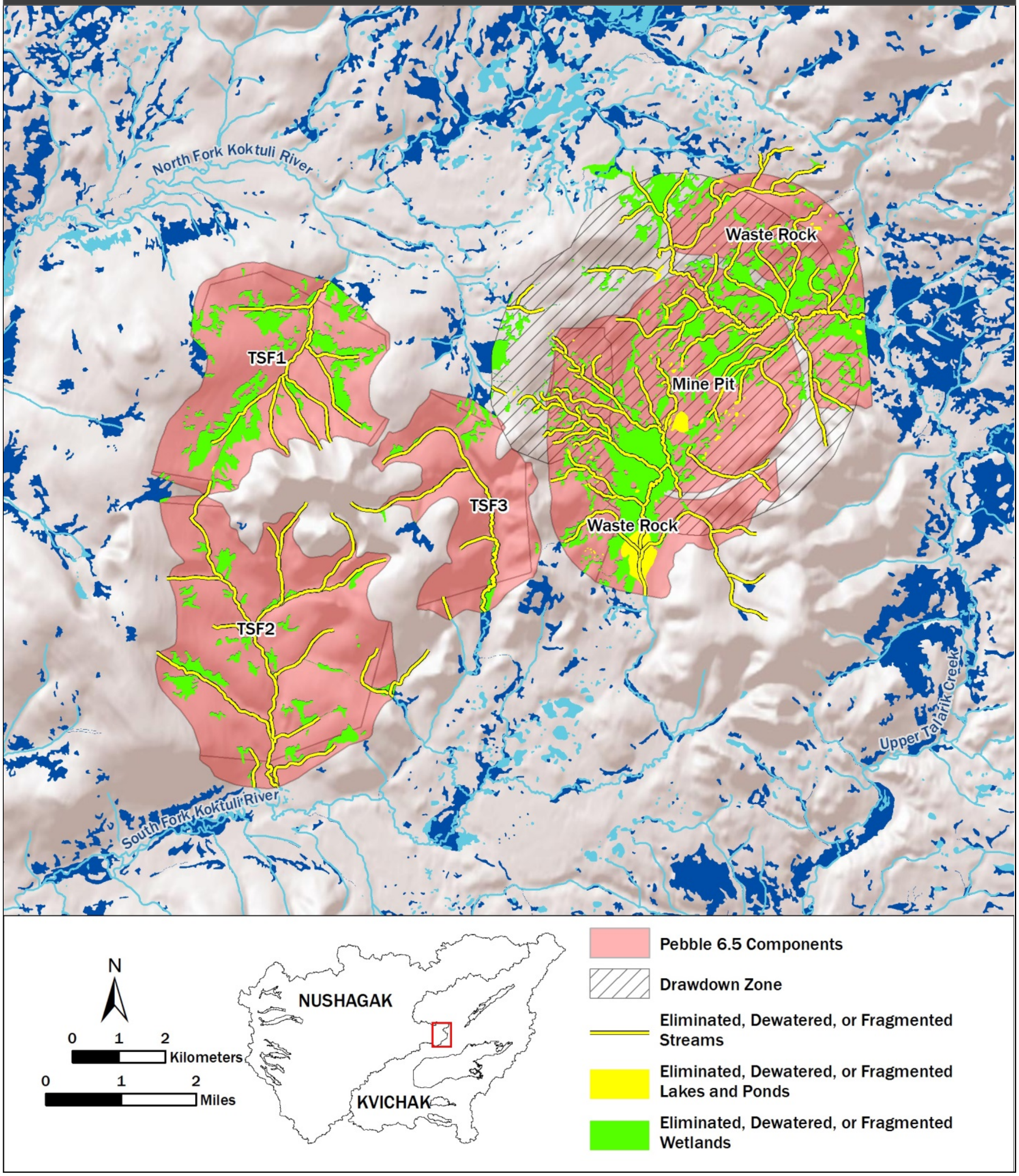


Figure 4 12. Streams and wetlands lost (eliminated, dewatered, or fragmented) under the Pebble 6.5 stage mine. Light blue areas indicate streams and rivers from the National Hydrography Dataset (USGS 2012) and lakes and ponds from the National Wetlands Inventory (USFWS 2012); dark blue areas indicate wetlands from the National Wetlands Inventory (USFWS 2012).



These larger mines would eliminate substantially more streams and other aquatic resources than the Pebble 0.25 stage mine (Section 4.2.1). The Pebble 2.0 and 6.5 stage mines would eliminate or dewater nearly 56 and 94 miles (89 and 151 km) of streams, respectively (Table 4-7), representing approximately 8 and 14% of the total mapped stream length in the SFK, NFK, and UTC watersheds (EPA 2014: Table 7-7). The Pebble 2.0 and 6.5 stage mines also would eliminate or dewater nearly 3,100 and 4,900 acres (12.5 and 19.8 km^2) of wetlands, ponds, and lakes, respectively (Table 4-8).

Table 4-7. Lengths of streams lost (eliminated, dewatered, or fragmented) under the Pebble 2.0 and 6.5 stage mines.

	Stream Length (miles)[a]				AWC Stream Length (miles)[b]			
Mine Stage	Eliminated by Major Mine Component	Dewatered by Mine Pit Drawdown Zone	Fragmented by Footprint	TOTAL Streams Lost to Footprint[c]	Eliminated by Major Mine Component	Dewatered by Mine Pit Drawdown Zone	Fragmented by Footprint	TOTAL AWC Streams Lost to Footprint
Pebble 2.0	44.9	4.2	6.4	55.6	10.9	1.5	1.1	13.5
Pebble 6.5	81.3	6.9	5.6	93.8	21.4	1.0	0.0	22.3

Notes:
[a] From the National Hydrography Dataset (USGS 2012).
[b] From the Anadromous Waters Catalog (Johnson and Blanche 2012.
AWC = Anadromous Waters Catalog.

Table 4-8. Area of wetlands, lakes, and ponds lost (eliminated, dewatered, or fragmented) under the Pebble 2.0 and 6.5 stage mines.

Mine Stage	Eliminated by Major Mine Component	Dewatered by Mine Pit Drawdown Zone	Fragmented by Footprint	TOTAL Area Lost to Footprint	Area Contiguous with AWC Streams and their Tributaries[a]
Pebble 2.0	2,516	148	427	3,091	2,827
Pebble 6.5	4,398	410	74	4,885	4,134

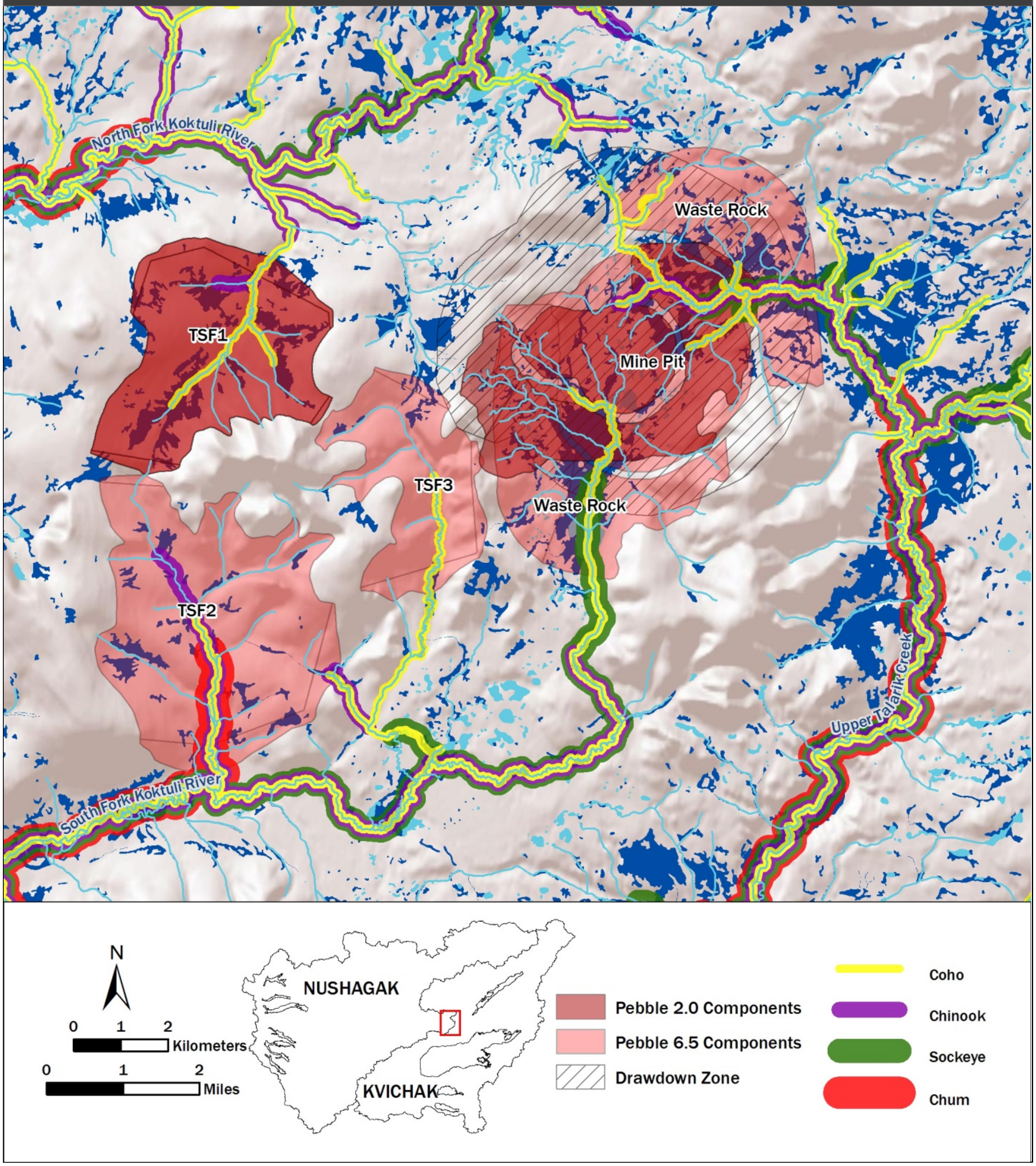
Note:
[a] From the Anadromous Waters Catalog (Johnson and Blanche 2012).
Source: National Wetlands Inventory (USFWS 2012).
AWC = Anadromous Waters Catalog.

Cumulative Effects from Loss of Anadromous Fish Streams

In total, the Pebble 2.0 and 6.5 stage mines would conservatively eliminate approximately 13.5 and 22.3 miles (21.7 and 35.9 km) of documented anadromous fish streams, respectively (Table 4-7).[44] The Pebble 2.0 stage mine would cause losses to documented coho, Chinook, and sockeye salmon streams (Figure 4-13). Sockeye salmon would lose additional habitat under the Pebble 6.5 stage mine in both the SFK and UTC watersheds, and chum salmon would be affected in a tributary of the SFK (Figure 4-13). The Pebble 6.5 stage mine would also eliminate habitat for chum salmon in a tributary of the SFK (Figure 4-13).

[44] See Section 4.2.1.2 for a discussion of the factors that contribute to the conservative nature of the stream and stream habitat loss estimates.

Figure 4 13. Reported salmon distributions under the Pebble 2.0 and 6.5 stage mines. Species distributions are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Light blue areas indicate streams and rivers from the National Hydrography Dataset (USGS 2012) and lakes and ponds from the National Wetlands Inventory (USFWS 2012); dark blue areas indicate wetlands from the National Wetlands Inventory (USFWS 2012).



As under the Pebble 0.25 stage mine, coho and Chinook would be the salmon species to lose the most habitat (Figure 4-13). Coho salmon habitat losses would represent 9 and 16% of currently documented coho salmon habitat in the SFK and UTC watersheds, respectively. Overall losses resulting from the Pebble 2.0 and 6.5 stage mines would be 6 and 11% of documented salmon streams in the combined SFK, NFK, and UTC watersheds, respectively (EPA 2014: Table 7-7). For Chinook salmon, the larger mines would extend losses into the SFK and UTC watersheds (Figure 4-13) and eliminate a total of 3 to 7% of the documented Chinook salmon habitat in the three watersheds. The Pebble 2.0 stage mine would eliminate some sockeye salmon habitat, which would increase to 3% of total documented sockeye habitat in the three watersheds under the Pebble 6.5 stage mine (Figure 4-13).

Eliminated and dewatered habitat likely would permanently lose the ability to support salmon. As discussed in Section 4.2.1, the substantial spatial and temporal extent of stream habitat losses would further reduce the overall capacity and productivity of coho, Chinook, and sockeye salmon in the SFK, NFK, and UTC watersheds. The genetic structure of these populations varies across fine spatial scales, and such extensive habitat losses may affect genetically distinct populations of coho and Chinook salmon in these watersheds. Coho salmon in particular may be more susceptible to extirpation through the loss of such populations (Olsen et al. 2003). Losses of small Chinook salmon populations with diverse life histories have also been reported from other regions (Lindley et al. 2009), with resulting impacts on overall population resilience (Healey 1991). Because coho and Chinook 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 more extensive habitat losses associated with Pebble 2.0 and 6.5 stage mines are likely to put such populations at risk.

Cumulative Effects of Loss of Tributaries

In addition to increasing the extent of direct habitat losses, the Pebble 2.0 and 6.5 stage mines would also substantially expand impacts in the headwaters of SFK and UTC tributaries (Figures 4-11 and 4-12) to approximately 22 and 46 miles of fish-bearing streams, respectively (ADF&G 2013). Many of these streams likely contain undocumented anadromous fish habitat (Sections 3.2.4 and 4.2.1) (EPA 2014: Chapter 7), and may be particularly valuable habitat for juvenile salmonids. The unprecedented losses of habitat associated with the Pebble 2.0 and 6.5 stage mines, which would occur in a high number of streams across a wide expanse of the SFK, NFK, and UTC watersheds, would further exacerbate any unacceptable adverse effects on salmon and other fish populations caused by the Pebble 0.25 stage mine.

Rainbow trout, Dolly Varden, Arctic grayling, northern pike, ninespine stickleback, and slimy sculpin also would lose additional habitat under the Pebble 2.0 and 6.5 stage mines. The Pebble 2.0 and 6.5 stage mines would expand rainbow trout habitat losses beyond the NFK watershed and into the UTC watershed (Figure 4-14). For Dolly Varden, habitat losses would expand beyond the NFK watershed and into the SFK and UTC watersheds (Figure 4-14). Arctic grayling, northern pike, ninespine stickleback, and slimy sculpin would all lose additional habitat in the SFK watershed with mine expansion; for Arctic grayling, stickleback, and sculpin, habitat losses would also extend into the UTC watershed (Figure 4-15).

Figure 4 14. Reported rainbow trout and Dolly Varden distribution under the Pebble 2.0 and 6.5 stage mines. Species distributions are based on the Alaska Freshwater Fish Inventory (point data, ADF&G 2012) and the Anadromous Waters Catalog (line data, Johnson and Blanche 2012). Light blue areas indicate streams and rivers from the National Hydrography Dataset (USGS 2012) and lakes and ponds from the National Wetlands Inventory (USFWS 2012); dark blue areas indicate wetlands from the National Wetlands Inventory (USFWS 2012).

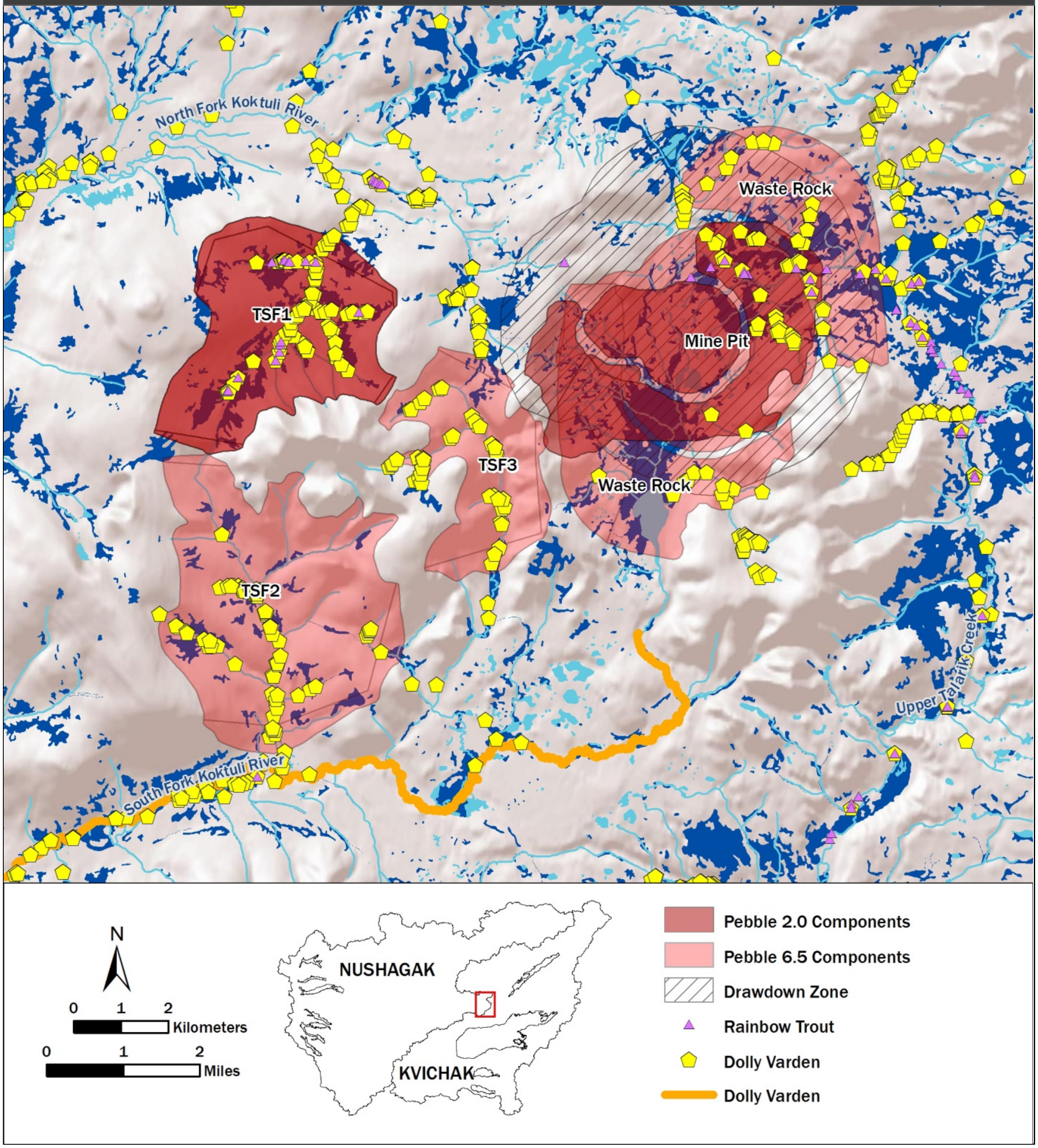
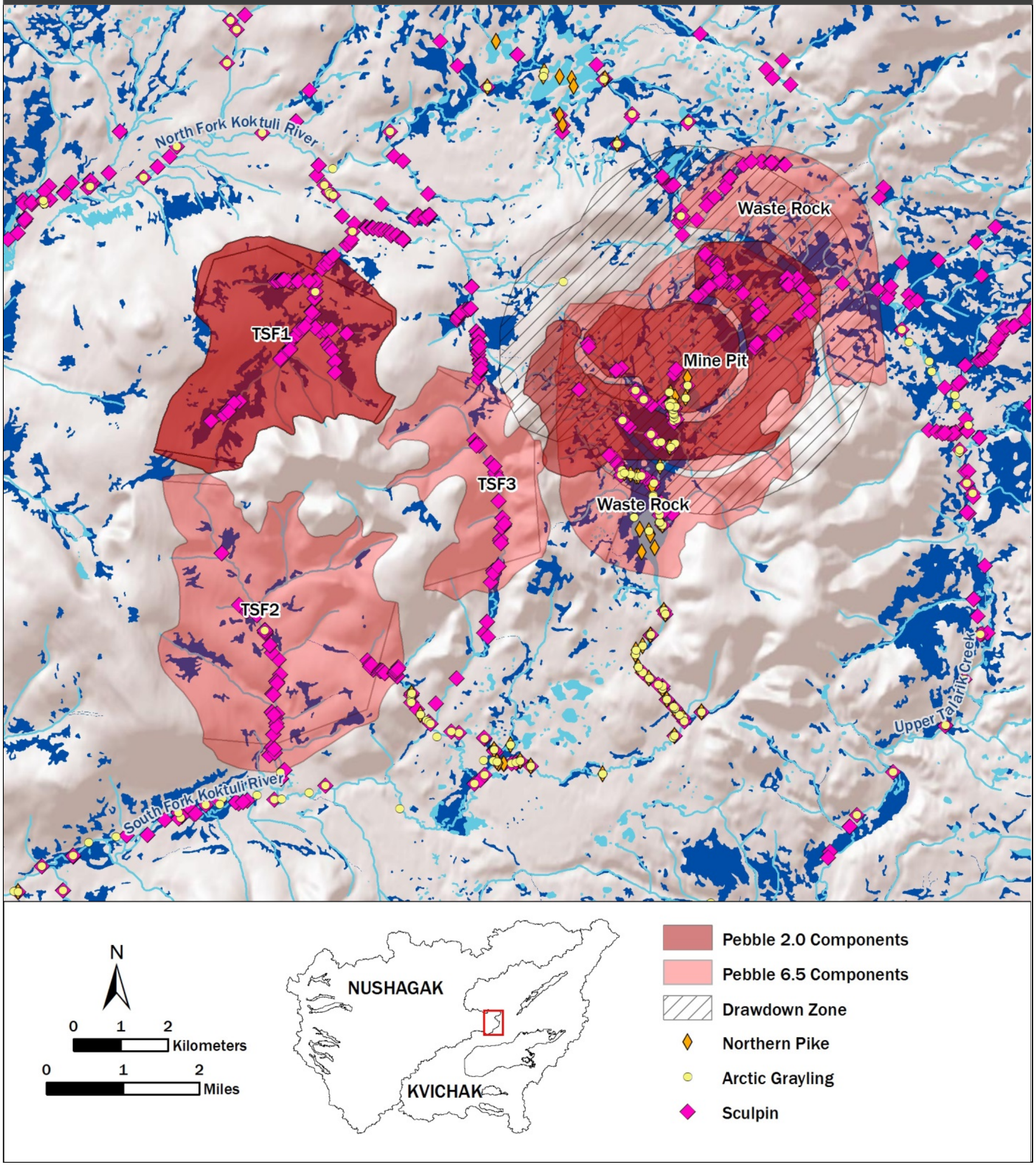


Figure 4 15. Reported distribution of other non salmon fish species under the Pebble 2.0 and 6.5 stage mines. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2012). Light blue areas indicate streams and rivers from the National Hydrography Dataset (USGS 2012) and lakes and ponds from the National Wetlands Inventory (USFWS 2012); dark blue areas indicate wetlands from the National Wetlands Inventory (USFWS 2012).



In addition to direct habitat losses, increased loss of stream, wetland, and other aquatic resources under the Pebble 2.0 and 6.5 stage mines would substantially alter water flows and other subsidies provided to downstream fish habitats in the SFK, NFK, and UTC watersheds (Figures 4-16 through 4-18). As noted above, lost streams under the Pebble 2.0 and 6.5 stage mines represent 8 to 14% of total mapped streams in the three watersheds, respectively. Associated reductions in streamflows to downstream 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.

Cumulative Effects of Loss of Wetlands, Lakes, and Ponds Contiguous with Anadromous Fish Streams or Their Tributaries

The Pebble 2.0 and 6.5 stage mines would eliminate or dewater nearly 3,100 and 4,900 acres (12.5 and 19.8 km^2) of wetlands, ponds, and lakes, respectively (Table 4-8). Of these, more than 2,800 and 4,100 acres are contiguous with documented anadromous fish streams or their tributaries, respectively. These resources likely play a crucial role in the life cycles of anadromous fish in the SFK, NFK, and UTC watersheds (Section 4.2.3).

The unprecedented losses of thousands of acres of wetlands associated with the Pebble 2.0 and 6.5 stage mines would eliminate of nutrient-rich, structurally complex, and thermally and hydraulically diverse habitats—including crucial overwintering areas—that are essential to rearing salmonids. Coho, Chinook and sockeye salmon would be affected under the Pebble 2.0 stage mine, and coho, Chinook, sockeye, and chum salmon would be affected under the Pebble 6.5 stage mine (Figure 4-13). In addition, groundwater pumping would cause changes in hydroperiods that could further eliminate, dewater or fragment wetlands or sever their connections to contiguous streams. This would result in a loss of direct fish habitat support for salmon in those reaches (Section 4.2.3). Where connections to streams become intermittent, rearing salmon and other fish can be stranded and thus lost as part of the cohort. There would also be a loss or reduction of water, nutrient, detritus, and macroinvertebrate exports to downstream areas, the losses of which would affect downstream foodwebs. These losses, of an even greater scope and scale than losses anticipated from the Pebble 0.25 stage mine, would affect the downstream commercial, subsistence, and recreational fisheries supported by these watersheds.

In addition to salmon, rainbow trout, Arctic grayling, and northern pike rear in these areas, and northern pike spawn in wetland areas (Figures 4-14 and 4-15). These species are fished downstream for both subsistence and recreation. 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.

Figure 4 16. Reported salmon distributions in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2.0 and 6.5 stage mines. Species distributions are based on the Anadromous Waters Catalog (Johnson and Blanche 2012).

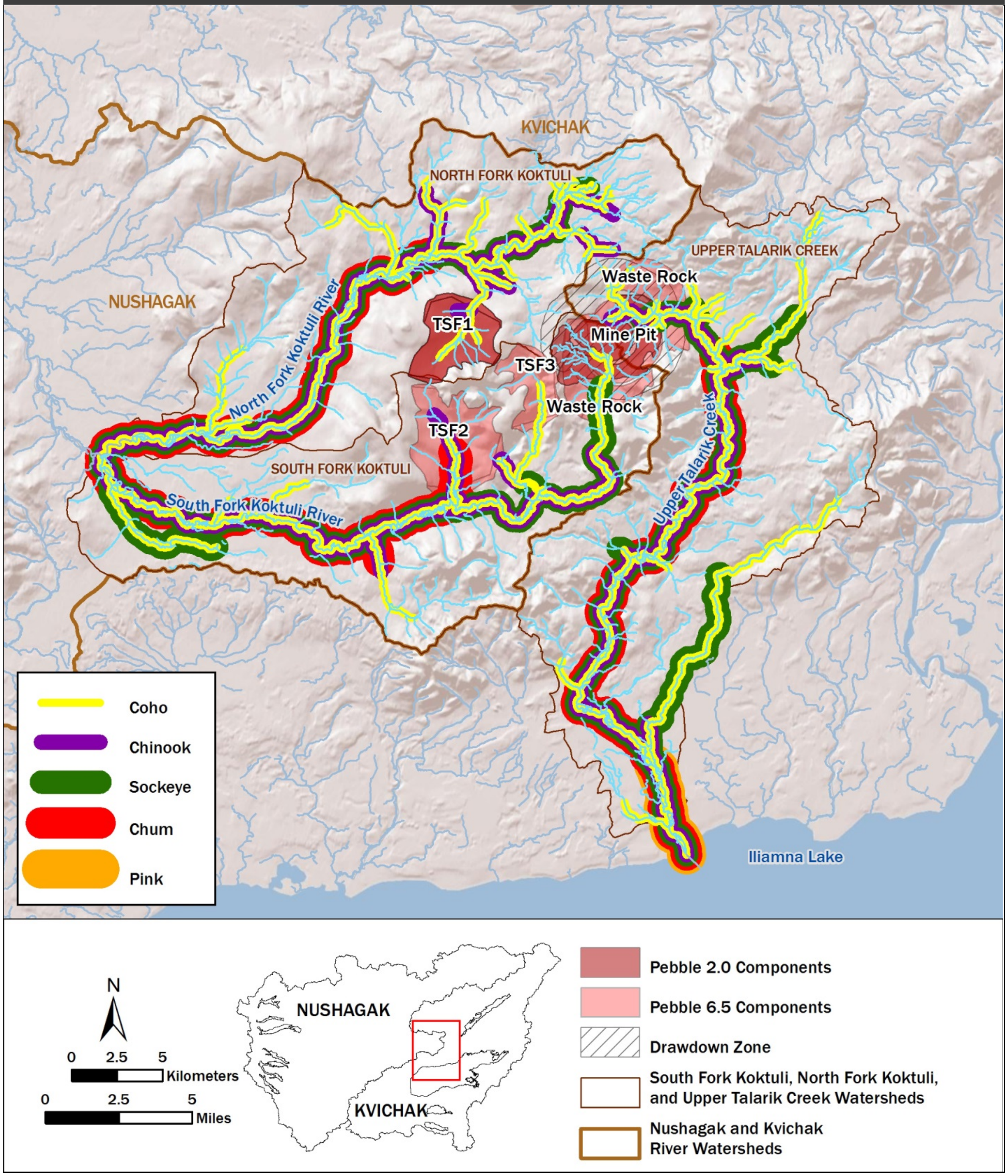


Figure 4 17. Reported rainbow trout and Dolly Varden distribution in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2.0 and 6.5 stage mines. Species distributions are based on the Alaska Freshwater Fish Inventory (point data, ADF&G 2012) and the Anadromous Waters Catalog (line data, Johnson and Blanche 2012).

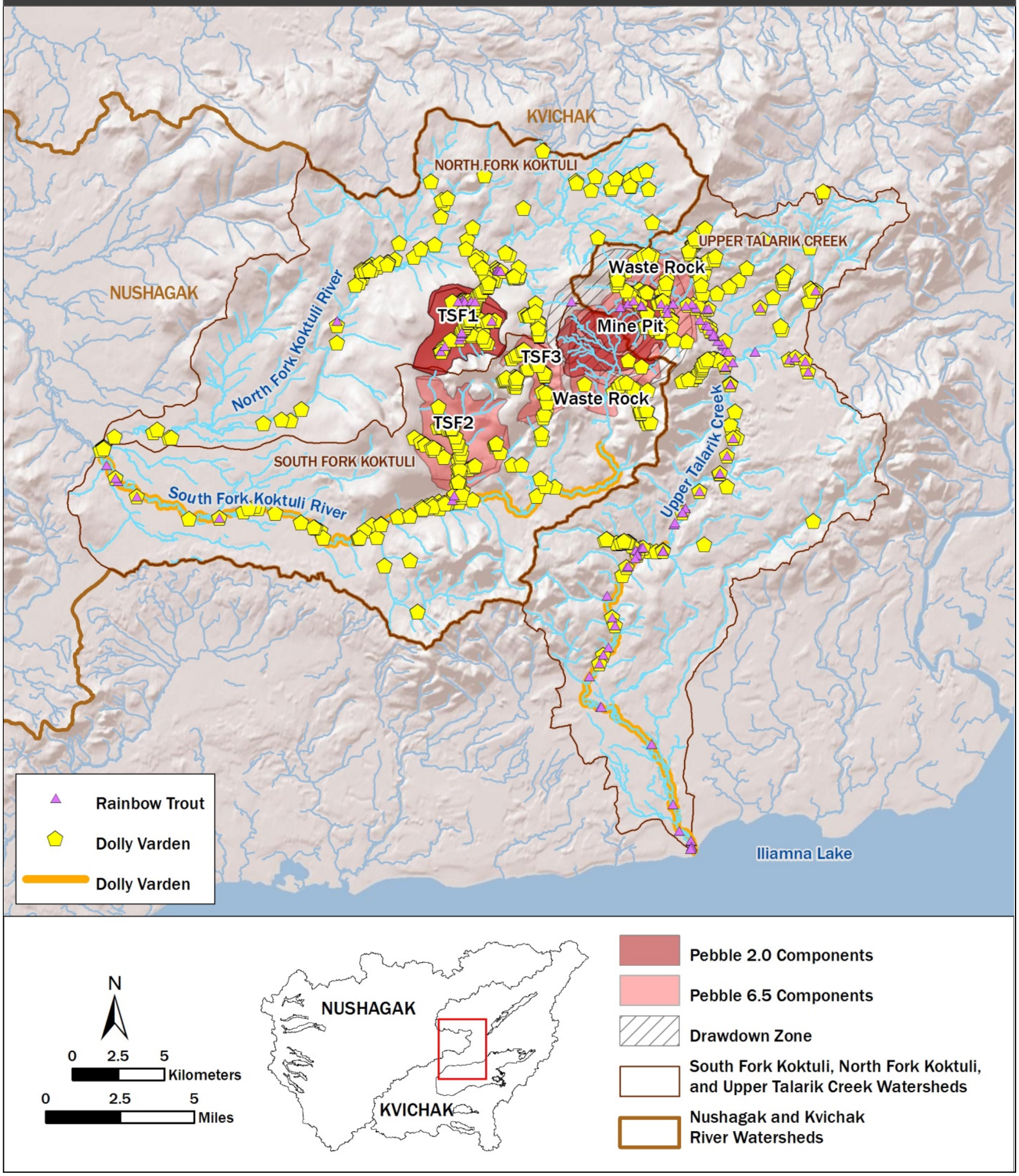
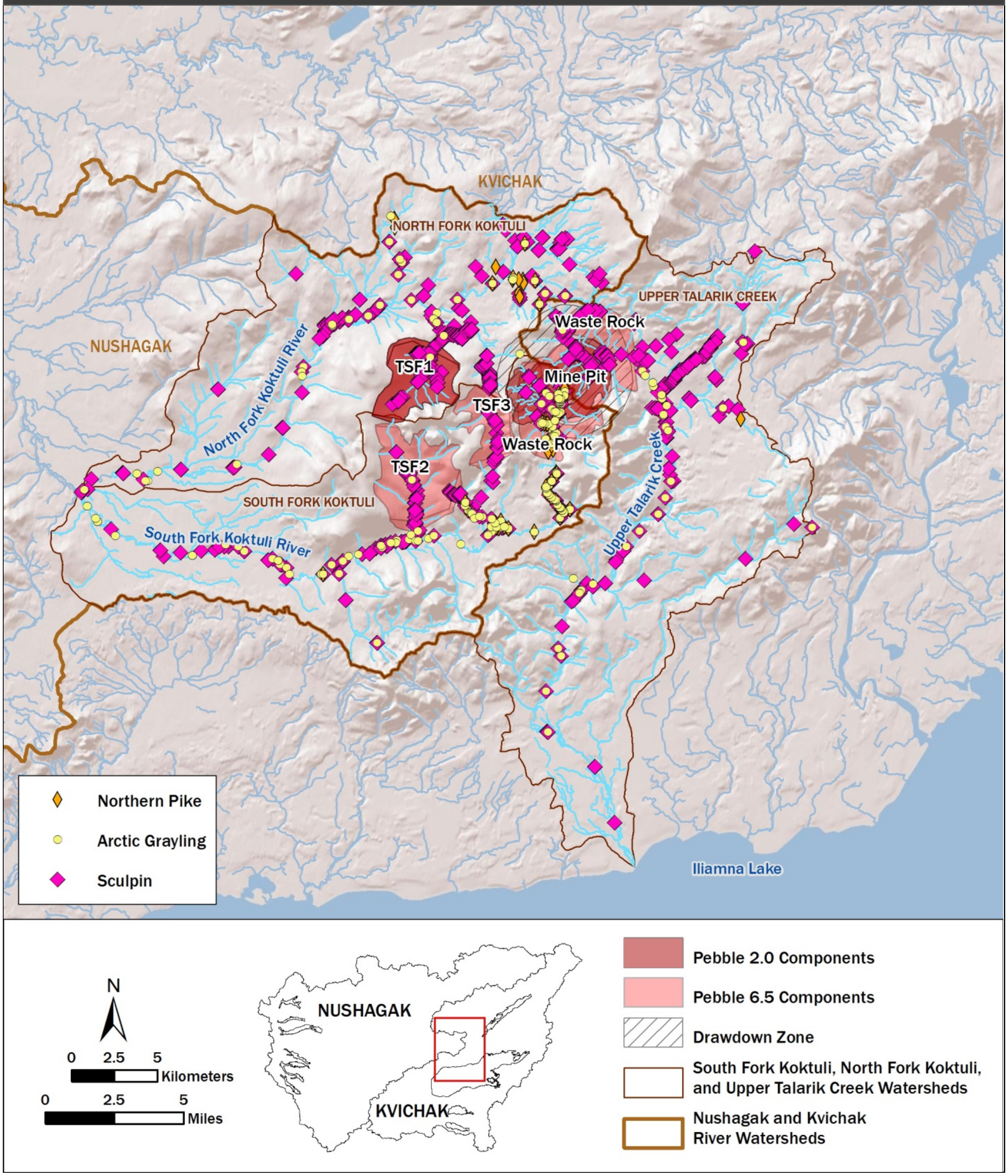


Figure 4 18. Reported distribution of other non salmon fish species in the South Fork Koktuli River, North Fork Koktuli River, and Upper Talarik Creek watersheds, downstream of the Pebble 2.0 and 6.5 stage mines. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2012).



Cumulative Effects of Downstream Flow Alterations

The large volume of water required for mine operations, drawn from both surface and groundwater sources, would result in great changes in the volume, distribution, and flowpaths of surface water and groundwater flows in and beyond the mine footprints. Groundwater pumping would result in losses or reductions of groundwater inputs to downstream areas, whereas recycled process water would be returned as discrete point source discharges. As discussed in Section 4.2.4, both increases and decreases in streamflows, but especially changes in the nature of flows, would affect multiple parameters that structure the aquatic ecosystem, particularly salmon habitat.

The Pebble 2.0 and 6.5 stage mines would alter daily streamflows by more than 20% in nearly two to three times as many stream miles as the Pebble 0.25 stage mine, respectively. With the Pebble 2.0 stage mine, 16.5 miles of streams would experience greater than 20% streamflow alteration; this value would increase to 32.8 miles under the Pebble 6.5 stage mine. The magnitude of these streamflow changes would also increase, particularly in the Pebble 6.5 stage mine, which the BBA estimates would cause streamflow reductions of as much as 86% and streamflow increases as high as 114% (EPA 2014: Table 7-19). In addition to affecting more streams and other aquatic resources than the Pebble 0.25 stage mine, the larger mines would also extend streamflow impacts into the UTC watershed.

Such streamflow increases and decreases, could severely diminish or degrade fish habitat (Section 4.2.4). Figures 4-19 through 4-24 show stream reaches that would be affected and the fish species documented to occur there. Rearing coho salmon use all of the streams affected by severe (>20%) streamflow changes (Figures 4-19 and 4-20). Chinook and sockeye salmon would also have widespread habitat impacts due to streamflow alterations, whereas chum salmon would experience effects in the SFK and UTC watersheds (Figures 4-19 and 4-20).

Figure 4 19. Reported salmon distributions in stream segments experiencing streamflow changes associated with the Pebble 2.0 stage mine. Species distributions are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Streamflow modification class is shown for each stream segment to indicate degree and direction of change. Classes are assigned at a gage and extend upstream to the next gage, confluence point, or mine footprint (see Chapter 7 in EPA [2014] for more detailed discussion of methodology).

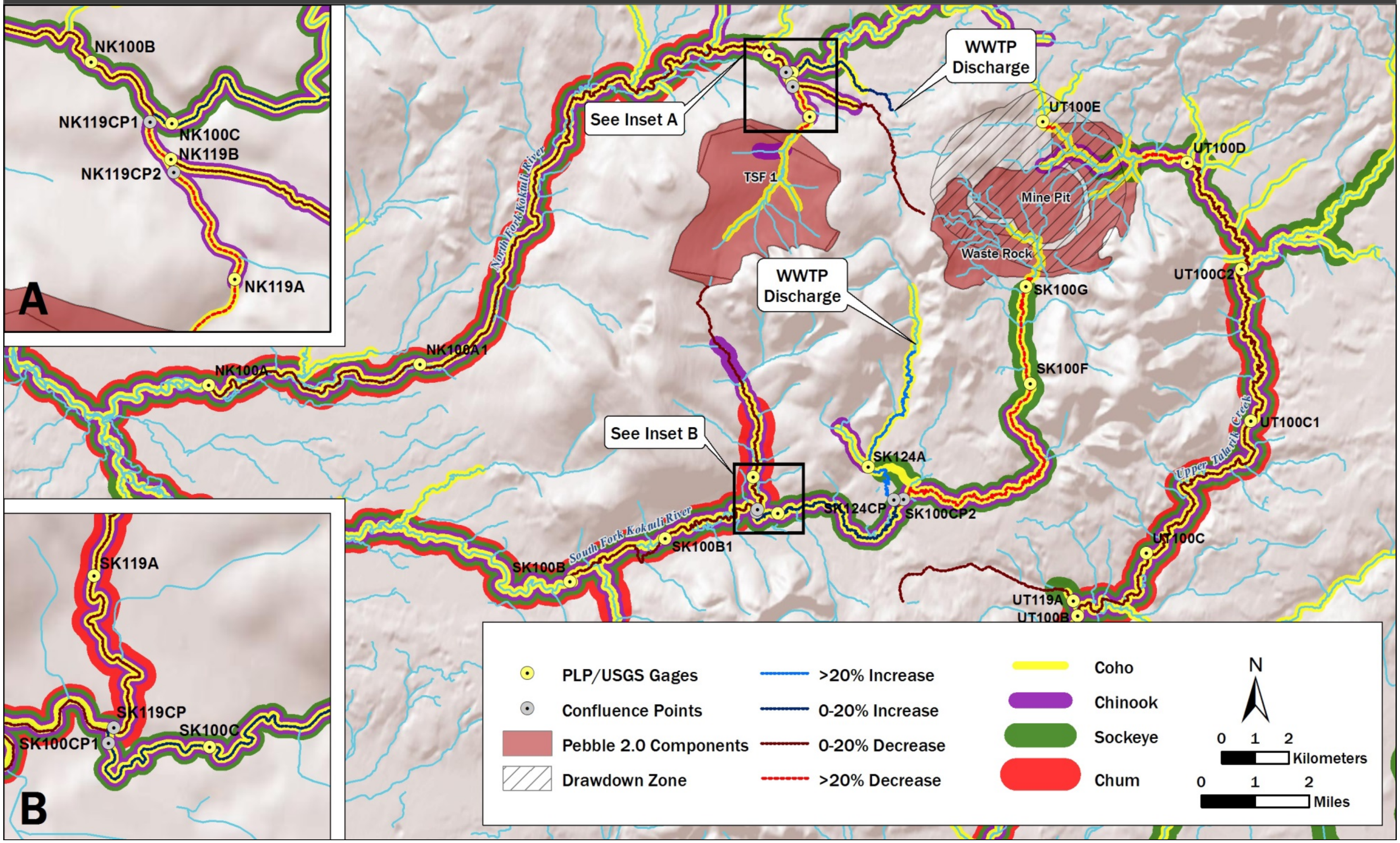


Figure 4 20. Reported salmon distributions in stream segments experiencing streamflow changes associated with the Pebble 6.5 stage mine. Species distributions are based on the Anadromous Waters Catalog (Johnson and Blanche 2012). Streamflow modification class is shown for each stream segment to indicate degree and direction of change. Classes are assigned at a gage and extend upstream to the next gage, confluence point, or mine footprint (see Chapter 7 in EPA [2014] for more detailed discussion of methodology).

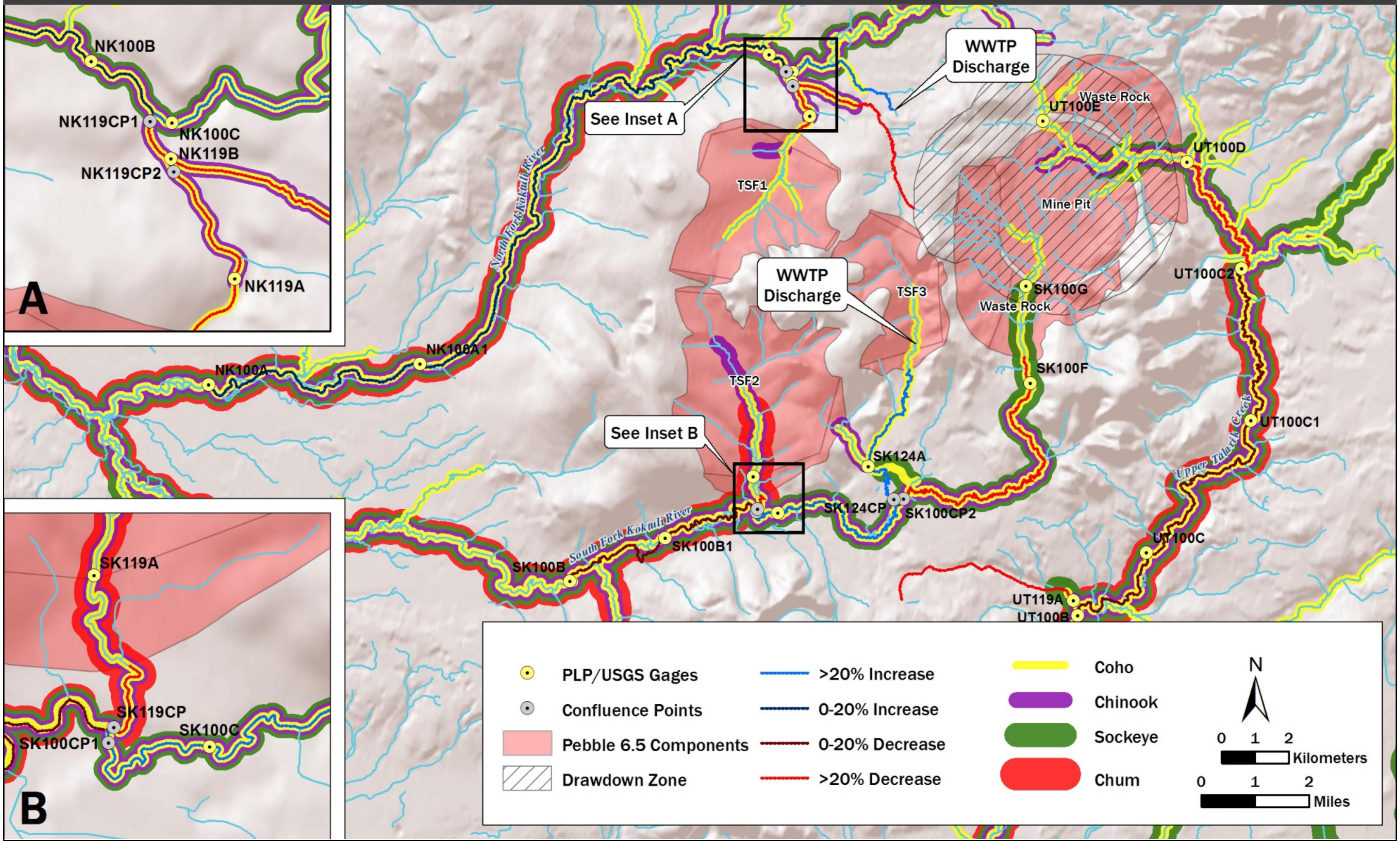


Figure 4 21. Reported rainbow trout and Dolly Varden distributions in stream segments experiencing streamflow changes associated with the Pebble 2.0 stage mine. Species distributions are based on the Alaska Freshwater Fish Inventory (point data, ADF&G 2012) and the Anadromous Waters Catalog (line data, Johnson and Blanche 2012). Streamflow modification class is shown for each stream segment to indicate degree and direction of change. Classes are assigned at a gage and extend upstream to the next gage, confluence point, or mine footprint (see Chapter 7 in EPA [2014] for more detailed discussion of methodology).

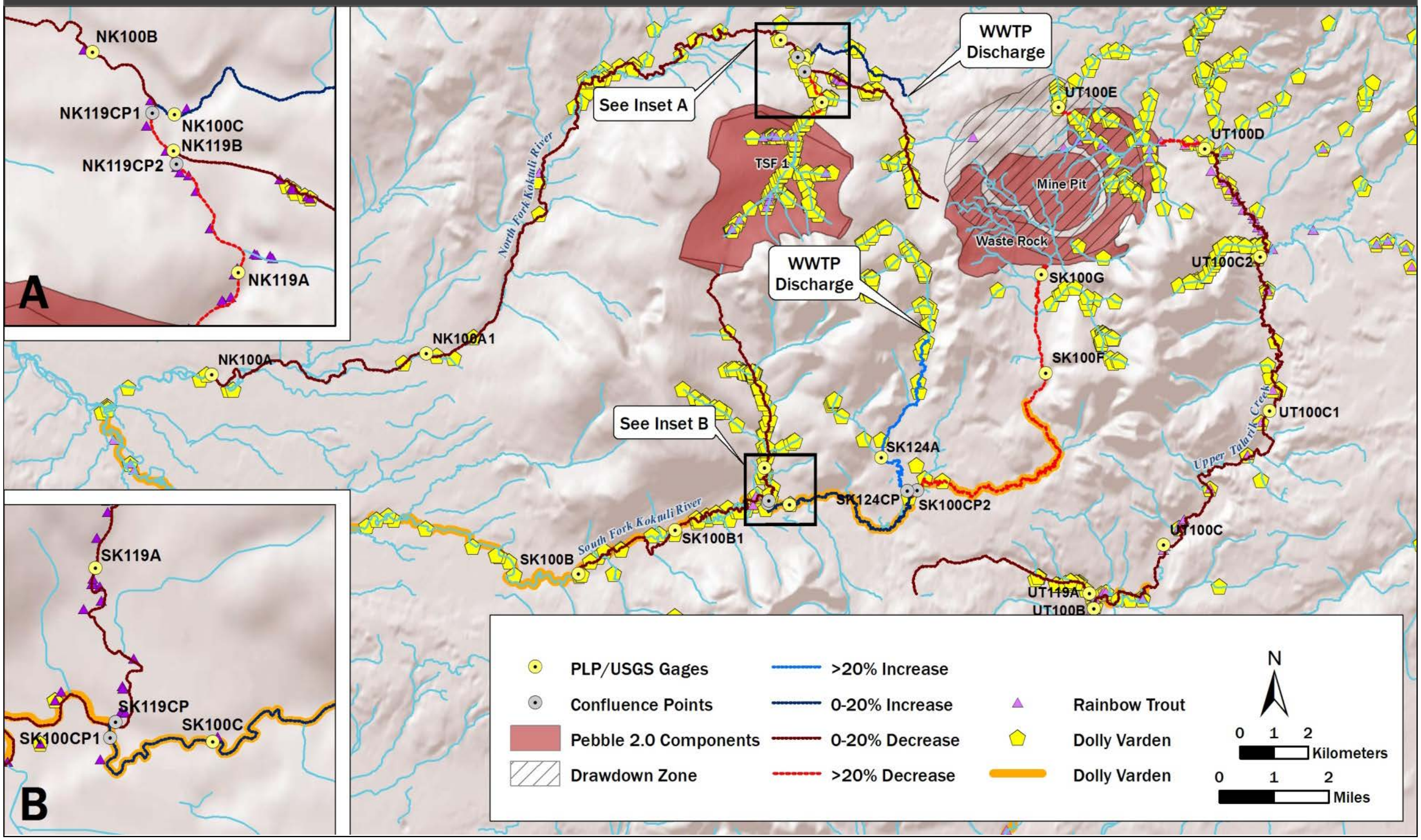


Figure 4 22. Reported rainbow trout and Dolly Varden distributions in stream segments experiencing streamflow changes associated with the Pebble 6.5 stage mine. Species distributions are based on the Alaska Freshwater Fish Inventory (point data, ADF&G 2012) and the Anadromous Waters Catalog (line data, Johnson and Blanche 2012). Streamflow modification class is shown for each stream segment to indicate degree and direction of change. Classes are assigned at a gage and extend upstream to the next gage, confluence point, or mine footprint (see Chapter 7 in EPA [2014] for more detailed discussion of methodology).

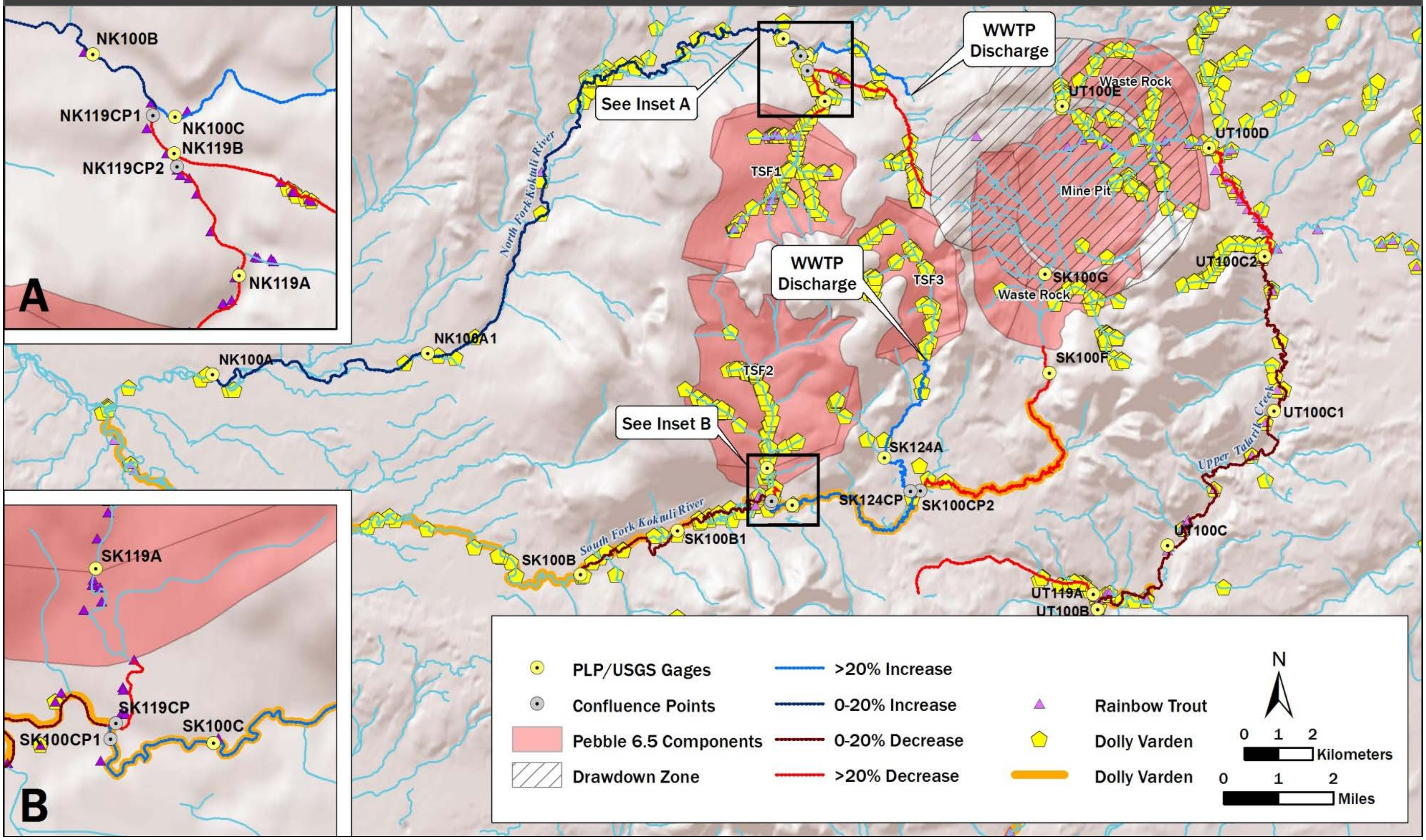


Figure 4 23. Reported distribution of other non salmon fish species in stream segments experiencing streamflow changes associated with the Pebble 2.0 stage mine. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2012). Streamflow modification class is shown for each stream segment to indicate degree and direction of change. Classes are assigned at a gage and extend upstream to the next gage, confluence point, or mine footprint (see Chapter 7 in EPA [2014] for more detailed discussion of methodology).

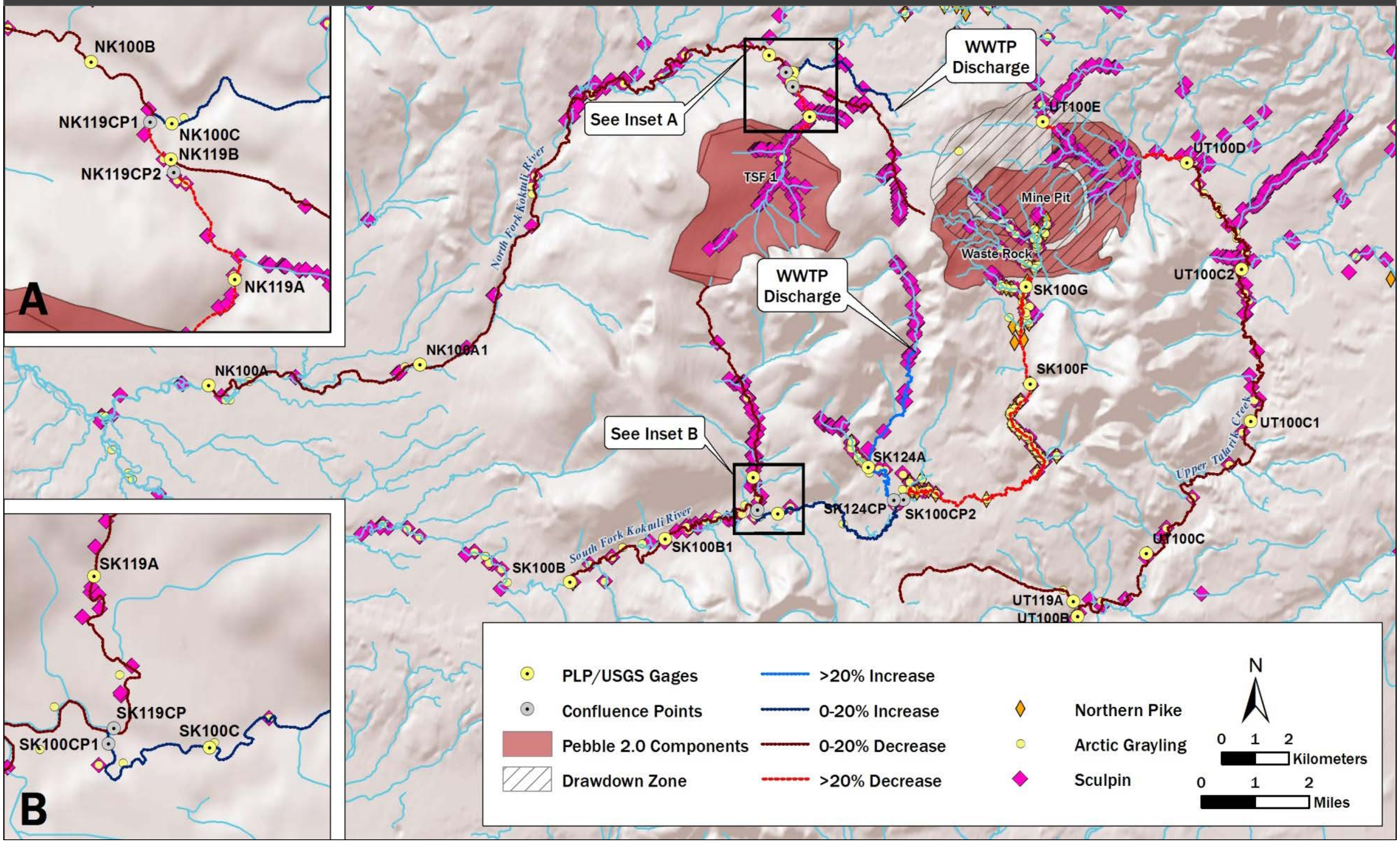
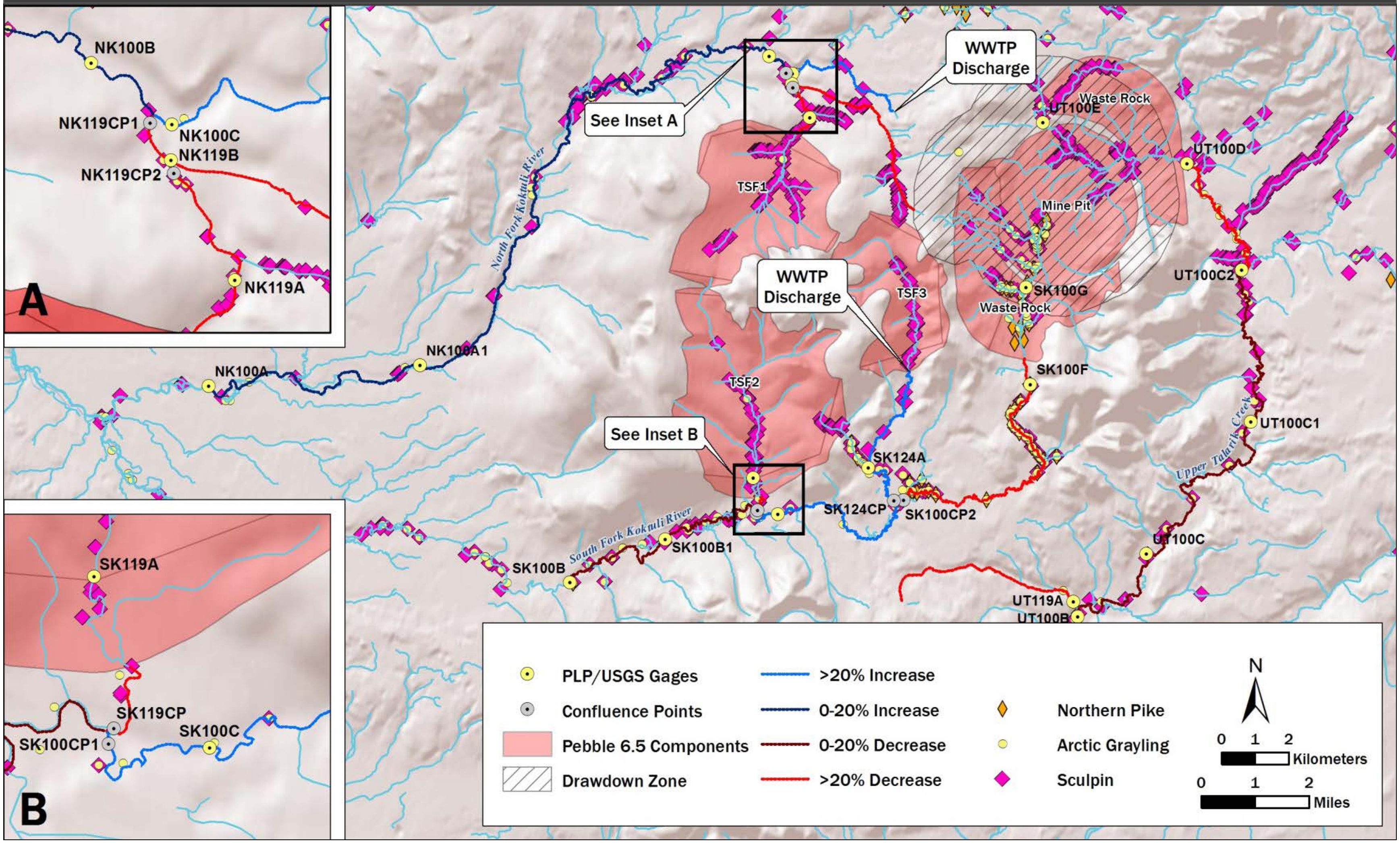


Figure 4 24. Reported distribution of other non salmon fish species in stream segments experiencing streamflow changes associated with the Pebble 6.5 stage mine. Species distributions are based on the Alaska Freshwater Fish Inventory (ADF&G 2012). Streamflow modification class is shown for each stream segment to indicate degree and direction of change. Classes are assigned at a gage and extend upstream to the next gage, confluence point, or mine footprint (see Chapter 7 in EPA [2014] for more detailed discussion of methodology).



Rainbow trout, Dolly Varden, Arctic grayling, and other fish would also be affected by these streamflow alterations (Figures 4-21 through 4-24). Contributing to the adverse effects from changes in surface flows would be long-term (several hundred years) changes in groundwater inputs to thesestreams, with associated impacts on fish habitat. Taken collectively, losses due to streamflow alterations under the Pebble 2.0 and 6.5 stage mines could result in significant adverse impacts on fish populations and could extirpate or severely affect genetically unique populations of species such as coho salmon.

Cumulative Effects of Copper Toxicity

Ore and waste rock from porphyry copper mines contain a mixture of metals (EPA 2014: Table 8-18). Copper is the primary contaminant of concern with regard to water quality, both because it is the major resource metal and because it is particularly toxic to aquatic organisms. Streams in the surficial deposit area—particularly tributaries of the SFK—show elevated levels of sulfate and some metals (i.e., copper, molybdenum, nickel, and zinc). Concentrations decrease with distance from the Pebble deposit, and the stream reaches with significantly elevated copper concentrations would largely be destroyed by the mine footprints and water diversions. In contrast to the NFK and UTC headwaters, fish surveys have not documented salmonids in the upper reaches of the SFK tributaries draining the Pebble deposit area.

As in the area of the surficial ore body, water in contact with tailings, waste rock, or the pit walls would leach copper and other metals. During routine operations, the mine's WWTP would presumably receive and treat water from the waste rock pile and TSF leachate collection systems, as well as captured runoff, excess process water, and mine pit water, which would contain leachate from both the waste rock piles and pit walls (EPA 2014: Chapter 8). Based on Ghaffari et al. (2011), the BBA assumes that the WWTP would discharge effluent to the SFK and NFK at locations shown in Figure 4-8. Estimated annual WWTP discharges would approximate 8,400 acre-feet (10 million m^3) for the Pebble 2.0 stage mine and 41,000 acre-feet (51 million m^3) for the Pebble 6.5 stage mine (EPA 2014: Tables 7-17 and 7-18). The BBA assumes that discharges would be split equally between the SFK and NFK (EPA 2014: Chapter 6). Discharges would be to surface waters and dilution would increase with distance downstream. The BBA assumes that WWTP operation would conform to Alaska water quality standards and, when they are more protective, to national water quality criteria. As such, routine discharges from the WWTP should be non-toxic (EPA 2014: Chapter 8).

Waste rock leachate would be the primary concern during routine operations. Waste rock would include both potentially acid-generating (PAG) and non-acid-generating (NAG) material (EPA 2014: Chapter 8). Leachate from NAG waste rock would be approximately neutral, whereas that from PAG material would be acidic. Incomplete collection of this leachate would result in acid mine drainage. Consistent with preliminary plans made public by NDM (Ghaffari et al. 2011), the BBA assumes that waste rock piles would be unlined. Within the mine pit's drawdown zone, leachate would flow toward and be captured in the pit for subsequent treatment. Outside the drawdown zone, the BBA estimates that half of the waste rock leachate would be captured through a leachate collection system and other means; the other half would escape to surface waters downslope of the source waste rock pile because the area's geological complexity and the permeability of surficial underlying layers would allow water to flow between wells and below their zone of interception (EPA 2014: Chapter 8).

The mine TSFs would presumably incorporate seepage collection systems, but it is realistic to expect that leachate would escape the systems, particularly since, as with the waste rock piles, NDM's preliminary plans indicate that the TSFs would be unlined (Ghaffari et al. 2011). The BBA estimates TSF leakage of roughly 1,900 acre-feet (2.4 million m^3) for the Pebble 2.0 stage mine TSF and roughly 6,000 acre-feet (7.2 million m^3) for the three Pebble 6.5 stage mine TSFs (EPA 2014: Tables 7-17 and 7-18).

Uncollected leachate from waste rock piles and the TSFs could enter area waters via either surface or shallow subsurface flow. Leachate that drains to shallow aquifers would reemerge via upwelling through the water body substrate. In the Pebble 2.0 and 6.5 stage mines, the receiving waters for uncollected leachate from the waste rock piles would be in the upper reaches of the SFK and UTC; some leachate would also enter UTC through interbasin transfer (EPA 2014: Chapter 8). TSF leakage and releases would be to the NFK watershed in the Pebble 2.0 stage mine and to both the SFK and NFK watersheds in the Pebble 6.5 stage mine. TSF leakage and releases would convey both leachate and ore-processing chemicals (EPA 2014: Tables 8-1 and 8-3). Aquatic biota downstream of the mine would be directly exposed to contaminants in discharged waters. Aquatic insects would be exposed in all juvenile stages, which constitute most of their life cycles. Benthic invertebrates and fish eggs could be exposed to a range of concentrations, from undiluted to highly diluted leachate (EPA 2014: Chapter 8).

Aqueous copper toxicity is well-known and the National Ambient Water Quality Criteria for copper were revised in 2007. The 2007 criteria apply the biotic ligand model (BLM), which derives the effects of copper as a function of the amount of metal bound to gills or other receptor sites on an aquatic organism. The BBA and this proposed determination use the BLM to analyze the effects of copper discharges from potential mines at the Pebble deposit, because it represents the most current science on the evaluation of copper's toxic effects on aquatic organisms.

The BBA estimates six BLM-derived benchmarks used to assess copper effects in waters downstream of potential mines at the Pebble deposit. These benchmarks are, in increasing order of toxicity (EPA 2014: Chapter 8), invertebrate chronic, invertebrate acute, fish avoidance, fish sensory, fish reproduction (chronic toxicity), and fish kill (acute toxicity). Chronic toxicity involves extended exposure and implies reduced survival, growth, and/or reproduction of copper-sensitive organisms, including partial to complete reproductive failure for salmonids. Acute toxicity involves lethality to sensitive organisms after short-term exposure. Invertebrates comprise the most sensitive 33% and 42% of genera in acute and chronic tests, respectively (EPA 2007). Thus, the BLM-derived copper toxicity benchmarks are substantially lower for invertebrates than for fish (e.g., 1.5 μg/L for chronic and 2.4 μg/L for acute toxicity to invertebrates, compared to 22 μg/L for chronic and 63 μg/L for acute toxicity to rainbow trout in the SFK) (EPA 2014: Tables 8-11 and 8-13). Studies of copper-contaminated streams in Colorado indicate that toxicity thresholds may be even lower for some aquatic insects, which may be even more sensitive taxa than the invertebrate species used to derive the copper criteria (Buchwalter et al. 2008, Schmidt et al. 2010).

Because the acute and chronic water quality criteria for copper are based on sensitive invertebrates, the BBA also defines benchmarks to assess effects on fish (EPA 2014: Chapter 8). Specifically, the BBA defines BLM-based acute and chronic values for rainbow trout, a standard test species and a member of the genus *Oncorhynchus*, the most sensitive group of vertebrates to both acute and chronic toxicity. Rainbow trout is at least as sensitive to copper as coho and Chinook salmon in acute tests (Chapman 1975, Chapman 1978). The BBA also defines a BLM-based threshold for habitat avoidance, which equates to loss of fish habitat; this threshold is the concentration at which 20% of rainbow trout would avoid the area of contamination (EPA 2014: Chapter 8). Finally, the BBA uses a 20% reduction in olfactory sensitivity in exposed rainbow trout to estimate a threshold for sensory acuity (EPA 2014: Chapter 8). Sensory acuity is important for locating natal streams, finding food, and avoiding predators.

Whereas copper loading from the Pebble 0.25 stage mine would affect only streams that already have naturally elevated levels of copper—and would either not, or only minimally increase those background levels—the Pebble 2.0 and 6.5 stage mines would substantially increase copper in streams spanning all three watersheds. As shown in Table 4-9, the BBA estimates that, even during routine operations, discharges from the Pebble 2.0 stage mine could exceed BLM-based copper criteria in a total of 39.1 miles (62.9 km) of streams in the SFK, NFK, and UTC watersheds (EPA 2014: Table 8-19). The total length of streams with chronic copper toxicity would go down slightly under the Pebble 6.5 stage mine, because the uppermost part of the affected SFK reach would be converted to a waste rock pile. Estimated impacts are conservative in that they do not include ungauged tributaries and do not include effects in any mixing zones or upwelling areas of contaminated water.

In the upper 13.9 miles (22.4 km) of the SFK, copper levels during routine operation of the Pebble 2.0 stage mine could be high enough to generate measurable effects on fish, including fish kills in the uppermost reaches. Coho salmon spawn or rear in more than 98% of the streams that would have some level of fish toxicity under the Pebble 2.0 stage mine; Chinook and sockeye salmon also use a substantial proportion of those streams (Johnson and Blanche 2012). Although the uppermost affected reach of the SFK would be converted to a waste rock pile in the Pebble 6.5 stage mine, effects on fish would extend farther downstream and cause some level of toxicity in 31.8 miles (51.2 km), including almost the entire SFK.[45] Copper would be at a concentration sufficient to kill rainbow trout and other salmonids in the upper 7.3 miles (11.7 km) of the remaining SFK downstream of the mine. Rearing coho, Chinook, and sockeye salmon would be affected in this reach. Acute and chronic effects of copper would affect eggs, fry, smolts, and returning salmon; chronic effects may have different levels of toxicity for different life stages. Dolly Varden, Arctic grayling, northern pike, burbot, and slimy sculpin would also be affected.

Downstream of the acutely toxic reaches of the SFK, levels sufficient to cause habitat avoidance would affect chum salmon, as well as rainbow trout, round whitefish, Arctic-Alaskan brook lamprey, threespine stickleback, and ninespine stickleback. Copper would also affect fish in the 4.0-mile (6.4-km) UTC tributary that receives interbasin transfers from the SFK, resulting in concentrations sufficient to cause

[45] As noted in the BBA (EPA 2014: Table 8-21), dilution at the lower end of the SFK could result in copper concentrations below the habitat aversion level for fish.

fish to avoid the habitat. Dolly Varden are widespread in this tributary, and the lower end also supports both spawning and rearing sockeye, rearing coho and Chinook salmon, rainbow trout, and Dolly Varden. In total, coho, Chinook, sockeye, and chum salmon would each lose more than 19 miles (31 km) of habitat to copper effects under the Pebble 6.5 stage mine.

Table 4-9. Stream reach lengths, copper concentrations, and benchmarks exceeded in ambient waters under routine operations of the Pebble 2.0 and 6.5 stage mines.[a]

Reach Designation[b]	Pebble 2.0			Pebble 6.5		
	Stream Length (miles)	Copper (µg/L)	Effects	Stream Length (miles)	Copper (µg/L)	Effects
South Fork Koktuli River—Mainstem						
SK100B	14.3	<1.9	IC	14.3	<7.9	IC/IA/FA
SK100B1	2.8	2.5	IC/IA	2.8	11	IC/IA/FA
SK100CP1/ SK119CP	2.7	3.9	IC/IA	2.7	16	IC/IA/FA
SK100C	0.7	6.5	IC/IA/FA	0.7	20	IC/IA/FA
SK100CP2/SK124CP	4.0	6.1	IC/IA/FA	4.0	20	IC/IA/FA
SK100F	6.8	16	IC/IA/FA	6.8	110	IC/IA/FA/FS/FR/FK
SK100G	2.1	61	IC/IA/FA/FS/FR	NA	NA	NA
SK Rock	NA	NA	NA	0.5	>160	IC/IA/FA/FS/FR/FK
SK Halo/Rock	0.3	>100	IC/IA/FA/FS/FR/FK	NA	NA	NA
North Fork Koktuli River—Tributaries						
NK119B/NK119CP2	0.2	1.1	IC	0.2	1.4	IC
NK119A	0.8	1.8	IC/IA	0.8	1.9	IC/IA
NK TSF1	0.4	>1.8	IC/IA	0.4	>1.9	IC/IA
Upper Talarik Creek—Mainstem						
UT100B	14.2	<1.0	-	14.2	<3.6	IC/IA
Upper Talarik Creek—Tributaries						
UT Headwaters (119A)	4.0	>5.8	IC/IA	4.0	>27	IC/IA/FA

Notes:
The dash (-) indicates that no effects are expected.
[a] See BBA Table 8-21 and Figures 7-15 and 7-16 (EPA 2014) for a description and depictions of the reaches.
[b] Reaches are designated by the gage or other feature at their heads. Designations in the form G1/G2 indicate the confluence of a stream and tributary with gages G1 and G2 above the confluence.
IC = invertebrate chronic; IA = invertebrate acute; FA = fish avoidance; FS = fish sensory; FR = fish reproduction; FK = fish kill; NA = not applicable.

In the long-term, acute toxicity to vertebrates can result in extirpation of populations. Eradication of fish from and long-term reductions in productivity and diversity of streams severely affected by mine operations have been documented in the past, even where dilution has lessened impacts (Marchand 2002, Jennings et al. 2008). Studies have not yet documented a relationship between effects on fish olfaction and effects on fish populations, but it is reasonable to expect such consequences (DeForest et al. 2011). For both the Pebble 2.0 and 6.5 stage mines, it is reasonable to expect that copper effects would significantly impair fish spawning success, and consequently productivity, in substantial segments of the SFK.

Beyond the stream reaches in which copper concentrations would be toxic to fish, levels would still be toxic to invertebrates (Table 4-9).[46] Under the Pebble 2.0 stage mine, copper would be at levels toxic to invertebrates in the entire SFK mainstem (33.7 miles [54.2 km]); most of the NFK tributary that drains the TSF (1.4 miles [2.3 km]); and the UTC tributary that receives interbasin transfer from the SFK (4.0 miles [6.5 km]). Fish within those reaches include juvenile coho and Chinook salmon, as well as Dolly Varden, Arctic grayling, and slimy sculpin (Johnson and Blanche 2012, ADF&G 2013).

Under the Pebble 6.5 stage mine, increased copper levels in the SFK would add to invertebrate toxicity in UTC via interbasin transfer, with acutely toxic levels extending 18.3 miles (29.5 km) to Iliamna Lake. Consequently, there would be not only a total loss of invertebrates from within the mine footprint, but also severe invertebrate losses in streams with acutely toxic copper levels and reduced invertebrate production in streams with chronically toxic copper levels. These invertebrates are an essential food source for the juvenile coho, Chinook, and sockeye salmon and northern pike that rear in those stream reaches or farther downstream, as well as all life stages of Dolly Varden and Arctic grayling (Johnson and Blanche 2012, ADF&G 2013, EPA 2014: Appendix B). Significant adverse impacts on food availability for fish, particularly in the SFK and lower UTC, as well as significant reductions in downstream export of macroinvertebrates, would be expected to reduce fish productivity in those systems and beyond. Tests on juvenile Chinook salmon have documented reduced body length and weight in response to subchronic copper exposures; application of these results to a population demographic model found that reduced individual growth led to reduced population growth due to increased mortality of smaller out-migrating fish (Mebane and Arthaud 2010). Low-level exposures to copper also appear to reduce out-migration success of coho salmon, with greater effects observed at higher exposures (Lorz and McPherson 1977).

Summary

As discussed above, the direct and secondary effects associated with discharge of dredged or fill material for a Pebble 0.25 stage mine could cause or contribute to significant degradation of the aquatic ecosystem (40 CFR 230.10(c)). As mine size expands over time to 2.0 billion tons, 6.5 billion tons, or even larger, any degradation also would increase.

Estimated effects of the Pebble 2.0 stage mine include elimination of nearly 56 miles of streams and more than 2,800 acres of wetlands contiguous with those streams. This affected stream length constitutes approximately 8% of mapped stream length in the SFK, NFK, and UTC watersheds. When the effects of significant streamflow alteration and copper toxicity are included, nearly 14% of the stream miles mapped in the SFK, NFK, and UTC watersheds would be eliminated or significantly degraded, with repercussions for downstream habitats throughout and beyond the three watersheds.

Estimated effects of the Pebble 6.5 stage mine include the loss of 94 miles of streams and more than 4,100 acres of wetlands. When the effects of significant streamflow alteration and copper toxicity are included, at least an additional 47 miles of streams would be affected. Ultimately, this would result in

[46] Copper concentrations that are toxic to fish are also toxic to invertebrates.

complete losses of approximately 14% of mapped stream miles in the SFK, NFK, and UTC watersheds and significant degradation of up to another 7% of stream miles, for a total of 21% of streams either lost or significantly degraded in the three watersheds.

Adverse impacts on remaining waters could be severe, resulting in significant effects on both salmon and non-salmon fisheries. These effects would be similar to those of the Pebble 0.25 stage mine, but larger in magnitude and extent. In addition to the elimination of large extents of pristine aquatic resources, associated losses of salmon habitat could cause the extirpation of unique local populations of coho and/or 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 commercial, subsistence, and recreational salmon fisheries.

The significance of the Pacific salmon populations produced in Bristol Bay is especially compelling when one considers the status of these species both in North America and globally. Pacific salmon have experienced declines and extinctions throughout other parts of their range (Section 3.3.6.3) (EPA 2014: Appendix A). For example, Pacific salmon are no longer found in 40% of their historical breeding ranges in the western United States, and populations tend to be significantly reduced or dominated by hatchery fish where they do remain (NRC 1996). Species with extended freshwater rearing periods—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, elimination, degradation, or fragmentation of discrete, high-quality salmon habitats may be more important to overall fish populations than is suggested by the absolute proportion of these affected habitats in the larger watershed. Additionally, losses of one or more distinct populations of species such as coho, Chinook, and sockeye salmon could degrade the overall stability of the region's fisheries.

Subsistence harvests and recreational fishing of non-salmon species would also suffer. For example, rainbow trout, Dolly Varden, and northern pike are found in the affected waters, and would suffer habitat losses for different life stages as a result of mine expansion.

Ultimately, the cumulative effects of mine expansion would likely impair the entire health of the SFK, NFK, and UTC watersheds. The combination of streamflow losses (particularly from loss of groundwater inputs), widespread flow regime changes, extensive losses of fish and invertebrate habitats, and copper toxicity in the three watersheds that would cumulatively result from mine expansion at the Pebble deposit would degrade the chemical, physical, and biological integrity of the affected waters.

4.3.2 Known Compensatory Mitigation Techniques are Unlikely to Adequately Offset Anticipated Impacts

The 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)). The guidelines also recognize that there may be instances when USACE cannot issue a permit "because of the lack of appropriate and practicable compensatory mitigation options" (40 CFR Part 230.91(c)(3)).

In this case, EPA Region 10 has reason to believe that the effects within the potential disposal site (described in Sections 4.2.1 through 4.2.4) could have an unacceptable adverse effect on fishery areas. As discussed below, impacts of this nature and magnitude would require compensatory mitigation. Although numerous techniques have been proposed to mitigate these impacts (as discussed in more detail below), known compensatory mitigation techniques are unlikely to adequately offset impacts of this nature and magnitude to the ecologically important stream and wetland resources in the SFK, NFK, and UTC watersheds.[47]

4.3.2.1 Overview of Compensatory Mitigation Requirements

Compensatory mitigation refers to the restoration, establishment, enhancement, and/or 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)). Compensatory mitigation measures are usually not part of project design, but are considered necessary to maintain the integrity of the nation's waters.

Given the nature and magnitude of potential impacts from the discharge of dredged or fill material associated with mining the Pebble deposit, impact avoidance and minimization measures would most likely fail to eliminate all adverse impacts on streams, wetlands, ponds, and fish from such a discharge. This is because of the large extent and wide distribution of streams, wetlands, and other aquatic resources in the watersheds; the fact that substantial infrastructure would need to be built to support porphyry copper mining in this largely undeveloped area; and the fact that ore body location constrains siting options (EPA 2014: Appendix J). Therefore, there would be unavoidable adverse impacts from the discharge of dredged or fill materials associated with mining the Pebble deposit that would require compensatory mitigation.

In addition, guidance issued by USACE Alaska District in 2009 clarifies that fill placed in streams or in wetlands adjacent to anadromous fish streams in Alaska will require compensatory mitigation (USACE 2009). A 2011 supplement to the Alaska District's 2009 guidance further recommends that projects in "difficult to replace" wetlands, fish-bearing waters, or wetlands within 500 feet of such waters will also likely require compensatory mitigation, as will "large scale projects with significant aquatic resource

[47] Under Section 404(c), EPA has discretionary authority to deny or restrict the use of any defined area as a disposal site whenever the Administrator determines that the discharge will have an unacceptable adverse effect on a number of identified categories. Therefore, as a legal matter, EPA can make a determination that a discharge of dredged or fill material will cause unacceptable adverse effects without consideration of compensatory mitigation. The statutory standard does not direct EPA to consider mitigation when determining what constitutes an unacceptable adverse effect. In other words, EPA does not need to determine that mitigation is somehow flawed or insufficient to conclude that a proposed or authorized discharge would have unacceptable adverse effects.

impacts," such as "mining development" (USACE 2011). For a more detailed discussion of compensatory mitigation requirements see Appendix J of the BBA (EPA 2014).

4.3.2.2 Evaluation of Potential Compensation Measures

During development of the BBA, 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 mining the Pebble deposit. Appendix J of the BBA (EPA 2014) provides a detailed evaluation of each of the following potential measures suggested by commenters.

- Purchasing mitigation bank credits.
- Purchasing in-lieu fee program credits.
- Implementing permittee-responsible compensatory mitigation projects within the SFK, NFK, and UTC watersheds including the following.
    - Increasing fish habitat connectivity through beaver dam removal and connecting off-channel habitats and habitat above impassible waterfalls.
    - Increasing fish habitat quality through the addition of large structural elements such as wood and boulders.
    - Increasing fish habitat quantity through the creation of spawning channels and off-channel habitat.
    - Managing water quantity through flow management, flow augmentation, and flow pump-back.
    - Manipulating water chemistry to improve fish production by increasing the following two groups of water chemistry parameters.
        - Basic parameters such as alkalinity, hardness, and total dissolved solids.
        - Nutrients such as nitrogen and phosphorus.
    - Preserving intact aquatic resources.
- Implementing permittee-responsible compensatory mitigation projects within the Nushagak and Kvichak River watersheds including the following.
    - Remediating old mine sites.
    - Removing roads.
    - Retrofitting road-stream crossings.
    - Constructing hatcheries.
    - Stocking fish.

4.3.2.3 Effectiveness of Compensation Measures at Offsetting Impacts on Fish Habitat

Appendix J of the BBA also reviewed available literature regarding the effectiveness of compensation measures at offsetting impacts on fish habitat (EPA 2014). In North America, 73% 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 2013), 40% 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). Approximately one-third of sockeye salmon population diversity is considered endangered or extinct (Rand et al. 2012b), and 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% 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. 1991b, Chapman 1996, Roni et al. 2002, Kondolf et al. 2008). Further, independent evaluations of the effectiveness of fish habitat compensation projects are rare (Harper and Quigley[48] 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 recent study by Roni et al. (2010) clearly questions the efficacy of mitigation to specifically offset salmon losses.

To date, the most comprehensive investigation of the efficacy of fish habitat mitigation measures was conducted by the Department of Fisheries and Oceans, Environment Canada (Harper and Quigley 2005a, Harper and Quigley 2005b, Quigley and Harper 2006a, Quigley and Harper 2006b). Quigley and Harper (2006a) showed that 67% of compensation projects resulted in net losses to fish habitat, 2% resulted in no net loss, and only 31% 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% of projects resulted in net losses to aquatic habitat productivity, 25% achieved no net loss, and only 12% provided net gains in aquatic habitat productivity. Quigley and Harper (2006b) concluded "the ability to replicate ecosystem function is clearly limited."

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[48] Dr. Jason Quigley, a scientist currently employed 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 noted 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.

Quigley and Harper (2006b) highlight the need for improvements in compensation science as well as institutional approaches such as better project planning, monitoring, and maintenance. However, they also recognize that, based on decades of experience in wetland replacement projects, simply achieving compliance with all regulatory requirements does not ensure that ecological functions are replaced (NRC 2001, Sudol and Ambrose 2002, Ambrose and Lee 2004, Kihslinger 2008). Although there are clearly opportunities to improve the performance of fish habitat compensation projects, Quigley and Harper (2006b) caution:

> 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.

4.3.2.4 Summary Regarding Compensatory Mitigation Measures

EPA Region 10 concluded that there are significant challenges regarding the potential efficacy, applicability, and sustainability of compensation measures proposed by commenters for use in the Bristol Bay region (EPA 2014: Appendix J), raising questions as to whether sufficient compensation measures exist that could address impacts of the nature and magnitude described in the proposed restrictions. Compensatory mitigation efforts typically involve restoration and enhancement of waters that have potential for improvement in ecological services. However, the waters of the Bristol Bay watershed are already among the most productive in the world. EPA Region 10 sees little likelihood that human activity could improve upon the high-quality natural environment in the Bristol Bay watershed that nature has created and that has thus far been preserved. Further, based on EPA's records, there do not appear to be any examples of past projects, in the Bristol Bay watershed or the rest of Alaska, where USACE authorized losses to documented anadromous waters of the nature and magnitude associated with the Pebble 0.25 stage mine described in Section 4.2. In its April 29, 2014, submittal as part of the initial Section 404(c) consultation process, PLP submitted some additional information regarding compensatory mitigation. EPA reviewed this material but determined that it did not change the conclusions drawn in Appendix J of the BBA (EPA 2014) (Section 2.1.3).

4.3.3 Summary Regarding Compliance with Relevant Portions of the Section 404(b)(1) Guidelines

Impacts on streams, wetlands, and other aquatic resources from the discharge of dredged or fill material associated with the construction and routine operation of the Pebble 0.25 stage mine could cause or contribute to significant degradation (40 CFR 230.10(c)) of fishery areas. EPA Region 10 concludes that degradation of these aquatic resources would be even more pronounced, given the extensive cumulative impacts expected to occur with successive stages of mine expansion at the Pebble deposit (i.e., the Pebble 2.0 and 6.5 stage mines or larger) (Section 4.3.1.2). According to EPA Region 10's records, losses of the nature and magnitude associated with the Pebble 0.25 stage mine would be unprecedented for the CWA Section 404 regulatory program in Alaska. Based on currently available information, EPA Region 10 is concerned that these impacts cannot be adequately offset by known compensatory mitigation techniques.

4.4 Effects of Accidents and Failures

This proposed determination does not consider impacts from potential accidents and failures as a basis for its findings; however, as discussed below there is a high likelihood that WWTP failures would occur, given the long management horizon expected for the mine (i.e., decades). There is also real uncertainty as to whether severe accidents or failures, such as a complete WWTP failure or a tailings dam failure, could be adequately prevented over a management horizon of centuries, or even in perpetuity, particularly in such a geographically remote area subject to climate extremes.

In addition to evaluating potential effects from construction and routine operation of a mine at the Pebble deposit, the BBA also evaluated potential impacts of an array of possible accidents and failures, the probability of such accidents, and their potential effects on fishery areas (EPA 2014). Two of these failure scenarios involve failures of key aspects of the mine facility's infrastructure—its WWTP and its tailings dams (Table 4-10). Both of these failures would involve extensive impacts on fishery areas in the SFK and NFK; failure of a tailings dam could affect downstream reaches of the Mulchatna and Nushagak Rivers as well.

Table 4 10. Probabilities and consequences of potential failures evaluated in the Bristol Bay Assessment (EPA 2014).

Failure Type	Probability[a]	Consequences
Tailings dam	4 x 10^{-4} to 4 x 10^{-6} per dam-year = recurrence frequency of 2,500 to 250,000 years[b]	More than 29 km of salmonid stream would be destroyed or degraded for decades.
Water collection and treatment, operation	0.93 = proportion of recent U.S. porphyry copper mines with reportable water collection and treatment failures	Water collection and treatment failures could result in exceedance of standards potentially including death of fish and invertebrates. However, these failures would not necessarily be as severe or extensive as estimated in the failure scenario, which would result in toxic effects from copper in more than 60 km of stream habitat.
Water collection and treatment, managed post-closure	Somewhat higher than operation	Post-closure collection and treatment failures are very likely to result in release of untreated or incompletely treated leachates for days to months, but the water would be less toxic due to elimination of potentially acid-generating waste rock.
Water collection and treatment, after site abandonment	Certain, by definition	When water is no longer managed, untreated leachates would flow to the streams. However, the water may be less toxic.

a Because of differences in derivation, the probabilities are not directly comparable.

b Based on expected state safety requirements. Observed failure rates for earthen dams are higher (about 5 x 10^{-4} per year or a recurrence frequency of 2,000 years).

4.4.1 Wastewater Treatment Plant Failure

Water collection and treatment system failures commonly occur at mines.[49] A review of 14 porphyry copper mines that have operated for at least 5 years in the United States found that all but one (93%) had experienced reportable aqueous releases, with the number of events per mine ranging from three to

[49] See EPA (2014: Chapter 8) for additional detail about WWTP failures.

54 (Earthworks 2012).[50] Mine water releases range from chronic releases of uncaptured leachate to acute events caused by equipment malfunctions, heavy rains, or power failures. Hence, the record of analogous mines suggests that releases of water contaminated beyond permit limits would be likely over the life of any mine at the Pebble deposit (EPA 2014: Chapter 8). The BBA summarizes the probabilities and consequences of failures of water collection and treatment systems at a mine at the Pebble deposit during operation, managed post-closure, and after site abandonment (Table 4-10).

There are innumerable ways in which wastewater treatment could fail at a mine, in terms of failure type (e.g., breakdown of treatment equipment, ineffective leachate collection, wastewater pipeline failure), location, duration, and magnitude (e.g., partial failure vs. no treatment). To bound the range of reasonable possibilities, the BBA assessed a reasonable but severe failure scenario in which the WWTP allowed untreated water to discharge directly to streams (EPA 2014: Chapter 8). This type of failure could result from a lack of storage or treatment capacity or treatment efficacy problems. Chronic releases would occur during operation if a lengthy process were required to repair a failure (EPA 2014: Chapter 8).[51]

The probability of the specific WWTP failure analyzed in the BBA cannot be estimated. It is improbable in that it requires that wastewater not be treated and not be diverted to storage. However, it is plausible that such an event could result from equipment failures, inadequate storage, or human errors. It is more likely that a partial failure (e.g., incomplete treatment) would occur, but any one of the innumerable incomplete treatment scenarios is also unlikely. Hence, the WWTP failure scenario analyzed here provides a reasonable upper bound of potential WWTP failures (EPA 2014: Chapter 8).

During the failure, aquatic biota would be directly exposed to contaminants in discharged waters (EPA 2014: Chapter 8).

- Fish embryos and larvae (e.g., salmon eggs and alevins) would be exposed to benthic pore water that would be provided by surface water or by groundwater in areas of upwelling.
- Juvenile fish (e.g., salmon fry and parr) would be exposed to surface water.
- Adult resident salmonids would also be exposed to surface water, but unlike the early life stages, they would occur in the smallest streams only during spawning.
- Adult anadromous salmonids would have brief exposures to waters near the site.
- Aquatic insects would be exposed at all juvenile stages, which constitute most of their life cycle. They would be exposed to benthic pore water or surface water depending on their habits.

[50] The definition of a reportable release is determined by local regulations and differs among mines.
[51] The WWTP failure scenario was based on a number of assumptions; see Chapter 8 of the BBA for a detailed discussion of these assumptions (EPA 2014).

The WWTP failure scenario evaluated in the BBA[52] would turn the WWTP effluent from a diluent for tailings leachates to a toxic input that would be diluted by tailings leachate. The effects of releasing untreated wastewater would, of course, be greatest at the points of release (on the SK124 tributary of the SFK below the tailings dam location and at the head of the NFK above gage NK100C) (EPA 2014: Table 8-17). Under the Pebble 6.5 stage mine, the copper chronic quotient at SK124A would increase from 1.3 (marginal toxicity) with routine operation to 100 (high toxicity) with the WWTP failure (EPA 2014: Table 8-20), resulting in levels sufficient to cause a fish kill extending down the SFK mainstem (EPA 2014: Table 8-23).

Untreated wastewater input above gage NK100C would increase the copper chronic risk quotient from 0.58 to 54 (EPA 2014: Table 8-20), resulting in early-life-stage toxicity to rainbow trout and other salmonids. Effects would increase as mine size increased. The most severe effects on rainbow trout in the SK124 tributary are estimated to be aversion (loss of habitat due to aversion), early-life-stage toxicity (partial to complete reproductive failure of salmonids), and lethality to all life stages (fish kill and, in the long term, local extirpation of fish populations) for the Pebble 0.25, 2.0, and 6.5 stage mines, respectively. The most severe effects on rainbow trout below the NFK outfall are estimated to be aversion for the Pebble 0.25 and Pebble 2.0 stage mines and early-life-stage toxicity for the Pebble 6.5 stage mine, implying a shift in severity from a depleted invertebrate community (that would reduce fish production) and fish aversion to loss of fish reproduction and death of all fish (EPA 2014: Table 8-23).

Toxic effects are functions of both duration of exposure and concentration. The WWTP failure described in the BBA could last from hours to months depending on the mechanics of the failure and whether replacement of components would be required (EPA 2014: Chapter 8). Alternatively, WWTP failure could be a result of an inadequately designed system, which could result in the release of inadequately treated water as at the Red Dog Mine, Alaska (Ott and Scannell 1994, EPA 1998, EPA 2008). In that case, the failure could continue for years, until a new or upgraded treatment system could be designed, approved, and constructed (EPA 2014: Chapter 8). As discussed above, toxic effects on salmonids for the Pebble 2.0 and 6.5 stage mines with WWTP failure would be severe in the SFK even if the failure was of short duration because the concentration of toxics in the effluent would be so high. However, in the NFK or downstream of the area analyzed, the effects of WWTP failure would depend on the duration of exposure for the Pebble 0.25 stage mine.

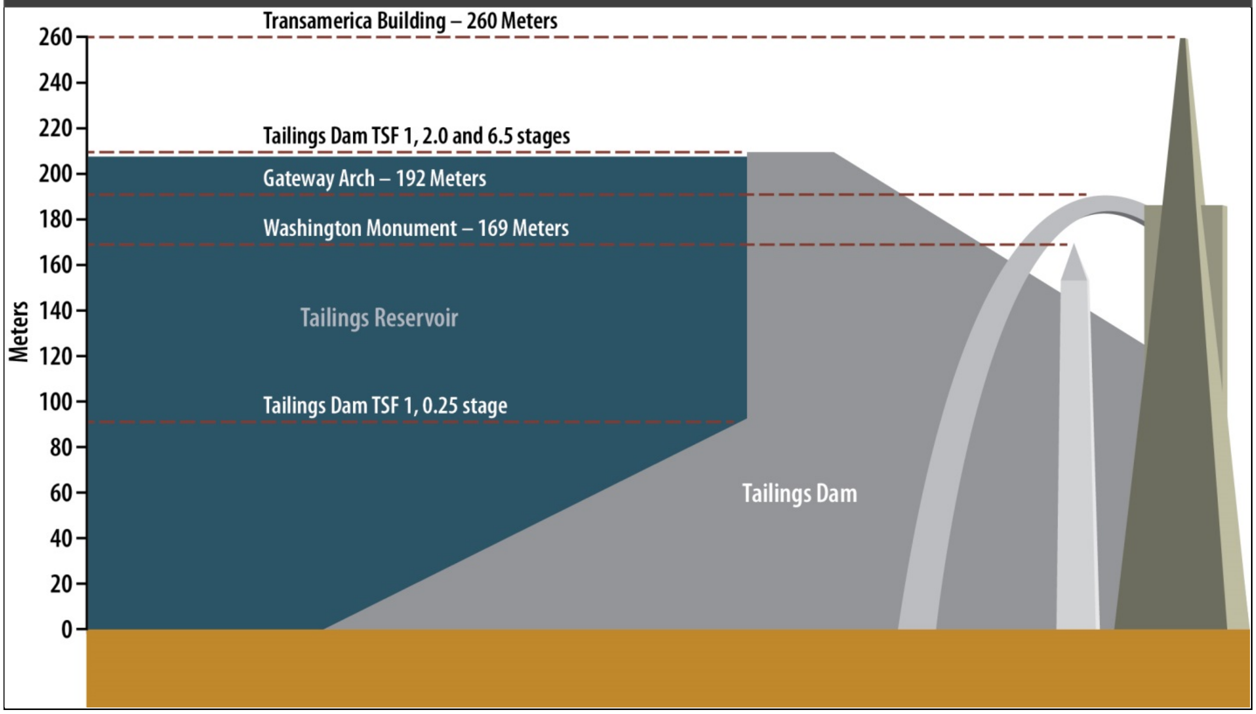
4.4.2 Tailings Dam Failure

Tailings are the waste materials produced during ore processing. In the scenarios evaluated in Chapter 9 of the BBA (EPA 2014), these wastes would be stored in TSFs consisting of tailings dams and impoundments. The probability of a tailings dam failure increases with the number of dams. The Pebble 0.25 stage mine includes one TSF with a single dam, the Pebble 2.0 stage mine includes one TSF with three dams, and the Pebble 6.5 stage mine includes three TSFs with a total of eight dams. Because their removal is not feasible, the TSFs and their component dams would be in place for hundreds to

[52] The steps involved in risk characterization, screening total metal toxicity in receiving waters, and screening for severity of effects for the WWTP failure scenario are described in Chapter 8 of the BBA (EPA 2014).

thousands of years, long beyond the life of the mine. Available reports from the NDM suggest a tailings dam as high as 685 feet (209 m) at TSF 1 (Figure 4-25) (Ghaffari et al. 2011, SEC 2011).

Figure 4 25. Height of the dam at tailings storage facility (TSF) 1 in the Pebble 0.25, 2.0, and 6.5 stage mines.



Two potential dam failures at TSF 1 were evaluated in the BBA: one at a volume approximating the complete Pebble 0.25 stage mine (302-ft [92-m] dam height) and one at a volume approximating the complete Pebble 2.0 stage mine (686-ft [209-m] dam height). In both cases it was assumed that 20% of the tailings would be released, a conservative estimate that is well within the range of historical tailings dam failures. Failures of the TSF 2 and TSF 3 tailings dams were not analyzed but would be expected to be similar in terms of types of effects (EPA 2014: Chapter 9).

As discussed in Chapter 9 of the BBA (EPA 2014), the range of estimated dam failure probabilities is wide, reflecting the great uncertainty concerning such failures. The most straightforward method of estimating the annual probability of a tailings dam failure is to use the historical failure rate of similar dams. Three reviews of tailings dam failures produced an average rate of approximately 1 failure per 2,000 dam-years, or 5×10^{-4} failures per dam-year. Strictly speaking, these frequencies are properties that apply to a group of dams. However, by extension, if there is one dam and it is typical of the population, it would be expected to fail, on average, within a 2,000-year period. This does not mean it is expected to fail 2,000 years after it is built. Rather, it indicates that, after 2,000 years have passed, it is more likely than not that the dam would have failed and that expected failure could occur any year in that 2,000-year window with an average annual probability of 0.0005 (EPA 2014: Chapter 9).

The argument against this method is that the record of past failures does not fully reflect current engineering practices. Some studies suggest that improved design, construction, and monitoring practices can reduce the failure rate by an order of magnitude or more, resulting in an estimated failure probability within the range assumed in the BBA (Table 4-10). The State of Alaska's guidelines suggest that an applicant follow accepted industry design practices such as those provided by USACE, the Federal Energy Regulatory Commission, and other agencies. Based on safety factors in USACE and Federal Energy Regulatory Commission guidance, the BBA estimates that the probability of failure for all causes requires a minimum factor of safety of 1.5 against slope instability for the loading condition corresponding to steady seepage from the filled TSF. An assessment of the correlation of dam failure probabilities with slope instability safety factors suggests an annual probability of failure of 1 in 250,000 per year for facilities designed, built, and operated with state-of-the-practice engineering (Category I facilities) and 1 in 2,500 per year for facilities designed, built, and operated using standard engineering practice (Category II facilities). The advantage of this approach is that it addresses current regulatory guidelines and engineering practices. The disadvantage is that it is uncertain whether standard practice or state-of-the practice dams will perform as expected, particularly given the potential dam heights and subarctic conditions in these scenarios (EPA 2014: Chapter 9).

Based on analyses presented in the BBA (EPA 2014: Chapter 9), failure of the dam at TSF 1 would result in the release of a flood of tailings slurry into the NFK. This flood would scour the valley and deposit many meters of tailings fines in a sediment wedge across the entire valley near the TSF dam, with lesser quantities of fines deposited as far as the NFK's confluence with the SFK. The NFK currently supports spawning and rearing populations of coho, Chinook, and sockeye salmon; spawning populations of chum salmon; and rearing populations of Dolly Varden and rainbow trout. The tailings slurry flood would continue down the mainstem Koktuli River with similar effects, the extent of which could not be estimated in the BBA due to model and data limitations (EPA 2014: Chapter 9).

The tailings dam failures evaluated in the assessment would be expected to have the following severe direct and indirect effects on aquatic resources, particularly salmonids (EPA 2014: Chapter 9).

- **The NFK below the TSF 1 dam and much of the mainstem Koktuli River would not support salmonids in the short term (less than 10 years).**
    - In the tailings dam failure scenarios, spilled tailings would bury salmon habitat under meters of fines along nearly the entire length of the NFK valley downstream of the dam (over 18 miles [29 km] in the Pebble 0.25 dam failure scenario), and beyond (in the Pebble 2.0 dam failure scenario).
    - Deposited tailings would degrade habitat quality for both fish and the invertebrates they eat. Based largely on their copper content, deposited tailings would be toxic to benthic macroinvertebrates, but existing data concerning toxicity to fish are less clear.
    - Deposited tailings would continue to erode from the NFK and mainstem Koktuli River valleys.

- Suspension and redeposition of tailings would be expected to cause serious habitat degradation in the mainstem Koktuli River and downstream into the Mulchatna River; however, the extent of these effects cannot be estimated at this time due to model and data limitations.

- **The affected streams would provide low-quality spawning and rearing habitat for a period of 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.
    - Ultimately, spring floods and stormflows would carry some of the tailings into the Nushagak River.
    - 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 fish.
- **Near-complete loss of NFK fish populations downstream of the TSF and additional fish population losses in the mainstem Koktuli, Nushagak, and Mulchatna Rivers would be expected to result from these habitat losses.**
    - The Koktuli River watershed is an important producer of Chinook salmon. The Nushagak River watershed, of which the Koktuli River watershed is a part, is the largest producer of Chinook salmon in the Bristol Bay region, with annual runs averaging over 190,000 fish.
    - A tailings spill could eliminate 29% or more of the Chinook salmon run in the Nushagak River due to loss of the Koktuli River watershed population. An additional 10 to 20% could be lost due to tailings deposited in the Mulchatna River and its tributaries.
    - Sockeye are the most abundant salmon returning to the Nushagak River watershed, with annual runs averaging more than 1.9 million fish. The proportion of sockeye and other salmon species of Koktuli-Mulchatna origin is unknown.
    - Similarly, NFK populations of rainbow trout and Dolly Varden would be lost for years to decades if they could not successfully be maintained entirely in headwater networks upstream of the affected zone. Quantitative estimates of these losses are not possible given available information.

These effects apply to both the 0.25 and the 2.0 dam failures. Effects would be qualitatively similar for both the Pebble 0.25 and Pebble 2.0 dam failures, although effects from the Pebble 2.0 dam failure would extend farther and last longer. Failure of dams at the two additional TSFs in the Pebble 6.5 scenario (TSF 2 and TSF 3) were not modeled in the BBA, but would have similar types of effects in the SFK and downstream rivers (EPA 2014: Chapter 9).

4.4.3 Summary

For the evaluated WWTP failure scenario, the risks to salmon, rainbow trout, Arctic grayling, and Dolly Varden can be summarized in terms of the total stream miles likely to experience different types of effects (EPA 2014: Table 8-25). In this scenario, copper concentrations would be sufficient to cause direct effects on salmonids in 17, 40 to 54, and 46 to 60 miles (27, 64 to 87, and 74 to 97 km) of streams under the Pebble 0.25, 2.0, and 6.5 stage mines, respectively. Aquatic invertebrates would be killed or their reproduction reduced in 48 to 62 miles (78 to 100 km) of streams under all three mine stages. In the Pebble 2.0 and 6.5 stage mines, a fish kill would occur rapidly in 2.4 and 19 miles (3.8 and 31 km) of streams, respectively, following treatment failure (EPA 2014: Chapter 8).

For the evaluated tailings dam failure scenario, the effects would be even more severe and involve near-complete loss of NFK fish populations downstream of the TSF and additional fish population losses in the mainstem Koktuli, Mulchatna, and Nushagak Rivers. This would include elimination of 29% or more of the Chinook salmon run in the Nushagak River due to loss of the Koktuli River watershed population with an additional 10 to 20% potentially lost due to tailings deposited in the Mulchatna River and downstream areas (EPA 2014: Chapter 9).

The environmental effects of either of these failure events would be catastrophic for fishery resources and any people and wildlife that rely upon them. Based on a review of historical and currently operating porphyry copper mines, failures of water collection and treatment systems would be expected to occur during operation and post-closure periods (EPA 2014: Chapter 8). Further, although the probability of a tailings dam failure assumed in the BBA (4×10^{-4} to 4×10^{-6} per dam-year = recurrence frequency of 2,500 to 250,000 years) is low, it is aspirational because it is based on expected safety requirements and it is uncertain whether standard practice or state-of-the practice dams will perform as expected, particularly given the potential dam heights and subarctic conditions at the Pebble deposit. Further, actual observed failure rates for earthen dams are higher (about 5×10^{-4} per year or a recurrence frequency of 2,000 years) (EPA 2014: Chapter 9).

Compounding these risks is the fact that the Pebble deposit would be mined for decades and wastes and wastewater would require management for centuries or even in perpetuity. Engineered mine waste storage systems have been in existence for only about 50 years, and their long-term behavior is not known. The response of current technology in tailings dam construction is untested and unknown in the face of centuries of unpredictable events such as extreme weather and earthquakes. Also, over the long time span (centuries) of mining and post-mining care, generations of mine operators must exercise due diligence. Priorities could change in the face of financial circumstances, changing markets for metals, new information about the resource, political priorities, or any number of currently unforeseeable changes in circumstance (EPA 2014: Chapters 8 and 9).

Although this proposed determination does not consider impacts from potential accidents and failures as a basis for its findings, there is real uncertainty as to whether severe accidents or failures could be adequately prevented over a management horizon of centuries, or even in perpetuity, particularly in such a geographically remote area subject to climate extremes. If such events were to occur, they would have profound ecological ramifications. By omitting consideration of potential accidents and failures, EPA Region 10 has employed a conservative analysis of potential adverse effects related to the discharge of dredged or fill material associated with mining the Pebble deposit.

SECTION 5. PROPOSED RESTRICTIONS

To protect important fishery areas in the SFK, NFK, and UTC watersheds from unacceptable adverse effects, EPA Region 10 recognizes that losses of streams, wetlands, lakes, and ponds and alterations of streamflows each provide a basis to issue this Section 404(c) proposed determination.

Given the proposals made by NDM to develop 2.0- and 6.5-billion-ton mines at the Pebble deposit (Ghaffari et al. 2011, SEC 2011) and EPA's evaluation of a 0.25-billion-ton mine (EPA 2014), the Regional Administrator has reason to believe that mining of the Pebble deposit at any of these sizes, even the smallest, could result in significant and unacceptable adverse effects on ecologically important streams, wetlands, lakes, and ponds and the fishery areas they support.

Accordingly, the Regional Administrator proposes that EPA restrict the discharge of dredged or fill material related to mining the Pebble deposit into waters of the United States within the potential disposal site that would, individually or collectively, result in any of the following.

4. **Loss of streams**
    a. The loss of 5 or more linear miles of streams with documented anadromous fish[53] occurrence; **or**
    b. The loss of 19 or more linear miles of tributaries of streams where anadromous fish are not currently documented, but that are tributaries of streams with documented anadromous fish occurrence; **or**
5. **Loss of wetlands, lakes, and ponds.** The loss of 1,100 or more acres of wetlands, lakes, and ponds contiguous with either streams with documented anadromous fish occurrence or tributaries of those streams; **or**
6. **Streamflow alterations.** Streamflow alterations greater than 20% of daily flow in 9 or more linear miles of streams with documented anadromous fish occurrence.

These restrictions derive from the estimated impacts resulting from the discharge of dredged or fill material associated with construction and routine operation of a 0.25 stage mine at the Pebble deposit, as evaluated in the BBA (EPA 2014). Mine alternatives with lower environmental impacts at the Pebble deposit are not evaluated in either the BBA or this Section 404(c) proposed determination. If these proposed restrictions are finalized, proposals to mine the Pebble deposit that have impacts below each of these restrictions would proceed to the Section 404 permitting process with USACE. Any such

[53] Anadromous fish 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 these restrictions, anadromous fish 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*).

proposals would have to meet the statutory and regulatory requirements for permitting under Section 404.

The following definitions are proposed to clarify application of the proposed restrictions.

"Loss," as in loss of streams, wetlands, lakes, or ponds, is defined as:

- Elimination, either as a direct result of the discharge of dredged or fill material (e.g., disposal of waste rock or construction of the tailings impoundment dam) or as a secondary effect of such disposal (e.g., drowning of streams and wetlands by the tailings impoundment created by the dam); or
- Dewatering (see definition below); or
- Fragmentation, meaning creation of discontinuities that separate a previously contiguous (see definition of "contiguous" below) aquatic habitat (stream, wetland, lake, pond) or complex of aquatic habitats from the tributary network in such a way that interferes with the efficient passage of fish species and life stages documented to occur in the habitat or reduces the downstream movement of water or dissolved or suspended materials.

"Contiguous" means physically connected by aquatic habitat, as in:

- Streams with no human-made breaks in open channels; or
- Wetlands that abut streams, ponds, or lakes without upland separation, except for wetland mosaics that include areas with complex microtopography in which wetland and non-wetland components are too closely associated to be delineated easily or mapped separately (USACE 2007); or
- Ponds or lakes that share an ordinary high water mark with a stream or are separated from the stream by wetlands or a wetland mosaic.

"Dewatering" means:

- For fish-bearing streams, removing sufficient flow to impede fish passage for the species and life stages documented to occur in the reach in question; or
- For streams with no documented fish use, removing sufficient water to change the surface flow regime (i.e., from perennial to intermittent or less, intermittent to ephemeral or less, ephemeral to subsurface or less, or hyporheic to no flow), under normal precipitation patterns (Alexander et al. 2007, USGS 2012); or
- For ponds or lakes, changing the spatial or temporal extent of inundation; or
- For wetlands, changing the hydrologic regime sufficiently that the wetland no longer exhibits wetland hydrology, as defined in the *Corps of Engineers Wetland Delineation Manual* (USACE 1987), or changing the wetland hydrologic regime to a drier classification, as defined by the NWI (e.g., from seasonally flooded to saturated [USFWS 2012]).

Documented anadromous fish occurrence means any use by anadromous coho, Chinook, sockeye, chum, or pink salmon. Note that documentation must be by a qualified observer.[54]

EPA Region 10 is soliciting public comment on all issues discussed in this proposed determination (Section 7). All comments will be fully considered as EPA Region 10 decides whether to withdraw the proposed determination or forward to EPA Headquarters a recommended determination to restrict the use of certain waters in the SFK, NFK, and UTC watersheds in southwest Alaska as disposal sites for the discharge of dredged or fill material associated with mining the Pebble deposit.

[54] ADF&G AWC Nomination Submission instructions: https://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=noms.instructions.

SECTION 6. OTHER CONSIDERATIONS

Although the restrictions put forth in this proposed determination are based on effects on fishery areas under Section 404(c) of the CWA, mining the Pebble deposit also could affect other potential Section 404(c) resources, as well as result in additional significant environmental, public health, and environmental justice concerns. This section discusses these issues, in terms of both other potential Section 404(c) resources and other tribal considerations.

6.1 Other Potential Section 404(c) Resources

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). 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 migrants and wintering waterfowl, and the region is 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 also have been documented to occur in the SFK, NFK, and UTC watersheds (PLP 2011: Chapter 16).

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. However, one of two freshwater harbor seal populations in North America is found in Iliamna Lake (Smith et al. 1996). The National Oceanic and Atmospheric Administration is currently conducting a status review on Iliamna Lake seals to determine if they represent a distinct population segment that may warrant protection under the Endangered Species Act.

Wildlife present in the SFK, NFK, and UTC watersheds—several of which are important subsistence species (Section 6.2.1)—would likely be adversely affected by large-scale mining at the Pebble deposit. Direct impacts of mining on wildlife would include 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. Direct copper toxicity to wildlife resulting from mine operations is less of a concern than indirect effects resulting from copper-related reductions in aquatic communities (EPA 2014: Chapter 12).

In addition to direct mine-related effects, wildlife species also would likely be affected indirectly via any reductions in salmon populations. MDN imported into freshwater systems by spawning salmon provide the foundation for the region's aquatic and terrestrial foodwebs, via both direct consumption of salmon in any of its forms (spawning adults, eggs, carcasses, and/or juveniles) and nutrient recycling (e.g., transport and distribution of MDN from aquatic to terrestrial environmental by wildlife) (Section 3.3.6.1). 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 fish, and terrestrial mammals. Aquatic invertebrate larvae also benefit from carcasses and are an important food source for water birds and land birds. It is likely that these species would be adversely affected by any mine-related reductions in salmon production.

6.1.2 Recreation

Next to commercial salmon fishing and processing, recreation is the most important private economic sector in the Bristol Bay region (EPA 2014: Appendix E), due largely 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 2009 dollars, are estimated at more than $170 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.

In particular, the abundance of large game fish 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, approximately 29,000 sport-fishing trips were taken to the Bristol Bay region (12,000 trips by people living outside Alaska, 4,000 trips by Alaskans living outside 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. 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 (EPA 2014: Chapter 5).

Much of the sport fishery in the region is relatively low-impact catch-and-release, although there is some recreational harvest. Between 2003 and 2007, an estimated 183,000 rainbow trout were caught in the BBMA (Dye and Schwanke 2009). From 1997 to 2008, total annual recreational harvest in the BBMA ranged from roughly 39,000 to roughly 72,000 fish (Dye and Schwanke 2009). Sockeye, Chinook, and coho salmon are the predominant fish harvested, although rainbow trout, Dolly Varden, Arctic char, Arctic grayling, northern pike, and whitefish are also important recreational species (Dye and Schwanke 2009). There are no reliable estimates of recreational harvests specific to the Nushagak and Kvichak River watersheds, although popular Chinook and sockeye salmon recreational fisheries have been identified in these two watersheds (Figure 3-15).

Sport fishing within the Bristol Bay region is a large and well-recognized share of recreational use and associated visitor expenditures (Section 3.3.5). 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, attracting around 65,000 recreational visitors in 2010. Rivers within Katmai National Park provide the best locations in North America to view wild brown bears (EPA 2014: Appendix E). 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 $5,170 (non-residents) and $1,319 (non-local residents) per trip (values updated to 2009 dollars), respectively (EPA 2014: Chapter 5). These hunting activities result in an estimated $8.2 million per year in direct hunting-related expenditures and directly employ over 100 full- and part-time workers (EPA 2014: Chapter 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, if any, effects routine operations of a mine at the Pebble deposit would 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 to which surface water influences the quality or quantity of the groundwater source for these wells is unknown. 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 2,000 people during construction and more than 1,000 people during mine operation (Ghaffari et al. 2011). 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 any contamination or degradation resulting from mine development and operation. 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.

6.2 Other Tribal Considerations

6.2.1 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 3.3.4. Although salmon and other fish provide the largest portion of subsistence harvests for Bristol Bay communities, non-fish resources also make up a significant portion of subsistence use (Table 6-1). On average, non-fish resources such as moose, caribou, waterfowl, plants, and other organisms represent just over 30% of subsistence harvests by local communities (Table 6-1). The relative importance of non-fish subsistence resources varies throughout the Bristol Bay watershed, and per capita subsistence harvest of non-fish resources actually exceeds fish harvests in two communities (Table 6-1).

Figure 6-1 highlights areas of subsistence use for fish, wildlife, and waterfowl in the Nushagak and Kvichak River watersheds. It should be noted that 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). It also should be noted that available subsistence data are coarse and incomplete, and it is likely that subsistence activities occur outside the areas identified in Figure 6-1. In addition, Figure 6-1 only indicates use, not abundance or harvest.

Table 6-1. Harvest of subsistence resources in the Nushagak and Kvichak River watersheds.[a]

Community	Year	Total Harvest (pounds)[b]	Estimated Per Capita Harvest (pounds)		
			All Resources	Fish	Non-Fish Resources
Aleknagik	2008	64,800	296	166	130
Dillingham	1984	564,000	242	158	84
Ekwok	1987	91,700	797	529	268
Igiugig	2005	27,100	542	269	273
Iliamna	2004	51,121	469	404	65
Kokhanok	2005	116,000	680	546	134
Koliganek	2005	188,000	899	650	249
Levelock	2005	36,400	527	190	337
New Stuyahok	2005	198,000	389	218	171
Newhalen	2004	131,000	692	532	160
Nondalton	2004	58,700	358	254	104
Pedro Bay	2004	12,900	306	265	41
Port Alsworth	2004	21,100	133	101	32

Notes:

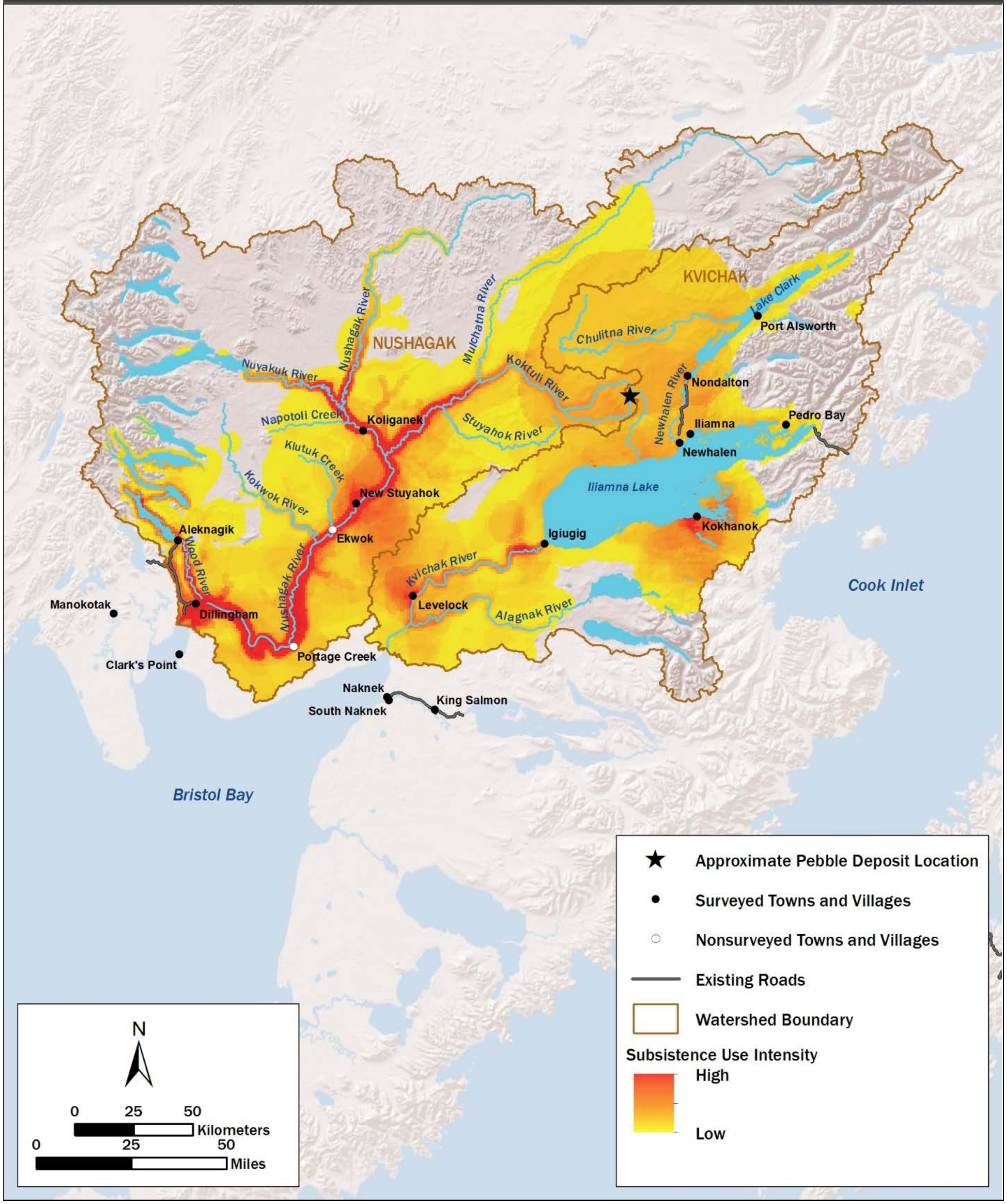
[a] Summarized from Tables 12 and 14 in Appendix D and Table 21 in Appendix E of the Bristol Bay Assessment (EPA 2014). Data are from Fall et al. 1986, Schichnes and Chythlook 1991, Fall et al. 2006, Fall et al. 2009, Krieg et al. 2009, and Holen et al. 2012.

[b] Total harvest values include fishes, land mammals, freshwater seals, beluga, other marine mammals, plant-based foods, birds or eggs, and marine invertebrates.

In Section 4, EPA Region 10 considers potential effects of mining the Pebble deposit on the region's fishery resources. All subsistence resources could be directly affected by 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 mine-related changes in salmon fisheries: as explained in Section 3.3.6.1, the loss or reduction of salmon populations would have repercussions for the productivity of the region's ecosystems.

Any mine-related impacts on fish—particularly salmon—and other subsistence resources would 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 on subsistence resources; however, non-Alaska Native populations in the region also rely heavily on subsistence resources.

Figure 6 1. Subsistence use intensity for salmon, other fishes, wildlife, and waterfowl within the Nushagak and Kvichak River watersheds.



As discussed in EPA (2014) and Section 4 above, routine development and operation of a large-scale mine, as well as potential mine accidents or failures, would likely affect salmon and other important fish resources in the Nushagak and Kvichak River watersheds. The mine footprints evaluated in the BBA (EPA 2014) would have some effects on subsistence resources. Although no subsistence salmon fisheries are documented directly in any of the evaluated mine footprints, subsistence use of the mine area is high and centers on hunting caribou and moose and trapping small mammals (PLP 2011: Chapter 23). Direct loss of non-salmon subsistence food resources likely would represent a greater direct effect than loss of salmon harvest areas in the mine footprints. Tribal Elders have expressed concerns about ongoing mine exploration activities directly affecting wildlife resources, especially the caribou herd range (EPA 2014: Appendix D).

Negative impacts on downstream fisheries from headwater disturbance (Section 4) could affect subsistence fish resources beyond the mine footprints. Those residents using the upper reaches of the SFK, NFK, and UTC 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 villagers.

Dietary transition away from subsistence foods in rural Alaska carries a high risk of increased consumption of processed simple carbohydrates and saturated fats. This 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). Also, available alternative food sources may not be economically obtainable and are certainly not as healthful. 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).

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 impacts on subsistence food resources, human health, or cultural and social organization, but a significant reduction in salmon quality or quantity would certainly have significant negative impacts on 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 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 important to subsistence users, even if there are no measureable changes in the quality and quantity of salmon (EPA 2014: Appendix D). Aside from actual exposure to environmental contamination, the perception of exposure to contamination is also 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).

6.2.2 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, entitled "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 Section 404(c) action has the potential to affect human health and the environment of low-income or minority populations, including tribal populations, EPA evaluates environmental justice concerns when undertaking an action pursuant to its authorities under 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 will be 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 Section 6.2.3.

The Bristol Bay communities of the Nushagak and Kvichak River watersheds are predominantly Alaska Native, specifically Yup'ik, Dena'ina and Sugpiaq (EPA 2014: Chapter 5). Although there are other Bristol Bay communities that are concerned with potential impacts on fishery resources and consequently their way of life, EPA Region 10 focused on communities who practice subsistence within the SFK, NFK, and UTC watersheds for this environmental justice analysis.

As described in Section 2, EPA Region 10 has conducted extensive community outreach. Public hearings were held in June 2012, at which EPA heard concerns about potential impacts from 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., in terms of schools closing because enrollment drops as parents make tough choices to go where jobs are available), potential tax revenue, ANCSA Corporation economic opportunities, and the State of Alaska's concerns regarding economic opportunities for the citizens of Alaska. EPA Region 10 also received a petition from a variety of stakeholders raising concerns related to environmental justice issues associated with porphyry copper mining in the Nushagak and Kvichak River watersheds.

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. 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 (EPA 2014: Appendix D). In interviews conducted for Appendix D of the BBA (EPA 2014), 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.

The Alaska Native community also depends 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%), recreation (15%), and mineral exploration (3%) (EPA 2014: Appendix E). It is estimated that local Bristol Bay residents held one-third of all jobs and earned almost $78 million (28%) 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 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). 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 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 and 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.

As discussed in Sections 3.3.4 and 6.2.1, 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.[55] EPA Region 10 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 Region 10 acknowledges that subsistence use areas and related subsistence activities provide not only food but also support important cultural and social connections within the region's communities. 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.

6.2.3 Tribal Consultation

Executive Order 13175, entitled "Consultation and Coordination with Indian Tribal Governments," directs federal agencies to have an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies on matters with tribal implications and to strengthen the government-to-government relationship with federally recognized tribal governments. 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.

Throughout development of the BBA, EPA Region 10 provided opportunities for consultation and coordination with federally recognized tribal governments (EPA 2014: Chapter 1). EPA Region 10 plans to provide similar opportunities for tribal consultation and coordination going forward.

Pursuant to Public Law 108-199, 118 Stat. 452, as amended by Public Law 108-447, 118 Stat. 3267, EPA also is required to consult with ANCSA Corporations[56] on the same basis as tribes, under Executive Order 13175. Accordingly, EPA Region 10 provided multiple engagement opportunities for ANCSA Regional and Village Corporations with lands in the Bristol Bay watershed throughout development of the BBA as well. EPA Region 10 plans to provide similar opportunities for ANCSA engagement going forward.

[55] The BBA did not evaluate threats to human health due to physical exposure to discharged pollutants or consumption of exposed organisms, as these effects were outside the scope of the assessment (EPA 2014: Chapter 2).

[56] Congress created regional and village corporations to manage the lands, funds, and other assets conveyed to Alaska Natives by ANCSA.

SECTION 7. SOLICITATION OF COMMENTS

Please see http://www.epa.gov/bristolbay for information about how to submit comments on the proposed determination. EPA Region 10 is soliciting comments on all issues discussed in the proposed determination, particularly the following.

1. Comments regarding whether the proposed determination should become the recommended determination and ultimately the final determination, and any corrective action that could be taken to reduce adverse impacts of discharges associated with mining the Pebble deposit.
2. Additional information on the likely adverse impacts on fish and other ecological resources of the receiving waters that would be directly or indirectly affected by mining the Pebble deposit (including the SFK, NFK, and UTC and downstream reaches of the Nushagak and Kvichak Rivers).
3. Additional information on the water quality, flora, fauna, and hydrology of the waters identified in No. 2, above, and information on the fish species that would be affected by aquatic ecosystem changes if discharges from mining the Pebble deposit were to occur.
4. Additional information about wildlife species that would be affected if discharges from mining the Pebble deposit were to occur.
5. Additional information about recreational uses of the project area and how they would be affected if discharges from mining the Pebble deposit were to occur.
6. Additional information about drinking water (including public water supplies and private sources of drinking water such as streams and/or wells) and how they would be affected if discharges from mining the Pebble deposit were to occur.
7. Additional information on the potential for mitigation to be successful in reducing the impacts of mining the Pebble deposit.
8. Comments regarding the approach used to define the potential disposal site, including how EPA Region 10 weighed the factors discussed in Section 2.2.3 and whether there are other factors or approaches EPA Region 10 should consider in defining the potential disposal site.
9. Whether the discharge of dredged or fill material associated with mining the Pebble deposit should be completely prohibited, restricted as proposed, restricted in another manner, or not restricted at all at this time. In particular, EPA Region 10 is seeking comment on whether environmental effects associated with other mine stages or scenarios (e.g., environmental effects from mining approximately 2.0 billion tons of ore over 25 years) could provide a basis for alternative or additional restrictions.
10. Comments on the definitions provided in Section 5.

11. Comments on whether and how EPA Region 10's proposed action under Section 404(c) should consider discharge of dredged or fill materials beyond those associated with the mine pit, TSFs, and waste rock piles and include such discharges associated with the construction of other mine infrastructure (e.g., WWTPs, transportation corridors).

All relevant data, studies, or informal observations are appropriate. All comments will be fully considered as EPA Region 10 decides whether to withdraw the proposed determination or forward to EPA Headquarters a recommended determination to restrict the use of certain waters in the SFK, NFK, and UTC watersheds in southwest Alaska as disposal sites for the discharge of dredged or fill material associated with mining the Pebble deposit.

Dated: 7/17/14

Dennis J. McLerran
Regional Administrator
EPA Region 10

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8.6 Section 5, Proposed Restrictions

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N/A

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