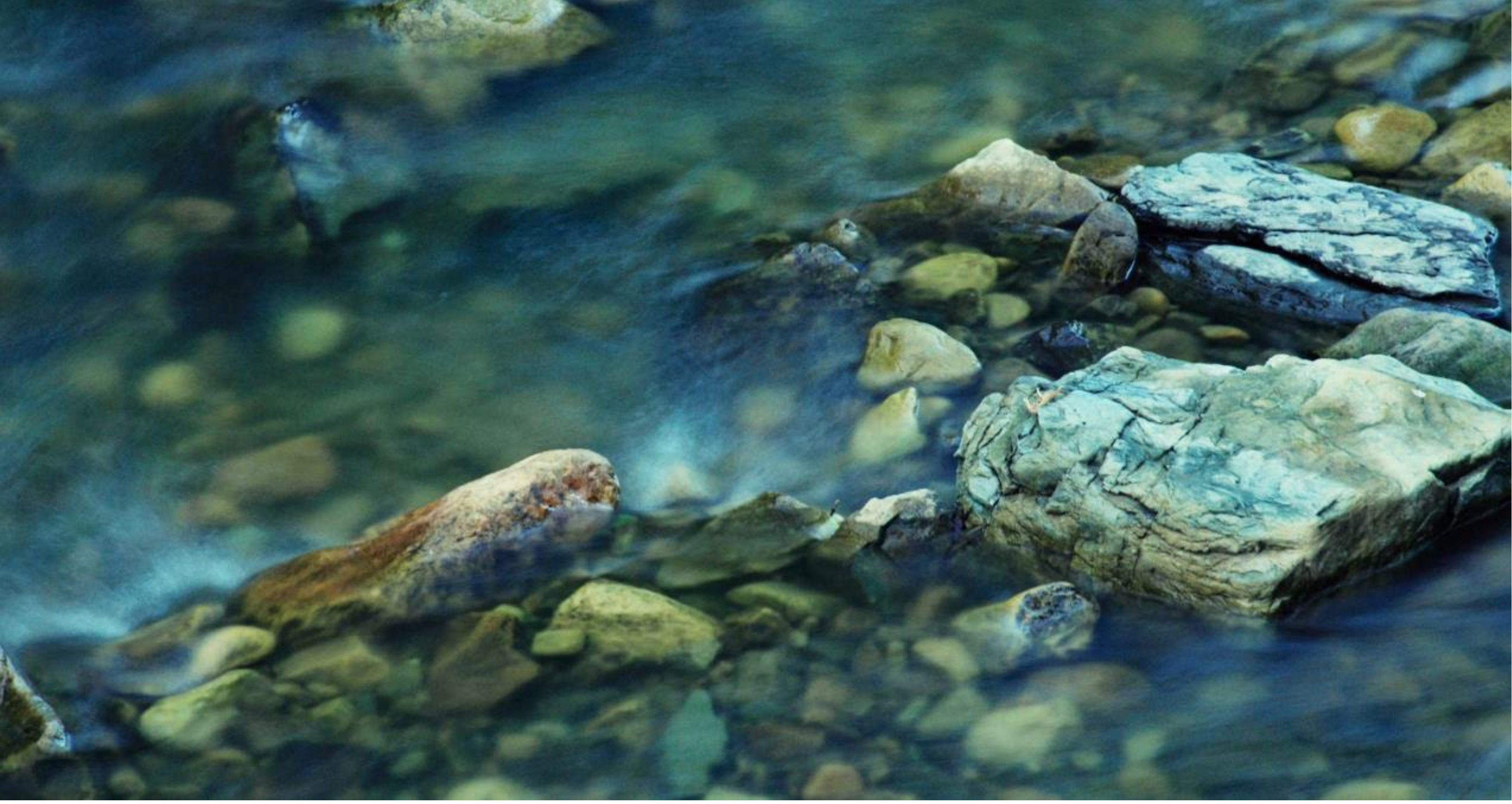

February 2024
Marine Carbon Dioxide Removal Pilot Study (Project Macoma)

Biological Assessment

Prepared for Ebb Carbon

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Biological Assessment

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APPENDICES

Appendix A Port Angeles Mixing Analysis Technical Memorandum
Appendix B Ecological Safety Methodology

ABBREVIATIONS

$CaCO_3$	calcium carbonate
CFR	Code of Federal Regulations
CMMP	contaminated materials management plan
CO_2	carbon dioxide
dBA	A-weighted decibels
DO	dissolved oxygen
DPS	Distinct Population Segment
Ecology	Washington State Department of Ecology
EFH	essential fish habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FMO	foraging, migration, and overwintering area
FR	Federal Register
HAPC	Habitat Area of Particular Concern
HCl	hydrochloric acid
kg/m^3	kilograms per cubic meter
L/hr	liters per hour
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
mCDR	marine carbon dioxide removal
mg/L	milligrams per liter
MHHW	mean higher high water
MLLW	mean lower low water
NaOH	sodium hydroxide
NLAA	not likely to adversely affect
NMFS	National Marine Fisheries Service
NTU	nephelometric turbidity unit
PAH	polycyclic aromatic hydrocarbon
PBF	physical and biological habitat feature
PCB	polychlorinated biphenyl
PNNL	Pacific Northwest National Laboratory
Port	Port of Port Angeles
RCW	Revised Code of Washington
RIWP	Remedial Investigation Work Plan
SU	standard unit
TMDL	Total Maximum Daily Load

Tribe	Lower Elwha Klallam Tribe
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources

1 Introduction

1.1 Project Overview

Project Macoma, LLC, a wholly owned subsidiary of Ebb Carbon, LLC, is proposing a temporary small-scale marine carbon dioxide removal (mCDR) pilot project sited at Terminal 7 of the Port of Port Angeles (Port) in Port Angeles, Washington ("Project Macoma") (Figure 1). Ebb Carbon has developed an mCDR technology to safely and permanently remove carbon dioxide from the atmosphere while reducing seawater acidity locally. Ebb Carbon's mCDR technology removes acid from seawater, generating alkaline-enhanced seawater in the process. The alkaline-enhanced seawater is returned to the ocean, which enables the ocean to draw down and store additional carbon dioxide (CO_2) from the atmosphere.

The proposed pilot project owned and operated by Project Macoma, LLC, would intake seawater via a barge moored at the Terminal 7 dock, pipe the seawater over the existing Terminal 7 pier structure to a modular treatment facility on land, and process and deacidify the seawater before returning it to Port Angeles Harbor via the barge-based outfall system (Figure 2). The purposes of the proposed pilot study are to operate Ebb Carbon's mCDR technology under real-world conditions, support scientific research through scientific and academic collaborations, and gather additional data to inform future deployments. Project Macoma, LLC, plans to assess the effects of this pilot study with local scientific and academic partners and is discussing the potential for partnership on this pilot project with the Lower Elwha Klallam Tribe (Tribe). The proposed pilot study would run for approximately 1.5 years, beginning in summer 2024.

1.2 Purpose

Excess CO_2 must be removed from the atmosphere to keep planetary warming to below 2°C above pre-industrial levels. The ocean, one of the largest carbon sinks on the planet and the single largest regulator and driver of our climate and weather systems, presents a potential solution. The earth regulates the chemistry of the ocean and draws CO_2 from the air through ocean alkalization, a process that happens naturally over millions of years. Ebb Carbon uses electrochemistry to accelerate this process so that atmospheric carbon can be safely removed fast enough to counteract climate change.

Ebb Carbon's mCDR technology also potentially reduces ocean acidification locally by deacidifying seawater. Project Macoma will study whether ocean acidification, primarily caused by human-generated excess CO_2 in the atmosphere, is reduced locally over the duration of the pilot project. Ocean acidification endangers ocean life and represents a stress on marine environments and marine-dependent communities. The Puget Sound and Pacific Northwest marine waters are particularly vulnerable to ocean acidification because of the location of these waters combined with global, natural, and human-driven factors (WSBRPOA 2012).

Ebb Carbon has partnered with Pacific Northwest National Laboratory (PNNL) – Sequim and the University of Washington to evaluate its mCDR technology in a laboratory setting and potential uses for acidic and alkaline process streams.

Project Macoma, LLC, proposes a small-scale pilot study to field test Ebb Carbon's technology and verify its effectiveness, benefits, and safety in the marine environment. The pilot-scale system will use electrochemical processes to remove acid from the ambient seawater of Port Angeles Harbor. The produced alkaline seawater that remains would be returned to the ocean where it can draw down CO_2 from the atmosphere and store it as bicarbonate—a safe and naturally abundant form of carbon storage in the ocean that does not acidify seawater. Numerous experiments would be performed in parallel to understand biological and toxicological impacts on target species, and Project Macoma, LLC, would continue to partner with local scientific and academic partners to validate the efficacy and safety of the system.

1.3 Endangered Species Act-Listed Species and Critical Habitats Potentially Present in the Action Area

Information on listed salmonid and marine species was obtained from the National Marine Fisheries Service (NMFS), and information on listed terrestrial species and bull trout (*Salvelinus confluentus*) was obtained from the U.S. Fish and Wildlife Service (USFWS) (NMFS 2023a; USFWS 2023a).

Listed species and designated critical habitat that may occur in the Action Area (described in Section 3) and the associated effect determinations are summarized in Table 1. Effects of Project Macoma that may occur during construction or operation include impacts to water quality (suspended sediment, turbidity, pH, temperature), entrainment, impacts to prey resources, and habitat modifications. Avoidance and minimization measures, as well as monitoring and adaptive management strategies, will be employed to avoid and minimize these effects. A detailed discussion of Project Macoma-related effects is provided in Section 6.

Table 1
Threatened and Endangered Species That May Occur in the Action Area and Effect Determinations

Species	Status	Agency	Effects Determination	Critical Habitat	Critical Habitat Effects Determination
Killer whale (*Orcinus orca*)	Endangered (Southern Resident DPS)	NMFS	NLAA	Designated	No Adverse Modification
Humpback whale (*Megapterus novaeangliae*)	Threatened (Mexico DPS); endangered (Central America DPS)	NMFS	NLAA	Designated, but not in Action Area	No Effect
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened (Puget Sound ESU)	NMFS	NLAA	Designated	No Adverse Modification
Puget Sound steelhead (*Oncorhynchus mykiss)*	Threatened (Puget Sound ESU)	NMFS	NLAA	Designated	No Effect
Hood Canal summer-run chum salmon (*Oncorhynchus keta)*	Threatened (Hood Canal ESU)	NMFS	NLAA	Designated, but not in Action Area	No Adverse Modification
Bull trout (*Salvelinus confluentus*)	Threatened (Coastal-Puget Sound ESU)	USFWS	NLAA	Designated	No Effect
Bocaccio (*Sebastes paucispinus)*	Endangered (Georgia Basin DPS)	NMFS	NLAA	Designated, but not in Action Area	No Adverse Modification
Yelloweye rockfish *(Sebastes ruberrimus)*	Threatened (Georgia Basin DPS)	NMFS	NLAA	Designated, but not in Action Area	No Effect
Sunflower sea star (*Pycnopodia helianthoides*)	Proposed Threatened	NMFS	No jeopardy	Not designated	Not applicable
Marbled murrelet *(Brachyramphus marmoratus*)	Threatened	USFWS	NLAA	Designated, but not in Action Area	No Effect

An additional nine species that occur in Washington are considered by NMFS or USFWS to potentially occur in the Action Area (as set forth in Section 3), but they are not addressed in this Biological Assessment because they are extremely unlikely to occur within the Action Area. Project

Macoma will have **no effect** on these species, which are listed as follows along with the rationale for eliminating them from this analysis:

- **Leatherback Sea Turtle *(Dermochelys coriacea)*:** Endangered
  - Rationale: Does not occur in Action Area; location is also outside of critical habitat. Leatherback sea turtles are occasionally sighted along the outer Washington coast; however, turtle nesting colonies are not present in Washington.
- **Pacific Eulachon/Smelt (*Thaleichthys pacificus*):** Southern Distinct Population Segment (DPS); Threatened
  - Rationale: Infrequent occurrences in coastal rivers and tributaries to Puget Sound; location is outside critical habitat (Willson et al. 2006; NOAA 2019). It is unlikely that eulachon would be found in the Action Area because there are no eulachon spawning rivers in proximity to or entering Port Angeles Harbor.
- **Green Sturgeon (*Acipenser medirostris*):** Southern DPS; Threatened
  - Rationale: Does not occur in Action Area; location is also outside of critical habitat. Observations of green sturgeon in Puget Sound are much less common compared to the other estuaries in Washington. Although two confirmed Southern DPS fish were detected there in 2006, the extent to which Southern DPS green sturgeon use Puget Sound remains uncertain, and very few green sturgeon have been observed there (74 Federal Register [FR] 52299; DeLacy et al. 1972; Miller and Borton 1980). In addition, Puget Sound does not appear to be part of the coastal migratory corridor that Southern DPS fish use to reach overwintering grounds north of Vancouver Island.
- **Northern Spotted Owl (*Strix occidentalis*):** Threatened
  - Rationale: Does not occur in Action Area; location is outside critical habitat (86 FR 62606; December 10, 2021) and does not contain suitable habitat (USFWS 2011). The northern spotted owl inhabits old-growth forests from southwest British Columbia through the Cascade Mountains and coastal ranges in Washington, Oregon, and California. The complex forests contain structures required for nesting, roosting, and foraging. The pilot study site does not contain old-growth forests, although suitable habitat is present within 3 miles of the pilot study site.
- **Short-Tailed Albatross (*Phoebastria albatrus*):** Endangered
  - Rationale: Does not occur in the Action Area due to lack of suitable habitat and does not have designated critical habitat. Short-tailed albatross require remote islands for breeding, nesting in open, treeless areas with low or no vegetation. They spend much of their time feeding in the open ocean along the continental shelf. Although the short-tailed albatross is occasionally observed along the outer coast of Washington on open beaches, the pilot study site is too far inland for short-tailed albatross and does not contain suitable resting habitat (USFWS 2008).

- **Streaked Horned Lark (*Eremophila alpestris strigata*):** Threatened
  - Rationale: Does not occur in Action Area; location is also outside of critical habitat (USFWS 2023b), and suitable habitat does not exist in the Action Area. The streaked horned lark is a subspecies of the horned lark and is endemic to the Pacific Northwest. They are small, ground-dwelling songbirds that nest in short-grass habitats, preferring large, open patches (i.e., 300 acres or more) with sparse trees. Their current range in Washington includes the south Puget Sound prairies, the Washington coast, and dredged material spoils sites along the Columbia River. The pilot study site does not contain suitable habitat.
- **Yellow-Billed Cuckoo (*Coccyzus americanus*):** Western DPS; Threatened
  - Rationale: Does not occur in Action Area; location is also outside of proposed critical habitat (USFWS 2023c), and suitable habitat does not exist in the Action Area. Yellow-billed cuckoos are migratory birds that breed in North America and winter in Central and South America. They nest within and use willow and cottonwood riparian forests with a dense closed canopy (Csuti et al. 2001). The pilot study site does not contain suitable habitat.
- **Western Pond Turtle (*Actinemys marmorata*):** Proposed Threatened
  - Rationale: Does not occur in Action Area; suitable habitat does not exist in the Action Area, and critical habitat has not been proposed. The western pond turtle occurs in two areas in Washington: along the Columbia River and in a restricted area near Puget Sound, which does not include the Action Area. They occur in large numbers in warm, shallow lakes; along larger rivers within their range near the banks or adjacent backwater habitats; and in slower moving streams where basking sites are available (WDFW 1993). The pilot study site does not contain suitable habitat.
- **Taylor's Checkerspot (*Euphydryas editha taylori*):** Endangered
  - Rationale: Does not occur in Action Area; location is also outside of proposed critical habitat (78 FR 61505; October 3, 2013), and suitable habitat does not exist in the Action Area. The Taylor's checkerspot inhabits prairies, meadows, coastal bluffs, and coastal beach deposits in the lowlands (USFWS 2022a). The Action Area is developed and contains no suitable prairie, meadow, or coastal beach habitat.

1.4 Site Background

Port Angeles Harbor is located along the northern coast of Washington's Olympic Peninsula in the Strait of Juan de Fuca (Figure 1). The harbor is the largest natural deepwater harbor on the west coast of the United States, with depths greater than 90 feet near the eastern extents (U.S. Department of the Interior 2024). Ediz Hook is a 2.5-mile-long jetty that protects the harbor from storms. The harbor and surrounding areas support diverse aquatic and upland habitats, as well as resources for fishing, shellfish harvesting, and many other aquatic uses.

The pilot study site and surrounding area have mixed land uses including industrial and commercial development. The upland portion of the site is within Terminal 7, an industrial property that has been used in the past for mill operations, wood processing, and log storage (Ecology 2023a). The Washington State Department of Ecology (Ecology) has finalized a legal agreement, Agreed Order DE 21560, with the Port to implement the Remedial Investigation Work Plan (RIWP) Phase I at Terminals 5, 6, and 7 Uplands. The Phase I investigation focuses on determining whether contaminated soil or groundwater is moving from the uplands into Port Angeles Harbor.

Beginning in 2008, Ecology conducted investigations of marine sediment in Western Port Angeles Harbor along sites in and adjacent to the Action Area. Per Agreed Order DE 9781, remedial actions are planned to clean up contaminated marine soils associated with industrial activities at the former M&R mill (1608 Marine Drive), Fiberboard mill (1313 Marine Drive), and NPIUSA paper mill (1805 Marine Drive), as well as the current and former locations of City of Port Angeles combined sewer overflow outfalls.

Based on environmental reports and information about these operations, investigations for hazardous chemicals present in soil and groundwater have been conducted in the study area. An initial site investigation has confirmed the presence of dioxins/furans, mercury, halogenated organics, and diesel petroleum in soil and/or groundwater, and ongoing remedial investigations will test for suspected arsenic, benzene, lead, other metals, non-halogenated organics, gasoline and other petroleum, phenolic compounds, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) (Ecology 2023b).

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Figure 1
Site Vicinity
Biological Assessment
Marine Carbon Dioxide Removal Pilot Project (Project Macoma)

2 Description of the Proposed Action

Project Macoma, LLC, is proposing to construct and operate a temporary pilot-scale mCDR project at a site within the Port's Terminal 7 (the Proposed Action). Ebb Carbon's mCDR technology removes acid from seawater, generating alkaline-enhanced seawater. Ebb Carbon returns the alkaline-enhanced seawater to the ocean, which enables the ocean to drawn down and store additional CO_2 from the atmosphere. Project Macoma would intake seawater via a barge moored at the Terminal 7 dock and convey the seawater through a pipe to a treatment facility that would process and remove acid from the seawater before returning the alkaline-enhanced seawater to Port Angeles Harbor.

Once pumped onshore, the seawater will undergo a series of process steps in a temporary modular facility. First, the seawater is pretreated to soften it and create a concentrated brine. The brine then undergoes an electrochemical process that separates the brine into acidic (hydrochloric acid [HCl]) and alkaline (sodium hydroxide [NaOH]) streams. The acidic stream is then neutralized through a reaction with locally sourced alkaline materials.

The process steps noted above result in the following three process streams:

1. **Alkaline Product Stream:** A saltwater solution with enhanced alkalinity produced via the electrochemical process
2. **Neutralized Acid Stream:** The aqueous stream that results from reacting the acidic stream produced by the electrochemical process with alkaline minerals
3. **Pretreatment Stream:** Saltwater that is filtered out during the initial filtration steps

Under routine operations, the three process streams would be discharged as a single combined flow through the outfall. See Table 2 for a description of operational scenarios. Under routine operations (Scenario 5a), the mCDR system would operate for 12 hours daily. Project Macoma anticipates that it would also conduct scientific operations in which one or two of the component flow streams are discharged for limited durations (on the order of a few times per month for single tidal cycles) for data collection and to further the understanding of potential impacts of the discharge to water chemistry/water quality. Project Macoma also anticipates conducting maintenance during which the characteristics of the discharge would vary. Brown and Caldwell (Appendix A) analyzed five release scenarios (and subscenarios) that reflect different proposed combinations of process flow streams. Predicted flow, pH, temperature, and density of the discharge (at the time of discharge) for the proposed operating scenarios are summarized in Table 2. Monitoring of impacts to water quality and aquatic organisms would occur during the pilot project.

Table 2
Effluent Flow and Water Quality Summary for Different Treatment Scenarios (Appendix A)

Scenario	Frequency	Duration	Discharge Flow (L/hr)	Temperature (°C)	Density (kg/m^3)	pH (SU)
Scientific Operations						
Scenario 1b – Alkaline Product Only (13.5 pH)	A few times a month	Single tidal cycle	5,900	30.0	1,028	13.5
Scenario 5b – All Three Process Flows ($CaCO_3$) neutralization)[1]	1 to 2 times, total	Single tidal cycle	38,000	20.4	1,038	12.1
Maintenance Operations						
Scenario 2a – Neutralized Acid Only (with Olivine)	Weekly	<8 hours	5,900	30.0	1,020	2.3
Scenario 2b – Neutralized Acid Only (with $CaCO_3$)	Weekly	<8 hours	5,900	30.0	1,028	8.1
Scenario 3 – Pretreatment Reject Only	Weekly	<8 hours	27,000	17.0	1,042	7.1
Scenario 4a – Neutralized Acid (with Olivine) + Pretreatment Reject	Weekly	<8 hours	32,900	19.3	1,038	6.4
Scenario 4b – Neutralized Acid (with $CaCO_3$) + Pretreatment Reject	Weekly	<8 hours	32,900	19.3	1,039	6.8
Routine Operations						
Scenario 5a – All Three Process Flows (with olivine neutralization)1	Daily	Up to 12 hours	38,000	20.4	1,037	9.8

Note:
1. Scenarios 5a and 5b assume contribution of the alkaline product at a pH of 13.9 (Scenario 1a).

Project Macoma will run for approximately 2 years, beginning in summer 2024. The remainder of this section provides additional information about the pilot study's elements along with a description of construction and operational activities.

2.1 Project Elements

As a pilot study, Project Macoma's elements would be installed as temporary features.

The main elements consist of the following:

- A moored barge at the Terminal 7 pier with pumps and pipes that are used to intake, transport, and discharge seawater to the Port Angeles Harbor and Strait of Juan de Fuca

- Onshore modular water treatment equipment that is used to filter and soften the water and create a concentrated brine
- Onshore electrochemical processing equipment that is used to deacidify the seawater before its return to the Port Angeles Harbor
- Onshore equipment used to neutralize the acidic byproduct

For safety, control, and research purposes, the project design also includes sensing and monitoring equipment that will be located at the site and throughout the harbor.

Project Macoma's footprint would occupy approximately 275 feet by 93 feet (25,575 square feet) on shore with the barge occupying approximately 30 feet by 80 feet (2,400 square feet) adjacent to the Terminal 7 dock. Both areas would be on Port property. The onshore area is currently being used by the Port as a log yard, which the Port would relocate. Access and parking would be provided by existing infrastructure at the Port. The in-water portion of the site is located on state-owned aquatic lands that are leased by the Port under a Port Management Agreement with the Washington State Department of Natural Resources (WDNR).

2.1.1 Onshore

Most process and treatment equipment would be located onshore and housed in shipping containers (up to 9.5 feet high with 2 additional feet for electrical lines) as machine housing. The treatment equipment would be procured from a combination of third-party manufacturers and manufactured by Ebb Carbon. The treatment equipment and process are summarized as follows and described in greater detail in Section 2.3:

In total, there would be 10 shipping containers, six mobile tanks, three utility sheds, and one office trailer, which would be used for the following functions:

- The shipping containers would contain seawater processing equipment.
- Alkaline minerals and the equipment used for acid neutralization would be stored on site in lined containers with weather coverings.
- The mobile tanks would be used to store pumped seawater and the acid and base extracted from the brine. The mobile tanks would be approximately 8,300 to 21,000 gallons and be 11 feet high with 2 additional feet for electrical lines. Any hazardous chemicals would be stored with appropriate secondary containment following best management practices. All tanks would have containment suitable for minor leaks.
- The two utility sheds would house electrical equipment, providing required electrical protective measures consistent with City of Port Angeles requirements. The third would be for storage and maintenance operations.
- The office trailer would be used for staff operations.

Onshore elements would also consist of plastic pipelines connecting the treatment facility to the barge's intake and outfall structures. There would also be a barge transfer area at the Port that would be used to transfer the barge to its temporary moorage location on the north side of the dock.

Project Macoma would use the Port's existing stormwater system at Terminal 7 for stormwater runoff. The area was previously graded to slope away from the shore to a collection point where it is filtered by the Port's stormwater system.

2.1.2 In-Water

The in-water elements of Project Macoma include the barge, which would be equipped with intake and outfall infrastructure, and water quality monitoring equipment.

The barge would be an approximately 30- by 80-foot platform (2,400 square feet) that houses the intake and outfall structures and pumps. The barge would also house some utilities and monitoring equipment. The intake would consist of a pipe that is attached to the barge, equipped with fish screening and mesh that complies with state and federal requirements. The outfall would be an approximately 4-inch-diameter and 50-foot-long pipe that is affixed to and runs the length of the barge, with half-inch perforation holes spaced approximately 2 feet apart and pointing toward the surface across the pipes to diffuse the discharged alkaline-enhanced seawater back into the harbor. The pipe would be submerged approximately 2 meters below the water surface (approximately 28 to 35 feet from the substrate at low to high tide levels, respectively).

Scientific monitoring would occur in the receiving waters throughout operations. Water quality sensors would be attached to existing piers to collect regular measurements at various locations and distances from the outfall to be determined based on coordination with partners. Ebb Carbon would use these measurements to adaptively manage operations, if needed, and to monitor environmental health and benefits.

2.2 Construction

Project construction is anticipated to begin in 2024. Construction activities would involve site preparation, installation, and assembly of onshore structures (i.e., electrical equipment enclosures); deployment of the barge; and assembly of intake/outfall and monitoring equipment. No existing structures would be demolished. All activities are expected to be conducted in a manner appropriate to minimize the potential for erosion or spills consistent with applicable regulations and required permits and approvals, and ground-disturbing activities are expected to be conducted outside sensitive cultural resource areas.

2.2.1 Upland

Site preparation is anticipated to require minimal ground disturbance, mainly in the form of targeted areas of excavation required for the electrical equipment (i.e., not for larger structures). Excavation may be required for the electrical shed, the existing utility vault's main electrical room, and to provide a conduit trench between the existing City of Port Angeles utility transformer vault and the electrical room. As stated, any excavation areas are expected to be located outside culturally sensitive areas.

Grading of the existing soil is not anticipated. Instead, gravel would be used to create a flat area for the new structures and as needed to improve access roadways. Installation of the shipping containers and office trailers would also require 10-foot-long, 3/4-inch-diameter copper ground rods adjacent to each corner, and up to four ground rods at each electrical building/shed. All cable and connections to equipment would be above grade.

Project Macoma, LLC, will also prepare and implement a Contaminated Materials Management Plan (CMMP) to address potential issues if contaminated soils are encountered. Although the level of ground disturbance would be minimal, the CMMP would help to ensure potential concerns are adequately addressed. Project Macoma, LLC, also expects to develop a Monitoring and Inadvertent Discovery Plan for cultural resources.

2.2.2 In-Water

In-water construction would be minimized to assembling and installing intake and outfall pipes along existing infrastructure and the barge. The barge would be moored on the north side of the existing dock. The pre-assembled pipelines and intake and outfall structures would then be mounted to the barge. Monitoring equipment would also be installed on the barge and to existing piers. No large equipment would be involved in in-water work.

2.3 Operation

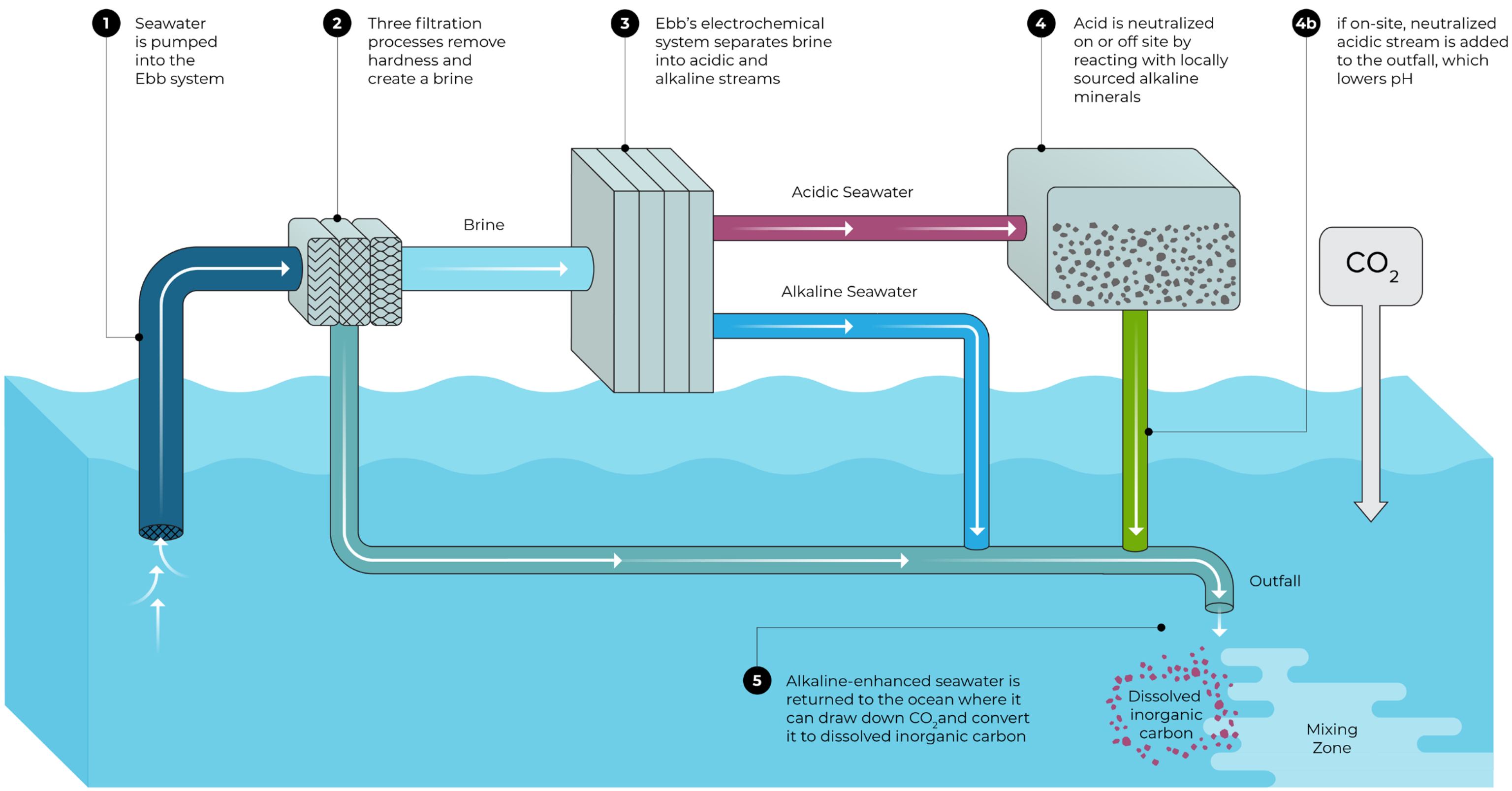
The intake and outfall infrastructure would intake and return approximately 97,000 gallons per day (367,000 liters per day) of seawater from Port Angeles Harbor. Project Macoma's operations are expected to last approximately 2 years post-construction.

Operational activities would include pilot-scale upland water treatment to deacidify seawater to support carbon capture, possible sale and/or transport of acidic byproduct off site, and transport on and off site of alkaline minerals for acid neutralization. This section describes these aspects. Monitoring and data collection activities are discussed in Section 2.5.

2.3.1 Water Treatment Process

A schematic of the treatment process is shown in Figure 2, and the main steps of the water treatment process include the following:

Figure 2
Water Treatment Process Diagram



1. **Water Intake:** Water intake would occur at the barge.
2. **Water Pretreatment:** Once pumped onshore, the seawater would undergo pretreatment, which includes particulate filtration (to remove solids), nanofiltration (to remove hardness, calcium and magnesium ions), and reverse osmosis to create a brine and permeate that will undergo electrochemical processing.
3. **Electrochemical Processing:** After pretreatment, the brine stream would be consumed electrochemically. Ebb Carbon's electrochemical technology uses low-carbon electricity to pass the brine through a series of ion-exchange membranes that separates the brine into two solutions: a base (NaOH) and an acid (HCl). The electrochemical process produces oxygen and hydrogen gases at ambient pressures that will be diluted below lower explosive limits and vented to the atmosphere following all applicable standards. The site generation rate of these are low, at 10 and 20 standard liters per minute undiluted, respectively.
4. **Acid Neutralization:** The acid produced from the brine may be neutralized at the site, so it does not return to the ocean. This would be done by reacting the acidic solution with alkaline materials such as ultramafic rocks, limestone, or unhardened concrete. If reacted on site, alkaline minerals would be transported to the site via truck and/or boat approximately once per week. The aqueous neutralized stream would then be filtered to remove solids and trace metals below acceptable limits before being recombined with the pretreated seawater and alkaline stream. Once combined, the streams would be pumped to the barge for outfall. Another option would be to remove and transport the acid off site rather than neutralizing on site, as discussed in Section 2.3.2.
5. **Discharge and Monitoring:** After processing on land, the combined streams (pretreated seawater, alkaline stream and, if applicable, the neutralized stream) form an alkaline-enhanced seawater that would be pumped to the barge-based outfall. The outfalled alkaline-enhanced seawater would mix with ambient seawater to remove CO_2 gas from the air and store it as dissolved inorganic carbon, primarily bicarbonate ions—a safe and naturally abundant form of carbon storage in the ocean.
    a. Discharge scenarios are outlined in Table 2. Discharge may stop if monitors indicate that certain thresholds have been met, as discussed further in Section 2.5.
    b. Although no new constituents would be added (e.g., no metals or organic compounds), the pH of the water could be altered from approximately 2.3 to 13.5 pH for short periods of time (a single tidal cycle). Preliminary mixing analyses indicate that surrounding pH would return to ambient within the nearfield mixing zone, approximately 21 feet from the discharge point at the barge (Appendix A). Water quality would return to ambient approximately 40 feet around the discharge, well within the allowable chronic mixing zone. During operations, the mixing zone will be maintained within permitted limits. The standard Ecology-required mixing zone distance is 207 feet from the point of discharge. Water quality monitoring and ecological monitoring would be conducted within both

zones to ensure safe operations of the pilot study and to collect data to help inform further development and deployment of this technology. Water quality monitoring would occur to assess for potential acute and chronic mixing zone exceedances at proposed distances of 15 and 150 feet, respectively.

2.3.2 Acid Byproduct Removal and Handling

When combined with the pretreated seawater and alkaline stream, the acidic byproduct would lower the pH of the alkaline-enhanced seawater, resulting in a final product with a pH that is similar to the receiving waters. There is also a potential that the HCl could be separated from the influent stream and used off site for other processes (e.g., in cement manufacturing or laboratory research). While on site, acid byproduct would be handled, stored, and transported consistent with applicable local, state, and federal regulations. It is assumed that entities receiving the acid would also adhere to required standards and regulations. Truck traffic to transport acid byproducts would occur approximately once per month.

2.4 Avoidance, Minimization, and Conservation Measures

The Proposed Action (set forth in Section 2) would minimize the amount of excavation conducted on the site, using the minimum necessary to establish utility access to the temporary structures. The structures would be placed on gravel to create a level grade rather than excavating the site. The existing slope would be graded away from the shoreline to direct stormwater to an existing collection point, where it would be managed by the Port's stormwater system that discharges to both freshwater and marine waterbodies.

A screen would be installed on the intake pipe that follows the Revised Code of Washington (RCW) 77.57.010 and RCW 77.57.070, as well as NMFS recommendations (NMFS 2022a), to prevent entrainment of juvenile salmonids.

2.5 Monitoring and Adaptive Management

The monitoring and adaptive management strategies are described in detail in the Ecological Safety Methodology (Appendix B).

2.5.1 Monitoring

Operation monitoring of pilot study effects would begin once project deployment occurs and would consist of water quality monitoring and biological monitoring, as detailed in the following subsections. Additional studies may be performed following discussions with partners, which may include the Tribe, PNNL-Sequim, and the University of Washington. The supplemental studies would investigate the beneficial impacts associated with the pilot project to determine if they are measurable and would be consulted separately.

2.5.1.1 Water Quality Monitoring

Water quality monitoring would be accomplished by attaching sensors to existing piers to collect regular measurements of water temperature, salinity, dissolved oxygen (DO), turbidity and suspended solids, chlorophyll, pH, and the partial pressure of CO_2 (pCO_2). Monitoring distances would be 15 and 150 feet from the outfall pipe, within the near- and far-field mixing zones. Water quality would be recorded prior to and during the release of each scenario to monitor for exceedances in water quality parameters. Less frequent seawater samples would be collected and analyzed for total alkalinity and dissolved inorganic carbon. Specific operational monitoring details will be prepared in coordination with the partners to meet desired study needs.

2.5.1.2 Biological Monitoring

Monitoring surveys could be periodically conducted to inform an understanding of pilot project effects. Areas for monitoring surveys would be identified during the baseline study, including areas with aquatic vegetation, rocky substrate, and shellfish beds. The observational studies would document presence/absence of species, delineate changes to aquatic vegetation boundaries, and otherwise note observable changes in habitat conditions. The periodic monitoring surveys would be analyzed by the partners and be used to identify when adaptive management strategies may be triggered and to track potential beneficial impacts related to the pilot project.

2.5.2 Adaptive Management

This section describes the initial adaptive management strategies that could be employed to adjust the pilot project's operations or monitoring based on results from ongoing monitoring efforts. Operations would be shut down within minutes of water quality or biological issues being observed or recorded. Table 3 addresses potential issues that may arise during operation and suggests actions to reduce adverse impacts.

It is expected that this protocol would also be developed with input from partners and stakeholders and would be included in documentation provided to NMFS and USFWS as part of the permitting process.

Table 3
Adaptive Management Strategies

Potential Issue	Indicator	Adaptive Management Strategy
Water quality parameter exceedances[1]	Remote monitoring from moored sensors indicates unanticipated changes from baseline levels (see Section 2.5.1.1 for parameters).	• Test and recalibrate moored sensors to ensure accurate readings. • Temporarily shut down operation to determine if all equipment is functioning properly. • Meet with partners to discuss changes to design prior to resuming operation.

Potential Issue	Indicator	Adaptive Management Strategy
Water quality parameter exceedances[1]	Weekly grab sample results document changes from baseline levels (see Section 2.5.1.1 for parameters).	• Follow monitoring plan to include duplicate samples for collection and laboratory quality assurance/quality control. • Resample to ensure accurate results and identify problem. • Temporarily shut down operation to determine if all equipment is functioning properly. • Meet with partners to discuss changes to design prior to resuming operation.
Observations of aquatic vegetation changes	Weekly visual inspections document algal growth or changes in visible aquatic vegetation compared to baseline assessment.	• Determine possible reason for observation and the role (if any) the Project Macoma operation had in development of algal growth or changes in visible aquatic vegetation. • Conduct additional water quality sampling to measure changes in nutrient levels and other water quality triggers to changes in aquatic vegetation. • Temporarily shut down operation to determine if all equipment is functioning properly. • Meet with partners to discuss changes to design prior to resuming operation.
Observations of aquatic organism behavioral changes (e.g., gill flaring, avoidance, or lack of startle response)	Collect additional water quality grab samples and review moored sensor readings leading up to and during observation.	• Determine possible reason for observation and the role (if any) Project Macoma operation played in the changes in behavior. • Temporarily shut down operation to determine if all equipment is functioning properly. • Meet with partners to discuss changes to design prior to resuming operation.
Observations of deceased aquatic organisms	Collect additional water quality grab samples and review moored sensor readings leading up to and during observation.	• Determine possible reason for observation and the role (if any) Project Macoma operation played in the die-off. • Temporarily shut down operation to determine if all equipment is functioning properly. • Meet with partners to discuss changes to design prior to resuming operation.

Note:

1. Washington State Marine Surface Waters, WAC 173-201A-210, WAC 173-201A-612.

2.6 Project Timing

Project Macoma, LLC, proposes to lease the property from the Port during the development and implementation of the Port's RIWP, which, along with the pilot study, would be completed prior to the Port's conducting remediation cleanup. While the RIWP is being prepared, the site has been leased to Project Macoma to use from April 2024 through June 2026. Project Macoma, LLC, aims to construct and begin operation in summer 2024 and operate until demobilizing in summer 2026, providing approximately 2 years of operation for the pilot study.

3 Action Area

The Action Area is defined as the area to be affected directly or indirectly by the federal action (50 Code of Federal Regulations [CFR] Section 402.04). This area is the geographic extent of the physical, chemical, and biological effects resulting from the Proposed Action. The Action Area boundary is thus set as the limits of the Proposed Action effects, as discussed in the following subsections.

3.1 Terrestrial Extent

Noise from construction equipment during minor excavation and placement of the temporary facilities is expected to be the pilot study impact with the most far-reaching terrestrial environmental effects. The Proposed Action would not generate in-air noise levels beyond the use of typical construction equipment and machinery, with the loudest equipment anticipated to be the use of an excavator, which generates in-air noise levels of 87 A-weighted decibels (dBA; WSDOT 2020). No nighttime work is expected to occur related to the construction of the upland facilities.

The pilot study setting is within an industrial area along the shoreline. There is no measured airborne noise data available to determine baseline sound levels. Based on the industrial setting and population density, 60 dBA was used as the ambient sound level.

Noise attenuates to ambient, or background, levels, as the distance from the source of the noise increases. In areas of hard ground cover, such as bare ground, concrete surfaces, or water, the standard reduction for point-source noise is 6.0 dBA for each doubling distance from the source. Using a 6.0-dBA reduction for each doubling distance (WSDOT 2020), in-air noise conditions were calculated for the distances at which they were expected to attenuate to ambient conditions using the spreading loss model.

Sound levels from the loudest anticipated construction activity would attenuate to background levels within approximately 1,119 feet (0.21 mile) from the Proposed Action footprint when an excavator is being used. Therefore, 1,119 feet (0.21 mile) from the Proposed Action footprint is used as the terrestrial extent of the Action Area (Figure 3).

3.2 Aquatic Extent

Operation of the Proposed Action would result in nearfield (acute) and far-field (diluted) changes to water quality extending from the diffuser ports that discharge the treated alkaline-enhanced seawater associated with Project Macoma. Based on modeling in the mixing zone analysis (Appendix A), the nearfield water quality changes are expected to dilute to meet Washington State marine surface water quality standards (Washington Administrative Code [WAC] 173-201A-210) within 40 feet (0.23 acre) for temperature, pH, and DO. Additional far-field water quality impacts are conservatively estimated to extend up to 207 feet in any horizontal direction of the diffuser ports and to include the entire vertical water column (Appendix A). With the 25 outfall ports spaced 2 feet apart (total outfall pipe length of 50 feet) and set 6 feet below the water surface along the offshore length of the barge, the aquatic extent of the Action Area representing the far-field water quality impacts encompasses 3.64 acres (Figure 3).

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Figure 3
Action Area
Biological Assessment
Marine Carbon Dioxide Removal Pilot Project (Project Macoma)

4 Environmental Baseline

4.1 Physical Conditions

Port Angeles Harbor is located along the northern coast of the Olympic Peninsula on the Strait of Juan de Fuca. The harbor is considered the largest natural deepwater harbor on the west coast of the United States, with water depths greater than 90 feet near the eastern end. Near the pilot study site, depths range from 25 feet at mean lower low water (MLLW) along the barge-mounted outfalls to 90 feet MLLW near the eastern end of Ediz Hook.

4.1.1 Shoreline Armoring, Substrate, and Slope

The existing upland component of the pilot study site has been cleared and is highly developed. The site is relatively flat with very little sloping. The shoreline is composed of fill material with a large boulder riprap wall preventing erosion. The WDNR Coastal Atlas map (WDNR 2024) classifies the geomorphology of the site as a "modified" slope stability, with no appreciable drift. The sediment of the harbor is documented as rock and gravel along the eastern portion and as a mix of mud and sand in the harbor's western portion, near the Action Area (NOAA 2024). Additionally, there are no rocky reefs documented within the harbor (NOAA 2024).

4.2 Chemical Conditions

4.2.1 Water Quality

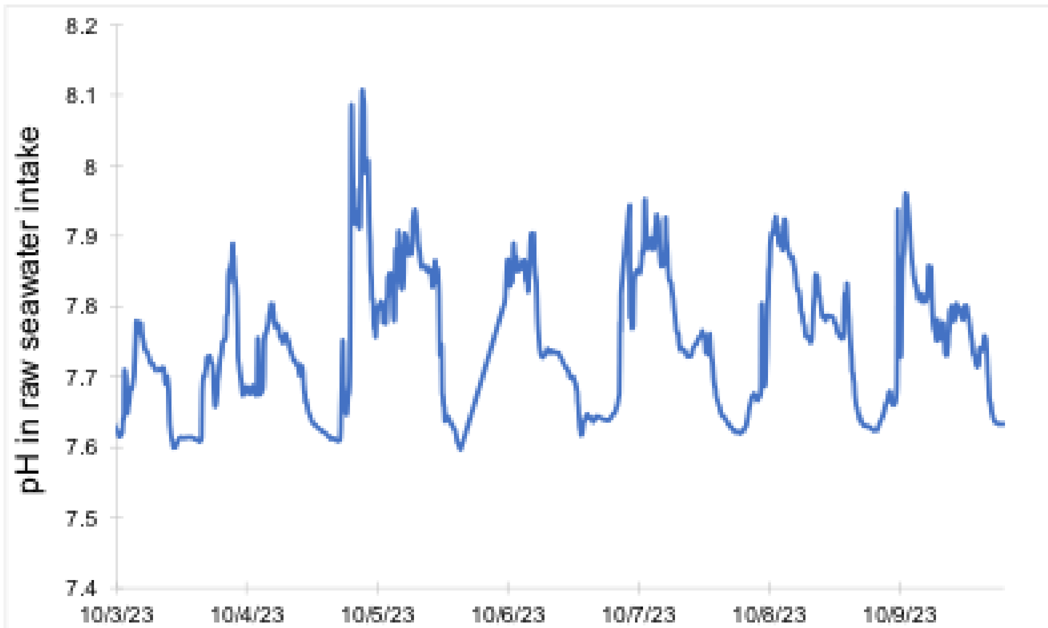
Ambient water quality parameters are provided in Table 4 and discussed in Appendix A.

Table 4
Ambient Water Quality Parameters

Water Quality Parameter	Ambient Conditions
pH	7.8 standard units
Temperature	10.0°C (October–April) 11.4°C (May–September)
DO	7.3 mg/L

The documented pH for Port Angeles Harbor and standard used for determining ambient conditions is 7.8 pH units; however, pH is variable, naturally fluctuating between 7.6 and 8.1 (Figure 4). The example of pH fluctuations in Figure 4 is provided for Sequim Harbor. Based on the proximity and similar conditions, it is anticipated that similar fluctuations in pH would be present in Port Angeles Harbor.

Figure 4
pH Fluctuations in Sequim Harbor



Turbidity and suspended sediment levels naturally fluctuate daily and seasonally in nearshore environments due to the interaction between wave and sandy substrate in intertidal areas and the amount of sunlight.

Ecology rated water quality in Port Angeles Harbor and surrounding areas as part of the State of Washington's most recent Water Quality Assessment. Waters within the pilot study area have been rated as Category 2 for coliform bacteria; PCBs; and 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalence (Ecology 2024a). Category 2 listings are waters that have an indication of a potential water quality problem, but not enough evidence to require preparing a Total Maximum Daily Load (TMDL), associated with water quality improvement projects. There are no Category 5 water quality listings in Port Angeles Harbor, indicating waters impaired or threatened by pollutant(s) for one or more designated uses that require a TMDL.

4.2.2 Sediment Quality

Port Angeles Harbor has historically been used as a site for plywood, pulp, and paper manufacturing; marine shipping; boat building and refurbishing; fueling facilities; marinas; and commercial fishing, with subsequent stormwater, sewer, and process wastewater discharge. As a result, the direct discharge of petrochemicals, organic toxins, heavy metals, and other hazardous substances into the harbor has resulted in a legacy of contaminated sediments (PAHNRT 2021). The pilot study site has been identified as an Ecology cleanup site and lies within "Terminal 5, 6, and 7 Uplands" (Cleanup

Site and Facility Identifier 15440) under Ecology's Toxics Cleanup Program. Additionally, a Natural Resource Damage Assessment was completed for the cleanup site and submitted with a restoration plan (PAHNRT 2021). The existing site and adjacent locations will be remediated per Agreed Order DE 9781 for contaminated marine substrate in Western Port Angeles Harbor.

Ecology documents the following contaminants in the soil and groundwater at this cleanup site: petroleum hydrocarbons; dioxins/furans; and tris(2-carboxyethyl)phosphine, phencyclidine, and related compounds (Ecology 2024b). Ecology's Water Quality Atlas Map lists the marine sediments in the nearshore of the pilot study site as Category 4b for cadmium, high molecular weight PAHs, low molecular weight PAHs, mercury, phenol, PCBs, and zinc (Ecology 2024a). A Category 4b listing means that the site has a pollution control program, similar to a TMDL plan, that is expected to resolve the pollution problems.

4.3 Biological Habitat Conditions

4.3.1 Habitat Access and Refugia

The pilot project site is highly developed and currently used as an industrial logging yard, with no undisturbed habitats in the vicinity. The shoreline is composed of a boulder riprap wall and lacks the complexity necessary for a diverse shoreline microhabitat. There is no overhanging vegetative cover or woody debris present that would provide refugia for juvenile salmon and forage fish from predators and heat stress. No Habitat Areas of Particular Concern (HAPCs) are documented within the nearshore of the pilot study area. The nearest documented HAPCs are an estuary HAPC located approximately 0.6 mile northwest, in the lagoon west of Marine Drive, and a canopy kelp HAPC located approximately 2.6 miles southeast of the pilot study site, in the eastern portion of the harbor (NOAA 2024).

4.3.2 Shoreline Vegetation

The pilot study site is currently used as an industrial log yard and is highly modified. The riparian vegetation is sparse and limited to grass and incidental herbaceous species. There are no trees, riparian vegetation communities, or buffers located within or adjacent to the pilot study area.

4.3.3 Aquatic Vegetation

WDNR's Coastal Atlas map (WDNR 2024) documents patchy (fringe) kelp in the nearshore of the pilot study site. There is no eelgrass (*Zostera marina*) documented in the nearshore of the pilot study site, and the nearest known location is approximately 2.2 miles northeast of the pilot study site, off the shore of Ediz Hook. As discussed previously in Section 4.3.1, the National Oceanic and Atmospheric Administration's Marine Cadastre National Viewer also documents a canopy kelp HAPC in the eastern portion of the harbor, approximately 2.6 miles away from the pilot study area (NOAA 2024).

4.3.4 Forage Fish Spawning Habitat

According to the Washington Department of Fish and Wildlife (WDFW), there is no documented forage fish spawning habitat in the nearshore of the pilot study site. The nearest documented forage fish spawning habitat is located approximately 0.6 mile north of the pilot study site, on the shore of Ediz Hook, and is in the form of Pacific sand lance (*Ammodytes hexapterus*) and surf smelt (*Hypomesus pretiosus*) spawning habitat (WDFW 2024). The boulder riprap shoreline and the mud and sand sediment documented in the nearshore do not provide a suitable habitat for Pacific sand lance and surf smelt spawning. Surf smelt deposit eggs near the water's edge in water a few inches deep, typically around the time of the high-water slack tide and in areas with a mixture of coarse sand and pea gravel sediment. Sand lance deposit eggs in the upper intertidal zone on beaches that also have a mixture of coarse sand and pea gravel sediment but will also use pure sand beaches not used by surf smelt (Moulton and Penttila 2001).

The nearest documented Pacific herring (*Clupea pallasii*) spawning habitat is located in Dungeness Bay, approximately 12.8 miles east of the pilot study site (WDFW 2024). Pacific herring deposit eggs on submerged aquatic vegetation between the upper limits of high tide down to a depth of -40 feet MLLW, but most spawning takes place between 0 and -20 feet MLLW in tidal elevation (WDFW 2019). The documented patchy (fringe) kelp in the pilot study area's nearshore may provide potential habitat for Pacific herring spawning (WDNR 2024).

5 Species and Critical Habitats Potentially Present in Action Area

This section describes federally listed species and critical habitat in the Action Area.

5.1 Southern Resident Killer Whale

The Southern Resident killer whale (SRKW) DPS was listed as endangered on November 18, 2005 (70 FR 69903). The SRKW contains J pod, K pod, and L pod, and its population is estimated in the 70s (NMFS 2023b). The geographic distribution of SRKW is year-round in the coastal waters off Oregon, Washington, and Vancouver Island and off the coast of central California and the Queen Charlotte Islands (Center for Biological Diversity 2001). In the summer, SRKW are typically found in the Georgia Strait, Strait of Juan de Fuca, and the outer coastal waters of the continental shelf. In the fall, the J pod migrates into Puget Sound, while the rest of the population makes extended trips through the Strait of Juan de Fuca. In the winter, the K and L pods retreat from inland waters and are seldom detected in the core areas until late spring. The J pod generally remains in inland waterways throughout the winter, with most of their activity in Puget Sound. Other winter movements and range of SRKW are not well understood (NMFS 2023b).

SRKW use the entire water column, including regular access to the ocean surface to breathe and rest (Bateson 1974; Herman 1991). They remain underwater 95% of the time, with 60% to 70% of their time spent between the surface and a depth of 65 feet (20 meters), while diving regularly to depths of greater than 655 feet (200 meters; Baird 1994; Baird et al. 1998). SRKW spend less than 5% of their time between depths of 200 and 820 feet (60 and 250 meters; Center for Biological Diversity 2001). Time-depth recorder tagging studies of SRKW have documented that whales regularly dive to greater than 490 feet (150 meters) but that there is a trend toward a greater frequency of shallower dives in recent years (Baird and Hanson 2004).

SRKW primarily feed on salmon species (Balcomb et al. 1980; Bigg et al. 1987; NMFS 2008; Hanson et al. 2010). Chinook salmon dominate their diet (71.5%), followed by chum salmon (22.7%) and other salmon species or unidentifiable salmon species (Ford et al. 1998; Ford and Ellis 2006). Recent studies have indicated that while in their summer range (outside of the Action Area), Chinook salmon from the Fraser River basin accounted for 80% to 90% of the salmonid prey for SRKW, and fish originating in Puget Sound accounted for 6% to 14% (Hanson et al. 2010). Other species such as lingcod (*Ophiodon elongates*), halibut (*Hippoglossus stenolepis*), rockfish (*Sebastes* spp.), and Dover sole (*Microstomus pacificus*) were identified as additional prey species and may increasingly contribute to the diet as salmon populations decline (Center for Biological Diversity 2001; Hanson et al. 2010).

5.1.1 *Critical Habitat Presence in the Action Area*

Critical habitat was designated on November 29, 2006 (71 FR 69054) and revised on August 21, 2021 (86 FR 41668). Critical habitat for SRKW is designated for marine areas greater than 20 feet deep and overlaps with the Action Area (NMFS 2024). Critical habitat provides the physical and biological habitat features (PBFs) that are essential for the conservation of the species or that require special management considerations, as follows:

- **PBF 1:** Water quality to support growth and development
- **PBF 2:** Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth
- **PBF 3:** Passage conditions to allow for migration, resting, and foraging

5.2 Humpback Whale

For the Marine Mammal Protection Act stock assessment reports (NOAA 2022a), the California-Oregon-Washington Stock is defined to include humpback whales that feed off the west coast of the United States, including animals from both the California-Oregon and Washington-southern British Columbia feeding groups. The Mexico humpback whale DPS feeds along the Washington coast and is listed as “threatened” under the Endangered Species Act (ESA; 81 FR 62259) and comprises 25% of humpback whales present in Washington. The Central America humpback whale DPS also is known to feed in the Washington-southern British Columbia area and is listed as “endangered” (81 FR 62259) and comprises 6% of the humpback whales in Washington. The Hawaii humpback whale DPS is not federally listed and comprises 69% of the humpback whales in Washington. A final humpback whale recovery plan was adopted in 1991 (NOAA 1991).

Humpback whales are baleen whales known for their long pectoral fins. They feed primarily on krill, plankton, and small fish, consuming up to 3,000 pounds per day. As with other baleen whales, the adult females are larger than adult males, with lengths reaching 60 feet. Humpbacks are grey in color, with significant variation such that the patterns on the undersides of the flukes can be used to identify individual whales.

Humpback whales have the longest migration of any mammal. Individuals of the Mexico DPS have been observed to make the 3,000-mile trip between Alaska and Hawaii in as little as 36 days. Humpbacks spend the warmer months in northern latitudes feeding and building fat stores; they migrate south during the winter for the breeding season (NOAA 2022b).

Humpback whales are found in coastal waters of Washington as they migrate from feeding grounds in Alaska to California to winter breeding grounds in Mexico. Humpbacks are historically only rare visitors to Puget Sound. In 1976 and 1978, two sightings were reported in Puget Sound, and one sighting was reported in 1986 (Osborne et al. 1988; Calambokidis and Steiger 1990;

Calambokidis and Baird 1994). More recently, sightings have increased, and, according to the Orca Network, humpbacks are regularly sighted in the Strait of Juan de Fuca, near the San Juan Islands and Whidbey Island, and in Puget Sound (Orca Network 2024).

5.2.1 Critical Habitat Presence in the Action Area

In Washington, the Central American DPS and Mexico DPS critical habitat includes coastal and nearshore waters beginning approximately 50 meters from MLLW, extending from the outer coast to include the Strait of Juan de Fuca to Angeles Point, approximately 5 miles west of the Action Area (86 FR 21082; May 21, 2021). Humpback whale critical habitat is present a few miles west of but not within the Action Area (NMFS 2024).

5.3 Puget Sound Chinook Salmon

The Puget Sound Chinook Salmon Evolutionarily Significant Unit (ESU) was listed as threatened on June 28, 2005, and updated on April 14, 2014 (79 FR 20802). The Puget Sound ESU of Chinook salmon includes all naturally spawned populations from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward. This ESU also includes Chinook salmon from 25 different artificial propagation programs. Nearshore areas along the Strait of Juan de Fuca are considered a major migratory corridor for Chinook salmon (Shared Strategy 2007).

The Elwha River (approximately 6 miles west of the pilot study site) and the Dungeness River (approximately 14 miles east of the pilot study site) are used for spawning by Chinook salmon. Morse Creek, approximately 4 miles east of the pilot study site, is also used by Chinook salmon for spawning. Ennis Creek, approximately 1 mile east of the pilot study site, has documented Chinook salmon presence but no documented spawning (NWIFC 2023).

The recent 5-year status review of Puget Sound Chinook salmon indicates that although population abundance has been highly variable since the 1980s, there appears to be an overall decline in most wild spawning populations in recent years (NMFS 2015, 2017). The Dungeness and Elwha Chinook salmon populations have had very low adult returns in recent decades. Millions of hatchery Chinook salmon from indigenous stock have been released in both the Dungeness and Elwha rivers to support recovery (Shared Strategy 2007).

Chinook salmon typically migrate into freshwater spawning areas in the Dungeness River between May and July and spawn between August and October. After emerging as fry in the early spring, most of these Chinook salmon emigrate to rear in the Dungeness estuary during their first year, whereas others rear in the river for a year and emigrate as yearlings. Estuarine and nearshore habitat is therefore important for juvenile Chinook salmon from the Dungeness River (Shared Strategy 2007).

Prior to the removal of two dams from the Elwha River between 2011 and 2014, Chinook salmon had access to only the lower 5 miles of the river below Elwha Dam. Chinook salmon runs returned to the river from late spring through late September and spawned from late August through mid-October. Because of the lack of both freshwater and estuarine habitat, most juvenile Chinook salmon in the river migrated quickly into saltwater and spent most of their first year in the marine nearshore environment (Shared Strategy 2007). Since removal of the dams, the use of the Elwha River by Chinook salmon has been evolving, and studies are ongoing. Chinook salmon have moved into areas upstream of the former dam sites (Duda et al. 2021). However, hatchery-produced Chinook salmon are still dominant, and there is still no evidence of an increase in natural production of Chinook salmon in the river (Weinheimer et al. 2018). Based on recent modeling, it is thought that an increased diversity of stream temperature regimes in the river following dam removal may allow the emergence of more diverse life-history strategies, with some Chinook salmon juveniles potentially spending more time in the river before moving to the ocean (Liermann et al. 2023).

Adult Chinook salmon could be present in the Action Area in the summer months during their migration toward spawning areas. Juveniles could be present in the Action Area during out-migration in the spring. Juveniles would be expected to use shallower nearshore waters, whereas adults would be expected to use the deeper waters of the harbor.

5.3.1 Critical Habitat Presence in the Action Area

Critical habitat for Puget Sound Chinook salmon was designated on September 2, 2005 (70 FR 52698) and includes marine waters in the Action Area (NMFS 2024). The designation of critical habitat is based on the life history and habitat needs of Puget Sound Chinook salmon and includes six PBFs necessary for their conservation in freshwater, estuarine, and nearshore marine habitats. Project Macoma would not affect any PBFs related to freshwater spawning, rearing, or migration. In the Action Area, the following PBFs could be affected by the Proposed Action:

- **PBF 5:** Nearshore marine areas free of obstruction and excessive predation that meet the following criteria:
  - Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation
  - Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels
- **PBF 6:** Offshore marine areas that meet the following criteria:
  - Water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation

5.4 Puget Sound Steelhead

Puget Sound steelhead were listed as threatened on May 11, 2007 (72 FR 26722) and updated on April 14, 2014 (79 FR 20802). The Puget Sound DPS of steelhead includes all naturally spawned anadromous steelhead originating below natural and manufactured impassable barriers from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, as well as populations from five artificial propagation programs.

Steelhead are anadromous salmonids that, unlike most other Pacific salmon, are iteroparous (i.e., they can spawn several times), with spawning starting in their fourth or fifth year and continuing until reaching a maximum age of approximately 11 years (76 FR 1392; PSP 2017). Anadromous steelhead exhibit two major life-history strategies. Stream-maturing or summer-run steelhead enter freshwater at an early stage of maturation, usually from May to October; migrate to headwater areas; and hold for several months prior to spawning the following spring. Ocean-maturing or winter-run steelhead enter freshwater from November to April at an advanced stage of maturation, spawning from February through June. The winter run of steelhead is the predominant run timing in Puget Sound (Myers et al. 2015).

Steelhead have been documented in most of the streams in the pilot study vicinity that drain north to the Strait of Juan de Fuca or Port Angeles Harbor. Winter steelhead spawning is documented in several streams that empty into the strait (outside of Port Angeles Harbor), including the Elwha River, Ennis Creek, Morse Creek, Siebert Creek, McDonald Creek, and the Dungeness River (NWIFC 2023).

Winter-run juveniles would be out-migrating from freshwater during spring through midsummer and could be present in or near the Action Area during that time. Information on general steelhead life history suggests that few, if any, juvenile steelhead will be in the shallow nearshore areas at any time during the year. Burgner et al. (1992) reports that the majority of steelhead smolts migrate directly to the open ocean and do not rear extensively in the estuarine or coastal environments. In addition, by the time steelhead reach the marine waters, they would be much larger in size and tend to move rapidly to offshore habitat.

As previously discussed for Chinook salmon (Section 5.3), the use of the Elwha River by steelhead has been evolving since removal of the two dams. Steelhead have moved into previously inaccessible areas of the river, and their increased access to diverse habitats including cold-water tributary streams could allow the development of more diverse life-history strategies (Duda et al. 2021, Munsch et al. 2023).

5.4.1 Critical Habitat Presence in the Action Area

Critical habitat for steelhead was finalized on February 24, 2016 (81 FR 9252). In the pilot study vicinity, steelhead critical habitat includes the Elwha and Dungeness rivers and numerous smaller streams between the two rivers that drain north into the Strait of Juan de Fuca or Port Angeles Harbor. Tumwater and Valley creeks, both draining into the harbor, are the closest streams to the pilot study site that are included in critical habitat mapping for this species (NMFS 2024).

Project Macoma would not affect any steelhead PBFs related to freshwater spawning, rearing, or migration. Marine and estuarine PBFs for steelhead are the same as those discussed previously for Chinook salmon (Section 5.1.3.1).

5.5 Hood Canal Chum Salmon

Hood Canal summer-run chum salmon were listed as threatened on March 25, 1999 (64 FR 14508), and June 28, 2005 (70 FR 37159), and updated on April 14, 2014 (79 FR 20802). The Hood Canal summer-run ESU of chum salmon includes all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries; populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington; and two artificial propagation programs: the Lilliwaup Creek Fish Hatchery and the Tahuya River Program. The nearest documented presence as well as spawning habitat is located in the Dungeness River, approximately 13 miles east of the Action Area (NWIFC 2023). Fall-run chum salmon, which are not federally listed, are present in small streams draining to the harbor and spawn in Frog Creek near the harbor mouth (NWIFC 2023).

Hood Canal summer-run chum salmon usually spawn from mid-August through October, and juveniles out-migrate immediately after emergence in spring, typically February through May (Haring 2000). Therefore, adults could be migrating through the deeper waters of the Action Area prior to and during this fall migration, and juveniles could use shallow mud substrate nearshore areas as they migrate and rear in the spring (Roni and Weitkamp 1996). However, no spawning or rearing streams for Hood Canal summer-run chum salmon are present in Port Angeles Harbor.

5.5.1 Critical Habitat Presence in the Action Area

Critical habitat for Hood Canal summer-run chum salmon was designated in 2005 (70 FR 52630). The closest mapped critical habitat is at Dungeness National Wildlife Refuge, approximately 13 miles east of the Action Area (NOAA Fisheries 2021).

5.6 Bull Trout

The U.S. lower 48 states (co-terminus) population of bull trout was listed as threatened on November 1, 1999 (64 FR 58910). The Coastal-Puget Sound DPS of bull trout includes all Pacific Coast drainages within the State of Washington.

Bull trout have specific cold-water requirements and are rarely found in waters with temperatures above 64°F (USFWS 2022b). They may also exhibit four different life-history types: anadromous, adfluvial, fluvial, and resident. Bull trout spawn from late summer through December, typically when water temperatures drop below 48°F (Wydoski and Whitney 2003). Juvenile bull trout feed on insects and then transition to small fish. Larger bull trout prey predominantly on fish. Anadromous bull trout use nearshore marine areas seasonally (spring and summer) and are typically present near their natal streams in shallow water (Hayes et al. 2011). Habitats used include shorelines adjacent to coastal deposits, sediment bluffs, and low bank areas with mixed substrate (Hayes et al. 2011).

Bull trout have been documented in the Dungeness and Elwha rivers. USFWS has identified two local populations of bull trout in the Dungeness watershed: one in the Dungeness River and one in the Gray Wolf tributary. The Elwha River is considered a core area for the species. Prior to removal of the two Elwha River dams, the river was thought to support both an "upper river" freshwater-only type and a "lower river" anadromous form of bull trout (Shared Strategy 2007). Following dam removal, bull trout moved into formerly inaccessible upstream areas, reaching the headwaters within 3 years, and moving between the river and its estuary (Brenkman et al. 2019).

Anadromous bull trout may occasionally be present in nearshore habitats in the Action Area. The low-elevation streams in the Action Area do not meet the cold-water spawning requirements of bull trout.

5.6.1 Critical Habitat Presence in the Action Area

Bull trout critical habitat was finalized on October 18, 2010 (75 FR 63898). It encompasses both freshwater streams and marine nearshore areas from mean higher high water (MHHW) offshore to depths of 33 feet. In the pilot study vicinity, bull trout critical habitat includes the Elwha and Dungeness rivers and numerous smaller streams between the two rivers that drain north into the Strait of Juan de Fuca or Port Angeles Harbor. The Action Area includes designated marine nearshore critical habitat. Valley Creek, which drains into Port Angeles Harbor, and Ennis Creek to the east of the harbor are the closest freshwater streams designated as critical habitat (USFWS 2024a).

The USFWS has designated several recovery units for bull trout. The Action Area is within the Coastal Recovery Unit, which includes the Olympic Peninsula, Puget Sound, and Lower Columbia River basin major geographic regions. The Olympic Peninsula region includes six core areas for bull trout recovery, which include the Elwha and Dungeness river watersheds. The Strait of Juan de Fuca is not considered a core area but is designated as a bull trout foraging, migration, and overwintering area (FMO). FMOs are defined as larger streams, mainstem rivers, estuaries, and nearshore environments used by subadult and adult migratory bull trout for foraging, migration, rearing, or overwintering (USFWS 2015a, 2015b).

The designation of critical habitat is based on the life history and habitat needs of Puget Sound bull trout and includes nine PBFs necessary for their conservation in freshwater, estuarine, and nearshore marine habitats. The PBFs relevant to Project Macoma include the following:

- **PBF-2:** Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers
- **PBF-3:** An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish
- **PBF-4:** Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure
- **PBF-8:** Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited
- **PBF-9:** Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout

5.7 Bocaccio

The Puget Sound/Georgia Basin DPS of bocaccio was listed as threatened on April 28, 2010 (75 FR 22276). Bocaccio are large, long-lived rockfish that inhabit deep waters, from 160 to more than 800 feet (ranging as deep as 1,500 feet; 50 CFR 223-224). Rockfish are viviparous (i.e., their eggs are fertilized internally) and produce 1 million to 3 million larvae annually. The larvae are released in the spring and are distributed widely in surface water, floating with tides and currents. After 3 to 6 months as larvae, juveniles move into offshore or nearshore benthic habitats including rocky reefs, kelp canopies, and structures such as piers and oil platforms. Juveniles feed on zooplankton including the larvae of crustaceans, small fish, and invertebrates, and as they grow larger, typically move into deeper water and habitats with high roughness (i.e., rocky reefs). Adult bocaccio have a diverse diet including numerous fish species (e.g., juvenile salmon, forage fish, flatfish, pollock, and lingcod) and larger invertebrates such as crabs, and can be found associated with rocky or bouldery benthic habitats but have also been captured in soft-bottomed habitats (NMFS 2017).

Bocaccio are difficult to sample. Historically, they appear to have been most abundant in the South Sound and Main Basin of Puget Sound (Drake et al. 2010 and Williams et al. 2010, cited in NMFS 2017). Juveniles and subadults are more common than adults in shallower water, and bocaccio are known to school in nearshore waters as juveniles (McCall and He 2002). Adults are generally associated with rocky areas and outcrops (Drake et al. 2010), but some are also frequently found in areas lacking hard substrate (Washington 1977; Miller and Borton 1980).

Port Angeles Harbor lacks the rocky reefs, substrates, and deep waters typical of bocaccio rockfish habitat.

5.7.1 Critical Habitat Presence in the Action Area

Critical habitat for Puget Sound/Georgia Basin bocaccio was designated on November 13, 2014 (79 FR 68042). The nearest designated critical habitat to the Action Area is mapped approximately 7 miles east, near the outlet of Siebert Creek (NMFS 2024).

5.8 Yelloweye Rockfish

The Puget Sound/Georgia Basin DPS of yelloweye rockfish was listed as threatened on April 28, 2010 (75 FR 22276). Critical habitat was designated on November 13, 2014 (79 FR 68042). The nearest critical habitat to the Action Area is located offshore of Dungeness Spit.

Yelloweye rockfish are a large, long-lived rockfish most commonly occurring in deep water from 300 to 600 feet in depth. Rockfish are viviparous (i.e., their eggs are fertilized internally) and produce 1 million to 3 million larvae annually. The larvae are released in the spring and are distributed widely in surface water, floating with tides and currents. Juveniles use shallow waters and habitats including rocky reefs, kelp canopies, and structures such as piers and oil platforms. Juvenile yelloweye rockfish rarely occur in nearshore areas. Juveniles feed on zooplankton including the larvae of crustaceans and invertebrates, as well as small fish. Adult yelloweye rockfish feed on many species of fish and larger invertebrates such as crabs and are more associated with rough rocky benthic habitats than bocaccio (NMFS 2017).

Yelloweye rockfish occur in waters 80 to 1,560 feet deep (Orr et al. 2000) but are most commonly found between 300 to 590 feet in depth (Love et al. 2002). They are highly associated with high relief zones with crevices and complex rock habitats (Love et al. 1991; Richards 1986). Port Angeles Harbor is not ideal habitat for yelloweye rockfish due to its natural lack of rocky reefs or substrate and shallow depths. Juvenile yelloweye rockfish do not typically occupy shallow waters (Love et al. 1991) and are thus unlikely to be present in the Action Area where operations would occur. Yelloweye rockfish were recently sampled in low numbers in Puget Sound (NMFS 2017).

5.8.1 Critical Habitat Presence in the Action Area

Critical habitat for Puget Sound/Georgia Basin yelloweye rockfish was designated on November 13, 2014 (79 FR 68042). The nearest critical habitat to the Action Area is located approximately 10 miles to the northeast, offshore of Dungeness Spit (NMFS 2024).

5.9 Sunflower Sea Star

On August 18, 2021, the Center for Biological Diversity petitioned NMFS to list the sunflower sea star under the ESA. NMFS determined that the Proposed Action may be warranted (86 FR 73230; December 27, 2021) and began a full status review to evaluate the overall extinction risk for the species. NMFS determined that the sunflower sea star is likely to become endangered within the foreseeable future throughout its range. On March 16, 2023, NMFS published a proposed rule to list the sunflower sea star as a threatened species (88 FR 16212; March 16, 2023). NMFS did not propose to designate critical habitat (88 FR 16212; March 16, 2023).

Information on the status of the species was provided by NMFS (Vigil 2023). The sunflower sea star is a large (up to 1 meter in diameter), fast-moving (up to 160 centimeters per minute), many-armed (up to 24 rays) echinoderm native to the West Coast of North America. It occupies waters from the intertidal to at least 435 meters deep, but it is most common at depths less than 25 meters and rare in waters deeper than 120 meters. Sunflower sea stars occur over a broad array of soft-, mixed-, and hard-bottom habitats from the Aleutian Islands, Alaska, to Baja California, Mexico, but are most abundant in waters off eastern Alaska and British Columbia.

Prior to 2013, the global abundance of sunflower sea star was estimated at several billion animals; however, from 2013 to 2017, sea star wasting syndrome reached pandemic levels, killing an estimated 90% or more of the population. Declines in the northern portion of its range were less pronounced than in the southern portion but still exceeded 60%. Species-level impacts both during the pandemic and on an ongoing basis have been identified as the major threat affecting the long-term persistence of the sunflower sea star.

The species has separate sexes and is a broadcast spawner with a planktonic larval stage. Females can release a million eggs or more. Reproduction also occurs via larval cloning, enhancing potential reproductive output beyond female fecundity. Sea stars can regenerate lost rays/arms and parts of the central disc. Rays may detach when a sea star is injured or as a defense reaction when attacked by a predator. The longevity of the sunflower sea star in the wild is unknown, as is the age at first reproduction and the period over which a mature individual is capable of reproducing.

The sunflower sea star hunts a range of bivalves, gastropods, crustaceans, and other invertebrates using chemosensory stimuli and will dig for preferred prey in soft sediment. It preys on sea urchins and plays a key role in controlling sea urchin numbers in kelp forests. Although generally solitary, they are also known to seasonally aggregate, perhaps for spawning purposes.

5.9.1 Critical Habitat Presence in the Action Area

NMFS has not yet proposed to designate critical habitat for sunflower sea star (88 FR 16212; March 16, 2023).

5.10 Marbled Murrelet

The marbled murrelet was listed as threatened on October 1, 1992 (57 FR 45328). Marbled murrelets are small seabirds of the family Alcidae that occur along the north Pacific Coast from Alaska to California. They nest mainly in late-successional and old-growth coniferous forests and may fly up to 45 miles to marine areas to forage on small fish and large zooplankton (Ralph et al. 1995; Pearson et al. 2022). High-use areas for murrelets include upwelling areas, mouths of bays, areas over underwater sills, tidal rips, narrow passages between islands, shallow banks, and kelp beds. Field observations of murrelets in Puget Sound have suggested that foraging distribution is linked to tidal patterns that increase prey availability for the birds (Speich and Wahl 1995).

The USFWS Marbled Murrelet Recovery Plan designated six conservation zones spanning coastal areas from the U.S.-Canada border south to San Francisco Bay (USFWS 1997). The Northwest Forest Plan requires ongoing monitoring of marbled murrelet populations in the five northern conservation zones (U.S. Forest Service 2024), including Zone 1, where the Action Area is located. Overall, the Washington state marbled murrelet population has been declining over the past two decades (Pearson et al. 2022). Murrelet abundance in Zone 1 declined by approximately 5% per year between 2000 and 2018 (McIver et al. 2021). Recent summer marine surveys by WDFW found a density of approximately two marbled murrelets per square kilometer in the Strait of Juan de Fuca (Lance and Pearson 2021).

The Action Area does not provide suitable nesting habitat for this species, but such habitat is present within a few miles (see Section 5.1.10.1), increasing the likelihood of the species using marine habitat for foraging in the Action Area. The species has recently been observed from Ediz Hook (eBird 2023).

5.10.1 Critical Habitat Presence in the Action Area

Critical habitat for marbled murrelet includes terrestrial areas containing suitable nesting platforms, adequate canopy cover over the nest, landscape condition, and distance to the marine environment (81 FR 51348; August 4, 2016). The nearest mapped critical habitat to the Action Area is located approximately 3 miles south (USFWS 2024b).

6 Effects Analysis

6.1 Noise

The activities associated with the Proposed Action are not expected to create a noise impact on species listed as endangered, threatened, or proposed for listing under the ESA ("ESA-listed") species. Underwater sound pressure waves are known to affect fish and can lead to injury or death (CalTrans 2001; Longmuir and Lively 2001; Stotz and Colby 2001) through the mechanisms of ruptured swim bladder and internal hemorrhaging (CalTrans 2001; Abbott and Bing-Sawyer 2002). Marine mammals may experience temporary or permanent hearing threshold shifts associated with underwater noise (NOAA 2018), as well as behavioral disturbances such as disruption of rest and foraging behavior or changes in migration routes. Marbled murrelets may be affected by both in-air and underwater noise, with construction and operation noise associated with the Proposed Action potentially resulting in reduced foraging success (Smith et al. 2023).

All equipment used for constructing the necessary pilot study elements would be operated in and from the uplands in an industrial area. All in-water elements (intake and outfall pipes) would be pre-assembled upland and then installed on the barge at the pier. Underwater noise associated with installation would be minimal and conducted at low tide and would not require the use of large equipment. Therefore, underwater noise effects to listed aquatic species from the Proposed Action are expected to be discountable, and in-air noise impacts are expected to be localized and minimal in areas that do not contain suitable habitat for marbled murrelet nesting or foraging.

6.2 Water Quality

Water quality within Port Angeles south and west of a line bearing 152 degrees true from Buoy 2 at the tip of Ediz Hook is categorized as "excellent" for aquatic life use, recreational use, and harvest use (WAC 173-201A-612). The Proposed Action would not create water quality impacts associated with construction because in-water work would be minimal and related to mooring the barge and the installation of temporary intake and outfall pipes along the barge and existing infrastructure.

Water quality impacts are defined as short term (releases over limited hours) and long term (continuous repeated releases or releases over days). The operation of the mCDR facility will include variable treatment and discharge scenarios and will evaluate the impacts of potential short-term increases in turbidity, pH, and temperature and reduction in DO. A mixing zone study (Appendix A) was conducted to evaluate potential water quality impacts associated with operating Project Macoma. The analyses include hydrodynamic dilution modeling using Visual Plumes software and water quality/chemistry modeling using commercial OLI Systems software. Modeling analyses are supported by collected data, where available, and conservative assumptions. Ebb Carbon will validate model predictions from the mixing zone study using a dye test. This will include collection of site-specific current data. The combined results of the dilution and chemistry modeling indicate that, under routine operating conditions, Project Macoma will not exceed water quality criteria for turbidity, pH, temperature, or DO. Discharges that could occur under maintenance and scientific operating conditions also would not result in an exceedance of water quality criteria considering the limited duration of the discharge and Project Macoma, LLC's adherence to process controls described in the Ecological Safety Methodology (Appendix B).

6.2.1 Turbidity

The pilot project may increase turbidity after seawater treatment through the precipitation of elements associated with the treatment process. Elevated turbidity may affect marine organisms and aquatic wildlife during various life stages by reducing visibility and the ability to forage or avoid predators, altering movement patterns (due to avoidance of turbid waters) (DeYoung 2007), and reducing aquatic vegetation and habitat through loss of water clarity and light transmission. Although an aquatic vegetation survey has not been completed for the site, patchy (fringe) kelp has been mapped in the nearshore within the Action Area that may experience reduced growth and survival associated with elevated turbidity. Planktonic rockfish and sunflower sea star larvae may experience reduced growth and feeding rates when exposed to elevated turbidity; however, some turbidity may increase survival by reducing predation (Fiksen et al. 2002).

Turbidity is measured in nephelometric turbidity units (NTU). Per WAC 173-201A-210(1)(e), turbidity criteria for marine waters are based on deviations from ambient conditions: extraordinary and excellent quality is achieved with 5 NTU over background conditions when the background is 50 NTU or less, or a 10% increase in turbidity when the background turbidity is more than 50 NTU; and good or fair quality is achieved when turbidity is within 10 NTU of background conditions when background turbidity is 50 NTU or less, or a 20% increase in turbidity when the background turbidity is more than 50 NTU. Baseline monitoring conducted prior to pilot project operation would inform natural fluctuations in turbidity from which pilot project operation impacts could be measured.

The mixing zone study prepared for Project Macoma predicts that the dominant particulate that could precipitate during operations is calcite. Academic research around mCDR operations similar to Ebb Carbon's process indicates the potential for brucite and calcite formation above certain pH and saturation state thresholds (Ringham et al. [forthcoming]; Hartmann et al. [forthcoming]). Brucite formation in seawater following an alkalinity addition is primarily understood to readily dissolve under most mixing conditions. Site-specific data correlating calcite concentrations to turbidity values are not available; therefore, a conservative mixing equation was used to predict mixed turbidity following the completion of nearfield dilution. Assuming a worst-case dilution of 195:1 and an ambient turbidity of 2.0 NTU, a discharge turbidity of 100 NTU would increase ambient turbidity approximately 0.5 NTU within the nearfield. Similarly, a discharge turbidity of 500 NTU would increase ambient turbidity approximately 2.5 NTU within the nearfield. Both discharge turbidity values, which are considered cautiously high and unlikely for the pilot project, would meet applicable turbidity criteria.

An increase in turbidity above the Washington State water quality standards associated with pilot project operations would indicate that the mCDR system is not functioning efficiently and effectively. Turbidity, among other water quality parameters, would be continuously monitored with sensors mounted at various locations to document water quality conditions at various distances throughout the pilot project operation. If an increase in turbidity above the Washington State water quality standards attributable to the pilot project operations occurs, Project Macoma, LLC, would stop discharging alkaline-enhanced seawater within minutes of the exceedance and begin troubleshooting to determine the possible trigger and to correct the system to reduce turbidity consistent with the pilot project's Ecological Safety Methodology (Appendix B). Project Macoma, LLC, proposes to gather site-specific data to correlate precipitate concentrations to turbidity values and to follow process controls for pH to maintain turbidity values within applicable standards. Any exposure to elevated turbidity thus would be short-term and localized, resulting in insignificant impacts to ESA-listed aquatic species.

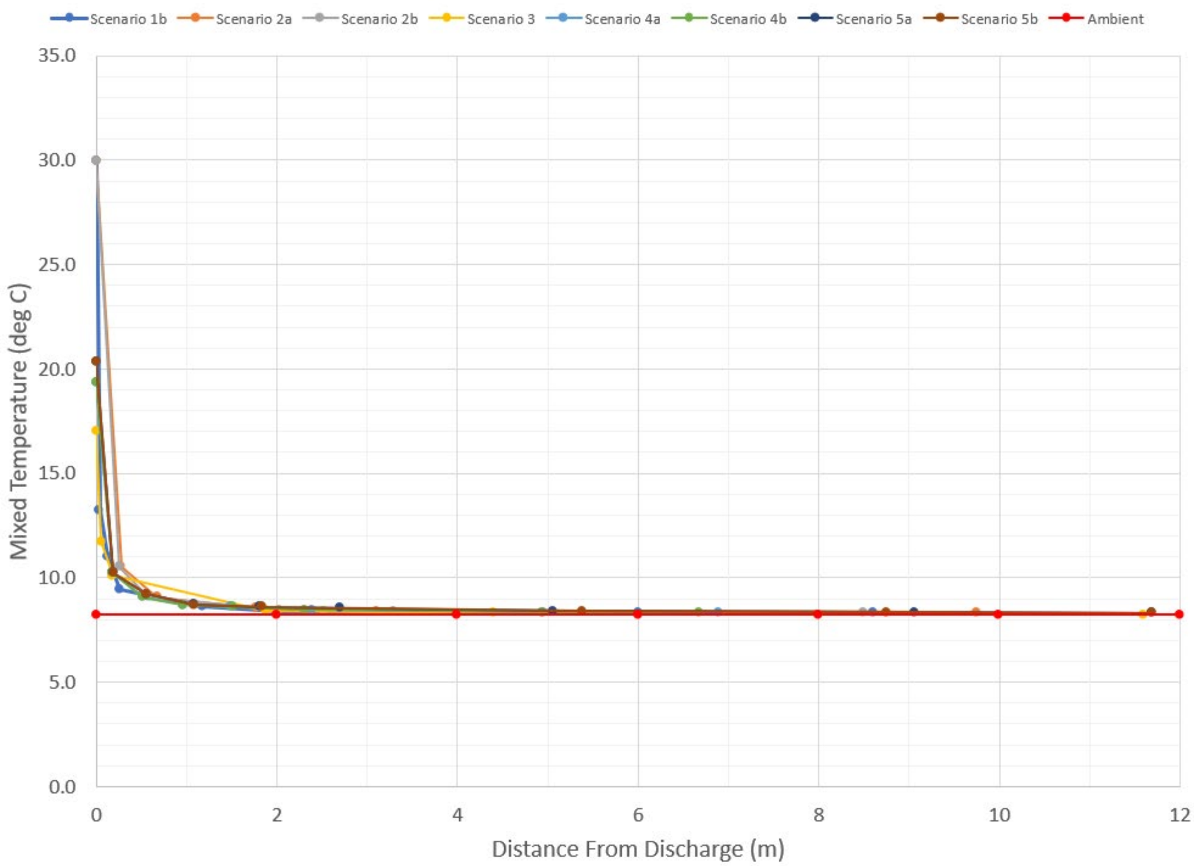
6.2.2 pH

Ocean acidification, which refers to a reduction in pH of the ocean over an extended period of time, is increasingly affecting marine life. Between 1950 and 2020, the global average pH of the world's oceans decreased from 8.15 to 8.05 (Terhaar et al. 2023). The purpose of Project Macoma is to increase the capacity of ocean CO_2 storage, increasing the pH of seawater and in turn reducing ocean acidification locally, and countering the anthropogenic-driven climate change impacts by accelerating the drawdown of additional CO_2 from the atmosphere.

Coastal ecosystems have particularly pronounced pH variability; the majority of 83 investigated coastal ecosystems displayed nonlinear trends, with seasonal and interannual variations exceeding 1 pH for some sites (Carstensen and Duarte 2019). In Port Angeles Harbor, pH is approximately 7.8, as described in Section 4.2.1, with a natural variation in nearby Sequim Bay between 7.6 and 8.1. Based on the proximity between harbors, it is likely that Port Angeles Harbor also experiences similar pH fluctuations.

Although Project Macoma is expected to have an overall beneficial impact on the environment and marine organisms during operations, changes in pH and higher pH can also impact aquatic species. The pH levels would be less differentiated from ambient with increasing distance from the discharge point (Figure 5). The range of pH levels released in the effluent would equilibrate into levels tolerable to aquatic life within less than 1 foot for acidic releases and less than 20 feet for alkaline releases. During the routine operations releases of 9.8 pH units, the pH level is modeled to increase to 10 pH units based on chemical reactions observed in laboratory conditions. This will be studied further during operations to evaluate how the discharge reacts in an open harbor environment.

Figure 5
pH Changes Modeled Over Distances From Outfall Pipe



Of the listed species addressed in this Biological Assessment, juvenile and adult salmonids (including bull trout), larval rockfish, and larval and adult sunflower sea stars could be affected by changes in pH that are likely to result from implementation of the Proposed Action. Impacts to juvenile and adult rockfish, humpback whales, and killer whales would be negligible due to the low likelihood of them entering Port Angeles Harbor, and marbled murrelets would similarly experience negligible impacts due to the limited and poor foraging habitat within the Action Area.

Per WAC 173-201-210(1)(f), pH within a range of 6.5 to 9.0 with a human-caused variation of less than 0.5 unit is fair quality; pH within a range of 7.0 to 8.5 with a human-caused variation of less than 0.5 unit is good to excellent quality; and a pH within the range of 7.0 to 8.5 with a human-caused variation of less than 0.2 unit is extraordinary quality. Because the pH of the discharge will be kept to below 13.5 under all operating conditions, pH would meet applicable water quality criteria and would be within 0.5 pH unit of ambient conditions (i.e., 7.8) within 12 meters. In the routine operating scenario (Scenario 5a), pH will be near ambient conditions within 2 meters.

Routine operations (with pH discharge of 9.8) will discharge alkaline-enhanced seawater to receiving waters for an anticipated 12 hours per day. Maintenance operations (Scenarios 2a, 2b, 3, 4a, and 4b) with pH discharges ranging from 2.3 to 8.1 will happen weekly for less than 8 hours. For scientific operations, Scenario 1b (with a pH discharge of 13.5) will be conducted a few times per month over a single tidal cycle, and Scenario 5b (with pH discharge of 12.1) will occur 1 to 2 times over the lifetime of the pilot project. Due to the frequency and duration of the pilot project's operations and the proportionally high dilution ratios (as described in Appendix A), the effects on water quality will be short term and would not result in a dead zone near the outfall.

Species have various preferences and tolerances to pH levels, with the optimal pH for most marine aquatic organisms between pH 6.5 to 8.5 (EPA 2023). Low, or acidic, pH can cause biological effects including damage to gill epithelium, increased mucus, decreased growth, reproductive failure, respiratory inhibition, ionoregulatory impacts, and mortality (EPA 2023). Most studies on the effects of pH on fish are from laboratory studies or closed systems, such as aquaculture facilities. These studies report that sudden changes in pH, even when within the range of tolerated pH levels, can be harmful, and pH higher than 9.5 can be lethal (Daye and Garside 1980; OpreX Analyzers 2020; Foldvik et al. 2022). Laboratory and field studies of ocean acidification impacts on salmon have documented olfactory disruptions and reduced avoidance responses when exposed to elevated CO_2 for 2 weeks; however, the responses returned to normal when in higher-pH waters for 6 hours (Williams et al. 2018).

Lowered pH significantly impacts survival, development, physiology, and growth in many benthic invertebrates (Dupont et al. 2013), such as the sunflower sea star. There are no specific studies of the impact of ocean acidification on sunflower sea stars, but it is considered a contributing factor that makes the sunflower sea star more vulnerable to wasting syndrome (NOAA Fisheries 2023). Planktonic larvae are particularly vulnerable to lower pH, which affects development and transition between life history stages, as well as increased mortality when exposed to more acidic pH (Dorey et al. 2022). Similar to salmon, low pH disrupts larvae chemosensation, altering behavioral choices and disrupting their response to potential predators (Pardo et al. 2021).

Short-term exposures of fish to high pH (approximately 9.5) are rarely lethal; however, prolonged exposure can damage outer surfaces such as gills, eyes, and skin (EPA 2023). Salmonids are mobile and are unlikely to spend extended periods within the nearfield zone. The intake and outfall pipes would be installed on an existing pier and barge. Studies on salmonid activity and presence in nearshore habitat show they avoid overwater structures in both fresh and marine waters

(Anchor QEA 2012), increasing the likelihood that their exposure would be short term as they migrate through the area.

Studies on other fish and invertebrate larvae were reviewed to determine potential effects to this life stage. Tests of increased pH on the success of the settlement stage of sea urchin (*Centrostephanus rodgersii*) larvae had little effect on morphological traits, but settlement was significantly reduced by 14% to 26% compared to ambient and low pH treatments (Mos et al. 2020). The design of the outfall ports is intended to direct the plume near the surface. The momentum of the discharge would push plankton away from the outfall and minimize potential exposure of planktonic rockfish larvae and sunflower sea star larvae. Although plankton have some mobility, they are generally subject to the movements of currents and tides; however, the nearest rockfish critical habitat is approximately 12 miles from the Action Area, and the current distribution of sunflower sea star within the Strait of Juan de Fuca has not been documented. The potential planktonic larval presence would represent a minute portion of the overall population.

The nearfield mixing zone, which extends 40 feet from the outfall ports, encompasses approximately 0.23 acre of nearshore habitat along an industrialized shoreline. Although juvenile salmonids migrate along the shoreline and would potentially be exposed to high/low pH within the mixing zone in the vicinity of the outfall during migration, the exposure would be short term and would not be likely to cause permanent physiological or behavioral changes. There are few suitable habitat features that would support rockfish or sunflower sea star presence. A sudden change of pH within the nearfield could have potentially harmful effects on fish and planktonic larvae; however, aquatic organism exposure within the boundary of the nearshore zone would be minimized due to tidal exchange within the mixing zone of a coastal environment.

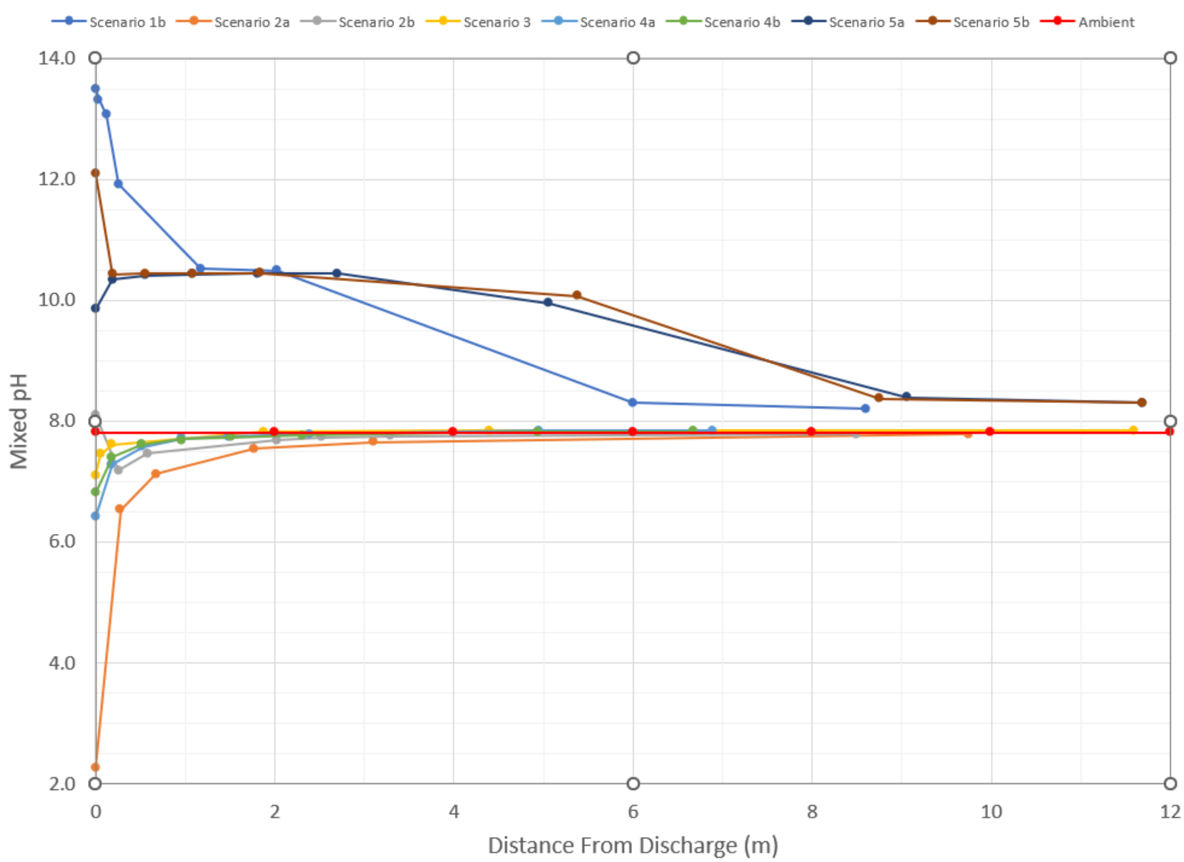
The larger far-field mixing zone, extending over 3.64 acres of nearshore and deeper water habitat within Port Angeles Harbor, represents a smaller change in pH (0.5 unit) that would have a minimal impact on aquatic organisms. Further deleterious impacts would be avoided by short residency in the affected area because the area lacks suitable rearing habitat and likely serves only as a migratory corridor for salmonids. Similarly, the nearshore habitat does not provide suitable settling habitat for rockfish larvae or sunflower sea star larvae. Exposures of these larvae would be limited to the few that may flow into the area.

The pH would be monitored at the site prior to and during release of each scenario. If an increase in pH in the near- and far-field mixing zones inconsistent with water quality criteria occurs, Project Macoma, LLC, would adjust its operations in accordance with the pilot project's Ecological Safety Methodology (Appendix B). Any exposure to pH outside of the acceptable range thus would be short term and localized, resulting in insignificant impacts to ESA-listed aquatic species. Per the monitoring and adaptive management strategies identified in the Ecological Safety Methodology, any observations of dead or dying aquatic organisms would trigger an immediate shutdown of operations (an action that can occur within seconds) to minimize the risk of lethal toxicity and prevent the creation of dead zones. Ebb Carbon is working with all regulatory agencies to meet requirements and requests for both information and measures to minimize potential harm to aquatic life.

6.2.3 Temperature

Ambient temperatures are approximately 10°C. Water temperatures at the time of discharge are expected to range from 17°C to 30°C. These temperatures are expected to reduce with distance away from the discharge locations. The incremental temperature increase within the nearfield mixing zone is predicted to be 0.1°C or less. For all operating scenarios, mixed temperature would be under 10°C within 0.5 meter (Figure 6).

Figure 6
Temperature Changes Modeled over Distances from Outfall Pipe



Per WAC 173-201A-210(1)(c), 1-day maximum aquatic temperatures classify as follows: 13°C is extraordinary quality, 16°C is excellent quality, 19°C is good quality, and 22°C is fair quality. The water temperatures above ambient conditions are expected to be categorized between fair and good quality per WAC 173-201A-210(1)(c).

The increase in temperature could affect salmonids, larval rockfish, and larval and adult sunflower sea star. As SRKW and humpback whales are not expected to be present in the area, they would not be directly affected by the increase in temperature. Similarly, because of the lack of suitable foraging habitat due to in-air and in-water disturbance associated with the industrialized shoreline and water uses, marbled murrelets are not expected to be present or affected by the increase in temperature.

There are extensive studies that document the impacts of increased freshwater temperatures on salmonids (Steel et al. 2014; Bowerman et al. 2021); however, few studies investigate the impact of sudden changes in marine temperatures on salmonids. Current research focuses on climate change-related increases in marine temperatures, documenting more dramatic impacts than changes in freshwater temperature increases to all species and populations (Crozier et al. 2021; Strøm et al. 2023). Increased ocean temperature will cause a reduction in salmonid productivity from a combination of bottom-up (a reduction in prey availability combined with an increase in metabolic needs) and top-down (increased predation and resource competition) trophic processes that jointly regulate growth and survival (Crozier et al. 2021; Strøm et al. 2023).

There are no specific studies of the impact of temperature on sunflower sea stars, but it is considered a contributing factor that makes the sunflower sea star more vulnerable to wasting syndrome (NOAA Fisheries 2023). Larval physiology is affected by an increase in temperature through impacts to metabolic rates, development, and settlement rate, reducing larval survival at higher temperatures (O'Connor et al. 2007; Marochi et al. 2022). Specifically in black rockfish (*Sebastes melanops*), dramatic increases in water temperature increase growth in the larval stage; however, without sufficient prey or with high predator abundance, extreme temperature fluctuations contribute to reduced survival (Fennie et al. 2023).

The increase in temperature above the Washington State water quality standards would extend up to 6 feet from the outfall pipe, affecting approximately 113.1 square feet of nearshore habitat before the temperature reduces to ambient levels below the state water quality standards. Salmonids potentially migrating through the area can avoid pockets of warmer water and thus are unlikely to sustain any short- or long-term physiological changes. Per WAC 173-201A-210(1)(c)(A), adult and juvenile salmonids are protected from acute lethality by discrete human actions in waters with a maximum daily temperature at or below 23°C. The lack of suitable rearing habitat in the pilot study area limits the potential for long-term exposure, and pilot study-related temperature increases are expected to remain below the 7-day maximum of 22°C. Similarly, sunflower sea stars can avoid the area of higher temperatures and are unlikely to be present due to the lack of suitable habitat features. Planktonic rockfish and sunflower sea star larvae may be affected by the increase in temperature; however, their exposure would be limited to one tidal cycle, and they would not be exposed for a prolonged period that could lead to adverse physiological effects.

Temperature would be monitored at the site. If an increase in temperature in the near- and far-field mixing zones inconsistent with water quality criteria occurs, Project Macoma, LLC, would adjust its operations in accordance with the pilot project's Ecological Safety Methodology (Appendix B). Any exposure to elevated temperature outside of the acceptable range thus would be short-term and localized, resulting in insignificant impacts to ESA-listed aquatic species.

6.2.4 Dissolved Oxygen

The proposed discharge is not anticipated to increase chemical and/or biological oxygen demand but may release discharge with DO less than ambient levels that may affect salmonids, rockfish, and sunflower sea star. Reductions in marine DO affects growth, alters behavior, increases mortality, and reduces reproduction of fish (Rose et al. 2019; Kim et al. 2023); increases sunflower sea star susceptibility to wasting disease (NMFS 2022b); and affects distribution and survival of larvae (Breitburg 1994).

The ambient DO levels (7.3 mg/L) are considered extraordinary per WAC 173-201A-210(1)(d). The minimum DO for all operating scenarios is estimated to be 7.0 mg/L based upon sample analyses of process streams at PNNL-Sequim. This concentration measured as a 1-day minimum is listed as extraordinary quality in WAC 173-201A-210(1)(d) above levels that would cause adverse impacts to listed aquatic species. Because the DO levels associated with discharge would remain in bounds of extraordinary quality levels in the marine environment, DO changes would have negligible impacts on salmonids, rockfish, and sunflower sea star. Moreover, DO would be monitored at the site. If a decrease in DO in the near- and far-field mixing zones inconsistent with water quality criteria occurs, Project Macoma, LLC, would adjust its operations in accordance with the pilot project's Ecological Safety Methodology (Appendix B). Any exposure to decreased DO outside of the acceptable range thus would be short-term and localized, resulting in insignificant impacts to ESA-listed aquatic species.

6.3 Entrainment

Intake pipes or other structures that draw in water for various reasons (e.g., irrigation, hydropower, and desalination) have the risk to entrain or impinge juvenile fish and larvae, causing injury and mortality (Barnthouse 2013; Zeug and Cavallo 2014; Mussen et al. 2015; Yao et al. 2023). A study that combined hydraulic modeling and hydroacoustic monitoring found that the risk of fish entrainment increased with increasing intake discharge amount and the number of intakes in the operation (Yao et al. 2023), and statistical modeling from another study identified a strong relationship between diversion rate and fish entrainment, recommending species-specific intake rates as a method for reducing entrainment of local species (Zeug and Cavallo 2014).

To minimize the risk of entrainment and impingement, the intake pipe would draw in seawater at a velocity of 3.48 feet per second for treatment under the Proposed Action, and the intake would be fitted with a screen. In the marine environment, juvenile salmonids should be large enough to avoid entrainment and impingement. Although the use of NMFS- and WDFW-recommended screening over the intake opening would not eliminate the risk of entrainment for rockfish and sunflower sea star larvae, the screens would minimize the risk of rockfish and sunflower sea star larval entrainment. All intake will go through multimedia filtration consisting of carbon filtration, sand filtration, and granular activated carbon filtration. All multimedia filters have to be backflushed daily, whereby trapped constituents like plankton will be returned to Port Angeles Harbor. Because of the lack of suitable rockfish and sunflower sea star habitat, combined with the distance to rockfish critical habitat, a large planktonic larval presence is not anticipated in the Action Area.

6.4 Invertebrate Prey Resources

The highly modified shoreline and industrial use of the upland area have reduced suitable habitat and recruitment for benthic invertebrates. The placement of the barge along the existing dock is within the existing mooring footprint in waters over 25 feet deep at MLLW, and there would be no construction or operation activities that affect shallow intertidal habitat. Therefore, impacts to benthic invertebrate prey for salmonids would be negligible.

6.5 Modification of Habitat

Project Macoma would result in habitat modifications that are expected to have short-term beneficial impacts (localized reduction in ocean acidification) as well as adverse impacts (barge presence shading aquatic vegetation) that extend for the duration of the pilot study (approximately 1.5 years). Eelgrass and other aquatic vegetation provide several important ecosystem functions, including foraging areas and shelter for young fish and invertebrates, food, and spawning surfaces. Aquatic vegetation also produces food and oxygen and improves water quality by filtering polluted runoff, absorbing excess nutrients, storing greenhouse gases, and protecting shoreline from erosion (NOAA 2014). Studies have also shown the value of eelgrass in providing nearshore foraging opportunities for juvenile salmonids and suggest that eelgrass habitat protection and restoration may provide critical support for growth, thereby easing the transition of juvenile salmonids from freshwater to the marine environment (Kennedy et al. 2018).

Eelgrass is documented around the tip, including the harbor-side edge, of Ediz Hook (Ecology 2024c). No documented eelgrass would be affected by overwater shading or short-term increases in turbidity; however, there may be fringe kelp present in the pilot study area. Furthermore, the placement of the barge is in deeper waters located at the edge of the photic zone.

7 Effects Determinations

For ESA-listed species and designated critical habitat, the range of conclusions that could result from the effects analysis for the effects determination include the following:

- **No effect** is the appropriate conclusion when the action agency determines that its Proposed Action will not affect listed species or critical habitat.
- **May affect, is not likely to adversely affect** is the appropriate conclusion when effects on listed species are expected to be discountable, insignificant, or completely beneficial. "Beneficial effects" are contemporaneous positive effects without any adverse effects to the species. "Insignificant effects" relate to the size of the impact and should never reach the scale where take occurs. "Discountable effects" are those extremely unlikely to occur. Based on best judgment, a person would not be able to meaningfully measure, detect, or evaluate insignificant effects and would not expect discountable effects to occur.
- **May affect, is likely to adversely affect** is the appropriate conclusion if any adverse effect to listed species may occur as a direct or indirect result of the Proposed Action or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial (see definition of "may affect, is not likely to adversely affect").
- **Not likely to jeopardize** is the appropriate conclusion when effects on species proposed for listing are expected to be discountable, insignificant, or completely beneficial.

For ESA-listed species, a key factor in making an effects determination and distinguishing between a significant and insignificant effect is determining if the effect would be significant enough to cause a take. "Take," as defined by the ESA, includes such activities that harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct [ESA Section 3(19)]. "Harm" is further defined to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering; "harass" is further defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding, or sheltering (50 CFR Section 17.3).

7.1 Southern Resident Killer Whale

Effects on SRKW were considered based on risk factors listed in the SRKW recovery plan (NMFS 2008). Potential pilot study effects include effects on SRKWs' food supply (primarily salmon) and water quality.

As discussed in Section 7.3, this Biological Assessment has determined that Project Macoma's potential effects to Puget Sound Chinook salmon, SRKW's favored and primary food source (78% of diet; NMFS 2008), are discountable, and it is reasonable to expect that Project Macoma would similarly not otherwise affect similar salmonid species using the area (coho and sockeye salmon, 2%

and 1% of typical SRKW diets, respectively; NMFS 2008). Some rockfish and herring could be present in the Action Area but compose such a small percentage of typical SRKW diets (NMFS 2008) that effects to SRKW via disturbance of these species can be considered insignificant.

There is a chance that other short-term water quality effects could occur related to pilot study operations; however, those impacts are localized and will achieve ambient conditions due to mixing with the surface water prior to reaching waters used by SRKW. These effects are therefore expected to be insignificant.

Based on the guidance and definitions provided within the context of ESA above and the previously discussed Project Macoma effects, the effect determination is that the pilot study **may affect, but is not likely to adversely affect SRKW.**

Project Macoma **may affect** SRKW because of the following:

- Pilot study operations will occur in marine aquatic habitat and have the potential to affect Chinook salmon, an important prey source.

Project Macoma **is not likely to adversely affect** SRKW because of the following:

- Water quality effects (turbidity, pH, temperature) are expected to be localized to within 207 feet of the discharge point and not where SRKW are expected to be. Water quality effects (turbidity, pH, temperature) are expected to reach ambient conditions within 40 feet of discharge. See Appendix B for monitoring and adaptive management strategies to further minimize potential impacts on listed species. As such, this potential impact to SRKW is expected to be insignificant.

The basis for this conclusion is that the likelihood of the potential effects can be discounted and/or their extent can be labeled as insignificant.

7.1.1 Critical Habitat Effects Determination

Critical habitat for SRKW is designated for areas containing the PBFs essential for the conservation of the species or that require special management considerations. PBFs include water quality, prey species, and passage conditions. Table 5 summarizes the PBFs applicable to this pilot study and the potential project effects on SRKW PBFs.

Table 5
Potential Project Effect on Southern Resident Killer Whale PBFs

SRKW PBFs Present	Effect from Proposed Action
PBF 1: Water quality to support growth and development	Increases in turbidity, pH, and temperature and a minor reduction in DO from extraordinary to excellent quality will have nearfield affects within 40 feet of the outfall ports. Water quality parameters are expected to achieve ambient conditions due to mixing 6 to 40 feet from the outfall pipe.
PBF 2: Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth	Project Macoma may affect Chinook salmon, SRKW's favored food source. However, the pilot study is not anticipated to have significant water quality effects to Chinook salmon because they are able to avoid areas of changing water quality and, if present, would limit exposure by migrating through the area quickly.
PBF 3: Passage conditions to allow for migration, resting, and foraging	If present, SRKW passage within critical habitat is unlikely to be affected because whales are not anticipated to occur in the nearshore vicinity of the pilot study.

Based on the preceding analysis, the effect determination is that Project Macoma **will not adversely affect** SRKW designated critical habitat because of the following:

- Water quality impacts will achieve ambient conditions due to mixing prior to reaching waters used by SRKW.
- Project Macoma is expected to result in marine aquatic habitat benefits by decreasing seawater acidity during operations.

No significant long-term negative habitat effects to the previously mentioned PBFs will result from the pilot study.

7.2 Humpback Whale

Effects on humpback whales from Project Macoma were considered based on risk factors discussed in the humpback whale recovery plan (Humpback Whale Recovery Team 1991). Potential pilot study effects include those relating to water quality and prey species. Effects based on water quality were discussed in Section 7.1, related to SRKW, and would be expected to be similar for humpback whales. Also, because prey species of humpback whales are similar to the prey types for salmon and include juvenile salmon, effects to humpback prey species would be expected to be discountable or insignificant, aligned with prey effects to salmon (discussed in Section 7.3) and SRKW (which also prey on salmon).

Based on the guidance and definitions previously provided within the context of the ESA and the pilot study effects discussed in Section 6, the effect determination is that Project Macoma **may affect, but is not likely to adversely affect humpback whales** for the same reasons as listed for SRKW (Section 7.1). No critical habitat for the humpback whale is designated in the pilot study area.

7.3 Puget Sound Chinook Salmon

Based on the guidance and definitions previously provided within the context of the ESA and the pilot study effects discussed in Section 6, the effect determination is that Project Macoma **may affect, but is not likely to adversely affect Puget Sound Chinook salmon.**

Project Macoma **may affect** Chinook salmon because of the following:

- Chinook salmon could be affected by elevated turbidity, pH, and temperature and reduction in DO during the pilot project operation.
- Water quality changes may affect Chinook salmon prey, including Pacific herring.

Project Macoma is **not likely to adversely affect** Chinook salmon because of the following:

- There is no mapped eelgrass that would support Pacific herring (Chinook salmon prey) spawning in the Action Area, and there are no studies that confirm the presence of Pacific herring.
- Juvenile and adult Chinook salmon are able to avoid the area or move through quickly, so exposure to changes in water quality are temporary. Chinook salmon do not spawn in marine waters.
- Nearfield water quality impacts are limited to a 40-foot boundary around the outfall ports in disturbed habitat that provides minimal habitat for juvenile and adult salmonids. This area is a small portion of the overall area within Port Angeles Harbor available for juvenile and adult salmonids to migrate. See Appendix B for monitoring and adaptive management strategies to further minimize potential impacts on listed species.
- The use of an approved screen on the pipe intake will minimize potential entrainment of juvenile Chinook salmon.

The basis for this conclusion is that the potential effects are insignificant.

7.3.1 Critical Habitat Effects Determination

The designation of critical habitat is based on the life history and habitat needs of Puget Sound Chinook salmon and includes six PBFs necessary for their conservation in freshwater, estuarine, and nearshore marine habitats. In the Action Area PBFs 5 and 6 are present. Table 6 summarizes the PBFs applicable to Project Macoma and the potential project effects on Chinook salmon PBFs.

Table 6
Potential Project Effect on Chinook Salmon PBFs

Chinook Salmon PBFs Present	Effect from Proposed Action
PBF 5: Nearshore marine areas free of obstruction and excessive predation that meet the following criteria: • Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation • Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels	Increases in turbidity, pH, and temperature and a minor reduction in DO will have nearfield affects within 40 feet of the outfall ports. Water quality parameters are expected to achieve ambient conditions 6 to 40 feet from the outfall and within 5 minutes under all scenarios due to mixing with the surface water. Project Macoma will use existing in-water infrastructure at the Port for the barge and placement of intake and outfall pipes and will not increase the amount of barriers to migration. The barge placement will be moored on the edge of the photic zone and will have minimal impacts on existing aquatic vegetation. Benthic invertebrates are not expected to experience adverse effects from operations because the discharge ports in the outfall are designed to maintain the effluent plume near the water surface, which promotes CO_2 absorption and maximizes dilution.
PBF 6: Offshore marine areas that meet the following criteria: • Water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation	Increases in turbidity, pH, and temperature and a minor reduction in DO will have nearfield affects within 40 feet of the outfall ports. Water quality parameters are expected to achieve ambient conditions 6 to 40 feet from the outfall and within 5 minutes under all scenarios due to mixing with the surface water. Planktonic larvae (Chinook salmon prey) may be impacted by water quality changes; however, the area of impact is small compared to the available habitat and would represent a minute fraction of available prey.

Based on the preceding analysis, the effect determination is that Project Macoma **will not adversely affect** designated critical habitat because of the following:

- Water quality impacts will achieve ambient conditions due to mixing and will meet Washington water quality standards within 40 feet of the outfall ports. See Appendix B for monitoring and adaptive management strategies to further minimize potential impacts on listed species.
- Forage material, including benthic organisms, is not expected to experience adverse impacts associated with the change in water quality associated with the effluent releases.

No significant long-term negative habitat effects to the previously mentioned PBFs are expected to result from the pilot study.

7.4 Puget Sound Steelhead

Based on the guidance and definitions previously provided within the context of the ESA and the pilot study effects discussed in Section 6, the effect determination is that Project Macoma **may affect, but is not likely to adversely affect steelhead** and **will not adversely modify** designated critical habitat for the same reasons as listed for Chinook salmon (Section 7.3).

7.5 Hood Canal Chum Salmon

Based on the guidance and definitions previously provided within the context of the ESA and the pilot study effects discussed in Section 6, the effect determination is that Project Macoma **may affect, but is not likely to adversely affect Hood Canal chum salmon** and **will not adversely modify** designated critical habitat for the same reasons as listed for Chinook salmon (Section 7.3).

7.6 Bull Trout

Based on the guidance and definitions previously provided within the context of the ESA and the pilot study effects discussed in Section 6, the effect determination is that Project Macoma **may affect, but is not likely to adversely affect bull trout** and **will not adversely modify** designated critical habitat for the same reasons as listed for Chinook salmon (Section 7.3).

7.7 Bocaccio Rockfish

Based on the guidance and definitions previously provided within the context of ESA and the distribution information above, the effect determination is that Project Macoma **may affect, but is not likely to adversely affect the Georgia Basin DPS of bocaccio**.

Project Macoma **may affect** bocaccio because of the following:

- Bocaccio are present in various basins of Puget Sound. The level of use by adults or juveniles of these species in the Action Area is expected to be low year-round due to the lack of suitable rocky habitat in the Action Area.
- The possibility of some presence of larval, juvenile, or adult individuals from these species in the Action Area during operation cannot be discounted.

Project Macoma is **not likely to adversely affect** bocaccio because of the following:

- Due to depth, geographic, and habitat preferences, the likelihood that bocaccio would occur in the Action Area is low. Adult rockfish generally inhabit deep water associated with rock outcroppings or coarse substrate, which is not found in the Action Area. Although nearfield water quality impacts extending 40 feet from the outfall ports may occur, the discharge is expected to achieve ambient conditions due to mixing with surface water within 207 feet and 5 minutes before reaching habitat suitable for and more likely to be used by rockfish. See

Appendix B for monitoring and adaptive management strategies to further minimize potential impacts on listed species.

The basis for this conclusion is that the potential effects are insignificant. No critical habitat for bocaccio is designated in the pilot study area.

7.8 Yelloweye Rockfish

Based on the guidance and definitions previously provided within the context of the ESA and the pilot study effects discussed in Section 6, the effect determination is that Project Macoma **may affect, but is not likely to adversely affect yelloweye rockfish** for the same reasons as listed for bocaccio rockfish (Section 7.7). No critical habitat for yelloweye rockfish is designated in the pilot study area.

7.9 Sunflower Sea Star

The potential impacts to sunflower sea star from Project Macoma include increased turbidity, pH, and temperature and reduced DO associated with pilot project operations, all of which may increase the sunflower sea star susceptibility to wasting disease. The nearfield changes to water quality are minimized to a 40-foot radius around the outfall ports that dilutes to ambient conditions within 207 feet and 5 minutes under all scenarios. See Appendix B for monitoring and adaptive management strategies to further minimize potential impacts on listed species. Based on the limited number of sea stars that may be exposed to changes in water quality and the expected limited duration of that potential exposure, the Proposed Action is **not likely to jeopardize** the sunflower sea star. The basis for this conclusion is that the potential effects are insignificant, and the pilot study is not likely to jeopardize the continued existence of this proposed species.

Critical habitat has not been designated for the sunflower sea star.

7.10 Marbled Murrelet

Potential direct and indirect effects to marbled murrelets resulting from Project Macoma include temporary airborne noise effects attributable to construction. Elevated noise will be due to use of construction equipment in upland areas. These noise conditions have the potential to disturb marbled murrelets that may be present nearby.

The currently recognized noise-only harassment/injury threshold for marbled murrelet is based on a distance threshold that is based on noise measurements. Use of heavy construction equipment greater than 0.25-mile from a known occupied marbled murrelet nest tree or suitable nest tree during the nesting season of April 1 to September 21 is understood to have no effect on marbled murrelet (WSDOT 2021).

No critical habitat for the marbled murrelet is designated in the pilot study area. The project Action Area is approximately 3 miles away from the nearest marbled murrelet critical habitat, which is where nesting would be expected to occur. This determination is appropriate because marbled murrelets have not been observed in the Action Area, and the likelihood is very low that their presence would coincide with the small areas and periods when construction would occur.

Because construction will occur more 0.25 mile away from marbled murrelet critical habitat, Project Macoma will have **no effect** on marbled murrelet. The basis for this conclusion is that the likelihood of the effect causing take is very unlikely to occur.

8 Essential Fish Habitat Assessment

This document was also prepared as a resource document for concurrent essential fish habitat (EFH) consultation with NMFS for compliance with the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) and the 1996 Sustainable Fisheries Act. EFH is defined by the Magnuson-Stevens Act in 50 CFR 600.905-930 as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The objective of this assessment is to describe potential adverse effects to designated EFH for these federally managed fisheries species within the Action Area.

8.1 Essential Fish Habitat Presence in Action Area

The Action Area for Project Macoma includes the following mapped EFH (NOAA Fisheries 2024):

- **Pacific Coast Groundfish EFH**, which includes all waters and substrate within areas with a depth less than or equal to 3,500 meters (1,914 fathoms) shoreward to the MHHW level or the upriver extent of saltwater intrusion (defined as upstream and landward to where ocean-derived salts measure less than 0.5 part per thousand during the period of average annual low flow). Numerous benthic species are included under the groundfish EFH, such as rockfish, sole, flounder, cod, and others (PFMC 2023a).
- **Pacific Coast Salmon EFH**, which includes those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. In estuarine and marine areas, salmon EFH extends from the extreme high tide line in nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (200 nautical miles or 370.4 kilometers) offshore. Managed salmon stocks include Chinook, coho, and pink salmon (odd-numbered years only) and any salmon species listed under the ESA that is measurably impacted by Pacific Fishery Management Council fisheries (PFMC 2022).
- **Coast Pelagic Species EFH,** which includes the following (PFMC 2023b):
  - For finfish and market squid: All marine and estuarine waters from the shoreline offshore to the limits of the exclusive economic zone and above the thermocline where sea surface temperatures range between 10°C to 26°C
  - For krill: From the shoreline to the 1,000-fathom isobath and to a depth of 400 meters
- **Habitat Areas of Particular Concern (HAPC)** are types or areas of habitat within EFH that are identified based on one or more of the following considerations:
  - The importance of the ecological function provided by the habitat
  - The extent to which the habitat is sensitive to human-induced environmental degradation

- Whether, and to what extent, development activities are or will be stressing the habitat type
- The rarity of the habitat type

Six HAPCs have been identified for Pacific coast groundfish EFH (PFMC 2020), none of which are found in the Action Area.

8.2 Potential Effects of the Proposed Project

The assessment of potential impacts from Project Macoma to the species' EFH is based on the information in the documents listed in the reference section (NOAA 2022c; PFMC 2019, 2020, 2022). The specific elements of the pilot study that could impact groundfish, coastal pelagic species, and Pacific salmon EFH are changes in water quality parameters (turbidity, pH, temperature, DO).

Based on the preceding information, it is concluded that the effects of the Proposed Action **will adversely affect Pacific Coast Salmon EFH, Coastal Pelagic Species EFH, and Pacific Coast Groundfish EFH**. A "will adversely affect" determination is appropriate because the Proposed Action will have nearfield water quality impacts that reduce the quality of habitat within a 40-foot radius from the outfall ports.

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Appendix A
Port Angeles Mixing Analysis Technical Memorandum

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DRAFT Technical Memorandum

Prepared for: Ebb Carbon (EC)

Project Title: Ebb Carbon Preliminary Design

Project No.: 159812

Technical Memorandum

Subject: Port Angeles Mixing Analyses

Date: February 1, 2024

To: Todd Pelman (EC)

From: Matt DeBoer, Brown and Caldwell (BC)

Prepared by: ______________________________
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Prepared by: ______________________________
Matt DeBoer

Reviewed by: ______________________________
Krystal Perez

Limitations:

This is a draft memorandum and is not intended to be a final representation of the work done or recommendations made by Brown and Caldwell. It should not be relied upon; consult the final report.

This document was prepared solely for Ebb Carbon, Inc. in accordance with professional standards at the time the services were performed and in accordance with the contract between Ebb Carbon, Inc. and Brown and Caldwell dated November 3, 2022. This document is governed by the specific scope of work authorized by Ebb Carbon, Inc; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Ebb Carbon, Inc. and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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Section 1: Introduction

This Technical Memorandum (TM) evaluates potential water quality impacts of the Project Macoma, LLC marine carbon dioxide removal (mCDR) system proposed to be constructed and operated temporarily at Terminal 7 of the Port of Port Angeles in Port Angeles, Washington. Project Macoma, LLC is a wholly owned subsidiary of Ebb Carbon. Ebb Carbon has developed an mCDR technology to safely and permanently remove carbon dioxide (CO2) from the atmosphere while reducing seawater acidity locally. The pilot-scale system would use electrochemical processes to remove acid from the ambient seawater of Port Angeles Harbor. The produced alkaline seawater that remains would be returned to the ocean where it can absorb carbon dioxide (CO_2) from the atmosphere and store it as bicarbonate—a safe and naturally abundant form of carbon storage in the ocean that doesn't acidify seawater.

The proposed Project Macoma, LLC facility would include a barge-mounted seawater intake and discharge outfall connected to process equipment and storage at the shoreline. The preliminary site layout is as shown in Figure 1-1.

Figure 1-1. Preliminary Site Layout

Brown and Caldwell (BC) analyses include hydrodynamic dilution modeling using Visual Plumes software (https://www.epa.gov/ceam/visual-plumes) and water quality/chemistry modeling using commercial OLI Systems software (www.olisystems.com). Modeling analyses are supported by collected data, where available, and conservative assumptions. The combined results of the dilution and chemistry modeling support evaluation of compliance with applicable water quality standards.

Section 2: Previous Analyses

The proposed facility will be a pilot scale version of an mCDR system developed by Ebb Carbon that has been running since Summer 2023 at the Department of Energy's (DOE) Pacific Northwest National Laboratory (PNNL) in Sequim, Washington. The Sequim facility is currently discharging alkaline seawater produced by Ebb Carbon's system from their existing wastewater outfall. Ebb Carbon is currently sampling water quality at the intake and several locations within the pre-treatment and electrochemical processes. PNNL has requested 2024 funding for monitoring carbonate chemistry in Sequim Bay. Data collected would be used to support and/or confirm the analyses presented herein.

In addition to PNNL, Ebb Carbon has partnered with other research institutions including the National Oceanic and Atmospheric Administration (NOAA) and the University of Washington to evaluate how its system could work at-scale and potential uses for acidic and alkaline process streams. Numerous experiments are being performed in parallel to understand biological and toxicological impacts on target species and to model the alkaline plume in the farfield beyond the immediate nearfield evaluated herein. Project Macoma, LLC will continue to partner with local scientific and academic partners to validate the efficacy and safety of the system.

Section 3: Ambient Water Quality

Ambient water column density data was collected by Ecology in Port Angeles Harbor between 2001 and 2004 at Station PAH003. Ecology mapping shows Station PAH003 approximately 650 feet north of the proposed Project Macoma, LLC discharge location. During the data collection period, 29 water column profiles were collected, including density, salinity, and temperature, at 0.5-meter depth increments. Most profiles indicated some level of density stratification. For the dilution model analyses presented in Section 5, representative maximum (June 2004) and minimum (March 2004) stratification conditions were selected to evaluate potential critical dilution conditions. Table 3-1 summarizes water column density (kilograms per cubic meter (kg/m^3)) data through a depth of 10 meters for the selected representative stratification conditions.

Table 3-1. Water Column Density – Maximum and Minimum Stratification Conditions

	Maximum Stratification (June 2004)	Minimum Stratification (March 2004)
Depth (meters)	Density (sigma t, kg/m^3)	Density (sigma t, kg/m^3)
1.0		24.02
1.5	23.62	24.02
2.0	23.65	24.02
2.5	23.79	24.02
3.0	23.93	24.02
3.5	24.04	24.02
4.0	24.10	24.02
4.5	24.17	24.02
5.0	24.22	24.02
5.5	24.26	24.02
6.0	24.30	24.03
6.5	24.33	24.03

7.0	24.39	24.03
7.5	24.46	24.03
8.0	24.47	24.03
8.5	24.48	24.03
9.0	24.48	24.03
9.5	24.49	24.03
10.0	24.50	24.03

Additional ambient water quality samples were collected by Ebb Carbon at the proposed discharge location to characterize the specific chemical (cation and anion) distribution of the process intake water. Ambient samples were also collected to determine the presence of trace metals. Anion, cation, and trace metals data are provided in Attachment A.

Section 4: Effluent Flow and Water Quality

The proposed Project Macoma, LLC facility would produce three process streams, as shown schematically in Figure 4-1. Typically, the three process streams would be discharged as a combined flow through the outfall. However, Project Macoma, LLC may operate the pilot facility, for limited durations, discharging only one or two of the component flow streams. These atypical operational strategies would provide additional data to Project Macoma, LLC and further the understanding of potential impacts of the discharge to water chemistry/water quality. Each individual process stream is summarized as follows:

1. Outfall Stream 1 Alkaline Product – Saltwater solution with enhanced alkalinity produced via the bipolar electrodialysis (BPED) process.

2. Outfall Stream 2 Neutralized Acid – The acidic process stream produced via the BPED process is neutralized followed by post-neutralization settling and filtration. Neutralization may be achieved using mafic rocks (i.e., Olivine or basalt) or calcium carbonate ($CaCO_3$).

3. Outfall Stream 3 Pretreatment Reject – Saltwater reject from various filtration pretreatment steps. Most of this stream is comprised of nanofiltration (NF) membrane reject, but the process stream also includes flushes of other pretreatment processes as part of routine maintenance.

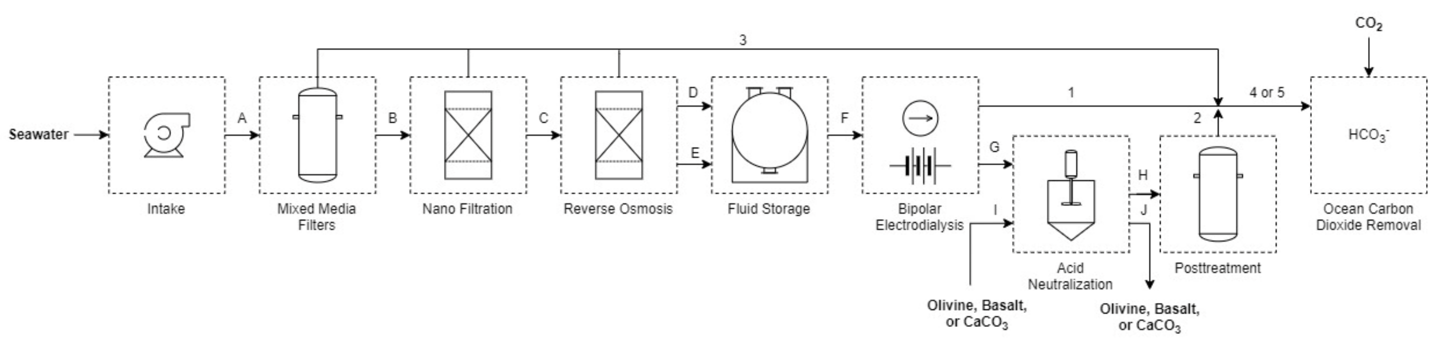

Figure 4-1. Process Flow Diagram

The dilution and water chemistry modeling discussed in this TM evaluated five discharge scenarios (and sub-scenarios) that reflect different combinations of process flow streams. Predicted effluent flow, pH, temperature, and density are summarized in Table 4-1 for the proposed scenarios. Table 4-1 also identifies anticipated frequency and duration for routine, maintenance, and scientific (targeted data collection) operating scenarios. These results and additional water chemistry data and assumptions specific to the water chemistry modeling are discussed in Section 6. Anion/cation and trace metals data for the effluent scenarios are provided in Attachment A. Trace metals data are based on samples collected in Port Angeles Harbor and from the Pretreatment Reject stream from the pilot at the PNNL facility.

Table 4-1. Effluent Flow and Water Quality Summary

Scenario	Frequency	Duration	Discharge Flow (L/hr.)	Temperature (deg C)	Density (kg/m³)	pH (s.u.)
Scientific Operations						
Scenario 1a – Alkaline Product Only (13.9 pH)	Not discharged – See Section 5.3		5,900	30.0	1,072	13.9
Scenario 1b – Alkaline Product Only (13.5 pH)	A few times per month	Single tidal cycle	5,900	30.0	1,028	13.5
Scenario 5b – All 3 Process Flows ($CaCO_3$ neutralization)[1]	1 or 2 times over project lifetime	Single tidal cycle	38,800	20.4	1,038	12.1
Maintenance Operations						
Scenario 2a – Neutralized Acid Only (with Olivine)	Weekly	< 8 hours	5,900	30.0	1,020	2.3
Scenario 2b – Neutralized Acid Only (with $CaCO_3$)	Weekly	< 8 hours	5,900	30.0	1,028	8.1
Scenario 3 – Pretreatment Reject Only	Weekly	< 8 hours	27,000	17.0	1,042	7.1
Scenario 4a – Neutralized Acid (with Olivine) + Pretreatment Reject	Weekly	< 8 hours	32,900	19.3	1,038	6.4
Scenario 4b – Neutralized Acid (with $CaCO_3$) + Pretreatment Reject	Weekly	< 8 hours	32,900	19.3	1,039	6.8
Routine Operations						
Scenario 5a – All 3 Process Flows (with Olivine neutralization)[1]	Daily	50% Operating Capacity	38,800	20.4	1,037	9.8

[1]Scenarios 5a and 5b assume contribution of the alkaline product at a pH of 13.9 (Scenario 1a).

L/hr. = liters per hour; deg C = degree Celsius; s.u = standard units

Section 5: Model Predicted Initial Dilution

BC evaluated predicted dilution using the outfall dilution model UM3, as included in the most recent release of the United States Environmental Protection Agency (USEPA)-supported Visual Plumes modeling package (https://www.epa.gov/ceam/visual-plumes). The model is applicable to submerged single and multi-port diffusers with both positively or negatively buoyant plumes. BC selected Visual Plumes for dilution modeling since it is well proven and widely used in Washington and is appropriate for the type of discharge and receiving water conditions. Model results provide predicted effluent plume dilution and effluent plume dimensions, including whether the plume rises to the surface or traps at neutral buoyancy within the water column.

5.1 General Plume Mixing Concepts

The mixing of effluent discharged from an outfall to receiving waters is typically described in two distinct phases: 1) rapid initial dilution in the nearfield, and 2) slower subsequent dilution in the farfield. Rapid initial dilution in the nearfield has two distinct physical components. The first component is turbulent jet mixing and entrainment resulting from the momentum of the discharge exiting the diffuser ports. The second component is turbulent mixing and entrainment resulting from the plume rising (or falling) in the water column due to the effluent buoyancy. When the jet momentum and buoyancy mixing forces dissipate, the slower process of subsequent dilution continues in the farfield. Mixing and dispersion in the farfield occurs along the boundaries of the plume, primarily in the horizontal plane laterally and longitudinally as the plume is carried by ambient currents. The dilution analysis in this section conservatively reports minimum initial dilution after completion of nearfield mixing.

5.2 Key Model Input Parameters

Input parameters to the UM3 model include the physical configuration of the proposed outfall discharge, and effluent and receiving water characteristics. Input parameters were selected consistent with the guidance provided in Ecology's Permit Writer's Manual (Ecology 2018).

5.2.1 Effluent Scenarios

BC performed dilution model analyses for the five scenarios and the discharge characteristics as shown in Table 4-1. The Project Macoma, LLC process is not influenced by seasonal conditions nor are flows anticipated to fluctuate significantly while process equipment is operational. The flows and effluent characteristics in Table 4-1 are conservatively representative of maximum daily and monthly conditions.

5.2.2 Ambient Conditions

Water column density, including representative maximum and minimum stratification conditions, are shown in Table 3-1. Model runs for each scenario were evaluated using both maximum and minimum stratification conditions.

Ambient current speed and direction data are not available for the proposed discharge location; however, current speed distribution was measured to support dilution analyses of the Port Angeles municipal wastewater treatment facility which discharges to Port Angeles Harbor near the Harbor mouth (Ecology 2016). Reported 10^{th} and 50^{th} percentile current speeds for Outfall 001 at the Harbor mouth are 5.6 centimeters per second (cm/s) and 15.5 cm/s, respectively. For the present analyses, current speeds are conservatively assumed to be lower within the Harbor (10^{th} percentile = 2 cm/s and 50^{th} percentile = 5 cm/s). Ambient current direction was conservatively assumed to be co-flowing with the effluent (cross current flows result in higher predicted dilution).

5.2.3 Discharge Parameters and Mixing Zone Dimensions

The proposed outfall discharge will be a barge-mounted multi-port diffuser located as shown in Figure 1-1. Water depth at the barge location, immediately adjacent to the pier, is approximately 25 feet mean lower low water (MLLW). Preliminary diffuser design parameters were selected to combine different momentum and negative buoyancy regimes to maintain the effluent plume near the water surface (promoting CO_2 absorption) and maximize dilution. Specifically, port depth and discharge angle, were used to generate initial plume trajectory upward through the water column before momentum dissipates and negative buoyancy draws the effluent plume downward prior to reaching equilibrium with ambient density. Input parameters used for model analyses include the following:

- Number of Ports = 25

- Port Diameter = 0.5 inches
- Port Spacing = 2 feet
- Port Discharge Angle = 45 degrees
- Port Depth = 2 meters

5.2.4 Mixing Zone Dimensions

Chronic water quality criteria apply at the boundary of an approved mixing zone. Applicable mixing zone dimensions are established in Washington Administrative Code (WAC) 173-201A-400. The analyses herein assume a designated chronic mixing zone of 207 feet in any horizontal direction of the diffuser ports and including the entire vertical water column. Acute water quality criteria apply within a smaller portion of the designated mixing zone, limited to 10 percent of the chronic mixing zone (20.7 feet), and including the entire vertical water column.

Figure 5-1 provides a plan view of the mixing zone with applicable dimensions scaled to the proposed outfall diffuser and in relationship to the existing pier and facility location.

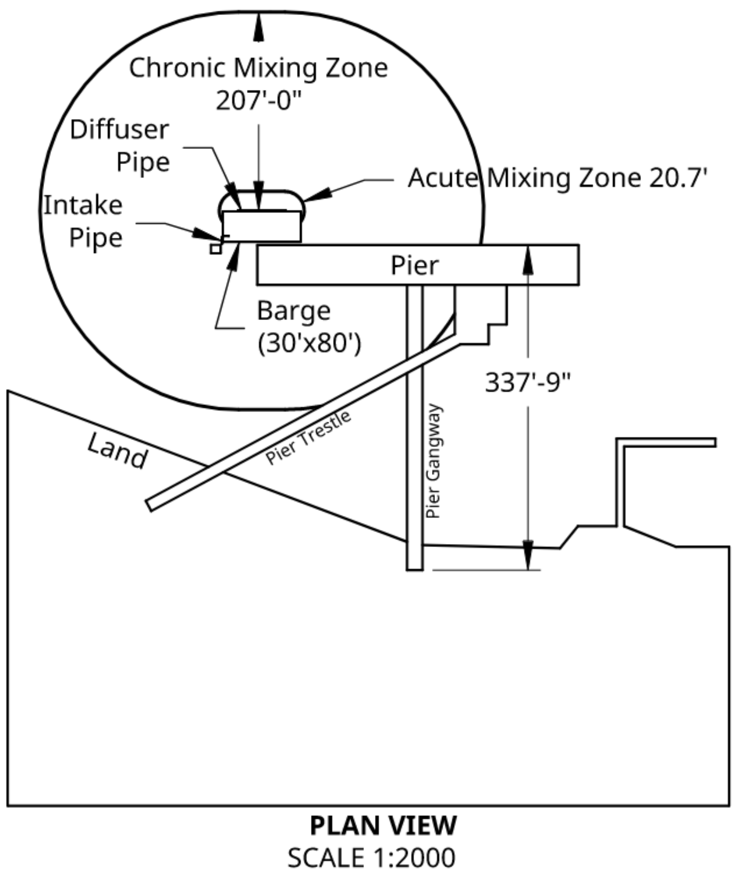

Figure 5-1. Mixing Zone Plan View

5.3 Model Results

Dilution model runs indicate that minimum dilutions occur for all scenarios using maximum stratification conditions. All model results presented herein conservatively assume maximum stratification conditions.

Under these stratification conditions, and based on the diffuser port design, the effluent plume trajectory is initially upward through the water column before momentum dissipates and negative buoyancy draws the effluent plume downward prior to reaching equilibrium with ambient density. For most scenarios, the effluent plume is generally bounded within the upper 3 meters of the water column, changing between minimum and maximum depths as the governing dynamics transition from momentum- to buoyancy-based driving forces. However, due to the high density of Scenario 1a, the effluent plume is predicted to quickly reach depths near or at the sea bottom at low current speeds (in the range of those assumed for acute conditions) prior to rising slightly and attaining neutral buoyancy. Because it is desirable for the effluent plume to be near the water surface to promote carbon dioxide absorption, Project Macoma, LLC would not operate at the identified Scenario 1a conditions. Project Macoma, LLC proposes to use 13.9 pH alkaline process stream waters when combined with other process streams (Scenarios 5a and 5b) but would control alkaline process stream pH at 13.5 or below if discharged alone (Scenario 1b).

For all proposed discharge scenarios, the effluent plume achieves neutral buoyancy with the ambient harbor waters within approximately 12 meters (40 feet) laterally from the multi-port diffuser at the assumed 50th percentile current speeds. The lateral distance to achieve neutral buoyancy decreases at lower current speeds. The UM3 model terminates at this neutral buoyancy (nearfield) location. Additional farfield dilution occurs within the chronic mixing zone, but at a much lower magnitude. The model results herein conservatively report minimum initial dilution at the acute mixing zone boundary and at completion of nearfield mixing. Minimum nearfield mixing is used for analyses at the chronic mixing zone in Section 7.

Table 5-1 summarizes dilution model results for the proposed effluent scenarios, including minimum acute and nearfield dilution, nearfield mixing distance, and range of effluent plume centerline depth. Minimum acute and nearfield dilutions assume 10th percentile and 50th percentile ambient current speeds, respectively. UM3 model input/output data are provided in Attachment B.

Table 5-1. Dilution Model Results Summary

Scenario	Minimum Acute Dilution[1]	Minimum Nearfield Dilution[2]	Nearfield Mixing Distance (m)	Effluent Plume Centerline Depth (m)
Scenario 1b – Alkaline Product Only (pH = 13.5)	240:1	580:1	8.6	1.8 – 2.8
Scenario 2a – Neutralized Acid Only (Olivine)	160:1	415:1	9.8	1.2 – 2.0
Scenario 2b – Neutralized Acid Only (CaCO3)	240:1	580:1	8.6	1.8 – 2.8
Scenario 3 – Pretreatment Reject Only	215:1	520:1	11.6	1.5 – 5.1
Scenario 4a – Neutralized Acid (Olivine) + Pretreatment Reject	160:1	415:1	10.9	1.3 – 4.1
Scenario 4b – Neutralized Acid (CaCO3) + Pretreatment Reject	170:1	430:1	11.1	1.3 – 4.4
Scenario 5a – All Process Flows (Olivine neutralization)	145:1	390:1	11.7	1.1 – 3.8
Scenario 5b – All Process Flows (CaCO3 neutralization)	150:1	395:1	11.4	1.2 – 4.0

1. Minimum acute dilution reported at the effluent plume centerline
2. Minimum nearfield dilution reported as the flux average dilution of the effluent plume.

Model predicted dilution ratios presented in Table 5-1 do not account for effluent reflux, the long-term buildup of effluent in tidally impacted areas. Reflux has not been quantified within Port Angeles Harbor. Ecology guidance in the Permit Writer's Manual conservatively recommends reducing measured/predicted dilution by a factor of two to account for unquantified tidal reflux. The water quality analyses in Section 7 address reflux and the impact on model predicted dilution using the conservative Ecology guidance.

Section 6: Water Chemistry Modeling

BC evaluated mixed water chemistry using the commercial water chemistry modeling software OLI Studio (www.olisystems.com). The software is an electrolytic water chemistry model based on first principles, that provides the predicted equilibrium composition of blended streams under variable conditions. Specific model outputs of interest were the mixed pH and the potential for solids formation within the mixed effluent plume.

6.1 Chemistry Model Input Data

Ebb Carbon provided the water quality data and ion concentrations for ambient Port Angeles Harbor waters and the three process streams generated onsite (see Section 4) to be used as modeling input. The chemistry model input data is tabulated in Attachment A, Table A-1 (ambient) and Table A-2 (process streams).

To conduct water chemistry modeling, the following assumptions were made:

- Ionic charge balance of the waste streams was performed by adjusting (adding or removing) chloride ions prior to the blending evaluation.
- The alkaline process stream in Scenarios 1a and 1b was assumed to be a pure stream of sodium hydroxide (NaOH) with a pH of 13.9 or 13.5, respectively. The solution strength of NaOH necessary to reach the target pH was generated in the model.

6.2 Water Chemistry Modeling

This section provides example dilution calculations used for the chemistry modeling and presents findings related to predicted pH trends and potential particulate formation.

6.2.1 Dilution Ratios

The process stream scenarios were modeled at various dilution ratios. The dilution ratio is calculated by dividing the total volume of process stream and harbor water with the incoming process stream volume. For example, a dilution ratio of 10 = (5,900 L/hr process stream+ 60,000 L/hr harbor)/5,900 L/hr process stream. The dilution ratios were simulated by using a fixed volume of process stream entering the Port Angeles Harbor waters and considering the addition of increasingly higher volumes of Port Angeles Harbor water. Examples of a few selected dilution ratio calculations are presented in Table 6-1. Model outputs, including mixed pH, ion concentrations and potential precipitation for each scenario, are summarized and presented in Attachment C.

Table 6-1. Blending Ratios Calculation Examples

Process stream volume L/hr	Port Angeles Harbor volume L/hr	Total volume L/hr	Dilution Ratio Ratio
5,900	761,100	767,000	130
5,900	1,410,100	1,416,000	240
5,900	1,646,100	1,652,000	580

6.2.2 pH Trends

For Scenarios 2 through 4, the process stream pH is near ambient pH (7.8) at the point of discharge and achieves a mixed pH equal to the ambient at dilutions less than 100:1. For Scenarios 1 and 5, the process stream pH is significantly higher than the ambient pH. For these scenarios, mixed pH initially decreases rapidly or after periods of steps where pH changes little with dilution (Figure 6-1). Mixed pH for Scenario 1b achieves a value within 0.5 standard units at a dilution of approximately 500:1. Mixed pH for Scenarios 5a and 5b achieve a value within 0.5 standard units at a dilution of approximately 200:1.

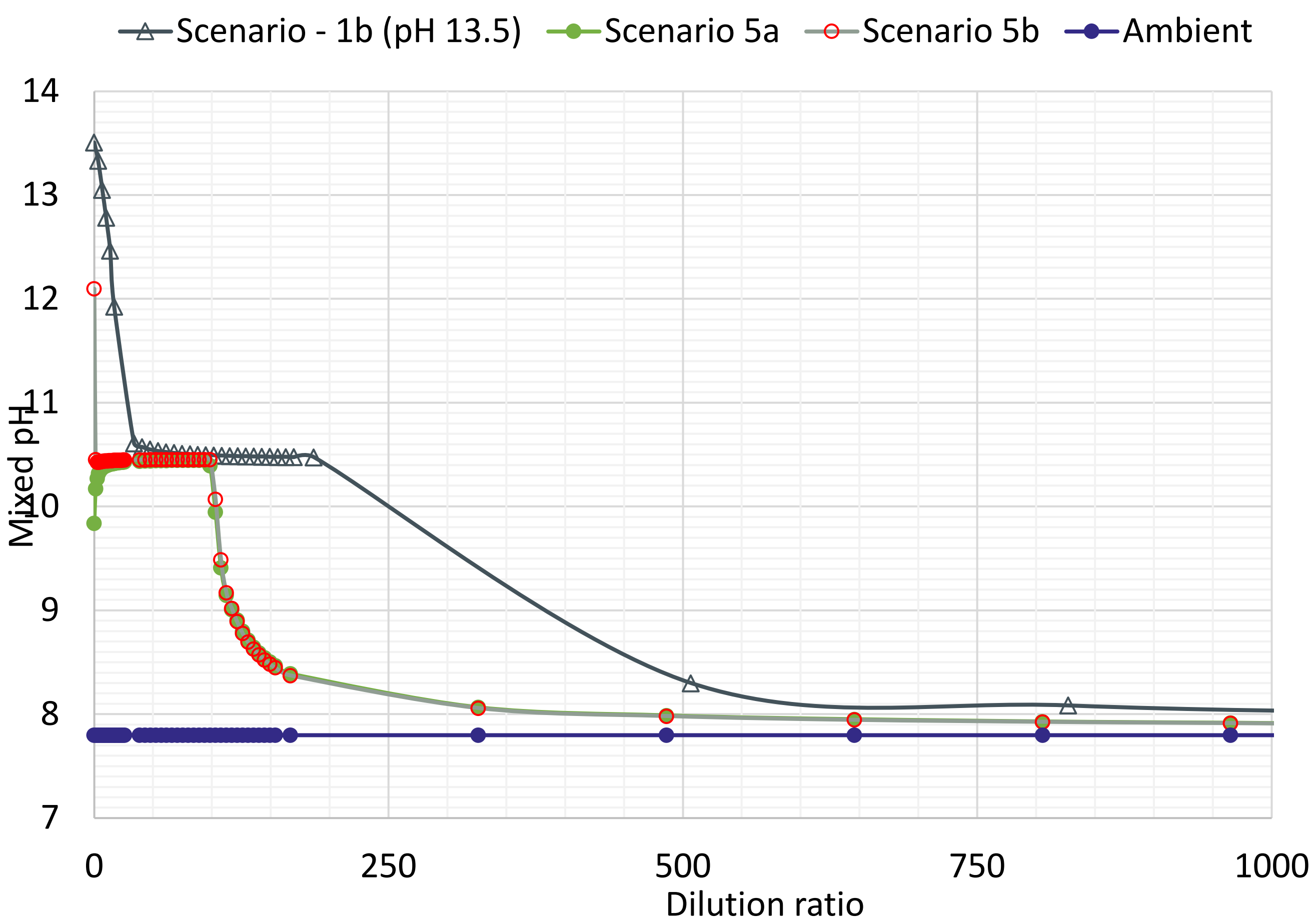

Figure 6-1. Chemistry Model Results – pH Trends

6.2.3 Potential for Particulate Formation

Solids precipitation in OLI Studio is calculated as a reaction taking place in a closed system and at equilibrium conditions (i.e., the reaction immediately going to completion). Therefore, the solids generation predicted in the model is conservative and may not occur in an open/dynamic system. Further, the model predicts all the solids that could potentially be formed based on thermodynamics of the system. However, all the solids predicted by the model may not actually form and depending on the system parameters such as pH, temperature, alkalinity, nucleation sites available, competing ions, etc., the dominant scaling compound would most likely be formed. The dominate particulate as predicted by the model is Calcite ($CaCO_3$). Particulate formation involving trace heavy metals is negligible even using the conservative model methodology.

Table 6-2 provides a conservative estimate of the solids that may be formed for the modeled scenarios at the minimum nearfield dilutions.

Table 6-2. Particulate Formation Summary

Scenario	Chronic Dilution[1]	Mixed pH[2]	$CaCO_3$ (mg/L)
Scenario 1b – Alkaline Product Only (pH = 13.5)	290:1	9.2	225
Scenario 2a – Neutralized Acid Only (Olivine)	207:1	7.7	0
Scenario 2b – Neutralized Acid Only ($CaCO_3$)	290:1	7.8	4
Scenario 3 – Pretreatment Reject Only	260:1	7.8	1
Scenario 4a – Neutralized Acid (Olivine) + Pretreatment Reject	207:1	7.8	1
Scenario 4b – Neutralized Acid ($CaCO_3$) + Pretreatment Reject	215:1	7.8	2
Scenario 5a – All Process Flows (Olivine neutralization)	195:1	8.3	150
Scenario 5b – All Process Flows ($CaCO_3$ neutralization)	200:1	8.3	150

[1]Minimum nearfield dilution divided by two to account for tidal reflux.

[2]OLI model runs assume an ambient pH of 7.8.

Section 7: Water Quality Analyses

This section presents water quality analyses based on the supporting modeling discussed in Sections 5 and 6. Water quality analyses reference marine water quality standards identified in WAC 173-201A. Port Angeles Harbor is designated as 'Excellent Quality' for aquatic life uses. Input data for the analyses discussed in each section herein were selected consistent with the guidance provided in Ecology's Permit Writer's Manual.

7.1 Temperature

Compliance with temperature criteria was evaluated using Ecology's Reasonable Potential Analysis (RPA) methodology and supporting *PermitCalc* spreadsheets (see Attachment D). Input values for the calculations were conservatively selected as follows:

- Chronic Dilution Factor – The minimum nearfield dilution for all scenarios in Table 5-1 (390:1) was selected and divided by a factor of two to account for reflux. Temperature analyses assume a dilution factor of 195:1.
- Ambient Temperature – Ambient surface temperature data for the 29 sample dates at Ecology Station PAH003 were evaluated to develop 90th percentile values for May – September (11.4°C) and October – April (10.0°C).
- Effluent Temperature – The maximum effluent temperature for any discharge scenario is 30°C.

Using the above input values, there is no reasonable potential to exceed water quality criteria for temperature. The incremental temperature increase within the area of nearfield mixing is predicted to be 0.1°C or less. The values above combine worst case dilution and effluent conditions that are unlikely to occur simultaneously.

7.2 Dissolved Oxygen

The proposed discharge is not anticipated to contain chemical and/or biological oxygen demand. Therefore, compliance with dissolved oxygen (DO) criteria was evaluated using a volumetric mixing calculation. Input values for the calculation were conservatively selected as follows:

- Chronic Dilution Factor – The minimum nearfield dilution for all scenarios in Table 5-1 (390:1) was selected and divided by a factor of two to account for reflux. DO analyses assume a dilution factor of 195:1.
- Ambient DO – Ambient DO concentrations at the proposed discharge location are assumed to be 7.3 mg/L, based on the Ecology Fact Sheet analyses for the Port Angeles municipal wastewater treatment facility (Ecology 2016).
- Effluent DO – The minimum effluent DO for any discharge scenario is estimated to be 7.0 mg/L based upon sample analyses of process streams at the PNNL – Project Macoma, LLC facility.

The mixed DO concentration meets the applicable minimum water quality criteria (6.0 mg/L) and has a negligible DO concentration change with respect to background. The input values above combine worst case dilution and effluent conditions that are unlikely to occur simultaneously.

7.3 pH

The OLI model discussed in Section 6 was used to predict mixed pH at the predicted minimum nearfield dilution for each scenario. Table 7-1 summarizes the minimum dilution factor (accounting for reflux), effluent pH, mixed pH, and pH change for each scenario. As shown in Table 7-1, except for Scenario 1b, all discharge scenarios meet applicable pH water quality criteria with a pH between 7.0 and 8.5, and a 0.5 standard unit change (or less) with respect to background.

Table 7-1. pH Water Quality Analyses Summary

Scenario	Chronic Dilution[1]	Effluent pH	Mixed pH[2]	pH Change
Scenario 1b – Alkaline Product Only (pH = 13.5)	290:1	13.5	9.2	1.4
Scenario 2a – Neutralized Acid Only (Olivine)	207:1	2.3	7.7	-0.1
Scenario 2b – Neutralized Acid Only (CaCO3)	290:1	8.1	7.8	No Change
Scenario 3 – Pretreatment Reject Only	260:1	7.1	7.8	No Change
Scenario 4a – Neutralized Acid (Olivine) + Pretreatment Reject	207:1	6.4	7.8	No Change
Scenario 4b – Neutralized Acid (CaCO3) + Pretreatment Reject	215:1	6.8	7.8	No Change
Scenario 5a – All Process Flows (Olivine neutralization)	195:1	9.8	8.3	+0.5
Scenario 5b – All Process Flows (CaCO3 neutralization)	200:1	12.1	8.3	+0.5

1. Minimum nearfield dilution divided by two to account for tidal reflux.
2. OLI model runs assume an ambient pH of 7.8.

For Scenario 1b, the predicted mixed pH would be 8.2 at the nearfield mixing boundary assuming the predicted effluent dilution (580:1) without accounting for tidal reflux. Therefore, Scenario 1b would meet pH standards without reflux. As noted in Section 4, Scenario 1 discharge would be for a limited duration, likely on the order of several hours to collect pilot data. Under this scenario, tidal reflux is not significant and should not be applied to the dilution predictions. Should Project Macoma, LLC temporarily discharge the alkaline product only, process controls would be in place to limit effluent pH below 13.5.

7.4 Bacteria

The proposed discharge is not anticipated to contain pathogenic bacteria. Source water for the Project Macoma, LLC process is ambient Port Angeles Harbor water and the proposed process will not introduce human or animal wastes.

7.5 Turbidity

The potential for solids formation in the effluent plume of the proposed discharge is discussed in Section 6.2.3. The dominant particulate predicted by the model is calcite. For the typical discharge scenario, Scenario 5a , the chemistry model predicts worst case calcite concentrations near 150 mg/L in the nearfield. However, as discussed in Section 6, actual solids formation may be less in a dynamic condition versus model assumptions. Site-specific data that would correlate calcite concentrations to turbidity values are not available.

A basic mixing equation was used to predict mixed turbidity following the completion of nearfield dilution. While turbidity values may not respond linearly with dilution, and the relationship of potential calcite concentrations to turbidity is currently unknown, the analysis is informative for comparison to WAC criteria which allow for a 5 NTU increase above background when background is less than 50 NTU. Turbidity measured by Ecology in Sequim Bay (Station SEQ002) ranged between 0.5 and 2.0 NTU in 2014. Assuming a worst-case dilution of 195:1 and an ambient turbidity of 2.0 NTU, a discharge turbidity of 100 NTU would increase ambient turbidity approximately 0.5 NTU within the nearfield. Similarly, a discharge turbidity of 500 NTU would increase ambient turbidity approximately 2.5 NTU within the nearfield. Both discharge turbidity values would meet applicable turbidity criteria.

Project Macoma, LLC proposes targeted monitoring of turbidity within the nearfield, along with pH, during initial operation of the facility to assess the impact of the discharge on the receiving water. Modeled calcite concentrations are higher at high pH values. Therefore, effluent pH controls could potentially be used to maintain turbidity values within applicable standards, as needed. Because calcite formation decreases the efficiency of the proposed system with respect to CO_2 absorption, Project Macoma, LLC is actively developing methods to minimize the potential for calcite precipitation.

7.6 Toxics

Trace heavy metals data collected from Port Angeles Harbor and the PNNL pretreatment reject stream are either non-detect or below applicable acute water quality criteria at the point of discharge. The proposed process does not concentrate toxic parameters present in the ambient Port Angeles Harbor waters.

Section 8: Conclusions

The combined results of the dilution and chemistry modeling presented herein support the determination of compliance with applicable water quality standards based upon collected data, where available, and conservative assumptions. For most parameters, except for temperature, pH and turbidity, the proposed discharge would not be anticipated to be significantly changed from the process source waters (Port Angeles Harbor). Specific conclusions related to the mixing zone as well as the modeled mixing of temperature, pH and turbidity within the mixing zone are as follows:

- Dilution model analyses indicate nearfield dilution, the basis of the conservative water quality analyses herein, is complete within 12 meters (40 feet) laterally from the diffuser at the assumed 50th percentile current speeds. The entire WAC-defined mixing zone (207 feet) is not required to attain applicable water quality standards. Project Macoma, LLC proposes monitoring acute and chronic mixing zone dimensions at 15 and 150 feet, respectively, to account for potential nearfield conditions and process assumptions that differ from those modeled.
- Except for Scenario 1b, mixed pH for all scenarios will meet applicable standards within the mixing zone and accounting for reflux. For Scenario 1b, the predicted mixed pH would be 8.2 at the nearfield mixing boundary assuming the predicted effluent dilution (580:1) without accounting for tidal reflux. As noted in Section 4, Scenario 1 discharge would be for a limited duration, likely on the order of several hours to collect pilot data. Under this scenario, tidal reflux is not significant and should not be applied to the dilution predictions. Should Project Macoma, LLC temporarily discharge the alkaline product only, process controls would be in place to limit effluent pH at or below 13.5.
- Assuming a maximum effluent temperature (30°C) and worst-case modeled conditions, the incremental temperature increase within the area of nearfield mixing is predicted to be 0.1°C or less. Mixed temperature decreases rapidly from the point of discharge and approaches background temperature well within the proposed chronic mixing zone dimensions.
- For the typical discharge, Scenario 5a, the chemistry model predicts worst case calcite precipitate concentrations near 150 mg/L in the nearfield. Turbidity analyses are qualitative, because site-specific data that would correlate calcite concentrations to turbidity values are not currently available. However, using high effluent turbidity assumptions (up to 500 NTU) simple dilution calculations indicate that predicted mixed turbidity would be within the allowable range of increase above background (5 NTU). Project Macoma, LLC proposes targeted monitoring of turbidity within the nearfield, along with pH, during initial operation of the facility to assess the impact of the discharge on the receiving water.

References

Ecology 2016. National Pollutant Discharge Elimination System Permit No. WA0023973 and Fact Sheet. Ecology Water Quality Program. Effective February 2016.

Ecology 2018. Water Quality Program Permit Writer's Manual. Publication No. 92-109. Revised July 2018.

Frick, et al. 2003. Dilution Models for Effluent Discharges, 4th Edition (Visual Plumes). Environmental Research Division, USEPA. Athens, Georgia.

Attachment A: Ambient and Process Stream Water Quality Data

Table A-1. Port of port Angeles Water Quality Data

Parameter	Units	Value
pH		7.78
Conductivity	μmhos/cm	47,000
Total sulfide	mg/L	< 0.05
Total dissolved solids	mg/L	34,000
Total suspended solids	mg/L	48.0
Bulk density	g/cm^3	1.002
Total organic carbon	mg/L as C	1.6
Total alkalinity	mg/L as $CaCO_3$	130
Carbonate alkalinity	mg/L as $CaCO_3$	< 2
Bicarbonate alkalinity	mg/L as $CaCO_3$	130
Bromide	mg/L	51.9
Chloride	mg/L	18,400
Fluoride	mg/L	< 5
Sulfate	mg/L	2,420
Calcium	mg/L	300
Potassium	mg/L	330
Magnesium	mg/L	460
Sodium	mg/L	8,570
Ammonia	mg/L as N	0.026
Nitrite	mg/L as N	< 0.5
Nitrate	mg/L as N	< 2.5
Orthophosphate	mg/L as P	0.04
Total phosphorus	mg/L as P	0.064
Aluminum	mg/L	< 0.30
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.01
Beryllium	mg/L	< 0.01
Cadmium	mg/L	< 0.005
Cobalt	mg/L	< 0.01
Chromium	mg/L	< 0.02
Copper	mg/L	< 0.01
Iron	mg/L	< 0.03

Table A-1. Port of port Angeles Water Quality Data		
Parameter	**Units**	**Value**
Mercury	mg/L	< 0.0001
Manganese	mg/L	< 0.01
Nickel	mg/L	< 0.01
Lead	mg/L	< 0.02
Antimony	mg/L	< 0.02
Silica	mg/L as SiO_2	1.40

Table A-2 Water Quality (Nominal) of various waste streams					
Parameter	**Units**	**Alkaline Product**	**Acid with Olivine**	**Acid with Limestone**	**Pretreat Reject**
Flow	L/hr	5,900	5,900	5,900	27,000
pH		13.93	2.26	8.10	8.00
Temperature	°C	30.0	30.0	30.0	17.0
Sodium	mg/L	--	--	--	12,500
Magnesium	mg/L	ND	7,379	198	4,631
Calcium	mg/L	ND	137.6	13,954	1,350
Iron	mg/L	ND	2.43	ND	ND
Nickel	mg/L	ND	18.13	0.001	ND
Cobalt	mg/L	ND	0.853	0.0003	ND
Silica	mg/L	ND	114.8	ND	ND
Aluminum	mg/L	ND	1.13	ND	ND
Phosphorus	mg/L	ND	0.133	ND	ND
Titanium	mg/L	ND	0.061	ND	ND
Chromium	mg/L	ND	0.051	ND	ND
Arsenic	mg/L	ND	ND	0.05	ND
Cadmium	mg/L	ND	ND	0.0002	ND
Mercury	mg/L	ND	ND	0.002	ND
Molybdenum	mg/L	ND	ND	0.0001	ND
Lead	mg/L	ND	ND	0.0025	ND
Selenium	mg/L	ND	ND	0.019	ND
Zinc	mg/L	ND	ND	0.0003	ND
Chloride	mg/L	--	22,055	26,300	27,203
Carbonate	mg/L	--	--	--	18.0
Bicarbonate	mg/L	--	--	172.26	216
Bromide	mg/L	--	--	--	53.0
Fluoride	mg/L	--	--	--	ND

Table A-2 Water Quality (Nominal) of various waste streams					
Parameter	Units	Alkaline Product	Acid with Olivine	Acid with Limestone	Pretreat Reject
Sulfate	mg/L	--	--	--	4,922
Carbon-dioxide	mg/L	--	--	0.42	--
CaHCO3+1	mg/L	--	--	92.8	--
Total dissolved solids	mg/L	--	30,629	41,033	50,893

Attachment B: Dilution Model Input/Output

Scenario 1b – Alkaline Product Only (pH=13.5)

Acute Conditions

Ambient Table:

Depth	Amb-cur	Amb-dir	Amb-den	Amb-tem	Amb-pol	Decay	Far-spd	Far-dir	Disprsn	Density
m	m/s	deg	psu	C	kg/kg	s-1	m/s	deg	m0.67/s2	sigma-T
0.0	0.020	90.00	30.95	11.20	0.0	0.0	-	-	0.0003	23.62000
3.000	0.020	90.00	31.17	10.35	0.0	0.0	-	-	0.0003	23.93000
6.000	0.020	90.00	31.16	9.690	0.0	0.0	-	-	0.0003	24.03000
9.000	0.020	90.00	31.68	9.440	0.0	0.0	-	-	0.0003	24.48000
12.00	0.020	90.00	31.76	9.340	0.0	0.0	-	-	0.0003	24.56000
15.00	0.020	90.00	31.87	9.220	0.0	0.0	-	-	0.0003	24.66000

Diffuser table:

P-dia	Ver angl	H-Angle	SourceX	SourceY	Ports	Spacing	MZ-dis	Isoplth	P-depth	Ttl-flo	Eff-den	Temp	Polutnt
(in)	(deg)	(deg)	(m)	(m)	()	(ft)	(ft)	(concent)	(m)	(m3/s)	(kg/m3)	(C)	(%)
0.5000	45.000	90.000	0.0	0.0	25.000	2.0000	200.00	0.0	2.0000	1.64E-3	1028.0	30.000	100.00

Simulation:
Froude No: -23.03; Strat No:-3.16E-4; Spcg No: 48.00; k: 25.89; eff den (sigmaT) 28.00000; eff vel 0.518(r

Step	Depth	Amb-cur	P-dia	Polutnt	Dilutn	CL-diln	x-posn	y-posn	Time	Iso dia	
	(m)	(cm/s)	(in)	(%)	()	()	(m)	(m)	(s)	(m)	
0	2.000	2.000	0.500	100.0	1.000	1.000	0.0	0.0	0.0	0.0127;	
50	1.962	2.000	1.346	36.10	2.770	1.385	0.000	0.0402	0.198	0.03418;	
100	1.885	2.000	3.389	13.94	7.173	3.586	0.000	0.144	1.354	0.08608;	
150	1.834	2.000	5.491	8.347	11.98	5.990	0.000	0.260	3.403	0.1395;	
200	1.815	2.000	6.968	6.329	15.80	7.901	0.000	0.372	5.917	0.1770;	
209	1.815	2.000	7.180	6.089	16.42	8.212	0.000	0.393	6.421	0.1824;	local maximum rise c
250	1.826	2.000	8.062	5.142	19.45	9.725	0.000	0.495	8.995	0.2048;	
300	1.888	2.000	10.09	3.535	28.29	14.15	0.000	0.667	13.92	0.2563;	
350	2.120	2.000	17.55	1.403	71.30	35.65	0.000	1.041	27.44	0.4458;	
376	2.286	2.000	24.01	0.838	119.3	59.66	0.000	1.304	38.51	0.6100;	merging;
400	2.498	2.000	32.43	0.528	189.3	103.8	0.000	1.702	56.41	0.8237;	
402	2.514	2.000	33.11	0.513	194.8	107.6	0.000	1.738	58.03	0.8409;	trap level;
450	2.722	2.000	43.05	0.368	271.7	169.5	0.000	2.371	87.55	1.0934;	
488	2.759	2.000	45.50	0.346	289.4	186.4	0.000	2.776	106.6	1.1557;	local maximum rise c
500	2.755	2.000	45.59	0.344	290.6	[illegible]	0.000	2.903	112.6	1.1580;	
549	2.505	2.000	51.26	0.278	359.4	239.6	0.000	3.998	164.5	1.3021;	trap level;

Horiz plane projections in effluent direction: radius(m): 0.0; CL(m): 3.9984

Chronic Conditions

Ambient Table:

Depth	Amb-cur	Amb-dir	Amb-den	Amb-tem	Amb-pol	Decay	Far-spd	Far-dir	Disprsn	Density
m	m/s	deg	psu	C	kg/kg	s-1	m/s	deg	m0.67/s2	sigma-T
0.0	0.050	90.00	30.95	11.20	0.0	0.0	-	-	0.0003	23.62000
3.000	0.050	90.00	31.17	10.35	0.0	0.0	-	-	0.0003	23.93000
6.000	0.050	90.00	31.16	9.690	0.0	0.0	-	-	0.0003	24.03000
9.000	0.050	90.00	31.68	9.440	0.0	0.0	-	-	0.0003	24.48000
12.00	0.050	90.00	31.76	9.340	0.0	0.0	-	-	0.0003	24.56000
15.00	0.050	90.00	31.87	9.220	0.0	0.0	-	-	0.0003	24.66000

Diffuser table:

P-dia	Ver angl	H-Angle	SourceX	SourceY	Ports	Spacing	MZ-dis	Isoplth	P-depth	Ttl-flo	Eff-den	Temp	Polutnt
(in)	(deg)	(deg)	(m)	(m)	()	(ft)	(ft)	(concent)	(m)	(m3/s)	(kg/m3)	(C)	(%)
0.5000	45.000	90.000	0.0	0.0	25.000	2.0000	200.00	0.0	2.0000	1.64E-3	1028.0	30.000	100.00

Simulation:
Froude No: -23.03; Strat No:-3.16E-4; Spcg No: 48.00; k: 10.36; eff den (sigmaT) 28.00000; eff vel 0.518(r

Step	Depth	Amb-cur	P-dia	Polutnt	Dilutn	CL-diln	x-posn	y-posn	Time	Iso dia	
	(m)	(cm/s)	(in)	(%)	()	()	(m)	(m)	(s)	(m)	
0	2.000	5.000	0.500	100.0	1.000	1.000	0.0	0.0	0.0	0.0127;	
50	1.965	5.000	1.296	36.17	2.765	1.382	0.000	0.039	0.177	0.03292;	
100	1.916	5.000	2.974	13.91	7.191	3.596	0.000	0.119	0.867	0.07555;	
150	1.872	5.000	5.259	6.473	15.45	7.725	0.000	0.258	2.639	0.1336;	
191	1.852	5.000	7.016	4.155	24.07	12.03	0.000	0.505	6.406	0.1782;	local maximum rise c
200	1.854	5.000	7.297	3.890	25.71	12.85	0.000	0.581	7.605	0.1854;	
250	1.943	5.000	11.87	1.631	61.32	30.66	0.000	1.167	17.65	0.3015;	
300	2.105	5.000	20.13	0.606	165.1	82.53	0.000	2.029	33.90	0.5113;	
318	2.184	5.000	24.24	0.424	235.7	117.9	0.000	2.530	43.62	0.6157;	merging;
334	2.282	5.000	28.79	0.309	323.6	170.3	0.000	3.277	58.22	0.7313;	trap level;
350	2.407	5.000	34.20	0.230	435.4	243.5	0.000	4.726	86.73	0.8686;	
361	2.433	5.000	35.67	0.215	[illegible]	265.2	0.000	5.787	107.7	0.9061;	local maximum rise c
382	2.272	5.000	40.65	0.172	581.6	351.8	0.000	8.609	163.4	1.0325;	trap level;

Horiz plane projections in effluent direction: radius(m): 0.0; CL(m): 8.6092

Scenario 2a – Neutralized Acid Only (Olivine)

Acute Conditions

```
Ambient Table:
     Depth   Amb-cur   Amb-dir   Amb-den   Amb-tem   Amb-pol     Decay   Far-spd   Far-dir   Disprsn   Density
         m       m/s       deg       psu         C     kg/kg       s-1       m/s       deg  m0.67/s2   sigma-T
       0.0     0.020     90.00     30.95     11.20       0.0       0.0         -         -    0.0003  23.62000
     3.000     0.020     90.00     31.17     10.35       0.0       0.0         -         -    0.0003  23.93000
     6.000     0.020     90.00     31.16     9.690       0.0       0.0         -         -    0.0003  24.03000
     9.000     0.020     90.00     31.68     9.440       0.0       0.0         -         -    0.0003  24.48000
     12.00     0.020     90.00     31.76     9.340       0.0       0.0         -         -    0.0003  24.56000
     15.00     0.020     90.00     31.87     9.220       0.0       0.0         -         -    0.0003  24.66000

Diffuser table:
   P-diaVer angl H-Angle SourceX SourceY   Ports Spacing  MZ-dis Isoplth P-depth Ttl-flo Eff-den    Temp Polutnt
    (in)   (deg)   (deg)     (m)     (m)      ()    (ft)    (ft)(concent)     (m)  (m3/s) (kg/m3)     (C)     (%)
  0.5000  45.000  90.000     0.0     0.0  25.000  2.0000  200.00     0.0  2.0000 1.64E-3  1020.0  30.000  100.00

Simulation:
Froude No:     23.95; Strat No: 3.44E-4; Spcg No:   48.00; k:   25.89; eff den (sigmaT)  20.00000; eff vel     0.518(
        Depth  Amb-cur    P-dia  Polutnt   Dilutn  CL-diln   x-posn   y-posn     Time  Iso dia
Step      (m)   (cm/s)     (in)      (%)       ()       ()      (m)      (m)      (s)      (m)
   0    2.000    2.000    0.500    100.0    1.000    1.000      0.0      0.0      0.0   0.0127;
  50    1.962    2.000    1.331    36.27    2.757    1.379    0.000   0.0395    0.194   0.0338;
 100    1.875    2.000    3.328    13.48    7.416    3.708    0.000    0.141    1.332  0.08453;
 150    1.731    2.000    7.585    5.011    19.96    9.979    0.000    0.342    5.642   0.1927;
 200    1.537    2.000    15.40    1.862    53.72    26.86    0.000    0.696    17.42   0.3913;
 233    1.379    2.000    23.34    0.968    103.3    51.63    0.000    1.109    34.30   0.5927; trap level;
 236    1.364    2.000    24.17    0.914    109.4    54.68    0.000    1.160    36.47   0.6139; merging;
 250    1.298    2.000    27.64    0.740    135.2    70.25    0.000    1.419    47.83   0.7022;
 294    1.214    2.000    32.38    0.584    171.1    93.74    0.000    2.203    83.20   0.8224; local maximum rise
 300    1.216    2.000    32.50    0.581    172.2    94.48    0.000    2.307    87.90   0.8255;
 334    1.371    2.000    37.57    0.453    220.8    128.6    0.000    3.425    139.2   0.9542; trap level;
 350    1.445    2.000    41.02    0.401    249.1    151.4    0.000    3.981    165.1   1.0420;
 367    1.459    2.000    41.99    0.389    256.8    158.0    0.000    4.349    182.4   1.0665; local maximum rise
Horiz plane projections in effluent direction: radius(m):     0.0; CL(m):   4.3489
Lmz(m):    4.3489
```

Chronic Conditions

```
Ambient Table:
     Depth   Amb-cur   Amb-dir   Amb-den   Amb-tem   Amb-pol     Decay   Far-spd   Far-dir   Disprsn   Density
         m       m/s       deg       psu         C     kg/kg       s-1       m/s       deg  m0.67/s2   sigma-T
       0.0     0.050     90.00     30.95     11.20       0.0       0.0         -         -    0.0003  23.62000
     3.000     0.050     90.00     31.17     10.35       0.0       0.0         -         -    0.0003  23.93000
     6.000     0.050     90.00     31.16     9.690       0.0       0.0         -         -    0.0003  24.03000
     9.000     0.050     90.00     31.68     9.440       0.0       0.0         -         -    0.0003  24.48000
     12.00     0.050     90.00     31.76     9.340       0.0       0.0         -         -    0.0003  24.56000
     15.00     0.050     90.00     31.87     9.220       0.0       0.0         -         -    0.0003  24.66000

Diffuser table:
   P-diaVer angl H-Angle SourceX SourceY   Ports Spacing  MZ-dis Isoplth P-depth Ttl-flo Eff-den    Temp Polutnt
    (in)   (deg)   (deg)     (m)     (m)      ()    (ft)    (ft)(concent)     (m)  (m3/s) (kg/m3)     (C)     (%)
  0.5000  45.000  90.000     0.0     0.0  25.000  2.0000  200.00     0.0  2.0000 1.64E-3  1020.0  30.000  100.00

Simulation:
Froude No:     23.95; Strat No: 3.44E-4; Spcg No:   48.00; k:   10.36; eff den (sigmaT)  20.00000; eff vel     0.518(
        Depth  Amb-cur    P-dia  Polutnt   Dilutn  CL-diln   x-posn   y-posn     Time  Iso dia
Step      (m)   (cm/s)     (in)      (%)       ()       ()      (m)      (m)      (s)      (m)
   0    2.000    5.000    0.500    100.0    1.000    1.000      0.0      0.0      0.0   0.0127;
  50    1.965    5.000    1.284    36.34    2.752    1.376    0.000   0.0384    0.174  0.03262;
 100    1.912    5.000    2.986    13.51    7.402    3.701    0.000    0.118    0.864  0.07585;
 150    1.844    5.000    6.084    5.020    19.92    9.960    0.000    0.278    3.012   0.1545;
 200    1.752    5.000    11.04    1.865    53.61    26.81    0.000    0.670    9.657   0.2804;
 250    1.608    5.000    18.87    0.693    144.3    72.15    0.000    1.769    30.25   0.4792;
 255    1.590    5.000    19.87    0.628    159.3    79.66    0.000    1.965    34.01   0.5047; trap level;
 274    1.515    5.000    24.17    0.431    232.1    116.0    0.000    3.089    55.79   0.6138; merging;
 285    1.484    5.000    26.45    0.364    274.6    140.9    0.000    4.568    84.69   0.6717; local maximum rise
 300    1.571    5.000    29.75    0.293    341.2    181.5    0.000    7.071    133.7   0.7557;
 301    1.578    5.000    30.08    0.287 [illegible]   185.8    0.000    7.239    137.0   0.7641; trap level;
 313    1.638    5.000    33.31    0.241    414.7    229.6    0.000    9.752    186.5   0.8460; local maximum rise
Horiz plane projections in effluent direction: radius(m):     0.0; CL(m):   9.7519
Lmz(m):    9.7519
```

Scenario 2b – Neutralized Acid Only ($CaCO_3$)

Acute Conditions

```
Ambient Table:
     Depth    Amb-cur    Amb-dir    Amb-den    Amb-tem    Amb-pol      Decay    Far-spd    Far-dir    Disprsn    Density
         m        m/s        deg        psu          C      kg/kg        s-1        m/s        deg    m0.67/s2   sigma-T
       0.0      0.020      90.00      30.95      11.20        0.0        0.0          -          -     0.0003   23.62000
     3.000      0.020      90.00      31.17      10.35        0.0        0.0          -          -     0.0003   23.93000
     6.000      0.020      90.00      31.16      9.690        0.0        0.0          -          -     0.0003   24.03000
     9.000      0.020      90.00      31.68      9.440        0.0        0.0          -          -     0.0003   24.48000
     12.00      0.020      90.00      31.76      9.340        0.0        0.0          -          -     0.0003   24.56000
     15.00      0.020      90.00      31.87      9.220        0.0        0.0          -          -     0.0003   24.66000

Diffuser table:
   P-diaVer angl H-Angle SourceX SourceY    Ports Spacing  MZ-dis Isoplth P-depth Ttl-flo Eff-den    Temp Polutnt
    (in)    (deg)    (deg)      (m)      (m)       ()     (ft)     (ft)(concent)      (m)  (m3/s) (kg/m3)     (C)      (%)
  0.5000  45.000  90.000      0.0      0.0   25.000  2.0000  200.00       0.0  2.0000 1.64E-3  1028.0  30.000  100.00

Simulation:
Froude No:    -23.03; Strat No:-3.16E-4; Spcg No:    48.00; k:    25.89; eff den (sigmaT)  28.00000; eff vel     0.518(r
        Depth  Amb-cur      P-dia  Polutnt    Dilutn  CL-diln    x-posn     y-posn      Time    Iso dia
Step      (m)   (cm/s)       (in)      (%)        ()       ()       (m)        (m)       (s)       (m)
   0    2.000    2.000      0.500    100.0     1.000    1.000       0.0        0.0       0.0    0.0127;
  50    1.962    2.000      1.346    36.10     2.770    1.385     0.000     0.0402     0.198   0.03418;
 100    1.885    2.000      3.389    13.94     7.173    3.586     0.000      0.144     1.354   0.08608;
 150    1.834    2.000      5.491    8.347     11.98    5.990     0.000      0.260     3.403    0.1395;
 200    1.815    2.000      6.968    6.329     15.80    7.901     0.000      0.372     5.917    0.1770;
 209    1.815    2.000      7.180    6.089     16.42    8.212     0.000      0.393     6.421    0.1824;  local maximum rise c
 250    1.826    2.000      8.062    5.142     19.45    9.725     0.000      0.495     8.995    0.2048;
 300    1.888    2.000      10.09    3.535     28.29    14.15     0.000      0.667     13.92    0.2563;
 350    2.120    2.000      17.55    1.403     71.30    35.65     0.000      1.041     27.44    0.4458;
 376    2.286    2.000      24.01    0.838     119.3    59.66     0.000      1.304     38.51    0.6100;  merging;
 400    2.498    2.000      32.43    0.528     189.3    103.8     0.000      1.702     56.41    0.8237;
 402    2.514    2.000      33.11    0.513     194.8    107.6     0.000      1.738     58.03    0.8409;  trap level;
 450    2.722    2.000      43.05    0.368     271.7    169.5     0.000      2.371     87.55    1.0934;
 488    2.759    2.000      45.50    0.346     289.4    186.4     0.000      2.776     106.6    1.1557;  local maximum rise c
 500    2.755    2.000      45.59    0.344     290.6    187.5     0.000      2.903     112.6    1.1580;
 549    2.505    2.000      51.26    0.278     359.4    239.6     0.000      3.998     164.5    1.3021;  trap level;
Horiz plane projections in effluent direction: radius(m):     0.0; CL(m):    3.9984
```

Chronic Conditions

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Ambient Table:
     Depth    Amb-cur    Amb-dir    Amb-den    Amb-tem    Amb-pol      Decay    Far-spd    Far-dir    Disprsn    Density
         m        m/s        deg        psu          C      kg/kg        s-1        m/s        deg    m0.67/s2   sigma-T
       0.0      0.050      90.00      30.95      11.20        0.0        0.0          -          -     0.0003   23.62000
     3.000      0.050      90.00      31.17      10.35        0.0        0.0          -          -     0.0003   23.93000
     6.000      0.050      90.00      31.16      9.690        0.0        0.0          -          -     0.0003   24.03000
     9.000      0.050      90.00      31.68      9.440        0.0        0.0          -          -     0.0003   24.48000
     12.00      0.050      90.00      31.76      9.340        0.0        0.0          -          -     0.0003   24.56000
     15.00      0.050      90.00      31.87      9.220        0.0        0.0          -          -     0.0003   24.66000

Diffuser table:
   P-diaVer angl H-Angle SourceX SourceY    Ports Spacing  MZ-dis Isoplth P-depth Ttl-flo Eff-den    Temp Polutnt
    (in)    (deg)    (deg)      (m)      (m)       ()     (ft)     (ft)(concent)      (m)  (m3/s) (kg/m3)     (C)      (%)
  0.5000  45.000  90.000      0.0      0.0   25.000  2.0000  200.00       0.0  2.0000 1.64E-3  1028.0  30.000  100.00

Simulation:
Froude No:    -23.03; Strat No:-3.16E-4; Spcg No:    48.00; k:    10.36; eff den (sigmaT)  28.00000; eff vel     0.518(r
        Depth  Amb-cur      P-dia  Polutnt    Dilutn  CL-diln    x-posn     y-posn      Time    Iso dia
Step      (m)   (cm/s)       (in)      (%)        ()       ()       (m)        (m)       (s)       (m)
   0    2.000    5.000      0.500    100.0     1.000    1.000       0.0        0.0       0.0    0.0127;
  50    1.965    5.000      1.296    36.17     2.765    1.382     0.000      0.039     0.177   0.03292;
 100    1.916    5.000      2.974    13.91     7.191    3.596     0.000      0.119     0.867   0.07555;
 150    1.872    5.000      5.259    6.473     15.45    7.725     0.000      0.258     2.639    0.1336;
 191    1.852    5.000      7.016    4.155     24.07    12.03     0.000      0.505     6.406    0.1782;  local maximum rise c
 200    1.854    5.000      7.297    3.890     25.71    12.85     0.000      0.581     7.605    0.1854;
 250    1.943    5.000      11.87    1.631     61.32    30.66     0.000      1.167     17.65    0.3015;
 300    2.105    5.000      20.13    0.606     165.1    82.53     0.000      2.029     33.90    0.5113;
 318    2.184    5.000      24.24    0.424     235.7    117.9     0.000      2.530     43.62    0.6157;  merging;
 334    2.282    5.000      28.79    0.309     323.6    170.3     0.000      3.277     58.22    0.7313;  trap level;
 350    2.407    5.000      34.20    0.230     435.4    243.5     0.000      4.726     86.73    0.8686;
 361    2.433    5.000      35.67    0.215     466.0    265.2     0.000      5.787     107.7    0.9061;  local maximum rise c
 382    2.272    5.000      40.65    0.172     581.6    351.8     0.000      8.609     163.4    1.0325;  trap level;
Horiz plane projections in effluent direction: radius(m):     0.0; CL(m):    8.6092
```

Scenario 3 – Pretreatment Reject Only

Acute Conditions

```
    Depth   Amb-cur   Amb-dir   Amb-den   Amb-tem   Amb-pol     Decay   Far-spd   Far-dir   Disprsn   Density
        m       m/s       deg       psu         C     kg/kg       s-1       m/s       deg   m0.67/s2  sigma-T
      0.0     0.020     90.00     30.95     11.20       0.0       0.0         -         -    0.0003  23.62000
    3.000     0.020     90.00     31.17     10.35       0.0       0.0         -         -    0.0003  23.93000
    6.000     0.020     90.00     31.16     9.690       0.0       0.0         -         -    0.0003  24.03000
    9.000     0.020     90.00     31.68     9.440       0.0       0.0         -         -    0.0003  24.48000
    12.00     0.020     90.00     31.76     9.340       0.0       0.0         -         -    0.0003  24.56000
    15.00     0.020     90.00     31.87     9.220       0.0       0.0         -         -    0.0003  24.66000

Diffuser table:
   P-diaVer angl H-Angle SourceX SourceY   Ports Spacing  MZ-dis Isoplth P-depth Ttl-flo Eff-den    Temp Polutnt
     (in)   (deg)   (deg)     (m)     (m)      ()    (ft)    (ft)(concent)     (m)  (m3/s) (kg/m3)     (C)     (%)
   0.5000  45.000  90.000     0.0     0.0  25.000  2.0000  200.00      0.0  2.0000 7.50E-3  1042.0  17.000  100.00

Simulation:
Froude No:    -50.81; Strat No:-7.25E-5; Spcg No:    48.00; k:    118.4; eff den (sigmaT)  42.00000; eff vel     2.368(r
        Depth  Amb-cur    P-dia  Polutnt   Dilutn  CL-diln   x-posn   y-posn     Time  Iso dia
Step      (m)   (cm/s)     (in)      (%)       ()       ()      (m)      (m)      (s)      (m)
   0    2.000    2.000    0.500    100.0    1.000    1.000      0.0      0.0      0.0   0.0127;
  50    1.951    2.000    1.594    30.73    3.255    1.627    0.000   0.0494   0.0626  0.04048;
 100    1.835    2.000    4.270    11.38    8.790    4.395    0.000    0.176    0.488   0.1085;
 150    1.614    2.000    10.36    4.746    21.07    10.53    0.000    0.483    2.822   0.2633;
 200    1.504    2.000    15.08    3.306    30.25    15.12    0.000    0.746    5.909   0.3830;
 250    1.473    2.000    18.31    2.694    37.12    18.56    0.000    0.964    9.036   0.4652;
 254    1.473    2.000    18.53    2.658    37.62    18.81    0.000    0.981    9.295   0.4706; local maximum rise c
 300    1.497    2.000    20.61    2.305    43.39    21.69    0.000    1.177    12.49   0.5235;
 350    1.592    2.000    22.82    1.923    52.00    26.00    0.000    1.423    16.92   0.5797;
 369    1.661    2.000    24.05    1.741    57.44    28.72    0.000    1.539    19.21   0.6109; merging;
 400    1.855    2.000    26.99    1.403    71.29    36.79    0.000    1.789    24.61   0.6855;
 450    3.090    2.000    45.55    0.656    152.5    98.31    0.000    2.838    54.07   1.1569;
 465    3.823    2.000    61.82    0.495    202.0    134.7    0.000    3.453    74.97   1.5703; trap level;
 500    4.588    2.000    91.73    0.383    261.2    174.1    0.000    4.256    104.4   2.3299;
 529    4.855    2.000    111.4    0.346    289.2    192.8    0.000    4.655    119.7   2.8294; begin overlap;
 550    4.974    2.000    122.8    0.331    302.5    201.7    0.000    4.897    129.1   3.1189;
 600    5.121    2.000    138.1    0.316    316.0    210.7    0.000    5.393    148.7   3.5086;
 632    5.142    2.000    141.1    0.314    318.2    212.2    0.000    5.680    160.0   3.5832; local maximum rise c
 650    5.134    2.000    140.8    0.314    318.6    212.4    0.000    5.840    166.3   3.5767;
 700    5.022    2.000    135.7    0.311    321.9    214.6    0.000    6.332    185.8   3.4465;
 726    4.873    2.000    131.8    0.305    327.9    218.6    0.000    6.672    199.3   3.3467; end overlap;
 750    4.576    2.000    129.7    0.292    342.1    228.1    0.000    7.171    219.2   3.2932;
 764    3.793    2.000    140.9    0.258    387.2    258.1    0.000    8.262    263.6   3.5789; trap level;
```

Chronic Conditions

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Ambient Table:
    Depth   Amb-cur   Amb-dir   Amb-den   Amb-tem   Amb-pol     Decay   Far-spd   Far-dir   Disprsn   Density
        m       m/s       deg       psu         C     kg/kg       s-1       m/s       deg   m0.67/s2  sigma-T
      0.0     0.050     90.00     30.95     11.20       0.0       0.0         -         -    0.0003  23.62000
    3.000     0.050     90.00     31.17     10.35       0.0       0.0         -         -    0.0003  23.93000
    6.000     0.050     90.00     31.16     9.690       0.0       0.0         -         -    0.0003  24.03000
    9.000     0.050     90.00     31.68     9.440       0.0       0.0         -         -    0.0003  24.48000
    12.00     0.050     90.00     31.76     9.340       0.0       0.0         -         -    0.0003  24.56000
    15.00     0.050     90.00     31.87     9.220       0.0       0.0         -         -    0.0003  24.66000

Diffuser table:
   P-diaVer angl H-Angle SourceX SourceY   Ports Spacing  MZ-dis Isoplth P-depth Ttl-flo Eff-den    Temp Polutnt
     (in)   (deg)   (deg)     (m)     (m)      ()    (ft)    (ft)(concent)     (m)  (m3/s) (kg/m3)     (C)     (%)
   0.5000  45.000  90.000     0.0     0.0  25.000  2.0000  200.00      0.0  2.0000 7.50E-3  1042.0  17.000  100.00

Simulation:
Froude No:    -50.81; Strat No:-7.25E-5; Spcg No:    48.00; k:    47.36; eff den (sigmaT)  42.00000; eff vel     2.368(r
        Depth  Amb-cur    P-dia  Polutnt   Dilutn  CL-diln   x-posn   y-posn     Time  Iso dia
Step      (m)   (cm/s)     (in)      (%)       ()       ()      (m)      (m)      (s)      (m)
   0    2.000    5.000    0.500    100.0    1.000    1.000      0.0      0.0      0.0   0.0127;
  50    1.952    5.000    1.576    30.78    3.249    1.625    0.000   0.0496   0.0613  0.04003;
 100    1.844    5.000    4.117    11.39    8.776    4.388    0.000    0.177    0.456   0.1046;
 150    1.666    5.000    9.618    4.565    21.90    10.95    0.000    0.465    2.258   0.2443;
 200    1.555    5.000    15.23    2.655    37.67    18.84    0.000    0.811    5.541   0.3869;
 239    1.525    5.000    18.46    2.062    48.49    24.24    0.000    1.138    9.255   0.4688; local maximum rise c
 250    1.528    5.000    19.22    1.945    51.42    25.71    0.000    1.241    10.49   0.4882;
 295    1.625    5.000    24.02    1.358    73.62    36.81    0.000    1.776    17.42   0.6101; merging;
 300    1.652    5.000    25.08    1.266    78.99    39.95    0.000    1.865    18.66   0.6369;
 350    2.377    5.000    47.13    0.491    203.8    134.2    0.000    3.545    45.55   1.1970;
 365    2.761    5.000    59.85    0.367    272.4    181.6    0.000    4.432    61.14   1.5201; trap level;
 400    3.203    5.000    80.08    0.274    365.6    243.7    0.000    5.908    87.90   2.0340;
 441    3.377    5.000    90.85    0.243    411.9    274.6    0.000    7.709    121.1   2.3077; local maximum rise c
 450    3.366    5.000    91.32    0.241    414.6    276.4    0.000    8.120    128.7   2.3195;
 494    2.708    5.000    108.5    0.191    522.6    348.4    0.000    11.63    194.3   2.7556; trap level;
Horiz plane projections in effluent direction: radius(m):       0.0; CL(m):    11.633
Lmz(m):    11.633
```

Scenario 4a – Neutralized Acid (Olivine) + Pretreatment Reject

Acute Conditions

Ambient Table:

Depth	Amb-cur	Amb-dir	Amb-den	Amb-tem	Amb-pol	Decay	Far-spd	Far-dir	Disprsn	Density
m	m/s	deg	psu	C	kg/kg	s-1	m/s	deg	m0.67/s2	sigma-T
0.0	0.020	90.00	30.95	11.20	0.0	0.0	-	-	0.0003	23.62000
3.000	0.020	90.00	31.17	10.35	0.0	0.0	-	-	0.0003	23.93000
6.000	0.020	90.00	31.16	9.690	0.0	0.0	-	-	0.0003	24.03000
9.000	0.020	90.00	31.68	9.440	0.0	0.0	-	-	0.0003	24.48000
12.00	0.020	90.00	31.76	9.340	0.0	0.0	-	-	0.0003	24.56000
15.00	0.020	90.00	31.87	9.220	0.0	0.0	-	-	0.0003	24.66000

Diffuser table:

P-dia	Ver angl	H-Angle	SourceX	SourceY	Ports	Spacing	MZ-dis	Isoplth	P-depth	Ttl-flo	Eff-den	Temp	Polutnt
(in)	(deg)	(deg)	(m)	(m)	()	(ft)	(ft)	(concent)	(m)	(m3/s)	(kg/m3)	(C)	(%)
0.5000	45.000	90.000	0.0	0.0	25.000	2.0000	200.00	0.0	2.0000	9.10E-3	1038.0	19.300	100.00

Simulation:

Froude No: -69.68; Strat No:-9.29E-5; Spcg No: 48.00; k: 143.7; eff den (sigmaT) 38.00000; eff vel 2.873(r

Step	Depth	Amb-cur	P-dia	Polutnt	Dilutn	CL-diln	x-posn	y-posn	Time	Iso dia	
	(m)	(cm/s)	(in)	(%)	()	()	(m)	(m)	(s)	(m)	
0	2.000	2.000	0.500	100.0	1.000	1.000	0.0	0.0	0.0	0.0127;	
50	1.949	2.000	1.655	29.64	3.374	1.687	0.000	0.0517	0.0559	0.04203;	
100	1.828	2.000	4.424	10.98	9.105	4.553	0.000	0.181	0.433	0.1124;	
150	1.548	2.000	11.64	4.173	23.97	11.98	0.000	0.542	2.972	0.2956;	
200	1.358	2.000	18.75	2.621	38.16	19.08	0.000	0.931	7.524	0.4763;	
250	1.294	2.000	23.51	2.075	48.20	24.10	0.000	1.241	12.15	0.5971;	
257	1.292	2.000	24.05	2.022	49.47	24.73	0.000	1.282	12.81	0.6109;	merging;
265	1.291	2.000	24.62	1.968	50.80	25.56	0.000	1.328	13.58	0.6252;	local maximum rise o
300	1.310	2.000	26.59	1.785	56.02	28.79	0.000	1.536	17.15	0.6754;	
350	1.416	2.000	28.99	1.543	64.80	34.18	0.000	1.868	23.32	0.7363;	
400	1.726	2.000	33.30	1.198	83.48	46.22	0.000	2.357	33.57	0.8459;	
442	2.952	2.000	53.61	0.656	152.5	101.7	0.000	3.596	66.49	1.3617;	trap level;
450	3.167	2.000	60.31	0.603	165.8	110.5	0.000	3.819	73.31	1.5320;	
500	3.811	2.000	90.58	0.471	212.2	141.5	0.000	4.698	101.9	2.3007;	
523	3.946	2.000	101.6	0.444	225.5	150.3	0.000	4.988	111.8	2.5808;	begin overlap;
550	4.044	2.000	111.1	0.425	235.5	157.0	0.000	5.295	122.4	2.8218;	
599	4.106	2.000	118.1	0.413	242.2	161.4	0.000	5.807	140.4	3.0001;	local maximum rise o
600	4.106	2.000	118.1	0.413	242.2	161.5	0.000	5.817	140.7	3.0009;	
650	4.031	2.000	116.6	0.408	245.3	163.5	0.000	6.353	159.6	2.9609;	
671	3.944	2.000	115.0	0.402	248.7	165.8	0.000	6.621	169.1	2.9214;	end overlap;
700	3.710	2.000	113.3	0.387	258.3	172.2	0.000	7.116	186.8	2.8788;	
726	2.755	2.000	126.0	0.328	304.9	203.3	0.000	8.557	239.6	3.2008;	trap level;

Chronic Conditions

Ambient Table:

Depth	Amb-cur	Amb-dir	Amb-den	Amb-tem	Amb-pol	Decay	Far-spd	Far-dir	Disprsn	Density
m	m/s	deg	psu	C	kg/kg	s-1	m/s	deg	m0.67/s2	sigma-T
0.0	0.050	90.00	30.95	11.20	0.0	0.0	-	-	0.0003	23.62000
3.000	0.050	90.00	31.17	10.35	0.0	0.0	-	-	0.0003	23.93000
6.000	0.050	90.00	31.16	9.690	0.0	0.0	-	-	0.0003	24.03000
9.000	0.050	90.00	31.68	9.440	0.0	0.0	-	-	0.0003	24.48000
12.00	0.050	90.00	31.76	9.340	0.0	0.0	-	-	0.0003	24.56000
15.00	0.050	90.00	31.87	9.220	0.0	0.0	-	-	0.0003	24.66000

Diffuser table:

P-dia	Ver angl	H-Angle	SourceX	SourceY	Ports	Spacing	MZ-dis	Isoplth	P-depth	Ttl-flo	Eff-den	Temp	Polutnt
(in)	(deg)	(deg)	(m)	(m)	()	(ft)	(ft)	(concent)	(m)	(m3/s)	(kg/m3)	(C)	(%)
0.5000	45.000	90.000	0.0	0.0	25.000	2.0000	200.00	0.0	2.0000	9.10E-3	1038.0	19.300	100.00

Simulation:

Froude No: -69.68; Strat No:-9.29E-5; Spcg No: 48.00; k: 57.47; eff den (sigmaT) 38.00000; eff vel 2.873(r

Step	Depth	Amb-cur	P-dia	Polutnt	Dilutn	CL-diln	x-posn	y-posn	Time	Iso dia	
	(m)	(cm/s)	(in)	(%)	()	()	(m)	(m)	(s)	(m)	
0	2.000	5.000	0.500	100.0	1.000	1.000	0.0	0.0	0.0	0.0127;	
50	1.950	5.000	1.638	29.69	3.369	1.684	0.000	0.0519	0.0549	0.04161;	
100	1.835	5.000	4.289	11.00	9.091	4.546	0.000	0.183	0.409	0.1089;	
150	1.614	5.000	10.64	4.141	24.15	12.07	0.000	0.515	2.322	0.2703;	
200	1.439	5.000	18.60	2.149	46.53	23.26	0.000	0.973	6.598	0.4724;	
243	1.372	5.000	24.00	1.537	65.06	32.53	0.000	1.479	12.50	0.6097;	merging;
250	1.371	5.000	24.67	1.479	67.60	34.04	0.000	1.573	13.67	0.6265;	local maximum rise o
300	1.487	5.000	30.25	1.085	92.18	49.30	0.000	2.395	24.56	0.7684;	
350	2.346	5.000	56.17	0.461	217.0	144.7	0.000	4.656	59.98	1.4267;	
354	2.461	5.000	60.17	0.426	234.7	156.5	0.000	4.959	65.14	1.5284;	trap level;
400	2.953	5.000	83.97	0.308	324.3	216.2	0.000	6.894	99.03	2.1328;	
425	2.999	5.000	87.80	0.296	337.5	225.0	0.000	7.707	113.5	2.2302;	local maximum rise o
450	2.939	5.000	89.36	0.289	346.5	231.0	0.000	8.562	128.8	2.2698;	
478	2.426	5.000	102.6	0.240	416.6	277.7	0.000	10.90	171.1	2.6060;	trap level;

Horiz plane projections in effluent direction: radius(m): 0.0; CL(m): 10.902

Scenario 4b – Neutralized Acid (CaCO3) + Pretreatment Reject

Acute Conditions

Ambient Table:

Depth	Amb-cur	Amb-dir	Amb-den	Amb-tem	Amb-pol	Decay	Far-spd	Far-dir	Disprsn	Density
m	m/s	deg	psu	C	kg/kg	s-1	m/s	deg	m0.67/s2	sigma-T
0.0	0.020	90.00	30.95	11.20	0.0	0.0	-	-	0.0003	23.62000
3.000	0.020	90.00	31.17	10.35	0.0	0.0	-	-	0.0003	23.93000
6.000	0.020	90.00	31.16	9.690	0.0	0.0	-	-	0.0003	24.03000
9.000	0.020	90.00	31.68	9.440	0.0	0.0	-	-	0.0003	24.48000
12.00	0.020	90.00	31.76	9.340	0.0	0.0	-	-	0.0003	24.56000
15.00	0.020	90.00	31.87	9.220	0.0	0.0	-	-	0.0003	24.66000

Diffuser table:

P-dia	Ver angl	H-Angle	SourceX	SourceY	Ports	Spacing	MZ-dis	Isoplth	P-depth	Ttl-flo	Eff-den	Temp	Polutnt
(in)	(deg)	(deg)	(m)	(m)	()	(ft)	(ft)	(concent)	(m)	(m3/s)	(kg/m3)	(C)	(%)
0.5000	45.000	90.000	0.0	0.0	25.000	2.0000	200.00	0.0	2.0000	9.10E-3	1039.0	19.300	100.00

Simulation:

Froude No: -67.38; Strat No:-8.68E-5; Spcg No: 48.00; k: 143.7; eff den (sigmaT) 39.00000; eff vel 2.873(r

Step	Depth	Amb-cur	P-dia	Polutnt	Dilutn	CL-diln	x-posn	y-posn	Time	Iso dia	
	(m)	(cm/s)	(in)	(%)	()	()	(m)	(m)	(s)	(m)	
0	2.000	2.000	0.500	100.0	1.000	1.000	0.0	0.0	0.0	0.0127;	
50	1.949	2.000	1.655	29.62	3.376	1.688	0.000	0.0517	0.0559	0.04204;	
100	1.828	2.000	4.427	10.98	9.111	4.556	0.000	0.181	0.434	0.1125;	
150	1.552	2.000	11.58	4.202	23.80	11.90	0.000	0.539	2.938	0.2943;	
200	1.373	2.000	18.38	2.684	37.26	18.63	0.000	0.911	7.233	0.4669;	
250	1.314	2.000	22.94	2.135	46.83	23.42	0.000	1.208	11.57	0.5827;	
264	1.312	2.000	23.96	2.031	49.23	24.61	0.000	1.286	12.83	0.6085;	local maximum rise c
265	1.312	2.000	24.03	2.025	49.39	24.70	0.000	1.292	12.92	0.6103;	merging;
300	1.331	2.000	25.98	1.832	54.59	27.87	0.000	1.490	16.27	0.6598;	
350	1.434	2.000	28.30	1.583	63.18	33.07	0.000	1.807	22.06	0.7189;	
400	1.729	2.000	32.35	1.234	81.06	44.39	0.000	2.268	31.57	0.8218;	
446	3.049	2.000	53.63	0.644	155.2	103.4	0.000	3.550	65.57	1.3622;	trap level;
450	3.184	2.000	57.50	0.612	163.3	108.9	0.000	3.682	69.59	1.4605;	
500	4.001	2.000	91.98	0.456	219.3	146.2	0.000	4.693	102.6	2.3362;	
526	4.175	2.000	105.9	0.424	236.0	157.4	0.000	5.036	114.4	2.6894;	begin overlap;
550	4.276	2.000	115.5	0.406	246.0	164.0	0.000	5.315	124.2	2.9347;	
600	4.361	2.000	124.7	0.393	254.1	169.4	0.000	5.841	142.9	3.1684;	
607	4.362	2.000	125.1	0.393	254.5	169.7	0.000	5.912	145.5	3.1767;	local maximum rise c
650	4.311	2.000	123.8	0.390	256.6	171.1	0.000	6.361	161.5	3.1454;	
685	4.171	2.000	120.8	0.382	261.7	174.5	0.000	6.799	177.2	3.0678;	end overlap;
700	4.060	2.000	119.6	0.376	266.3	177.5	0.000	7.042	186.0	3.0375;	
735	2.993	2.000	131.5	0.315	317.1	211.4	0.000	8.679	246.5	3.3404;	trap level;

Chronic Conditions

Ambient Table:

Depth	Amb-cur	Amb-dir	Amb-den	Amb-tem	Amb-pol	Decay	Far-spd	Far-dir	Disprsn	Density
m	m/s	deg	psu	C	kg/kg	s-1	m/s	deg	m0.67/s2	sigma-T
0.0	0.050	90.00	30.95	11.20	0.0	0.0	-	-	0.0003	23.62000
3.000	0.050	90.00	31.17	10.35	0.0	0.0	-	-	0.0003	23.93000
6.000	0.050	90.00	31.16	9.690	0.0	0.0	-	-	0.0003	24.03000
9.000	0.050	90.00	31.68	9.440	0.0	0.0	-	-	0.0003	24.48000
12.00	0.050	90.00	31.76	9.340	0.0	0.0	-	-	0.0003	24.56000
15.00	0.050	90.00	31.87	9.220	0.0	0.0	-	-	0.0003	24.66000

Diffuser table:

P-dia	Ver angl	H-Angle	SourceX	SourceY	Ports	Spacing	MZ-dis	Isoplth	P-depth	Ttl-flo	Eff-den	Temp	Polutnt
(in)	(deg)	(deg)	(m)	(m)	()	(ft)	(ft)	(concent)	(m)	(m3/s)	(kg/m3)	(C)	(%)
0.5000	45.000	90.000	0.0	0.0	25.000	2.0000	200.00	0.0	2.0000	9.10E-3	1039.0	19.300	100.00

Simulation:

Froude No: -67.38; Strat No:-8.68E-5; Spcg No: 48.00; k: 57.47; eff den (sigmaT) 39.00000; eff vel 2.873(r

Step	Depth	Amb-cur	P-dia	Polutnt	Dilutn	CL-diln	x-posn	y-posn	Time	Iso dia	
	(m)	(cm/s)	(in)	(%)	()	()	(m)	(m)	(s)	(m)	
0	2.000	5.000	0.500	100.0	1.000	1.000	0.0	0.0	0.0	0.0127;	
50	1.950	5.000	1.639	29.67	3.370	1.685	0.000	0.0519	0.0549	0.04162;	
100	1.835	5.000	4.291	10.99	9.097	4.549	0.000	0.183	0.410	0.1090;	
150	1.616	5.000	10.61	4.160	24.04	12.02	0.000	0.514	2.309	0.2696;	
200	1.448	5.000	18.28	2.202	45.42	22.71	0.000	0.958	6.415	0.4643;	
249	1.386	5.000	23.98	1.540	64.93	32.47	0.000	1.514	12.88	0.6090;	local maximum rise c
250	1.386	5.000	24.07	1.531	65.30	32.65	0.000	1.526	13.04	0.6114;	merging;
300	1.498	5.000	29.52	1.121	89.19	47.32	0.000	2.298	23.12	0.7499;	
350	2.314	5.000	53.66	0.484	206.8	137.9	0.000	4.372	55.31	1.3630;	
358	2.544	5.000	61.48	0.414	241.6	161.1	0.000	4.943	65.00	1.5615;	trap level;
400	3.015	5.000	84.28	0.306	327.0	218.0	0.000	6.667	95.25	2.1407;	
431	3.091	5.000	90.01	0.288	346.8	231.2	0.000	7.724	114.2	2.2864;	local maximum rise c
450	3.054	5.000	91.11	0.283	352.8	235.2	0.000	8.403	126.3	2.3141;	
486	2.467	5.000	106.2	0.231	432.8	288.5	0.000	11.12	175.5	2.6965;	trap level;

Horiz plane projections in effluent direction: radius(m): 0.0; CL(m): 11.118

Scenario 5a – All Process Flows (Olivine neutralization)

Acute Conditions

Depth	Amb-cur	Amb-dir	Amb-den	Amb-tem	Amb-pol	Decay	Far-spd	Far-dir	Disprsn	Density
m	m/s	deg	psu	C	kg/kg	s-1	m/s	deg	m0.67/s2	sigma-T
0.0	0.020	90.00	30.95	11.20	0.0	0.0	-	-	0.0003	23.62000
3.000	0.020	90.00	31.17	10.35	0.0	0.0	-	-	0.0003	23.93000
6.000	0.020	90.00	31.16	9.690	0.0	0.0	-	-	0.0003	24.03000
9.000	0.020	90.00	31.68	9.440	0.0	0.0	-	-	0.0003	24.48000
12.00	0.020	90.00	31.76	9.340	0.0	0.0	-	-	0.0003	24.56000
15.00	0.020	90.00	31.87	9.220	0.0	0.0	-	-	0.0003	24.66000

Diffuser table:

P-dia	Ver angl	H-Angle	SourceX	SourceY	Ports	Spacing	MZ-dis	Isoplth	P-depth	Ttl-flo	Eff-den	Temp	Polutnt
(in)	(deg)	(deg)	(m)	(m)	()	(ft)	(ft)	(concent)	(m)	(m3/s)	(kg/m3)	(C)	(%)
0.5000	45.000	90.000	0.0	0.0	25.000	2.0000	200.00	0.0	2.0000	0.0108	1037.0	20.400	100.00

Simulation:
Froude No: -85.74; Strat No:-1.00E-4; Spcg No: 48.00; k: 170.5; eff den (sigmaT) 37.00000; eff vel 3.410(

Step	Depth	Amb-cur	P-dia	Polutnt	Dilutn	CL-diln	x-posn	y-posn	Time	Iso dia	
	(m)	(cm/s)	(in)	(%)	()	()	(m)	(m)	(s)	(m)	
0	2.000	2.000	0.500	100.0	1.000	1.000	0.0	0.0	0.0	0.0127;	
50	1.946	2.000	1.721	28.52	3.506	1.753	0.000	0.0542	0.0512	0.0437;	
100	1.820	2.000	4.601	10.57	9.460	4.730	0.000	0.188	0.395	0.1169;	
150	1.510	2.000	12.31	3.926	25.47	12.74	0.000	0.571	2.825	0.3127;	
200	1.242	2.000	21.57	2.270	44.05	22.02	0.000	1.067	8.385	0.5479;	
218	1.195	2.000	24.01	2.041	48.99	24.49	0.000	1.211	10.39	0.6098;	merging;
250	1.149	2.000	27.36	1.796	55.68	28.85	0.000	1.449	13.99	0.6949;	
273	1.140	2.000	29.18	1.680	59.53	31.46	0.000	1.613	16.64	0.7412;	local maximum rise c
300	1.154	2.000	30.88	1.571	63.64	34.28	0.000	1.806	19.88	0.7844;	
350	1.263	2.000	33.44	1.385	72.18	40.02	0.000	2.197	26.91	0.8493;	
400	1.589	2.000	37.70	1.117	89.51	52.21	0.000	2.759	38.12	0.9576;	
439	2.790	2.000	57.17	0.674	148.4	98.95	0.000	4.071	70.41	1.4520;	trap level;
450	3.057	2.000	66.26	0.613	163.2	108.8	0.000	4.374	78.95	1.6831;	
500	3.565	2.000	93.42	0.508	196.9	131.3	0.000	5.152	102.2	2.3729;	
515	3.643	2.000	100.0	0.491	203.8	135.8	0.000	5.335	107.9	2.5401;	begin overlap;
550	3.754	2.000	110.7	0.468	213.6	142.4	0.000	5.725	120.3	2.8130;	
589	3.791	2.000	115.4	0.459	217.7	145.1	0.000	6.128	133.2	2.9310;	local maximum rise c
600	3.788	2.000	115.6	0.458	218.2	145.5	0.000	6.241	136.8	2.9370;	
650	3.681	2.000	113.4	0.451	222.0	148.0	0.000	6.792	154.6	2.8809;	
662	3.626	2.000	112.6	0.447	224.0	149.3	0.000	6.948	159.6	2.8593;	end overlap;
700	3.281	2.000	110.6	0.423	236.5	157.7	0.000	7.619	181.6	2.8102;	
720	2.519	2.000	119.7	0.373	268.3	178.9	0.000	8.704	218.3	3.0412;	trap level;

Horiz plane projections in effluent direction: radius(m): 0.0; CL(m): 8.7036

Chronic Conditions

Ambient Table:

Depth	Amb-cur	Amb-dir	Amb-den	Amb-tem	Amb-pol	Decay	Far-spd	Far-dir	Disprsn	Density
m	m/s	deg	psu	C	kg/kg	s-1	m/s	deg	m0.67/s2	sigma-T
0.0	0.050	90.00	30.95	11.20	0.0	0.0	-	-	0.0003	23.62000
3.000	0.050	90.00	31.17	10.35	0.0	0.0	-	-	0.0003	23.93000
6.000	0.050	90.00	31.16	9.690	0.0	0.0	-	-	0.0003	24.03000
9.000	0.050	90.00	31.68	9.440	0.0	0.0	-	-	0.0003	24.48000
12.00	0.050	90.00	31.76	9.340	0.0	0.0	-	-	0.0003	24.56000
15.00	0.050	90.00	31.87	9.220	0.0	0.0	-	-	0.0003	24.66000

Diffuser table:

P-dia	Ver angl	H-Angle	SourceX	SourceY	Ports	Spacing	MZ-dis	Isoplth	P-depth	Ttl-flo	Eff-den	Temp	Polutnt
(in)	(deg)	(deg)	(m)	(m)	()	(ft)	(ft)	(concent)	(m)	(m3/s)	(kg/m3)	(C)	(%)
0.5000	45.000	90.000	0.0	0.0	25.000	2.0000	200.00	0.0	2.0000	0.0108	1037.0	20.400	100.00

Simulation:
Froude No: -85.74; Strat No:-1.00E-4; Spcg No: 48.00; k: 68.20; eff den (sigmaT) 37.00000; eff vel 3.410(

Step	Depth	Amb-cur	P-dia	Polutnt	Dilutn	CL-diln	x-posn	y-posn	Time	Iso dia	
	(m)	(cm/s)	(in)	(%)	()	()	(m)	(m)	(s)	(m)	
0	2.000	5.000	0.500	100.0	1.000	1.000	0.0	0.0	0.0	0.0127;	
50	1.947	5.000	1.705	28.56	3.501	1.750	0.000	0.0543	0.0504	0.04331;	
100	1.826	5.000	4.477	10.59	9.445	4.723	0.000	0.190	0.376	0.1137;	
150	1.575	5.000	11.32	3.932	25.43	12.72	0.000	0.548	2.262	0.2875;	
200	1.345	5.000	21.08	1.913	52.27	26.13	0.000	1.091	7.097	0.5353;	
217	1.294	5.000	24.15	1.612	62.04	31.02	0.000	1.305	9.438	0.6133;	merging;
250	1.240	5.000	28.45	1.312	76.24	39.97	0.000	1.795	15.26	0.7226;	
257	1.239	5.000	29.12	1.272	78.59	41.51	0.000	1.908	16.66	0.7397;	local maximum rise
300	1.333	5.000	33.75	1.029	97.14	54.06	0.000	2.708	26.99	0.8571;	
350	2.188	5.000	58.66	0.492	203.1	135.4	0.000	5.063	62.24	1.4900;	
355	2.348	5.000	64.17	0.446	224.0	149.4	0.000	5.480	69.07	1.6298;	trap level;
400	2.844	5.000	89.03	0.331	302.5	201.7	0.000	7.413	101.9	2.2614;	
426	2.894	5.000	93.43	0.317	315.4	210.2	0.000	8.259	116.5	2.3732;	local maximum rise
450	2.838	5.000	95.04	0.309	323.2	215.4	0.000	9.073	130.7	2.4140;	
481	2.252	5.000	110.4	0.255	392.0	261.3	0.000	11.68	176.5	2.8031;	trap level;

Horiz plane projections in effluent direction: radius(m): 0.0; CL(m): 11.676
Lmz(m): 11.676

Scenario 5b – All Process Flows (CaCO3 neutralization)

Acute Conditions

Ambient Table:

Depth	Amb-cur	Amb-dir	Amb-den	Amb-tem	Amb-pol	Decay	Far-spd	Far-dir	Disprsn	Density
m	m/s	deg	psu	C	kg/kg	s-1	m/s	deg	m0.67/s2	sigma-T
0.0	0.020	90.00	30.95	11.20	0.0	0.0	-	-	0.0003	23.62000
3.000	0.020	90.00	31.17	10.35	0.0	0.0	-	-	0.0003	23.93000
6.000	0.020	90.00	31.16	9.690	0.0	0.0	-	-	0.0003	24.03000
9.000	0.020	90.00	31.68	9.440	0.0	0.0	-	-	0.0003	24.48000
12.00	0.020	90.00	31.76	9.340	0.0	0.0	-	-	0.0003	24.56000
15.00	0.020	90.00	31.87	9.220	0.0	0.0	-	-	0.0003	24.66000

Diffuser table:

P-dia	Ver angl	H-Angle	SourceX	SourceY	Ports	Spacing	MZ-dis	Isoplth	P-depth	Ttl-flo	Eff-den	Temp	Polutnt
(in)	(deg)	(deg)	(m)	(m)	()	(ft)	(ft)	(concent)	(m)	(m3/s)	(kg/m3)	(C)	(%)
0.5000	45.000	90.000	0.0	0.0	25.000	2.0000	200.00	0.0	2.0000	0.0108	1038.0	20.400	100.00

Simulation:

Froude No: -82.70; Strat No:-9.29E-5; Spcg No: 48.00; k: 170.5; eff den (sigmaT) 38.00000; eff vel 3.410(

Step	Depth	Amb-cur	P-dia	Polutnt	Dilutn	CL-diln	x-posn	y-posn	Time	Iso dia	
	(m)	(cm/s)	(in)	(%)	()	()	(m)	(m)	(s)	(m)	
0	2.000	2.000	0.500	100.0	1.000	1.000	0.0	0.0	0.0	0.0127;	
50	1.946	2.000	1.721	28.51	3.508	1.754	0.000	0.0542	0.0512	0.04371;	
100	1.819	2.000	4.603	10.56	9.466	4.733	0.000	0.188	0.395	0.1169;	
150	1.512	2.000	12.32	3.930	25.44	12.72	0.000	0.571	2.824	0.3130;	
200	1.259	2.000	21.16	2.323	43.05	21.52	0.000	1.045	8.073	0.5375;	
223	1.206	2.000	24.08	2.043	48.94	24.47	0.000	1.220	10.48	0.6117;	merging;
250	1.173	2.000	26.76	1.841	54.31	27.96	0.000	1.411	13.34	0.6796;	
272	1.165	2.000	28.45	1.727	57.91	30.36	0.000	1.561	15.72	0.7226;	local maximum rise o
300	1.180	2.000	30.16	1.611	62.08	33.17	0.000	1.752	18.88	0.7661;	
350	1.286	2.000	32.62	1.420	70.43	38.69	0.000	2.127	25.50	0.8287;	
400	1.598	2.000	36.62	1.149	87.05	50.11	0.000	2.657	35.90	0.9301;	
443	2.895	2.000	57.08	0.664	150.5	100.4	0.000	4.020	69.34	1.4500;	trap level;
450	3.100	2.000	63.60	0.619	161.6	107.7	0.000	4.237	75.46	1.6154;	
500	3.745	2.000	94.40	0.495	202.1	134.7	0.000	5.132	102.3	2.3978;	
521	3.870	2.000	104.7	0.470	212.7	141.8	0.000	5.403	110.9	2.6582;	begin overlap;
550	3.976	2.000	114.9	0.451	222.0	148.0	0.000	5.740	121.7	2.9186;	
597	4.034	2.000	121.7	0.439	227.6	151.7	0.000	6.239	138.0	3.0914;	local maximum rise o
600	4.034	2.000	121.8	0.439	227.8	151.8	0.000	6.270	139.0	3.0941;	
650	3.953	2.000	120.1	0.433	230.7	153.8	0.000	6.816	156.8	3.0502;	
673	3.852	2.000	118.2	0.427	234.2	156.1	0.000	7.115	166.7	3.0031;	end overlap;
700	3.627	2.000	116.4	0.413	242.4	161.6	0.000	7.577	182.0	2.9565;	
729	2.640	2.000	126.9	0.353	282.9	188.6	0.000	9.004	230.7	3.2234;	trap level;

Chronic Conditions

Ambient Table:

Depth	Amb-cur	Amb-dir	Amb-den	Amb-tem	Amb-pol	Decay	Far-spd	Far-dir	Disprsn	Density
m	m/s	deg	psu	C	kg/kg	s-1	m/s	deg	m0.67/s2	sigma-T
0.0	0.050	90.00	30.95	11.20	0.0	0.0	-	-	0.0003	23.62000
3.000	0.050	90.00	31.17	10.35	0.0	0.0	-	-	0.0003	23.93000
6.000	0.050	90.00	31.16	9.690	0.0	0.0	-	-	0.0003	24.03000
9.000	0.050	90.00	31.68	9.440	0.0	0.0	-	-	0.0003	24.48000
12.00	0.050	90.00	31.76	9.340	0.0	0.0	-	-	0.0003	24.56000
15.00	0.050	90.00	31.87	9.220	0.0	0.0	-	-	0.0003	24.66000

Diffuser table:

P-dia	Ver angl	H-Angle	SourceX	SourceY	Ports	Spacing	MZ-dis	Isoplth	P-depth	Ttl-flo	Eff-den	Temp	Polutnt
(in)	(deg)	(deg)	(m)	(m)	()	(ft)	(ft)	(concent)	(m)	(m3/s)	(kg/m3)	(C)	(%)
0.5000	45.000	90.000	0.0	0.0	25.000	2.0000	200.00	0.0	2.0000	0.0108	1038.0	20.400	100.00

Simulation:

Froude No: -82.70; Strat No:-9.29E-5; Spcg No: 48.00; k: 68.20; eff den (sigmaT) 38.00000; eff vel 3.410(

Step	Depth	Amb-cur	P-dia	Polutnt	Dilutn	CL-diln	x-posn	y-posn	Time	Iso dia	
	(m)	(cm/s)	(in)	(%)	()	()	(m)	(m)	(s)	(m)	
0	2.000	5.000	0.500	100.0	1.000	1.000	0.0	0.0	0.0	0.0127;	
50	1.947	5.000	1.705	28.55	3.502	1.751	0.000	0.0544	0.0504	0.04332;	
100	1.826	5.000	4.479	10.58	9.451	4.726	0.000	0.190	0.376	0.1138;	
150	1.576	5.000	11.32	3.934	25.42	12.71	0.000	0.548	2.263	0.2876;	
200	1.356	5.000	20.75	1.955	51.14	25.57	0.000	1.075	6.919	0.5270;	
220	1.300	5.000	24.15	1.615	61.91	30.96	0.000	1.319	9.570	0.6135;	merging;
250	1.258	5.000	27.81	1.352	73.97	38.51	0.000	1.744	14.58	0.7064;	
256	1.257	5.000	28.37	1.317	75.93	39.78	0.000	1.836	15.69	0.7206;	local maximum rise o
300	1.350	5.000	32.94	1.062	94.20	51.93	0.000	2.604	25.49	0.8367;	
350	2.155	5.000	55.87	0.518	193.2	128.8	0.000	4.755	57.34	1.4191;	
358	2.411	5.000	64.39	0.442	226.1	150.7	0.000	5.385	67.61	1.6354;	trap level;
400	2.914	5.000	89.18	0.328	304.4	203.0	0.000	7.175	97.99	2.2651;	
432	2.989	5.000	95.38	0.310	322.3	214.9	0.000	8.186	115.5	2.4226;	local maximum rise o
450	2.959	5.000	96.38	0.306	327.0	218.0	0.000	8.761	125.6	2.4480;	
488	2.368	5.000	111.0	0.253	395.0	263.4	0.000	11.44	172.8	2.8188;	trap level;

Horiz plane projections in effluent direction: radius(m): 0.0; CL(m): 11.437

Lmz(m): 11.437

Attachment C: Chemistry Model Output

Model Scenarios				
Scenario No.		Streams	Flow Rate* (L/hr.)	Refernce Tab
Scenario 1		Alkaline product only	5,900	
		at pH 13.5		Scenario1_pH13-5
		at pH 13.9		Scenario1_pH13-9
Scenario 2		Reacted acid only	5,900	
	2A	Reacted acid with Olivine		Scenario2A
	2B	Reacted acid with CaCO3		Scenario2B
Scenario 3		Pretreat NF reject +IX waste	27,000	Scenario3
Scenario 4		Reacted acid+Pretreat reject waste	32,900	
	4A	Reacted acid with Olivine		Scenario4A
	4B	Reacted acid with CaCO3		Scenario4B
Scenario 5		Alkaline+Reacted acid+Pretreat reject waste	38,800	
	5A	Reacted acid with Olivine		Scenario5A
	5B	Reacted acid with CaCO3		Scenario5B

SCENARIO 1 at pH 13.5

Dilution Ratio	Volume - PoPA	Volume - Total	pH	Total Dissolved Solids	Temperature	Density - Total	Cl(-1) Liq1	Salinity	Si(+4)	Se(+4)	Sb(+5)	S(+6)	Pb(+2)	P(+5)	Ni(+2)	Na(+1)	N(-3)	N(+5)	N(+3)	Mn(+2)	Mg(+2)
	L/hr	L/hr		mg/L	°C	kg/m3	mg/L	g/kg	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	5,900	13.5	19,860	30.0	1,028	0	0	0	0	0	0	0	0.000	0	17,434	0.000	0.000	0.000	0	0
3	20,000	25,908	13.3	30,350	13.2	1,026	14,210	25.0	0.505	6.05E-04	0.008	624	0	0.002	0	13,054	0.016	0.218	0.059	0.004	0.001
7	40,000	45,927	13.1	31,748	11.0	1,025	16,033	28.2	0.125	6.82E-04	0.009	704	0	0.001	0	12,488	0.018	0.246	0.066	0.004	0.005
10	60,000	65,948	12.8	32,280	10.2	1,025	16,749	29.5	0.044	7.13E-04	0.009	735	0	0.001	0	12,265	0.018	0.257	0.069	0.005	0.013
14	80,000	85,969	12.5	32,322	9.71	1,025	17,131	30.2	0.017	7.29E-04	0.009	752	0	0.001	0	12,146	0.019	0.263	0.071	0.005	0.048
17	1.00E+05	1.06E+05	11.9	32,349	9.43	1,025	17,369	30.6	0.004	7.39E-04	0.009	763	0	0.001	0	12,072	0.019	0.267	0.072	0.005	0.500
34	2.00E+05	2.06E+05	10.6	32,929	8.87	1,025	17,869	31.5	0.000	7.60E-04	0.010	785	0	0.008	0	11,921	0.020	0.274	0.074	0.005	216.407
41	2.40E+05	2.46E+05	10.6	33,073	8.77	1,025	17,956	31.6	0.000	7.64E-04	0.010	788	0	0.009	0	11,894	0.020	0.276	0.074	0.005	261.486
47	2.80E+05	2.86E+05	10.6	33,191	8.70	1,025	18,018	31.7	0.000	7.67E-04	0.010	791	0	0.010	0	11,876	0.020	0.277	0.075	0.005	293.982
54	3.20E+05	3.26E+05	10.5	33,273	8.65	1,025	18,065	31.8	0.000	7.69E-04	0.010	793	0	0.011	0	11,862	0.020	0.277	0.075	0.005	318.514
61	3.60E+05	3.66E+05	10.5	33,325	8.61	1,025	18,102	31.9	0.000	7.70E-04	0.010	795	0	0.011	0	11,850	0.020	0.278	0.075	0.005	337.688
68	4.00E+05	4.06E+05	10.5	33,368	8.58	1,025	18,131	31.9	0.000	7.71E-04	0.010	796	0	0.011	0	11,842	0.020	0.278	0.075	0.005	353.086
75	4.40E+05	4.46E+05	10.5	33,409	8.55	1,025	18,155	32.0	0.000	7.72E-04	0.010	797	0	0.011	0	11,834	0.020	0.279	0.075	0.005	365.724
81	4.80E+05	4.86E+05	10.5	33,462	8.53	1,025	18,175	32.0	0.000	7.73E-04	0.010	798	0	0.012	0	11,828	0.020	0.279	0.075	0.005	376.282
88	5.20E+05	5.26E+05	10.5	33,473	8.51	1,025	18,192	32.1	0.000	7.74E-04	0.010	799	0	0.012	0	11,823	0.020	0.279	0.075	0.005	385.236
95	5.60E+05	5.66E+05	10.5	33,522	8.49	1,025	18,207	32.1	0.000	7.75E-04	0.010	799	0	0.012	0	11,819	0.020	0.279	0.075	0.005	392.924
102	6.00E+05	6.06E+05	10.5	33,538	8.48	1,025	18,220	32.1	0.000	7.75E-04	0.010	800	0	0.012	0	11,815	0.020	0.280	0.075	0.005	399.597
108	6.40E+05	6.46E+05	10.5	33,547	8.47	1,025	18,231	32.1	0.000	7.76E-04	0.010	800	0	0.012	0	11,811	0.020	0.280	0.075	0.005	405.444
115	6.80E+05	6.86E+05	10.5	33,553	8.46	1,025	18,241	32.1	0.000	7.76E-04	0.010	801	0	0.012	0	11,808	0.020	0.280	0.075	0.005	410.609
122	7.20E+05	7.26E+05	10.5	33,559	8.45	1,025	18,250	32.2	0.000	7.76E-04	0.010	801	0	0.012	0	11,806	0.020	0.280	0.075	0.005	415.206
129	7.60E+05	7.66E+05	10.5	33,564	8.44	1,025	18,257	32.2	0.000	7.77E-04	0.010	802	0	0.012	0	11,803	0.020	0.280	0.076	0.005	419.322
136	8.00E+05	8.06E+05	10.5	33,569	8.43	1,025	18,265	32.2	0.000	7.77E-04	0.010	802	0	0.012	0	11,801	0.020	0.280	0.076	0.005	423.030
142	8.40E+05	8.46E+05	10.5	33,573	8.42	1,025	18,271	32.2	0.000	7.77E-04	0.010	802	0	0.012	0	11,799	0.020	0.280	0.076	0.005	426.387
149	8.80E+05	8.86E+05	10.48	33,577	8.42	1,025	18,277	32.2	0.000	7.78E-04	0.010	802	0	0.013	0	11,798	0.020	0.280	0.076	0.005	429.441
156	9.20E+05	9.26E+05	10.48	33,580	8.41	1,025	18,282	32.2	0.000	7.78E-04	0.010	803	0	0.013	0	11,796	0.020	0.281	0.076	0.005	432.232
163	9.60E+05	9.66E+05	10.48	33,583	8.40	1,025	18,287	32.2	0.000	7.78E-04	0.010	803	0	0.013	0	11,794	0.020	0.281	0.076	0.005	434.791
169	1.00E+06	1.01E+06	10.48	33,586	8.40	1,025	18,292	32.2	0.000	7.78E-04	0.010	803	0	0.013	0	11,793	0.020	0.281	0.076	0.005	437.147
186	1.10E+06	1.11E+06	10.48	33,593	8.39	1,025	18,301	32.2	0.000	7.79E-04	0.010	803	0	0.013	0	11,790	0.020	0.281	0.076	0.005	442.291
507	2.99E+06	3.00E+06	8.30	33,657	8.31	1,026	18,364	32.3	0.653	7.81E-04	0.010	806	0	0.040	0	11,771	0.020	0.282	0.076	0.005	459.090
827	4.88E+06	4.89E+06	8.09	33,680	8.28	1,026	18,378	32.4	0.654	7.82E-04	0.010	807	0	0.040	0	11,767	0.020	0.282	0.076	0.005	459.442
1147	6.77E+06	6.78E+06	8.01	33,691	8.27	1,026	18,384	32.4	0.654	7.82E-04	0.010	807	0	0.040	0	11,765	0.020	0.282	0.076	0.005	459.598
1468	8.66E+06	8.67E+06	7.97	33,696	8.27	1,026	18,387	32.4	0.654	7.82E-04	0.010	807	0	0.040	0	11,764	0.020	0.282	0.076	0.005	459.685
1788	1.06E+07	1.06E+07	7.95	33,703	8.27	1,026	18,390	32.4	0.654	7.82E-04	0.010	807	0	0.040	0	11,763	0.020	0.282	0.076	0.005	459.742
2108	1.24E+07	1.24E+07	7.93	33,709	8.26	1,026	18,391	32.4	0.654	7.82E-04	0.010	807	0	0.040	0	11,763	0.020	0.282	0.076	0.005	459.781
2429	1.43E+07	1.43E+07	7.92	33,713	8.26	1,026	18,392	32.4	0.654	7.82E-04	0.010	807	0	0.040	0	11,762	0.020	0.282	0.076	0.005	459.810
2749	1.62E+07	1.62E+07	7.92	33,716	8.26	1,026	18,393	32.4	0.654	7.82E-04	0.010	808	0	0.040	0	11,762	0.020	0.282	0.076	0.005	459.832
3069	1.81E+07	1.81E+07	7.91	33,718	8.26	1,026	18,394	32.4	0.654	7.83E-04	0.010	808	0	0.040	0	11,762	0.020	0.282	0.076	0.005	459.849
3390	2.00E+07	2.00E+07	7.90	33,720	8.26	1,026	18,395	32.4	0.654	7.83E-04	0.010	808	0	0.040	0	11,762	0.020	0.282	0.076	0.005	459.864

Dilution Ratio	K(+1)	Hg(+2)	Fe(+2)	F(-1)	Cu(+2)	Cr(+6)	Cr(+3)	Co(+2)	Zn(+2)	Cd(+2)	Ca(+2)	Br(-1)	Be(+2)	Ba(+2)	As(+5)	Al(+3)	NiCr2O4	NaAlCO3(OH)2 (Dawsonite) -	CoCr2O4 -	CaCO3 (Calcite) -
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	254.86	2.70E-07	1.16E-02	1.93E+00	1.44E-03	9.77E-05	0.0	0.0	4.94E-03	2.61E-05	1.53E+02	40.0827	0.004	0.004	0.0033	0.116	0	0.000	0.003	195.449
7	287.55	3.05E-07	1.31E-02	2.18E+00	1.62E-03	1.10E-04	0	0.0	5.58E-03	2.95E-05	1.72E+02	45.2241	0.004	0.004	0.0037	0.131	0	0.000	0.003	222.677
10	300.39	3.19E-07	1.37E-02	2.28E+00	1.69E-03	1.15E-04	0	0.0	5.83E-03	3.08E-05	1.80E+02	47.2432	0.005	0.005	0.0039	0.137	0	0.000	0.003	233.29
14	307.25	3.26E-07	1.23E-02	2.33E+00	1.73E-03	1.18E-04	0	0.0	5.96E-03	3.15E-05	1.84E+02	48.3217	0.005	0.005	0.0040	0.140	0	0.000	0.003	238.93
17	311.51	3.30E-07	8.20E-03	2.36E+00	1.76E-03	1.19E-04	0	0.0	6.04E-03	3.19E-05	1.86E+02	48.9927	0.005	0.005	0.0041	0.142	0	0.000	0.003	242.42
34	320.48	3.40E-07	1.46E-02	2.43E+00	1.25E-04	1.23E-04	0	0.0	6.22E-03	3.28E-05	1.92E+02	50.4034	0.004	0.005	0.0042	0.081	0	0.000	0.004	248.37
41	322.03	3.42E-07	1.46E-02	2.44E+00	1.15E-04	1.23E-04	0	0.0	6.25E-03	3.30E-05	1.93E+02	50.6469	0.004	0.005	0.0042	0.073	0	0.000	0.004	249.42
47	323.15	3.43E-07	1.47E-02	2.45E+00	1.10E-04	1.24E-04	0	0.0	6.27E-03	3.31E-05	1.94E+02	50.8222	0.004	0.005	0.0042	0.069	0	0.000	0.004	250.19
54	323.99	3.44E-07	1.47E-02	2.45E+00	1.07E-04	1.24E-04	0	0.0	6.28E-03	3.32E-05	1.94E+02	50.9546	0.004	0.005	0.0042	0.066	0	0.000	0.004	250.76
61	324.65	3.44E-07	1.48E-02	2.46E+00	1.04E-04	1.24E-04	0	0.0	6.30E-03	3.33E-05	1.94E+02	51.058	0.004	0.005	0.0042	0.064	0	0.000	0.004	251.21
68	325.17	3.45E-07	1.48E-02	2.46E+00	1.03E-04	1.25E-04	0	0.0	6.31E-03	3.33E-05	1.95E+02	51.141	0.004	0.005	0.0042	0.062	0	0.000	0.004	251.58
75	325.61	3.45E-07	1.48E-02	2.47E+00	1.01E-04	1.25E-04	0	0.0	6.31E-03	3.34E-05	1.95E+02	51.2091	0.004	0.005	0.0042	0.061	0	0.000	0.004	251.88
81	325.97	3.46E-07	1.48E-02	2.47E+00	1.00E-04	1.25E-04	0	0.0	6.32E-03	3.34E-05	1.95E+02	51.266	0.004	0.005	0.0043	0.060	0	0.000	0.004	252.13
88	326.28	3.46E-07	1.48E-02	2.47E+00	9.94E-05	1.25E-04	0	0.0	6.33E-03	3.34E-05	1.96E+02	51.3142	0.004	0.005	0.0043	0.059	0	0.000	0.004	252.34
95	326.54	3.46E-07	1.48E-02	2.47E+00	9.87E-05	1.25E-04	0	0.0	6.33E-03	3.34E-05	1.96E+02	51.3557	0.004	0.005	0.0043	0.059	0	0.000	0.004	252.52
102	326.77	3.47E-07	1.49E-02	2.48E+00	9.80E-05	1.25E-04	0	0.0	6.34E-03	3.35E-05	1.96E+02	51.3916	0.004	0.005	0.0043	0.058	0	0.000	0.004	252.68
108	326.97	3.47E-07	1.49E-02	2.48E+00	9.75E-05	1.25E-04	0	0.0	6.34E-03	3.35E-05	1.96E+02	51.4231	0.004	0.005	0.0043	0.058	0	0.000	0.004	252.82
115	327.15	3.47E-07	1.49E-02	2.48E+00	9.71E-05	1.25E-04	0	0.0	6.34E-03	3.35E-05	1.96E+02	51.451	0.004	0.005	0.0043	0.057	0	0.000	0.004	252.94
122	327.30	3.47E-07	1.49E-02	2.48E+00	9.67E-05	1.25E-04	0	0.0	6.35E-03	3.35E-05	1.96E+02	51.4757	0.004	0.005	0.0043	0.057	0	0.000	0.004	253.05
129	327.44	3.47E-07	1.49E-02	2.48E+00	9.63E-05	1.26E-04	0	0.0	6.35E-03	3.35E-05	1.96E+02	51.4979	0.004	0.005	0.0043	0.057	0	0.000	0.004	253.15
136	327.57	3.47E-07	1.49E-02	2.48E+00	9.60E-05	1.26E-04	0	0.0	6.35E-03	3.36E-05	1.96E+02	51.5179	0.004	0.005	0.0043	0.056	0	0.000	0.004	253.24
142	327.69	3.48E-07	1.49E-02	2.48E+00	9.58E-05	1.26E-04	0	0.0	6.36E-03	3.36E-05	1.96E+02	51.536	0.004	0.005	0.0043	0.056	0	0.000	0.004	253.31
149	327.79	3.48E-07	1.49E-02	2.48E+00	9.55E-05	1.26E-04	0	0.0	6.36E-03	3.36E-05	1.96E+02	51.5524	0.004	0.005	0.0043	0.056	0	0.000	0.004	253.39
156	327.89	3.48E-07	1.49E-02	2.48E+00	9.53E-05	1.26E-04	0	0.0	6.36E-03	3.36E-05	1.97E+02	51.5674	0.005	0.005	0.0043	0.056	0	0.000	0.004	253.45
163	327.97	3.48E-07	1.49E-02	2.48E+00	9.51E-05	1.26E-04	0	0.0	6.36E-03	3.36E-05	1.97E+02	51.5812	0.005	0.005	0.0043	0.056	0	0.000	0.004	253.51
169	328.05	3.48E-07	1.49E-02	2.49E+00	9.49E-05	1.26E-04	0	0.0	6.36E-03	3.36E-05	1.97E+02	51.5939	0.005	0.005	0.0043	0.055	0	0.000	0.004	253.57
186	328.23	3.48E-07	1.49E-02	2.49E+00	9.45E-05	1.26E-04	0	0.0	6.37E-03	3.36E-05	1.97E+02	51.6216	0.005	0.005	0.0043	0.055	0	0.000	0.004	253.69
507	329.35	3.49E-07	1.50E-02	2.50E+00	1.86E-03	1.26E-04	0	0.0	6.39E-03	3.37E-05	2.41E+02	51.7973	0.005	0.005	0.0043	0.000	0	0.797	0.003	144.65
827	329.60	3.50E-07	1.50E-02	2.50E+00	1.86E-03	1.26E-04	0	0.0	6.39E-03	3.38E-05	2.64E+02	5.18E+01	0.005	0.005	0.0043	0.000	0	0.799	0.003	88.6126
1147	329.71	3.50E-07	1.50E-02	2.50E+00	1.86E-03	1.26E-04	0	0.0	6.39E-03	3.38E-05	2.74E+02	5.19E+01	0.005	0.005	0.0043	0.000	0	0.799	0.003	64.0244
1468	329.77	3.50E-07	1.50E-02	2.50E+00	1.86E-03	1.26E-04	0	0.0	6.40E-03	3.38E-05	2.80E+02	5.19E+01	0.005	0.005	0.0043	0.000	0	0.800	0.003	50.2176
1788	329.82	3.50E-07	1.50E-02	2.50E+00	1.86E-03	1.26E-04	0	0.0	6.40E-03	3.38E-05	2.83E+02	5.19E+01	0.005	0.005	0.0043	0.000	0	0.800	0.003	41.3772
2108	329.84	3.50E-07	1.50E-02	2.50E+00	1.86E-03	1.26E-04	0	0.0	6.40E-03	3.38E-05	2.86E+02	5.19E+01	0.005	0.005	0.0043	0.000	0	0.800	0.003	35.2322
2429	329.86	3.50E-07	1.50E-02	2.50E+00	1.86E-03	1.26E-04	0	0.0	6.40E-03	3.38E-05	2.88E+02	5.19E+01	0.005	0.005	0.0043	0.000	0	0.800	0.003	30.713
2749	329.88	3.50E-07	1.50E-02	2.50E+00	1.86E-03	1.26E-04	0	0.0	6.40E-03	3.38E-05	2.89E+02	5.19E+01	0.005	0.005	0.0043	0.000	0	0.800	0.003	27.2499
3069	329.89	3.50E-07	1.50E-02	2.50E+00	1.86E-03	1.26E-04	0	0.0	6.40E-03	3.38E-05	2.90E+02	5.19E+01	0.005	0.005	0.0043	0.000	0	0.800	0.003	24.5113
3390	329.90	3.50E-07	1.50E-02	2.50E+00	1.86E-03	1.26E-04	0	0.0	6.40E-03	3.38E-05	2.91E+02	5.19E+01	0.005	0.005	0.0043	0.000	0	0.800	0.003	22.2915

SCENARIO 1 at pH 13.93

Dilution Ratio	Volume PoPA	Volume - Total	pH	Total Dissolved Solids	Temperature	Density	Cl(-1)	Salinity	Pb(+2)	P(+5)	Ni(+2)	Na(+1)	N(-3)
	L/hr	L/hr		mg/L	°C	kg/m3	mg/L	g/kg	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	5,900	13.9	49,508	30.0	1,072	0	0.0	0	0	0	43,459	0
3	20,000	25,882	13.8	36,840	13.2	1,037	14,226	24.8	3.30E-05	0.018	5.03E-07	19,004	0.016
7	40,000	45,894	13.6	35,498	11.0	1,032	16,045	28.1	3.72E-05	0.002	4.69E-07	15,845	0.018
10	60,000	65,912	13.4	34,906	10.1	1,030	16,758	29.4	3.89E-05	0.002	4.47E-07	14,603	0.018
14	80,000	85,932	13.3	34,591	9.69	1,028	17,139	30.1	3.98E-05	0.001	4.36E-07	13,939	0.019
17	1.00E+05	1.06E+05	13.1	34,397	9.41	1,028	17,375	30.5	4.03E-05	0.001	4.37E-07	13,527	0.019
34	2.00E+05	2.06E+05	12.5	33,707	8.82	1,026	17,869	31.5	4.15E-05	0.001	9.77E-07	12,666	0.020
41	2.40E+05	2.46E+05	12.1	33,504	8.72	1,026	17,954	31.6	4.17E-05	0.001	2.69E-06	12,517	0.020
47	2.80E+05	2.86E+05	11.2	33,396	8.65	1,026	18,015	31.7	4.18E-05	0.003	2.71E-05	12,411	0.020
54	3.20E+05	3.26E+05	10.9	33,420	8.61	1,026	18,062	31.8	4.19E-05	0.005	5.99E-05	12,331	0.020
61	3.60E+05	3.66E+05	10.8	33,445	8.57	1,026	18,099	31.9	4.20E-05	0.006	7.82E-05	12,269	0.020
68	4.00E+05	4.06E+05	10.7	33,466	8.54	1,026	18,129	31.9	4.21E-05	0.007	9.06E-05	12,218	0.020
75	4.40E+05	4.46E+05	10.7	33,484	8.52	1,026	18,153	32.0	4.21E-05	0.008	9.99E-05	12,177	0.020
81	4.80E+05	4.86E+05	10.6	33,498	8.50	1,026	18,174	32.0	4.22E-05	0.008	1.02E-04	12,143	0.020
88	5.20E+05	5.26E+05	10.6	33,510	8.48	1,026	18,191	32.0	4.22E-05	0.009	9.81E-05	12,114	0.020
95	5.60E+05	5.66E+05	10.6	33,532	8.47	1,026	18,206	32.1	4.22E-05	0.009	9.55E-05	12,089	0.020
102	6.00E+05	6.06E+05	10.6	33,557	8.46	1,026	18,218	32.1	4.23E-05	0.009	9.34E-05	12,067	0.020
108	6.40E+05	6.46E+05	10.6	33,579	8.44	1,026	18,230	32.1	4.23E-05	0.010	9.17E-05	12,048	0.020
115	6.80E+05	6.86E+05	10.6	33,599	8.43	1,026	18,240	32.1	4.23E-05	0.010	9.04E-05	12,031	0.020
122	7.20E+05	7.26E+05	10.6	33,616	8.43	1,026	18,248	32.1	4.23E-05	0.010	8.92E-05	12,016	0.020
129	7.60E+05	7.66E+05	10.6	33,630	8.42	1,026	18,256	32.2	4.24E-05	0.010	8.82E-05	12,003	0.020
136	8.00E+05	8.06E+05	10.5	33,639	8.41	1,026	18,264	32.2	4.24E-05	0.010	8.74E-05	11,991	0.020
142	8.40E+05	8.46E+05	10.5	33,645	8.41	1,026	18,270	32.2	4.24E-05	0.011	8.67E-05	11,980	0.020
149	8.80E+05	8.86E+05	10.5	33,650	8.40	1,026	18,276	32.2	4.24E-05	0.011	8.60E-05	11,970	0.020
156	9.20E+05	9.26E+05	10.5	33,652	8.39	1,026	18,281	32.2	4.24E-05	0.011	8.55E-05	11,961	0.020
163	9.60E+05	9.66E+05	10.5	33,655	8.39	1,026	18,286	32.2	4.24E-05	0.011	8.50E-05	11,953	0.020
169	1.00E+06	1.01E+06	10.5	33,662	8.39	1,026	18,291	32.2	4.24E-05	0.011	8.45E-05	11,945	0.020
186	1.10E+06	1.11E+06	10.5	33,677	8.38	1,026	18,301	32.2	4.25E-05	0.011	8.35E-05	11,928	0.020
507	2.99E+06	3.00E+06	10.5	33,697	8.31	1,026	18,363	32.3	4.26E-05	0.013	7.84E-05	11,822	0.020
827	4.88E+06	4.89E+06	8.87	33,686	8.30	1,026	18,378	32.4	4.26E-05	0.040	7.68E-05	11,798	0.020
1147	6.77E+06	6.78E+06	8.37	33,694	8.28	1,026	18,384	32.4	4.27E-05	0.040	2.51E-05	11,788	0.020
1468	8.66E+06	8.67E+06	8.21	33,700	8.28	1,026	18,387	32.4	4.27E-05	0.040	1.75E-05	11,782	0.020
1788	1.06E+07	1.06E+07	8.13	33,703	8.27	1,026	18,390	32.4	4.27E-05	0.040	1.45E-05	11,778	0.020
2108	1.24E+07	1.24E+07	8.08	33,705	8.27	1,026	18,391	32.4	4.27E-05	0.040	1.30E-05	11,775	0.020
2429	1.43E+07	1.43E+07	8.04	33,707	8.27	1,026	18,392	32.4	4.27E-05	0.040	1.20E-05	11,773	0.020
2749	1.62E+07	1.62E+07	8.02	33,708	8.26	1,026	18,393	32.4	4.27E-05	0.040	1.13E-05	11,772	0.020
3069	1.81E+07	1.81E+07	8.00	33,709	8.26	1,026	18,394	32.4	4.27E-05	0.040	1.08E-05	11,770	0.020
3390	2.00E+07	2.00E+07	7.98	33,710	8.26	1,026	18,395	32.4	4.27E-05	0.040	1.05E-05	11,769	0.020

Dilution Ratio	N(+5)	N(+3)	Mn(+2)	Mg(+2)	K(+1)	Hg(+2)	Fe(+2)	F(-1)	Cu(+2)	Cr(+6)	Cr(+3)	Co(+2)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	0	0	0	0	0	0	0	0	0	0	0
3	0.218	0.059	3.87E-03	0.000	255	2.71E-07	0.012	1.93	1.44E-03	9.78E-05	1.80E-07	3.19E-03
7	0.246	0.066	4.36E-03	0.001	288	3.05E-07	0.013	2.18	1.62E-03	1.10E-04	5.35E-08	3.59E-03
10	0.257	0.069	4.55E-03	0.002	301	3.19E-07	0.014	2.28	1.69E-03	1.15E-04	2.58E-08	3.75E-03
14	0.263	0.071	4.66E-03	0.003	307	3.26E-07	0.014	2.33	1.73E-03	1.18E-04	1.51E-08	3.84E-03
17	0.267	0.072	4.72E-03	0.004	312	3.31E-07	0.014	2.36	1.76E-03	1.19E-04	9.81E-09	3.89E-03
34	0.274	0.074	4.86E-03	0.048	320	3.40E-07	0.012	2.43	1.81E-03	1.23E-04	2.06E-09	4.00E-03
41	0.276	0.074	4.88E-03	0.258	322	3.42E-07	0.008	2.44	1.81E-03	1.23E-04	1.21E-09	4.02E-03
47	0.276	0.075	4.90E-03	16.3	323	3.43E-07	0.015	2.45	4.27E-04	1.24E-04	8.09E-10	4.01E-03
54	0.277	0.075	4.91E-03	71.4	324	3.44E-07	0.015	2.45	2.09E-04	1.24E-04	8.06E-10	3.99E-03
61	0.278	0.075	4.92E-03	117	325	3.44E-07	0.015	2.46	1.66E-04	1.24E-04	8.13E-10	3.97E-03
68	0.278	0.075	4.93E-03	154	325	3.45E-07	0.015	2.46	1.47E-04	1.25E-04	8.19E-10	3.97E-03
75	0.279	0.075	4.93E-03	184	326	3.45E-07	0.015	2.47	1.35E-04	1.25E-04	8.23E-10	3.97E-03
81	0.279	0.075	4.94E-03	210	326	3.46E-07	0.015	2.47	1.28E-04	1.25E-04	8.49E-10	3.76E-03
88	0.279	0.075	4.94E-03	231	326	3.46E-07	0.015	2.47	1.23E-04	1.25E-04	8.90E-10	3.44E-03
95	0.279	0.075	4.95E-03	250	327	3.46E-07	0.015	2.47	1.19E-04	1.25E-04	9.23E-10	3.21E-03
102	0.280	0.075	4.95E-03	266	327	3.47E-07	0.015	2.48	1.16E-04	1.25E-04	9.51E-10	3.04E-03
108	0.280	0.075	4.95E-03	280	327	3.47E-07	0.015	2.48	1.13E-04	1.25E-04	9.75E-10	2.90E-03
115	0.280	0.075	4.96E-03	292	327	3.47E-07	0.015	2.48	1.11E-04	1.25E-04	9.96E-10	2.79E-03
122	0.280	0.075	4.96E-03	304	327	3.47E-07	0.015	2.48	1.10E-04	1.25E-04	1.01E-09	2.70E-03
129	0.280	0.076	4.96E-03	314	327	3.47E-07	0.015	2.48	1.08E-04	1.26E-04	1.03E-09	2.63E-03
136	0.280	0.076	4.96E-03	322	328	3.47E-07	0.015	2.48	1.07E-04	1.26E-04	1.04E-09	2.56E-03
142	0.280	0.076	4.96E-03	331	328	3.48E-07	0.015	2.48	1.06E-04	1.26E-04	1.06E-09	2.51E-03
149	0.280	0.076	4.97E-03	338	328	3.48E-07	0.015	2.48	1.05E-04	1.26E-04	1.07E-09	2.46E-03
156	0.281	0.076	4.97E-03	345	328	3.48E-07	0.015	2.48	1.04E-04	1.26E-04	1.08E-09	2.42E-03
163	0.281	0.076	4.97E-03	351	328	3.48E-07	0.015	2.48	1.03E-04	1.26E-04	1.09E-09	2.38E-03
169	0.281	0.076	4.97E-03	357	328	3.48E-07	0.015	2.49	1.03E-04	1.26E-04	1.09E-09	2.35E-03
186	0.281	0.076	4.97E-03	369	328	3.48E-07	0.015	2.49	1.01E-04	1.26E-04	1.11E-09	2.28E-03
507	0.282	0.076	4.99E-03	448	329	3.49E-07	0.015	2.50	9.42E-05	1.26E-04	1.22E-09	1.93E-03
827	0.282	0.076	4.99E-03	459	330	3.50E-07	0.015	2.50	7.71E-04	1.26E-04	3.12E-08	4.04E-03
1147	0.282	0.076	5.00E-03	460	330	3.50E-07	0.015	2.50	1.86E-03	1.26E-04	1.83E-07	4.09E-03
1468	0.282	0.076	5.00E-03	460	330	3.50E-07	0.015	2.50	1.86E-03	1.26E-04	3.42E-07	4.10E-03
1788	0.282	0.076	5.00E-03	460	330	3.50E-07	0.015	2.50	1.86E-03	1.26E-04	4.88E-07	4.10E-03
2108	0.282	0.076	5.00E-03	460	330	3.50E-07	0.015	2.50	1.86E-03	1.26E-04	6.15E-07	4.11E-03
2429	0.282	0.076	5.00E-03	460	330	3.50E-07	0.015	2.50	1.86E-03	1.26E-04	7.24E-07	4.11E-03
2749	0.282	0.076	5.00E-03	460	330	3.50E-07	0.015	2.50	1.86E-03	1.26E-04	8.19E-07	4.11E-03
3069	0.282	0.076	5.00E-03	460	330	3.50E-07	0.015	2.50	1.86E-03	1.26E-04	9.01E-07	4.11E-03
3390	0.282	0.076	5.00E-03	460	330	3.50E-07	0.015	2.50	1.86E-03	1.26E-04	9.73E-07	4.11E-03

Dilution Ratio	Cd(+2)	Ca(+2)	Br(-1)	Be(+2)	Ba(+2)	As(+5)	Al(+3)	Zn(+2)	Si(+4)	Se(+4)	Sb(+5)	S(+6)	NiCr2O4
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2.61E-05	63.8	40.1	0.0039	0.0039	0.0033	0.116	0.005	0.506	0.001	0.008	625	0.0011
7	2.95E-05	173	45.3	0.0044	0.0044	0.0038	0.131	0.006	0.571	0.001	0.009	704	0.0012
10	3.08E-05	180	47.3	0.0046	0.0046	0.0039	0.137	0.006	0.370	0.001	0.009	736	0.0013
14	3.15E-05	184	48.3	0.0047	0.0047	0.0040	0.140	0.006	0.197	0.001	0.009	752	0.0013
17	3.19E-05	186	49.0	0.0047	0.0047	0.0041	0.142	0.006	0.118	0.001	0.009	763	0.0013
34	3.28E-05	191	50.4	0.0049	0.0049	0.0042	0.146	0.006	0.016	0.001	0.010	784	0.0014
41	3.30E-05	192	50.6	0.0049	0.0049	0.0042	0.146	0.006	0.006	0.001	0.010	788	0.0014
47	3.31E-05	193	50.8	0.0049	0.0049	0.0042	0.147	0.006	0.001	0.001	0.010	791	0.0013
54	3.32E-05	194	50.9	0.0049	0.0049	0.0042	0.140	0.006	0.000	0.001	0.010	793	0.0012
61	3.32E-05	194	51.1	0.0045	0.0049	0.0042	0.109	0.006	0.000	0.001	0.010	795	0.0011
68	3.33E-05	194	51.1	0.0042	0.0049	0.0042	0.095	0.006	0.000	0.001	0.010	796	0.0010
75	3.33E-05	195	51.2	0.0042	0.0049	0.0042	0.086	0.006	0.000	0.001	0.010	797	0.0010
81	3.34E-05	195	51.3	0.0042	0.0049	0.0042	0.081	0.006	0.000	0.001	0.010	798	0.0010
88	3.34E-05	195	51.3	0.0042	0.0049	0.0043	0.077	0.006	0.000	0.001	0.010	799	0.0010
95	3.34E-05	195	51.4	0.0042	0.0049	0.0043	0.074	0.006	0.000	0.001	0.010	799	0.0010
102	3.35E-05	196	51.4	0.0042	0.0050	0.0043	0.072	0.006	0.000	0.001	0.010	800	0.0010
108	3.35E-05	196	51.4	0.0042	0.0050	0.0043	0.070	0.006	0.000	0.001	0.010	800	0.0010
115	3.35E-05	196	51.4	0.0042	0.0050	0.0043	0.068	0.006	0.000	0.001	0.010	801	0.0011
122	3.35E-05	196	51.5	0.0042	0.0050	0.0043	0.067	0.006	0.000	0.001	0.010	801	0.0011
129	3.35E-05	196	51.5	0.0043	0.0050	0.0043	0.066	0.006	0.000	0.001	0.010	801	0.0011
136	3.35E-05	196	51.5	0.0043	0.0050	0.0043	0.065	0.006	0.000	0.001	0.010	802	0.0011
142	3.36E-05	196	51.5	0.0043	0.0050	0.0043	0.064	0.006	0.000	0.001	0.010	802	0.0011
149	3.36E-05	196	51.5	0.0043	0.0050	0.0043	0.063	0.006	0.000	0.001	0.010	802	0.0011
156	3.36E-05	196	51.6	0.0043	0.0050	0.0043	0.062	0.006	0.000	0.001	0.010	803	0.0011
163	3.36E-05	196	51.6	0.0043	0.0050	0.0043	0.062	0.006	0.000	0.001	0.010	803	0.0011
169	3.36E-05	197	51.6	0.0043	0.0050	0.0043	0.061	0.006	0.000	0.001	0.010	803	0.0011
186	3.36E-05	197	51.6	0.0044	0.0050	0.0043	0.060	0.006	0.000	0.001	0.010	803	0.0011
507	3.37E-05	197	51.8	0.0046	0.0050	0.0043	0.054	0.006	0.000	0.001	0.010	806	0.0011
827	3.38E-05	211	51.8	0.0050	0.0050	0.0043	0.001	0.006	0.654	0.001	0.010	807	0.0011
1147	3.38E-05	236	51.9	0.0050	0.0050	0.0043	0.000	0.006	0.654	0.001	0.010	807	0.0013
1468	3.38E-05	250	51.9	0.0050	0.0050	0.0043	0.000	0.006	0.654	0.001	0.010	807	0.0013
1788	3.38E-05	259	51.9	0.0050	0.0050	0.0043	0.000	0.006	0.654	0.001	0.010	807	0.0014
2108	3.38E-05	265	51.9	0.0050	0.0050	0.0043	0.000	0.006	0.654	0.001	0.010	807	0.0014
2429	3.38E-05	270	51.9	0.0050	0.0050	0.0043	0.000	0.006	0.654	0.001	0.010	807	0.0014
2749	3.38E-05	273	51.9	0.0050	0.0050	0.0043	0.000	0.006	0.654	0.001	0.010	807	0.0014
3069	3.38E-05	276	51.9	0.0050	0.0050	0.0043	0.000	0.006	0.654	0.001	0.010	808	0.0014
3390	3.38E-05	278	51.9	0.0050	0.0050	0.0043	0.000	0.006	0.654	0.001	0.010	808	0.0014

Dilution Ratio	NaAlCO3(OH)2 (Dawsonite)	Mg3Si2O5(OH)4 (Poor-crystalline Antigorite)	Mg(OH)2 (Brucite)	Fe(OH)2 (Amakinite)	CuO	CoCr2O4	Co3(PO4)2.8H2O	CaCO3 (Calcite)	Ca3(PO4)2	Ca(OH)2 (Portlandite)	Be2(OH)2CO3	Al(OH)3 (Gibbsite)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	0	0	0	0	0	0	0	0	0	0	0
3	0.0	0	853	0	0	0.0026	0	177	0.064	179	0	0
7	0.0	0	962	0	0	0.0030	0	221	0.163	0	0	0
10	0.0	1.11	1,005	0	0	0.0031	0	232	0.174	0	0	0
14	0.0	2.04	1,027	0	0	0.0032	0	238	0.180	0	0	0
17	0.0	2.47	1,041	0	0	0.0032	0	242	0.183	0	0	0
34	0.0	3.06	1,070	3.55E-03	0	0.0033	0	249	0.189	0	0	0
41	0.0	3.12	1,074	0.010	0	0.0033	0	251	0.190	0	0	0
47	0.0	3.16	1,040	0	0.0017	0.0034	0	251	0.183	0	0	0
54	0.0	3.17	910	0	0.0020	0.0036	0	252	0.173	0	0	0.020
61	0.0	3.17	803	0	0.0021	0.0036	0	252	0.167	0	0.0028	0.111
68	0.0	3.18	716	0	0.0021	0.0037	0	252	0.163	0	0.0042	0.153
75	0.0	3.18	645	0	0.0021	0.0037	0	253	0.159	0	0.0047	0.178
81	0.0	3.19	585	0	0.0021	0.0037	0.0006	253	0.156	0	0.0049	0.194
88	0.0	3.19	534	0	0.0021	0.0037	0.0015	253	0.154	0	0.0049	0.206
95	0.0	3.19	491	0	0.0022	0.0037	0.0022	253	0.152	0	0.0048	0.215
102	0.0	3.20	453	0	0.0022	0.0037	0.0027	253	0.150	0	0.0048	0.223
108	0.0	3.20	420	0	0.0022	0.0037	0.0031	253	0.148	0	0.0047	0.228
115	0.0	3.20	390	0	0.0022	0.0037	0.0035	253	0.147	0	0.0046	0.233
122	0.0	3.20	364	0	0.0022	0.0037	0.0037	253	0.146	0	0.0045	0.237
129	0.0	3.20	341	0	0.0022	0.0037	0.0040	254	0.145	0	0.0044	0.240
136	0.0	3.20	320	0	0.0022	0.0037	0.0042	254	0.144	0	0.0043	0.243
142	0.0	3.20	301	0	0.0022	0.0037	0.0043	254	0.143	0	0.0042	0.246
149	0.0	3.21	283	0	0.0022	0.0037	0.0045	254	0.142	0	0.0041	0.248
156	0.0	3.21	268	0	0.0022	0.0037	0.0046	254	0.142	0	0.0040	0.250
163	0.0	3.21	253	0	0.0022	0.0037	0.0047	254	0.141	0	0.0040	0.252
169	0.0	3.21	240	0	0.0022	0.0037	0.0048	254	0.140	0	0.0039	0.254
186	0.0	3.21	210	0	0.0022	0.0037	0.0050	254	0.139	0	0.0038	0.257
507	0.0	3.22	25	0	0.0022	0.0037	0.0061	255	0.132	0	0.0027	0.275
827	0.0	0	0	0	0.0014	0.0037	0	222	0	0	0	0.429
1147	0.798	0	0	0	0	0.0035	0	160	0	0	0	0
1468	0.799	0	0	0	0	0.0034	0	125	0	0	0	0
1788	0.799	0	0	0	0	0.0034	0	102	0	0	0	0
2108	0.799	0	0	0	0	0.0034	0	86.7	0	0	0	0
2429	0.800	0	0	0	0	0.0034	0	75.3	0	0	0	0
2749	0.800	0	0	0	0	0.0034	0	66.6	0	0	0	0
3069	0.800	0	0	0	0	0.0034	0	59.7	0	0	0	0
3390	0.800	0	0	0	0	0.0034	0	54.2	0	0	0	0

SCENARIO 2A

Dilution Ratio	Volume PoPA	Volume - Total	pH	Total Dissolved Solids	Temperature	Density - Total	Cl(-1)	Salinity	Si(+4)	S(+6)	Ni(+2)	Na(+1)	Mg(+2)	K(+1)	Fe(+3)	Cr(+3)	Co(+2)	Ca(+2)	Br(-1)	Al(+3)	Ti(+4)	TiO2 (Rutile)	SiO2 (lechatelierite)	NiFe2O4 (Trevorite)	NiCr2O4	NaAlCO3(OH)2 (Dawsonite)	CaCO3 (Calcite)
	L/hr	L/hr		mg/L	°C	kg/m3	mg/L	g/kg	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	5,900	2.26	28,755	30	1,020	22,041	39.0	53.6	0	18.1	0	7,379	0	2.43	0.05	0.853	138	0	1.13	0.002	0.098906	131	0	0	0	0
8	50,000	55,894	6.53	33,419	10.5	1,025	18,787	33.1	12.7	723	1.78	10,520	1,190	295	4.29E-08	1.07E-05	0.095	283	46.4	0.0099	0.001	8.41E-03	0	0.5379	0.016	1.300	0
17	1.00E+05	105,893	6.92	33,640	9.46	1,025	18,604	32.8	7.01	763	0.94	11,106	846	312	1.25E-08	1.28E-06	0.052	291	49.0	0.0008	0.001	3.31E-03	0	0.2839	0.011	1.088	0
25	1.50E+05	1.56E+05	7.12	33,500	9.07	1,025	18,539	32.7	4.97	777	0.64	11,315	722	318	7.48E-09	4.55E-07	0.037	294	49.9	0.0002	0.001	1.48E-03	0	0.1929	0.009	0.997	0
34	2.00E+05	2.06E+05	7.24	33,646	8.87	1,026	18,505	32.6	3.92	785	0.48	11,423	658	321	5.59E-09	2.37E-07	0.029	295	50.4	0.0001	0.001	5.36E-04	0	0.1460	0.008	0.950	0
42	2.50E+05	2.56E+05	7.34	33,735	8.75	1,026	18,485	32.6	3.29	789	0.39	11,489	620	322	4.63E-09	1.51E-07	0.025	296	50.7	7.60E-05	0.001	0	0	0.1175	0.007	0.921	0
51	3.00E+05	3.06E+05	7.40	33,794	8.67	1,026	18,471	32.5	2.86	792	0.32	11,533	593	324	4.07E-09	1.08E-07	0.021	297	50.9	5.95E-05	0.001	0	0	0.0983	0.007	0.901	0
59	3.50E+05	3.56E+05	7.46	33,837	8.61	1,026	18,461	32.5	2.55	794	0.28	11,565	575	325	3.71E-09	8.44E-08	0.019	297	51.0	5.16E-05	0.001	0	0	0.0845	0.007	0.887	0
68	4.00E+05	4.06E+05	7.50	33,870	8.56	1,026	18,453	32.5	2.31	796	0.24	11,589	561	325	3.47E-09	6.96E-08	0.017	298	51.1	4.75E-05	8.92E-04	0	0	0.0741	0.006	0.876	0
76	4.50E+05	4.56E+05	7.54	33,895	8.53	1,026	18,447	32.5	2.13	797	0.22	11,608	550	326	3.30E-09	5.98E-08	0.016	298	51.2	4.55E-05	7.94E-04	0	0	0.0660	0.006	0.868	0
85	5.00E+05	5.06E+05	7.57	33,884	8.50	1,026	18,443	32.5	1.99	798	0.20	11,623	541	326	3.17E-09	5.29E-08	0.015	298	51.3	4.44E-05	7.16E-04	0	0	0.0594	0.006	0.861	0
93	5.50E+05	5.56E+05	7.59	33,871	8.48	1,026	18,439	32.5	1.87	799	0.18	11,635	533	327	3.09E-09	4.80E-08	0.014	298	51.3	4.40E-05	6.52E-04	0	0	0.0541	0.006	0.856	0
102	6.00E+05	6.06E+05	7.62	33,861	8.46	1,026	18,436	32.5	1.77	800	0.16	11,646	527	327	3.02E-09	4.43E-08	0.013	298	51.4	4.39E-05	5.98E-04	0	0	0.0496	0.006	0.851	0
110	6.50E+05	6.56E+05	7.64	33,851	8.44	1,026	18,433	32.5	1.68	801	0.15	11,654	522	327	2.97E-09	4.15E-08	0.013	299	51.4	4.40E-05	5.52E-04	0	0	0.0458	0.006	0.847	0
119	7.00E+05	7.06E+05	7.65	33,849	8.43	1,026	18,431	32.5	1.61	801	0.14	11,662	518	327	2.94E-09	3.93E-08	0.012	299	51.5	4.43E-05	5.13E-04	0	0	0.0426	0.006	0.844	0
127	7.50E+05	7.56E+05	7.67	33,851	8.42	1,026	18,429	32.5	1.55	801	0.13	11,668	514	327	2.92E-09	3.76E-08	0.012	299	51.5	4.46E-05	4.79E-04	0	0	0.0398	0.006	0.841	0
136	8.00E+05	8.06E+05	7.68	33,853	8.41	1,026	18,427	32.5	1.49	802	0.12	11,674	511	328	2.90E-09	3.62E-08	0.011	299	51.5	4.49E-05	4.49E-04	0	0	0.0373	0.006	0.839	0
144	8.50E+05	8.56E+05	7.69	33,825	8.40	1,026	18,425	32.5	1.44	802	0.12	11,679	508	328	2.89E-09	3.50E-08	0.011	299	51.5	4.53E-05	4.23E-04	0	0	0.0351	0.006	0.836	0
153	9.00E+05	9.06E+05	7.70	33,856	8.39	1,026	18,424	32.5	1.40	803	0.11	11,684	505	328	2.89E-09	3.41E-08	0.011	299	51.6	4.56E-05	4.00E-04	0	0	0.0332	0.005	0.834	0
161	9.50E+05	9.56E+05	7.71	33,858	8.38	1,026	18,423	32.5	1.36	803	0.10	11,688	503	328	2.89E-09	3.33E-08	0.010	299	51.6	4.60E-05	3.79E-04	0	0	0.0315	0.005	0.833	0
169	1.00E+06	1.01E+06	7.72	33,813	8.38	1,026	18,422	32.4	1.32	803	0.10	11,691	501	328	2.89E-09	3.27E-08	0.010	299	51.6	4.64E-05	3.60E-04	0	0	0.0299	0.005	0.831	0
254	1.50E+06	1.51E+06	7.78	33,789	8.33	1,026	18,414	32.4	1.10	805	0.07	11,714	487	329	3.03E-09	3.02E-08	0.008	299	51.7	4.94E-05	2.40E-04	0	0	0.0200	0.005	0.821	0
330	1.95E+06	1.96E+06	7.81	33,777	8.32	1,026	18,411	32.4	1.00	805	0.05	11,725	481	329	3.21E-09	3.03E-08	0.008	300	51.7	5.12E-05	1.85E-04	0	0	0.0154	0.005	0.816	0
407	2.40E+06	2.41E+06	7.82	33,874	8.30	1,026	18,409	32.4	0.93	806	0.04	11,731	477	329	3.40E-09	3.11E-08	0.007	300	51.8	5.24E-05	1.51E-04	0	0	0.0125	0.005	0.813	0
483	2.85E+06	2.86E+06	7.84	33,876	8.29	1,026	18,408	32.4	0.89	806	0.03	11,736	474	329	3.60E-09	3.21E-08	0.007	300	51.8	5.33E-05	1.27E-04	0	0	0.0105	0.005	0.811	0
559	3.30E+06	3.31E+06	7.84	33,877	8.29	1,026	18,407	32.4	0.86	806	0.03	11,739	472	329	3.79E-09	3.33E-08	0.007	300	51.8	5.40E-05	1.10E-04	0	0	0.0091	0.005	0.810	0
636	3.75E+06	3.76E+06	7.85	33,878	8.28	1,026	18,406	32.4	0.83	807	0.03	11,742	471	329	3.98E-09	3.45E-08	0.006	300	51.8	5.45E-05	9.64E-05	0	0	0.0080	0.005	0.808	0
712	4.20E+06	4.21E+06	7.85	33,878	8.28	1,026	18,405	32.4	0.81	807	0.02	11,744	470	330	4.20E-09	3.64E-08	0.006	300	51.8	5.46E-05	8.61E-05	0	0	0.0071	0.005	0.808	0.096
788	4.65E+06	4.66E+06	7.85	33,879	8.28	1,026	18,405	32.4	0.80	807	0.02	11,745	469	330	4.43E-09	3.84E-08	0.006	300	51.8	5.46E-05	7.78E-05	0	0	0.0065	0.005	0.807	0.191
864	5.10E+06	5.11E+06	7.85	33,879	8.28	1,026	18,404	32.4	0.79	807	0.02	11,746	468	330	4.65E-09	4.03E-08	0.006	300	51.8	5.46E-05	7.09E-05	0	0	0.0059	0.005	0.806	0.269
941	5.55E+06	5.56E+06	7.85	33,880	8.27	1,026	18,404	32.4	0.78	807	0.02	11,748	467	330	4.85E-09	4.21E-08	0.006	300	51.8	5.46E-05	6.52E-05	0	0	0.0054	0.005	0.806	0.334
1017	6.00E+06	6.01E+06	7.85	33,880	8.27	1,026	18,404	32.4	0.77	807	0.02	11,749	467	330	5.06E-09	4.38E-08	0.006	300	51.8	5.46E-05	6.03E-05	0	0	0.0050	0.005	0.805	0.390
1102	6.50E+06	6.51E+06	7.85	33,881	8.27	1,026	18,403	32.4	0.76	807	0.01	11,749	466	330	5.27E-09	4.57E-08	0.006	300	51.9	5.46E-05	5.57E-05	0	0	0.0046	0.005	0.805	0.443

SCENARIO 2B

Dilution Ratio	Volume - Reconcile_PoPA_WO	Volume - Total	pH	Total Dissolved Solids	Temperature	Density - Total	Cl(-1)	Salinity	Si(+4)	Se(+4)	S(+6)	Pb(+2)	P(+5)	Ni(+2)	Na(+1)	N(-3)	Mo(+6)	Mg(+2)	K(+1)	Hg(+2)	Co(+2)	Zn(+2)	Cd(+2)	Ca(+2)	Br(-1)	As(+5)	NiCr2O4	NaAlCO3(OH)2 (Dawsonite)	CoCr2O4	CaF2 (Fluorite)	CaCO3 (Calcite)
	L/hr	L/hr		mg/L	°C	kg/m3	mg/L	g/kg	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	5,901	8.10	39,282	30.0	1,028	25,165	44.2	0	0.0192	0	2.50E-03	0	1.00E-03	107	0	1.00E-04	198	0	2.00E-03	3.00E-04	3.00E-04	2.00E-04	13,805	0	0.100	0	0	0	0	463
8	50,000	55,892	7.18	34,511	10.5	1,026	19,117	33.7	0.585	0.0027	723	3.02E-04	0.036	2.02E-06	10,532	0.018	1.06E-05	432	295	2.11E-04	3.89E-03	5.76E-03	5.14E-05	1,718	46.4	0.014	0.0017	0.72	0.0024	0.09	67.1
17	#######	105,891	7.36	34,217	9.45	1,026	18,779	33.1	0.618	0.0018	763	1.80E-04	0.038	2.80E-06	11,112	0.019	5.57E-06	445	312	1.12E-04	3.98E-03	6.06E-03	4.31E-05	1,047	49.0	0.010	0.0015	0.76	0.0029	0	38.9
25	#######	#######	7.46	33,567	9.06	1,026	18,657	32.9	0.630	0.0015	777	1.36E-04	0.038	3.40E-06	11,320	0.019	3.78E-06	450	318	7.60E-05	4.02E-03	6.17E-03	4.01E-05	807	49.9	0.008	0.0015	0.77	0.0031	0	27.8
34	#######	#######	7.52	34,056	8.87	1,026	18,595	32.8	0.636	0.0013	785	1.13E-04	0.039	3.88E-06	11,427	0.020	2.87E-06	453	321	5.77E-05	4.04E-03	6.23E-03	3.86E-05	684	50.4	0.007	0.0015	0.78	0.0032	0	21.9
42	#######	#######	7.57	34,023	8.75	1,026	18,557	32.7	0.639	0.0012	789	9.94E-05	0.039	4.26E-06	11,492	0.020	2.31E-06	454	322	4.65E-05	4.06E-03	6.26E-03	3.76E-05	608	50.7	0.007	0.0015	0.78	0.0032	0	18.1
51	#######	#######	7.60	34,000	8.67	1,026	18,531	32.6	0.642	0.0011	792	9.01E-05	0.039	4.58E-06	11,536	0.020	1.93E-06	455	324	3.89E-05	4.07E-03	6.28E-03	3.70E-05	558	50.9	0.006	0.0014	0.78	0.0032	0	15.6
59	#######	#######	7.63	33,984	8.61	1,026	18,513	32.6	0.644	0.0011	794	8.34E-05	0.039	4.84E-06	11,567	0.020	1.66E-06	456	325	3.35E-05	4.07E-03	6.30E-03	3.66E-05	522	51.0	0.006	0.0014	0.79	0.0033	0	13.7
68	#######	#######	7.65	33,972	8.56	1,026	18,499	32.6	0.645	0.0011	796	7.84E-05	0.039	5.07E-06	11,591	0.020	1.45E-06	456	325	2.94E-05	4.08E-03	6.31E-03	3.62E-05	494	51.1	0.006	0.0014	0.79	0.0033	0	12.2
76	#######	#######	7.67	33,962	8.53	1,026	18,488	32.6	0.646	0.0010	797	7.45E-05	0.039	5.26E-06	11,610	0.020	1.29E-06	457	326	2.62E-05	4.08E-03	6.32E-03	3.60E-05	473	51.2	0.006	0.0014	0.79	0.0033	0	11.1
85	#######	#######	7.68	33,955	8.50	1,026	18,479	32.5	0.647	9.98E-04	798	7.14E-05	0.040	5.43E-06	11,624	0.020	1.17E-06	457	326	2.37E-05	4.09E-03	6.33E-03	3.57E-05	456	51.3	0.005	0.0014	0.79	0.0033	0	10.2
93	#######	#######	7.70	33,948	8.48	1,026	18,472	32.5	0.647	9.78E-04	799	6.88E-05	0.040	5.58E-06	11,637	0.020	1.06E-06	457	327	2.16E-05	4.09E-03	6.34E-03	3.56E-05	442	51.4	0.005	0.0014	0.79	0.0033	0	9.38
102	#######	#######	7.71	33,943	8.46	1,026	18,466	32.5	0.648	9.62E-04	800	6.66E-05	0.040	5.71E-06	11,647	0.020	9.74E-07	457	327	1.98E-05	4.09E-03	6.34E-03	3.54E-05	430	51.4	0.005	0.0014	0.79	0.0033	0	8.73
110	#######	#######	7.72	33,939	8.44	1,026	18,461	32.5	0.649	9.49E-04	801	6.48E-05	0.040	5.82E-06	11,655	0.020	8.99E-07	458	327	1.83E-05	4.09E-03	6.35E-03	3.53E-05	420	51.4	0.005	0.0014	0.79	0.0033	0	8.18
119	#######	#######	7.72	33,935	8.43	1,026	18,457	32.5	0.649	9.37E-04	801	6.32E-05	0.040	5.93E-06	11,663	0.020	8.36E-07	458	327	1.71E-05	4.09E-03	6.35E-03	3.52E-05	411	51.5	0.005	0.0014	0.79	0.0033	0	7.70
127	#######	#######	7.73	33,932	8.42	1,026	18,453	32.5	0.649	9.27E-04	802	6.19E-05	0.040	6.02E-06	11,669	0.020	7.80E-07	458	327	1.60E-05	4.10E-03	6.35E-03	3.51E-05	404	51.5	0.005	0.0014	0.79	0.0033	0	7.28
136	#######	#######	7.74	33,929	8.41	1,026	18,450	32.5	0.650	9.18E-04	802	6.07E-05	0.040	6.11E-06	11,675	0.020	7.32E-07	458	328	1.50E-05	4.10E-03	6.36E-03	3.50E-05	397	51.5	0.005	0.0014	0.79	0.0033	0	6.92
144	#######	#######	7.74	33,926	8.40	1,026	18,447	32.5	0.650	9.10E-04	802	5.96E-05	0.040	6.19E-06	11,680	0.020	6.89E-07	458	328	1.41E-05	4.10E-03	6.36E-03	3.49E-05	392	51.5	0.005	0.0014	0.79	0.0034	0	6.59
153	#######	#######	7.75	33,924	8.39	1,026	18,444	32.5	0.650	9.03E-04	803	5.87E-05	0.040	6.26E-06	11,684	0.020	6.51E-07	458	328	1.34E-05	4.10E-03	6.36E-03	3.49E-05	387	51.6	0.005	0.0014	0.80	0.0034	0	6.30
161	#######	#######	7.75	33,922	8.38	1,026	18,442	32.5	0.650	8.97E-04	803	5.79E-05	0.040	6.32E-06	11,688	0.020	6.17E-07	458	328	1.27E-05	4.10E-03	6.36E-03	3.48E-05	382	51.6	0.005	0.0014	0.80	0.0034	0	6.04
169	#######	#######	7.76	33,920	8.38	1,026	18,440	32.5	0.651	8.91E-04	803	5.71E-05	0.040	6.38E-06	11,692	0.020	5.86E-07	458	328	1.21E-05	4.10E-03	6.36E-03	3.48E-05	378	51.6	0.005	0.0014	0.80	0.0034	0	5.80
254	#######	#######	7.79	33,908	8.33	1,026	18,427	32.5	0.652	8.55E-04	805	5.23E-05	0.040	6.80E-06	11,714	0.020	3.92E-07	459	329	8.18E-06	4.10E-03	6.38E-03	3.45E-05	352	51.7	0.005	0.0014	0.80	0.0034	0	4.27
330	#######	#######	7.80	33,903	8.31	1,026	18,421	32.4	0.652	8.38E-04	805	5.01E-05	0.040	7.01E-06	11,725	0.020	3.02E-07	459	329	6.38E-06	4.11E-03	6.38E-03	3.43E-05	340	51.7	0.005	0.0014	0.80	0.0034	0	3.56
407	#######	#######	7.81	33,899	8.30	1,026	18,417	32.4	0.653	8.28E-04	806	4.87E-05	0.040	7.15E-06	11,732	0.020	2.45E-07	459	329	5.25E-06	4.11E-03	6.39E-03	3.42E-05	332	51.8	0.005	0.0014	0.80	0.0034	0	3.10
483	#######	#######	7.82	33,897	8.29	1,026	18,414	32.4	0.653	8.21E-04	806	4.78E-05	0.040	7.25E-06	11,736	0.020	2.07E-07	459	329	4.48E-06	4.11E-03	6.39E-03	3.41E-05	327	51.8	0.005	0.0014	0.80	0.0034	0	2.79
559	#######	#######	7.82	33,895	8.29	1,026	18,412	32.4	0.653	8.16E-04	806	4.71E-05	0.040	7.33E-06	11,739	0.020	1.78E-07	460	329	3.92E-06	4.11E-03	6.39E-03	3.41E-05	323	51.8	0.004	0.0014	0.80	0.0034	0	2.56
635	#######	#######	7.83	33,894	8.28	1,026	18,411	32.4	0.653	8.12E-04	807	4.66E-05	0.040	7.39E-06	11,742	0.020	1.57E-07	460	329	3.49E-06	4.11E-03	6.39E-03	3.41E-05	321	51.8	0.004	0.0014	0.80	0.0034	0	2.38
712	#######	#######	7.83	33,893	8.28	1,026	18,410	32.4	0.653	8.09E-04	807	4.61E-05	0.040	7.43E-06	11,744	0.020	1.40E-07	460	330	3.16E-06	4.11E-03	6.39E-03	3.40E-05	318	51.8	0.004	0.0014	0.80	0.0034	0	2.24
788	#######	#######	7.83	33,892	8.28	1,026	18,409	32.4	0.654	8.06E-04	807	4.58E-05	0.040	7.47E-06	11,745	0.020	1.27E-07	460	330	2.88E-06	4.11E-03	6.39E-03	3.40E-05	316	51.8	0.004	0.0014	0.80	0.0034	0	2.13
864	#######	#######	7.83	33,891	8.27	1,026	18,408	32.4	0.654	8.04E-04	807	4.55E-05	0.040	7.50E-06	11,747	0.020	1.16E-07	460	330	2.66E-06	4.11E-03	6.39E-03	3.40E-05	315	51.8	0.004	0.0014	0.80	0.0034	0	2.04
941	#######	#######	7.83	33,891	8.27	1,026	18,407	32.4	0.654	8.02E-04	807	4.53E-05	0.040	7.53E-06	11,748	0.020	1.06E-07	460	330	2.47E-06	4.11E-03	6.39E-03	3.40E-05	314	51.8	0.004	0.0014	0.80	0.0034	0	1.96
1017	#######	#######	7.84	33,890	8.27	1,026	18,407	32.4	0.654	8.01E-04	807	4.51E-05	0.040	7.55E-06	11,749	0.020	9.82E-08	460	330	2.31E-06	4.11E-03	6.39E-03	3.40E-05	313	51.8	0.004	0.0014	0.80	0.0034	0	1.90
1102	#######	#######	7.84	33,890	8.27	1,026	18,406	32.4	0.654	7.99E-04	807	4.49E-05	0.040	7.57E-06	11,750	0.020	9.07E-08	460	330	2.16E-06	4.11E-03	6.39E-03	3.40E-05	312	51.9	0.004	0.0014	0.80	0.0034	0	1.83
2158	#######	#######	7.85	33,887	8.26	1,026	18,403	32.4	0.654	7.91E-04	807	4.38E-05	0.040	7.71E-06	11,755	0.020	4.63E-08	460	330	1.28E-06	4.11E-03	6.40E-03	3.39E-05	306	51.9	0.004	0.0014	0.80	0.0034	0	1.46
3214	#######	#######	7.85	33,886	8.26	1,026	18,402	32.4	0.654	7.89E-04	808	4.35E-05	0.040	7.75E-06	11,756	0.020	3.11E-08	460	330	9.72E-07	4.11E-03	6.40E-03	3.39E-05	304	51.9	0.004	0.0014	0.80	0.0034	0	1.34
4270	#######	#######	7.85	33,886	8.26	1,026	18,402	32.4	0.654	7.87E-04	808	4.33E-05	0.040	7.78E-06	11,757	0.020	2.34E-08	460	330	8.18E-07	4.11E-03	6.40E-03	3.38E-05	303	51.9	0.004	0.0014	0.80	0.0034	0	1.27
5327	#######	#######	7.85	33,886	8.25	1,026	18,401	32.4	0.654	7.86E-04	808	4.32E-05	0.040	7.79E-06	11,758	0.020	1.88E-08	460	330	7.25E-07	4.11E-03	6.40E-03	3.38E-05	302	51.9	0.004	0.0014	0.80	0.0034	0	1.23
6383	#######	#######	7.85	33,885	8.25	1,026	18,401	32.4	0.654	7.86E-04	808	4.31E-05	0.040	7.80E-06	11,758	0.020	0	460	330	6.63E-07	4.11E-03	6.40E-03	3.38E-05	302	51.9	0.004	0.0014	0.80	0.0034	0	1.21
7439	#######	#######	7.85	33,885	8.25	1,026	18,401	32.4	0.654	7.85E-04	808	4.30E-05	0.040	7.81E-06	11,758	0.020	0	460	330	6.19E-07	4.11E-03	6.40E-03	3.38E-05	301	51.9	0.004	0.0014	0.80	0.0034	0	1.19
8496	#######	#######	7.85	33,885	8.25	1,026	18,401	32.4	0.654	7.85E-04	808	4.30E-05	0.040	7.81E-06	11,759	0.020	0	460	330	5.85E-07	4.11E-03	6.40E-03	3.38E-05	301	51.9	0.004	0.0014	0.80	0.0034	0	1.17
9552	#######	#######	7.85	33,885	8.25	1,026	18,401	32.4	0.654	7.85E-04	808	4.30E-05	0.040	7.82E-06	11,759	0.020	0	460	330	5.59E-07	4.11E-03	6.40E-03	3.38E-05	301	51.9	0.004	0.0014	0.80	0.0034	0	1.16
10608	#######	#######	7.85	33,885	8.25	1,026	18,401	32.4	0.654	7.85E-04	808	4.29E-05	0.040	7.82E-06	11,759	0.020	0	460	330	5.38E-07	4.11E-03	6.40E-03	3.38E-05	301	51.9	0.004	0.0014	0.80	0.0034	0	1.15
11665	#######	#######	7.85	33,885	8.25	1,026	18,401	32.4	0.654	7.84E-04	808	4.29E-05	0.040	7.82E-06	11,759	0.020	0	460	330	5.21E-07	4.11E-03	6.40E-03	3.38E-05	301	51.9	0.004	0.0014	0.80	0.0034	0	1.15
12721	#######	#######	7.85	33,885	8.25	1,026	18,401	32.4	0.654	7.84E-04	808	4.29E-05	0.040	7.82E-06	11,759	0.020	0	460	330	5.07E-07	4.11E-03	6.40E-03	3.38E-05	301	51.9	0.004	0.0014	0.80	0.0034	0	1.14
13777	#######	#######	7.85	33,885	8.25	1,026	18,401	32.4	0.654	7.84E-04	808	4.29E-05	0.040	7.83E-06	11,759	0.020	0	460	330	4.95E-07	4.11E-03	6.40E-03	3.38E-05	301	51.9	0.004	0.0014	0.80	0.0034	0	1.14
14834	#######	#######	7.85	33,885	8.25	1,026	18,401	32.4	0.654	7.84E-04	808	4.29E-05	0.040	7.83E-06	11,759	0.020	0	460	330	4.85E-07	4.11E-03	6.40E-03	3.38E-05	300	51.9	0.004	0.0014	0.80	0.0034	0	1.13
15890	#######	#######	7.85	33,885	8.25	1,026	18,400	32.4	0.654	7.84E-04	808	4.29E-05	0.040	7.83E-06	11,759	0.020	0	460	330	4.76E-07	4.11E-03	6.40E-03	3.38E-05	300	51.9	0.004	0.0014	0.80	0.0034	0	1.13
16946	#######	#######	7.85	33,885	8.25	1,026	18,400	32.4	0.654	7.84E-04	808	4.28E-05	0.040	7.83E-06	11,759	0.020	0	460	330	4.68E-07	4.11E-03	6.40E-03	3.38E-05	300	51.9	0.004	0.0014	0.80	0.0034	0	1.12

SCENARIO 3

Dilution Ratio	Volume - PoPA	Volume - Total	pH	Total Dissolved Solids	Temperature	Density - Total	Cl(-1)	Salinity	Si(+4)	Se(+4)	Sb(+5)	S(+6)	Pb(+2)
	L/hr	L/hr		mg/L	°C	kg/m3	mg/L	g/kg	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	27,001	7.10	55,069	17.0	1,042	31,372	54.4	0	7.83E-04	0	1,643	0.003
0.4	10,000	36,995	7.24	49,219	14.6	1,037	27,870	48.5	0.18	7.83E-04	0.003	1,417	0.002
0.7	20,000	46,992	7.33	45,859	13.3	1,035	25,857	45.1	0.28	7.83E-04	0.004	1,288	0.001
1.1	30,000	56,990	7.39	43,681	12.4	1,033	24,549	42.9	0.34	7.83E-04	0.005	1,204	0.001
1.5	40,000	66,989	7.44	42,157	11.8	1,032	23,632	41.4	0.39	7.83E-04	0.006	1,145	0.001
1.9	50,000	76,987	7.48	41,032	11.3	1,031	22,952	40.2	0.43	7.83E-04	0.006	1,101	9.05E-04
2.2	60,000	86,987	7.51	40,463	10.9	1,031	22,429	39.3	0.45	7.83E-04	0.007	1,067	8.05E-04
2.6	70,000	96,986	7.54	39,785	10.7	1,030	22,014	38.6	0.47	7.83E-04	0.007	1,040	7.27E-04
3.0	80,000	1.07E+05	7.56	39,234	10.4	1,030	21,676	38.0	0.49	7.83E-04	0.007	1,019	6.63E-04
3.3	90,000	1.17E+05	7.58	38,777	10.3	1,029	21,396	37.5	0.50	7.83E-04	0.008	1,001	6.10E-04
3.7	1.00E+05	1.27E+05	7.60	38,392	10.1	1,029	21,160	37.1	0.52	7.83E-04	0.008	985	5.65E-04
7	2.00E+05	2.27E+05	7.70	36,406	9.28	1,028	19,945	35.1	0.58	7.83E-04	0.009	907	3.35E-04
44	1.18E+06	1.21E+06	7.82	34,359	8.44	1,026	18,691	32.9	0.64	7.83E-04	0.010	826	9.77E-05
80	2.16E+06	2.19E+06	7.83	34,146	8.36	1,026	18,560	32.7	0.65	7.83E-04	0.010	818	7.30E-05
116	3.14E+06	3.17E+06	7.84	34,065	8.32	1,026	18,511	32.6	0.65	7.83E-04	0.010	815	6.36E-05
153	4.12E+06	4.15E+06	7.84	34,022	8.31	1,026	18,485	32.6	0.65	7.83E-04	0.010	813	5.87E-05
189	5.10E+06	5.13E+06	7.85	33,996	8.30	1,026	18,468	32.5	0.65	7.83E-04	0.010	812	5.56E-05
225	6.08E+06	6.11E+06	7.85	33,978	8.29	1,026	18,457	32.5	0.65	7.83E-04	0.010	811	5.36E-05
261	7.06E+06	7.09E+06	7.85	33,965	8.28	1,026	18,450	32.5	0.65	7.83E-04	0.010	811	5.21E-05
298	8.04E+06	8.07E+06	7.85	33,955	8.28	1,026	18,444	32.5	0.65	7.83E-04	0.010	811	5.09E-05
334	9.02E+06	9.05E+06	7.85	33,948	8.28	1,026	18,439	32.5	0.65	7.83E-04	0.010	810	5.00E-05
370	1.00E+07	1.00E+07	7.85	33,941	8.27	1,026	18,435	32.5	0.65	7.83E-04	0.010	810	4.93E-05
37	1.00E+06	1.03E+06	7.81	34,442	8.48	1,026	18,741	33.0	0.64	7.83E-04	0.010	830	1.07E-04
404	1.09E+07	1.09E+07	7.85	33,937	8.27	1,026	18,432	32.5	0.65	7.83E-04	0.010	810	4.88E-05
770	2.08E+07	2.08E+07	7.85	33,912	8.26	1,026	18,417	32.4	0.65	7.83E-04	0.010	809	4.59E-05
1137	3.07E+07	3.07E+07	7.85	33,903	8.26	1,026	18,411	32.4	0.65	7.83E-04	0.010	809	4.49E-05
1504	4.06E+07	4.06E+07	7.85	33,898	8.26	1,026	18,409	32.4	0.65	7.83E-04	0.010	808	4.43E-05
1870	5.05E+07	5.05E+07	7.85	33,896	8.25	1,026	18,407	32.4	0.65	7.83E-04	0.010	808	4.40E-05
2237	6.04E+07	6.04E+07	7.85	33,894	8.25	1,026	18,406	32.4	0.65	7.83E-04	0.010	808	4.38E-05
2604	7.03E+07	7.03E+07	7.85	33,893	8.25	1,026	18,405	32.4	0.65	7.83E-04	0.010	808	4.36E-05
2970	8.02E+07	8.02E+07	7.85	33,892	8.25	1,026	18,404	32.4	0.65	7.83E-04	0.010	808	4.35E-05
3337	9.01E+07	9.01E+07	7.85	33,891	8.25	1,026	18,404	32.4	0.65	7.83E-04	0.010	808	4.34E-05
3704	1.00E+08	1.00E+08	7.85	33,890	8.25	1,026	18,404	32.4	0.65	7.83E-04	0.010	808	4.34E-05

Dilution Ratio	P(+5)	Ni(+2)	Na(+1)	N(-3)	N(+5)	N(+3)	Mn(+2)	Mg(+2)	Zn(+2)	K(+1)	Hg(+2)	Fe(+2)	F(-1)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	1.26E-07	12,500	0	0	0	0	4,631	0.001	0	6.50E-08	0	0
0.4	0.011	4.22E-06	12,302	0.005	0.076	0.021	0.001	3,504	0.003	89.2	1.42E-07	0.004	0.68
0.7	0.017	5.05E-06	12,187	0.009	0.120	0.032	0.002	2,857	0.004	140	1.86E-07	0.006	1.06
1.1	0.021	5.40E-06	12,113	0.011	0.149	0.040	0.003	2,436	0.004	174	2.15E-07	0.008	1.32
1.5	0.024	5.63E-06	12,060	0.012	0.169	0.045	0.003	2,141	0.004	197	2.35E-07	0.009	1.49
1.9	0.026	5.79E-06	12,022	0.013	0.183	0.049	0.003	1,923	0.005	214	2.50E-07	0.010	1.62
2.2	0.028	5.92E-06	11,992	0.014	0.195	0.053	0.003	1,755	0.005	228	2.62E-07	0.010	1.72
2.6	0.029	6.04E-06	11,968	0.015	0.204	0.055	0.004	1,621	0.005	238	2.71E-07	0.011	1.80
3.0	0.030	6.13E-06	11,948	0.015	0.211	0.057	0.004	1,513	0.005	247	2.78E-07	0.011	1.87
3.3	0.031	6.22E-06	11,932	0.016	0.217	0.059	0.004	1,423	0.005	254	2.84E-07	0.012	1.92
3.7	0.031	6.29E-06	11,919	0.016	0.222	0.060	0.004	1,347	0.005	260	2.89E-07	0.012	1.97
7	0.035	6.78E-06	11,849	0.018	0.249	0.067	0.004	956	0.006	291	3.16E-07	0.013	2.20
44	0.039	7.58E-06	11,777	0.020	0.276	0.074	0.005	553	0.006	323	3.44E-07	0.015	2.44
80	0.040	7.70E-06	11,769	0.020	0.279	0.075	0.005	511	0.006	326	3.46E-07	0.015	2.47
116	0.040	7.74E-06	11,766	0.020	0.280	0.075	0.005	496	0.006	327	3.48E-07	0.015	2.48
153	0.040	7.77E-06	11,765	0.020	0.281	0.076	0.005	487	0.006	328	3.48E-07	0.015	2.48
189	0.040	7.78E-06	11,764	0.020	0.281	0.076	0.005	482	0.006	328	3.49E-07	0.015	2.49
225	0.040	7.79E-06	11,763	0.020	0.281	0.076	0.005	478	0.006	329	3.49E-07	0.015	2.49
261	0.040	7.80E-06	11,763	0.020	0.281	0.076	0.005	476	0.006	329	3.49E-07	0.015	2.49
298	0.040	7.81E-06	11,763	0.020	0.281	0.076	0.005	474	0.006	329	3.49E-07	0.015	2.49
334	0.040	7.81E-06	11,762	0.020	0.282	0.076	0.005	472	0.006	329	3.49E-07	0.015	2.49
370	0.040	7.81E-06	11,762	0.020	0.282	0.076	0.005	471	0.006	329	3.49E-07	0.015	2.49
37	0.039	7.54E-06	11,780	0.020	0.275	0.074	0.005	570	0.006	321	3.43E-07	0.015	2.43
404	0.040	7.82E-06	11,762	0.020	0.282	0.076	0.005	470	0.006	329	3.49E-07	0.015	2.49
770	0.040	7.83E-06	11,761	0.020	0.282	0.076	0.005	465	0.006	330	3.50E-07	0.015	2.50
1137	0.040	7.84E-06	11,761	0.020	0.282	0.076	0.005	464	0.006	330	3.50E-07	0.015	2.50
1504	0.040	7.84E-06	11,761	0.020	0.282	0.076	0.005	463	0.006	330	3.50E-07	0.015	2.50
1870	0.040	7.84E-06	11,760	0.020	0.282	0.076	0.005	462	0.006	330	3.50E-07	0.015	2.50
2237	0.040	7.84E-06	11,760	0.020	0.282	0.076	0.005	462	0.006	330	3.50E-07	0.015	2.50
2604	0.040	7.84E-06	11,760	0.020	0.282	0.076	0.005	462	0.006	330	3.50E-07	0.015	2.50
2970	0.040	7.84E-06	11,760	0.020	0.282	0.076	0.005	461	0.006	330	3.50E-07	0.015	2.50
3337	0.040	7.84E-06	11,760	0.020	0.282	0.076	0.005	461	0.006	330	3.50E-07	0.015	2.50
3704	0.040	7.85E-06	11,760	0.020	0.282	0.076	0.005	461	0.006	330	3.50E-07	0.015	2.50

Dilution Ratio	Cu(+2)	Cr(+6)	Cr(+3)	Co(+2)	Cd(+2)	Ca(+2)	Br(-1)	Be(+2)	Ba(+2)	As(+5)	Al(+3)	NiCr2O4	NaAlCO3(OH)2 (Dawsonite)	CoCr2O4	CaCO3 (Calcite)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	3.74E-04	2.69E-04	7.82E-04	0	7.79E-05	1,328	53.0	0	0	3.26E-03	0	0.003	0	0	54.9
0.4	7.76E-04	2.30E-04	6.36E-05	0.0008	6.60E-05	1,050	52.7	0.0014	0.0014	0.0035	3.84E-05	0.003	0.216	0.0020	39.7
0.7	0.0010	2.08E-04	3.53E-05	0.0015	5.91E-05	891	52.5	0.0021	0.0021	0.0037	3.82E-05	0.002	0.341	0.0024	31.3
1.1	0.0012	1.94E-04	2.39E-05	0.0020	5.47E-05	787	52.4	0.0026	0.0026	0.0038	3.84E-05	0.002	0.421	0.0026	25.9
1.5	0.0013	1.84E-04	1.79E-05	0.0023	5.16E-05	714	52.4	0.0030	0.0030	0.0039	3.89E-05	0.002	0.478	0.0027	22.1
1.9	0.0013	1.76E-04	1.43E-05	0.0025	4.93E-05	661	52.3	0.0032	0.0032	0.0039	3.94E-05	0.002	0.520	0.0028	19.4
2.2	0.0014	1.71E-04	1.19E-05	0.0027	4.75E-05	619	52.2	0.0034	0.0034	0.0040	4.00E-05	0.002	0.552	0.0029	17.3
2.6	0.0014	1.66E-04	1.02E-05	0.0029	4.61E-05	586	52.2	0.0036	0.0036	0.0040	4.05E-05	0.002	0.578	0.0029	15.6
3.0	0.0015	1.62E-04	9.00E-06	0.0030	4.49E-05	559	52.2	0.0037	0.0037	0.0040	4.10E-05	0.002	0.598	0.0030	14.3
3.3	0.0015	1.59E-04	8.07E-06	0.0031	4.40E-05	537	52.2	0.0038	0.0038	0.0041	4.15E-05	0.002	0.616	0.0030	13.1
3.7	0.0015	1.57E-04	7.35E-06	0.0031	4.32E-05	518	52.1	0.0039	0.0039	0.0041	4.20E-05	0.002	0.630	0.0030	12.2
7	0.0017	1.43E-04	4.36E-06	0.0036	3.90E-05	422	52.0	0.0044	0.0044	0.0042	4.55E-05	0.002	0.705	0.0032	7.32
44	0.0018	1.30E-04	2.31E-06	0.0040	3.48E-05	323	51.9	0.0049	0.0049	0.0043	5.22E-05	0.001	0.782	0.0034	2.26
80	0.0018	1.28E-04	2.14E-06	0.0041	3.43E-05	312	51.9	0.0049	0.0049	0.0043	5.31E-05	0.001	0.790	0.0034	1.73
116	0.0018	1.28E-04	2.08E-06	0.0041	3.42E-05	308	51.9	0.0050	0.0050	0.0043	5.35E-05	0.001	0.793	0.0034	1.53
153	0.0019	1.27E-04	2.05E-06	0.0041	3.41E-05	306	51.9	0.0050	0.0050	0.0043	5.38E-05	0.001	0.795	0.0034	1.42
189	0.0019	1.27E-04	2.03E-06	0.0041	3.40E-05	305	51.9	0.0050	0.0050	0.0043	5.39E-05	0.001	0.796	0.0034	1.35
225	0.0019	1.27E-04	2.02E-06	0.0041	3.40E-05	304	51.9	0.0050	0.0050	0.0043	5.40E-05	0.001	0.797	0.0034	1.31
261	0.0019	1.27E-04	2.01E-06	0.0041	3.40E-05	303	51.9	0.0050	0.0050	0.0043	5.40E-05	0.001	0.797	0.0034	1.28
298	0.0019	1.27E-04	2.00E-06	0.0041	3.39E-05	303	51.9	0.0050	0.0050	0.0043	5.41E-05	0.001	0.798	0.0034	1.25
334	0.0019	1.27E-04	2.00E-06	0.0041	3.39E-05	303	51.9	0.0050	0.0050	0.0043	5.41E-05	0.001	0.798	0.0034	1.23
370	0.0019	1.27E-04	1.99E-06	0.0041	3.39E-05	302	51.9	0.0050	0.0050	0.0043	5.42E-05	0.001	0.798	0.0034	1.22
37	0.0018	1.30E-04	2.37E-06	0.0040	3.50E-05	327	51.9	0.0049	0.0049	0.0043	5.18E-05	0.001	0.779	0.0034	2.47
404	0.0019	1.27E-04	1.99E-06	0.0041	3.39E-05	302	51.9	0.0050	0.0050	0.0043	5.42E-05	0.001	0.798	0.0034	1.21
770	0.0019	1.27E-04	1.97E-06	0.0041	3.39E-05	301	51.9	0.0050	0.0050	0.0043	5.43E-05	0.001	0.799	0.0034	1.14
1137	0.0019	1.27E-04	1.96E-06	0.0041	3.38E-05	300	51.9	0.0050	0.0050	0.0043	5.44E-05	0.001	0.800	0.0034	1.12
1504	0.0019	1.27E-04	1.96E-06	0.0041	3.38E-05	300	51.9	0.0050	0.0050	0.0043	5.44E-05	0.001	0.800	0.0034	1.11
1870	0.0019	1.27E-04	1.96E-06	0.0041	3.38E-05	300	51.9	0.0050	0.0050	0.0043	5.44E-05	0.001	0.800	0.0034	1.10
2237	0.0019	1.27E-04	1.96E-06	0.0041	3.38E-05	300	51.9	0.0050	0.0050	0.0043	5.44E-05	0.001	0.800	0.0034	1.10
2604	0.0019	1.27E-04	1.96E-06	0.0041	3.38E-05	300	51.9	0.0050	0.0050	0.0043	5.44E-05	0.001	0.800	0.0034	1.09
2970	0.0019	1.27E-04	1.96E-06	0.0041	3.38E-05	300	51.9	0.0050	0.0050	0.0043	5.44E-05	0.001	0.800	0.0034	1.09
3337	0.0019	1.27E-04	1.96E-06	0.0041	3.38E-05	300	51.9	0.0050	0.0050	0.0043	5.44E-05	0.001	0.800	0.0034	1.09
3704	0.0019	1.27E-04	1.96E-06	0.0041	3.38E-05	300	51.9	0.0050	0.0050	0.0043	5.44E-05	0.001	0.800	0.0034	1.09

SCENARIO 4A

Dilution Ratio	Volume - PoPA	Volume - Total	pH	Total Dissolved Solid	Temperature	Density - Total	Cl(-1) Liq1	Salinity	Zn(+2) Liq1	Ti(+4) Liq1	Si(+4) Liq1	Se(+4) Liq1	Sb(+5) Liq1	S(+6) Liq1	Pb(+2) Liq1	P(+5) Liq1
	L/hr	L/hr		mg/L	°C	kg/m3	mg/L	g/kg	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	32,900	6.40	50,390	19.3	1,038	29,699	51.7	0.0	1.43E-03	20.1064	0	#######	1,348	0.002	0
2	50,000	82,883	6.92	40,246	12.6	1,031	22,889	40.1	0.00	1.43E-03	8.564	0	6.03E-03	1,023	0.001	0
3	#######	#######	7.14	37,717	11.0	1,029	21,200	37.2	0.01	1.44E-03	5.588	0	7.53E-03	942	0.001	0
5	#######	#######	7.28	36,875	10.2	1,028	20,435	35.9	0.01	1.44E-03	4.239	0	8.20E-03	905	0.000	0
6	#######	#######	7.37	36,233	9.80	1,027	19,998	35.2	0.01	1.44E-03	3.469	0	8.59E-03	884	0.000	0
8	#######	#######	7.44	35,591	9.53	1,027	19,716	34.7	0.01	1.28E-03	2.972	0	8.84E-03	871	0.000	0
9	#######	#######	7.49	35,528	9.34	1,027	19,518	34.3	0.01	1.09E-03	2.624	0	9.01E-03	861	0.000	0
11	#######	#######	7.54	35,313	9.19	1,027	19,372	34.1	0.01	9.46E-04	2.367	0	9.14E-03	854	0.000	0
12	#######	#######	7.57	35,148	9.08	1,027	19,260	33.9	0.01	8.37E-04	2.169	0	9.24E-03	849	0.000	0
14	#######	#######	7.60	35,018	9.00	1,027	19,171	33.7	0.01	7.50E-04	2.012	0	9.32E-03	845	0.000	0
15	#######	#######	7.62	34,678	8.93	1,026	19,099	33.6	0.01	6.80E-04	1.885	0	9.38E-03	841	0.000	0
17	#######	#######	7.64	34,628	8.87	1,026	19,039	33.5	0.01	6.21E-04	1.779	0	9.44E-03	838	0.000	0
18	#######	#######	7.66	34,587	8.82	1,026	18,988	33.4	0.01	5.72E-04	1.690	0	9.48E-03	836	0.000	0
20	#######	#######	7.68	34,551	8.78	1,026	18,945	33.4	0.01	5.30E-04	1.614	0	9.52E-03	834	0.000	0
21	#######	#######	7.69	34,520	8.74	1,026	18,908	33.3	0.01	4.94E-04	1.549	0	9.55E-03	832	0.000	0
23	#######	#######	7.70	34,493	8.71	1,026	18,875	33.2	0.01	4.63E-04	1.492	0	9.58E-03	831	0.000	0
24	#######	#######	7.71	34,470	8.68	1,026	18,847	33.2	0.01	4.35E-04	1.442	0	9.60E-03	829	0.000	0
26	#######	#######	7.72	34,449	8.66	1,026	18,822	33.1	0.01	4.10E-04	1.397	0	9.63E-03	828	0.000	0
27	#######	#######	7.73	34,471	8.64	1,026	18,799	33.1	0.01	3.88E-04	1.357	0	9.65E-03	827	0.000	0
29	#######	#######	7.74	34,414	8.62	1,026	18,779	33.1	0.01	3.68E-04	1.321	0	9.67E-03	826	0.000	0
30	#######	#######	7.75	34,398	8.60	1,026	18,760	33.0	0.01	3.51E-04	1.289	0	9.68E-03	825	0.000	0
46	#######	#######	7.79	34,301	8.49	1,026	18,643	32.8	0.01	2.36E-04	1.082	0	9.79E-03	819	0.000	0
59	#######	#######	7.82	34,191	8.43	1,026	18,588	32.7	0.01	1.83E-04	0.985	0	9.83E-03	817	0.000	0
73	#######	#######	7.83	34,109	8.40	1,026	18,553	32.7	0.01	1.49E-04	0.924	0	9.86E-03	815	0.000	0
87	#######	#######	7.84	34,074	8.38	1,026	18,529	32.6	0.01	1.26E-04	0.882	0	9.89E-03	814	0.000	0
100	#######	#######	7.84	34,049	8.36	1,026	18,512	32.6	0.01	1.09E-04	0.851	0	9.90E-03	813	0.000	0
114	#######	#######	7.84	34,029	8.35	1,026	18,498	32.6	0.01	9.57E-05	0.828	0	9.91E-03	813	0.000	0
128	#######	#######	7.84	34,014	8.34	1,026	18,488	32.6	0.01	8.56E-05	0.809	0	9.92E-03	812	0.000	0
141	#######	#######	7.84	34,001	8.33	1,026	18,480	32.5	0.01	7.73E-05	0.794	0	9.93E-03	812	0.000	0
155	#######	#######	7.84	33,991	8.32	1,026	18,473	32.5	0.01	7.06E-05	0.782	0	9.94E-03	811	0.000	0
169	#######	#######	7.84	33,982	8.31	1,026	18,467	32.5	0.01	6.49E-05	0.772	0	9.94E-03	811	0.000	0
182	#######	#######	7.85	33,975	8.31	1,026	18,462	32.5	0.01	6.00E-05	0.763	0	9.95E-03	811	0.000	0
198	#######	#######	7.85	33,968	8.31	1,026	18,457	32.5	0.01	5.54E-05	0.755	0	9.95E-03	811	0.000	0
482	#######	#######	7.85	33,919	8.27	1,026	18,423	32.5	0.01	2.28E-05	0.696	0	9.98E-03	809	0.000	0
766	#######	#######	7.85	33,906	8.26	1,026	18,415	32.4	0.01	1.44E-05	0.680	0	9.99E-03	809	0.000	0
1050	#######	#######	7.85	33,900	8.26	1,026	18,411	32.4	0.01	1.05E-05	0.673	0	9.99E-03	808	0.000	0
1334	#######	#######	7.85	33,897	8.26	1,026	18,409	32.4	0.01	8.24E-06	0.669	0	9.99E-03	808	0.000	0
1619	#######	#######	7.85	33,895	8.26	1,026	18,407	32.4	0.01	6.80E-06	0.667	0	9.99E-03	808	0.000	0
1903	#######	#######	7.85	33,893	8.26	1,026	18,406	32.4	0.01	5.78E-06	0.665	0	9.99E-03	808	0.000	0
2187	#######	#######	7.85	33,892	8.26	1,026	18,405	32.4	0.01	5.03E-06	0.664	0	9.99E-03	808	0.000	0
2471	#######	#######	7.85	33,891	8.25	1,026	18,405	32.4	0.01	4.45E-06	0.662	0	1.00E-02	808	0.000	0
2755	#######	#######	7.85	33,890	8.25	1,026	18,404	32.4	0.01	3.99E-06	0.662	0	1.00E-02	808	0.000	0
3040	#######	#######	7.85	33,890	8.25	1,026	18,404	32.4	0.01	3.62E-06	0.661	0	1.00E-02	808	0.000	0

Dilution Ratio	Ni(+2) Liq1	Na(+1) Liq1	N(-3) Liq1	N(+5) Liq1	N(+3) Liq1	Mn(+2) Liq1	Mg(+2) Liq1	K(+1) Liq1	Hg(+2) Liq1	Fe(+3) Liq1	Fe(+2) Liq1	F(-1) Liq1	Cu(+2) Liq1	Cr(+6) Liq1
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	3.01722	10,258	0	0	0	0.000	5123.84	0	5.33E-08	6.88E-08	0	0	3.07E-04	2.21E-04
2	1.197	11,166	0.012	0.170	0	0.003	2,311	199	2.32E-07	1.28E-08	0.009	1.51	0.0012	1.64E-04
3	0.746	11,390	0.015	0.213	0	0.004	1,615	248	2.77E-07	7.03E-09	0.011	1.88	0.0015	1.50E-04
5	0.542	11,491	0.017	0.232	0	0.004	1,299	271	2.97E-07	5.12E-09	0.012	2.05	0.0016	1.43E-04
6	0.426	11,549	0.017	0.243	0	0.004	1,119	283	3.08E-07	4.22E-09	0.013	2.15	0.0016	1.40E-04
8	0.350	11,586	0.018	0.250	0	0.004	1,002	292	3.16E-07	3.71E-09	0.013	2.21	0.0017	1.37E-04
9	0.297	11,613	0.018	0.254	0	0.005	921	297	3.21E-07	3.40E-09	0.014	2.25	0.0017	1.36E-04
11	0.258	11,632	0.018	0.258	0	0.005	861	302	3.25E-07	3.19E-09	0.014	2.29	0.0017	1.35E-04
12	0.229	11,647	0.019	0.261	0	0.005	814	305	3.27E-07	3.05E-09	0.014	2.31	0.0017	1.34E-04
14	0.205	11,658	0.019	0.263	0	0.005	778	308	3.30E-07	2.95E-09	0.014	2.33	0.0018	1.33E-04
15	0.185	11,668	0.019	0.265	0	0.005	748	310	3.32E-07	2.88E-09	0.014	2.35	0.0018	1.32E-04
17	0.169	11,676	0.019	0.266	0	0.005	723	311	3.33E-07	2.84E-09	0.014	2.36	0.0018	1.32E-04
18	0.156	11,682	0.019	0.268	0	0.005	702	313	3.35E-07	2.80E-09	0.014	2.37	0.0018	1.31E-04
20	0.145	11,688	0.019	0.269	0	0.005	685	314	3.36E-07	2.78E-09	0.014	2.38	0.0018	1.31E-04
21	0.135	11,693	0.019	0.270	0	0.005	669	315	3.37E-07	2.77E-09	0.014	2.39	0.0018	1.31E-04
23	0.126	11,697	0.019	0.271	0	0.005	656	316	3.38E-07	2.76E-09	0.014	2.40	0.0018	1.30E-04
24	0.118	11,701	0.019	0.271	0	0.005	644	317	3.38E-07	2.76E-09	0.014	2.40	0.0018	1.30E-04
26	0.112	11,704	0.019	0.272	0	0.005	634	318	3.39E-07	2.76E-09	0.014	2.41	0.0018	1.30E-04
27	0.106	11,707	0.019	0.272	0	0.005	624	318	3.40E-07	2.77E-09	0.014	2.41	0.0018	1.30E-04
29	0.100	11,710	0.020	0.273	0	0.005	616	319	3.40E-07	2.78E-09	0.014	2.42	0.0018	1.30E-04
30	0.095	11,713	0.020	0.273	0	0.005	609	319	3.41E-07	2.79E-09	0.015	2.42	0.0018	1.30E-04
46	0.064	11,728	0.020	0.276	0	0.005	560	323	3.44E-07	2.97E-09	0.015	2.45	0.0018	1.29E-04
59	0.049	11,735	0.020	0.278	0	0.005	537	325	3.45E-07	3.17E-09	0.015	2.46	0.0018	1.28E-04
73	0.040	11,740	0.020	0.279	0	0.005	523	326	3.46E-07	3.37E-09	0.015	2.47	0.0018	1.28E-04
87	0.034	11,743	0.020	0.279	0	0.005	513	326	3.47E-07	3.63E-09	0.015	2.47	0.0018	1.28E-04
100	0.029	11,745	0.020	0.280	0	0.005	506	327	3.47E-07	3.88E-09	0.015	2.48	0.0018	1.27E-04
114	0.025	11,747	0.020	0.280	0	0.005	501	327	3.47E-07	4.12E-09	0.015	2.48	0.0018	1.27E-04
128	0.023	11,748	0.020	0.280	0	0.005	496	327	3.48E-07	4.35E-09	0.015	2.48	0.0018	1.27E-04
141	0.020	11,750	0.020	0.280	0	0.005	493	328	3.48E-07	4.57E-09	0.015	2.48	0.0018	1.27E-04
155	0.018	11,751	0.020	0.281	0	0.005	490	328	3.48E-07	4.78E-09	0.015	2.48	0.0019	1.27E-04
169	0.017	11,751	0.020	0.281	0	0.005	487	328	3.48E-07	4.98E-09	0.015	2.49	0.0019	1.27E-04
182	0.016	11,752	0.020	0.281	0	0.005	485	328	3.48E-07	5.18E-09	0.015	2.49	0.0019	1.27E-04
198	0.014	11,753	0.020	0.281	0	0.005	483	328	3.49E-07	5.39E-09	0.015	2.49	0.0019	1.27E-04
482	0.005	11,757	0.020	0.282	0	0.005	470	329	3.49E-07	8.67E-09	0.015	2.49	0.0019	1.27E-04
766	0.003	11,758	0.020	0.282	0	0.005	466	330	3.50E-07	1.15E-08	0.015	2.50	0.0019	1.27E-04
1050	0.002	11,759	0.020	0.282	0	0.005	464	330	3.50E-07	1.42E-08	0.015	2.50	0.0019	1.27E-04
1334	0.001	11,759	0.020	0.282	0	0.005	463	330	3.50E-07	1.70E-08	0.015	2.50	0.0019	1.27E-04
1619	0.001	11,759	0.020	0.282	0	0.005	463	330	3.50E-07	2.01E-08	0.015	2.50	0.0019	1.27E-04
1903	0.001	11,759	0.020	0.282	0	0.005	462	330	3.50E-07	2.37E-08	0.015	2.50	0.0019	1.27E-04
2187	0.001	11,759	0.020	0.282	0	0.005	462	330	3.50E-07	2.81E-08	0.015	2.50	0.0019	1.27E-04
2471	0.000	11,759	0.020	0.282	0	0.005	462	330	3.50E-07	3.39E-08	0.015	2.50	0.0019	1.27E-04
2755	0.000	11,760	0.020	0.282	0	0.005	462	330	3.50E-07	4.25E-08	0.015	2.50	0.0019	1.27E-04
3040	0.000	11,760	0.020	0.282	0	0.005	462	330	3.50E-07	5.81E-08	0.015	2.50	0.0019	1.27E-04

Dilution Ratio	Cr(+3) Liq1	Co(+2) Liq1	Cd(+2) Liq1	Ca(+2) Liq1	Br(-1) Liq1	Be(+2) Liq1	Ba(+2) Liq1	As(+5) Liq1	Al(+3) Liq1	TiO2 (Rutile)	NiFe2O4 (Trevorite)	NiCr2O4	NaAlSi2.306.6.4H2O (sodium aluminosili	NaAlCO3(OH)2 (Dawsonite)	CaCO3 (Calcite)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	1.21E-05	0.153	0	1,133	43.5	0.0	0	2.68E-03	0.005	0.016	0.914	0.024	2.141	0.00	0
2	9.05E-07	0.064	0	631	48.6	0.0	0.0030	0.0037	0.0004	4.90E-03	3.63E-01	0.012	0.0	0.91	0
3	3.03E-07	0.042	0	506	49.8	0.0	0.0038	0.0039	0.0001	2.15E-03	2.26E-01	0.010	0.0	0.87	0
5	1.59E-07	0.032	0	450	50.4	0.0	0.0041	0.0040	0.0001	9.08E-04	1.64E-01	0.008	0.0	0.85	0
6	1.04E-07	0.026	0	418	50.7	0.0	0.0043	0.0041	0.0001	1.98E-04	1.29E-01	0.007	0.0	0.84	0
8	7.70E-08	0.022	0	397	50.9	0.0	0.0044	0.0041	0.0000	#######	0.10629	0.007	0.0	0.83	0
9	6.18E-08	0.020	0	382	51.1	0.0	0.0045	0.0041	0.0000	#######	0.09032	0.007	0.0	0.83	0
11	5.24E-08	0.018	0	372	51.2	0.0	0.0046	0.0042	0.0000	#######	0.07853	0.006	0.0	0.82	0
12	4.62E-08	0.016	0	363	51.3	0.0	0.0046	0.0042	0.0000	#######	0.06946	0.006	0.0	0.82	0
14	4.18E-08	0.015	0	357	51.3	0.0	0.0047	0.0042	0.0000	#######	0.06227	0.006	0.0	0.82	0
15	3.87E-08	0.014	0	351	51.4	0.0	0.0047	0.0042	0.0000	#######	0.05642	0.006	0.0	0.82	0
17	3.63E-08	0.013	0	347	51.4	0.0	0.0047	0.0042	0.0000	#######	0.05158	0.006	0.0	0.82	0
18	3.45E-08	0.013	0	343	51.5	0.0	0.0047	0.0042	0.0000	#######	0.04751	0.006	0.0	0.81	0
20	3.31E-08	0.012	0	340	51.5	0.0	0.0048	0.0042	0.0000	#######	0.04403	0.006	0.0	0.81	0
21	3.20E-08	0.012	0	337	51.5	0.0	0.0048	0.0042	0.0000	#######	0.04103	0.006	0.0	0.81	0
23	3.12E-08	0.011	0	335	51.5	0.0	0.0048	0.0042	0.0000	#######	0.03841	0.006	0.0	0.81	0
24	3.05E-08	0.011	0	333	51.6	0.0	0.0048	0.0042	0.0000	#######	0.0361	0.006	0.0	0.81	0
26	2.99E-08	0.011	0	331	51.6	0.0	0.0048	0.0042	0.0000	#######	0.03406	0.006	0.0	0.81	0
27	2.95E-08	0.010	0	329	51.6	0.0	0.0048	0.0042	0.0000	#######	0.03223	0.005	0.0	0.81	0
29	2.91E-08	0.010	0	328	51.6	0.0	0.0048	0.0042	0.0000	#######	0.03059	0.005	0.0	0.81	0
30	2.88E-08	0.010	0	327	51.6	0.0	0.0048	0.0043	0.0000	#######	0.02911	0.005	0.0	0.81	0
46	2.81E-08	0.008	0	318	51.7	0.0	0.0049	0.0043	0.0001	#######	0.01961	0.005	0.0	0.81	0
59	2.88E-08	0.007	0	314	51.8	0.0	0.0049	0.0043	0.0001	#######	0.01516	0.005	0.0	0.80	0
73	2.99E-08	0.007	0	311	51.8	0.0	0.0049	0.0043	0.0001	#######	0.01236	0.005	0.0	0.80	0
87	3.20E-08	0.007	0	309	51.8	0.0	0.0049	0.0043	0.0001	#######	0.01043	0.005	0.0	0.80	0.15
100	3.42E-08	0.006	0	308	51.8	0.0	0.0050	0.0043	0.0001	#######	9.02E-03	0.005	0.0	0.80	0.27
114	3.62E-08	0.006	0	307	51.8	0.0	0.0050	0.0043	0.0001	#######	7.95E-03	0.005	0.0	0.80	0.37
128	3.82E-08	0.006	0	306	51.8	0.0	0.0050	0.0043	0.0001	#######	7.10E-03	0.005	0.0	0.80	0.44
141	4.00E-08	0.006	0	306	51.8	0.0	0.0050	0.0043	0.0001	#######	6.42E-03	0.005	0.0	0.80	0.50
155	4.18E-08	0.006	0	305	51.8	0.0	0.0050	0.0043	0.0001	#######	5.86E-03	0.005	0.0	0.80	0.55
169	4.36E-08	0.006	0	305	51.9	0.0	0.0050	0.0043	0.0001	#######	5.39E-03	0.005	0.0	0.80	0.60
182	4.53E-08	0.006	0	304	51.9	0.0	0.0050	0.0043	0.0001	#######	4.98E-03	0.005	0.0	0.80	0.63
198	4.71E-08	0.006	0	304	51.9	0.0	0.0050	0.0043	0.0001	#######	4.60E-03	0.005	0.0	0.80	0.67
482	7.55E-08	0.005	0	301	51.9	0.0	0.0050	0.0043	0.0001	#######	1.89E-03	0.005	0.0	0.80	0.91
766	9.96E-08	0.005	0	301	51.9	0.0	0.0050	0.0043	0.0001	#######	1.19E-03	0.005	0.0	0.80	0.97
1050	1.23E-07	0.005	0	300	51.9	0.0	0.0050	0.0043	0.0001	#######	8.69E-04	0.005	0.0	0.80	1.00
1334	1.48E-07	0.005	0	300	51.9	0.0	0.0050	0.0043	0.0001	#######	6.84E-04	0.005	0.0	0.80	1.01
1619	1.75E-07	0.005	0	300	51.9	0.0	0.0050	0.0043	0.0001	#######	5.64E-04	0.005	0.0	0.80	1.03
1903	2.06E-07	0.005	0	300	51.9	0.0	0.0050	0.0043	0.0001	#######	4.80E-04	0.005	0.0	0.80	1.03
2187	2.44E-07	0.005	0	300	51.9	0.0	0.0050	0.0043	0.0001	#######	4.18E-04	0.005	0.0	0.80	1.04
2471	2.95E-07	0.005	0	300	51.9	0.0	0.0050	0.0043	0.0001	#######	3.70E-04	0.005	0.0	0.80	1.04
2755	3.69E-07	0.005	0	300	51.9	0.0	0.0050	0.0043	0.0001	#######	3.31E-04	0.005	0.0	0.80	1.05
3040	5.05E-07	0.005	0	300	51.9	0.0	0.0050	0.0043	0.0001	#######	3.00E-04	0.005	0.0	0.80	1.05

SCENARIO 4B

Dilution Ratio	Volume - Reconcile_PoPA_WQ	Volume - Total	pH	Total Dissolved Solids, Rigorous	Temperature	Density - Total	Cl(-1) Liq1	Salinity	Si(+4) Liq1	Se(+4) Liq1	S(+6) Liq1	Pb(+2) Liq1	P(+5) Liq1	Ni(+2) Liq1	Na(+1) Liq1
	L/hr	L/hr		mg/L	°C	kg/m3	mg/L	g/kg	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	32,905	6.81	50,547	19.3	1,039	30,269	52.6	0	0.0041	1,141	2.50E-03	0	1.05E-05	10,281
2	50,000	82,883	7.16	40,487	12.6	1,031	23,112	40.5	0.395	0.0021	1,023	1.02E-03	0.024	3.06E-06	11,174
3	1.00E+05	1.33E+05	7.31	38,455	11.0	1,029	21,340	37.5	0.492	0.0016	942	6.51E-04	0.030	3.46E-06	11,395
5	1.50E+05	1.83E+05	7.40	37,206	10.2	1,028	20,536	36.1	0.537	0.0014	905	4.85E-04	0.033	3.84E-06	11,495
6	2.00E+05	2.33E+05	7.46	36,043	9.80	1,028	20,078	35.3	0.562	0.0012	884	3.90E-04	0.034	4.16E-06	11,552
8	2.50E+05	2.83E+05	7.51	36,033	9.53	1,027	19,781	34.8	0.578	0.0012	871	3.29E-04	0.035	4.44E-06	11,589
9	3.00E+05	3.33E+05	7.55	35,710	9.33	1,027	19,574	34.4	0.590	0.0011	861	2.86E-04	0.036	4.68E-06	11,615
11	3.50E+05	3.83E+05	7.58	35,023	9.19	1,027	19,420	34.2	0.598	0.0011	854	2.54E-04	0.037	4.89E-06	11,634
12	4.00E+05	4.33E+05	7.60	35,289	9.08	1,027	19,303	34.0	0.605	0.0010	849	2.29E-04	0.037	5.08E-06	11,648
14	4.50E+05	4.83E+05	7.62	35,143	9.00	1,027	19,209	33.8	0.610	0.0010	845	2.10E-04	0.037	5.24E-06	11,660
15	5.00E+05	5.33E+05	7.64	35,025	8.93	1,027	19,133	33.7	0.614	0.0010	841	1.94E-04	0.038	5.38E-06	11,669
17	5.50E+05	5.83E+05	7.65	34,927	8.87	1,026	19,070	33.6	0.618	0.0010	838	1.81E-04	0.038	5.51E-06	11,677
18	6.00E+05	6.33E+05	7.67	34,845	8.82	1,026	19,017	33.5	0.620	0.0010	836	1.70E-04	0.038	5.63E-06	11,684
20	6.50E+05	6.83E+05	7.68	34,775	8.78	1,026	18,972	33.4	0.623	0.0009	834	1.61E-04	0.038	5.74E-06	11,689
21	7.00E+05	7.33E+05	7.69	34,714	8.74	1,026	18,933	33.3	0.625	0.0009	832	1.53E-04	0.038	5.83E-06	11,694
23	7.50E+05	7.83E+05	7.70	34,661	8.71	1,026	18,899	33.3	0.627	0.0009	831	1.46E-04	0.038	5.92E-06	11,698
24	8.00E+05	8.33E+05	7.70	34,614	8.68	1,026	18,869	33.2	0.629	0.0009	829	1.40E-04	0.038	6.00E-06	11,702
26	8.50E+05	8.83E+05	7.71	34,573	8.66	1,026	18,843	33.2	0.630	0.0009	828	1.34E-04	0.039	6.08E-06	11,705
27	9.00E+05	9.33E+05	7.72	34,536	8.64	1,026	18,819	33.1	0.631	0.0009	827	1.29E-04	0.039	6.14E-06	11,708
29	9.50E+05	9.83E+05	7.72	34,503	8.62	1,026	18,798	33.1	0.633	0.0009	826	1.25E-04	0.039	6.21E-06	11,711
30	1.00E+06	1.03E+06	7.73	34,473	8.60	1,026	18,778	33.1	0.634	0.0009	825	1.21E-04	0.039	6.27E-06	11,713
46	1.50E+06	1.53E+06	7.77	34,281	8.49	1,026	18,655	32.9	0.640	0.0009	819	9.54E-05	0.039	6.68E-06	11,728
59	1.95E+06	1.98E+06	7.78	34,191	8.43	1,026	18,597	32.8	0.644	0.0008	817	8.35E-05	0.039	6.91E-06	11,736
73	2.40E+06	2.43E+06	7.80	34,134	8.40	1,026	18,561	32.7	0.646	0.0008	815	7.59E-05	0.039	7.06E-06	11,740
87	2.85E+06	2.88E+06	7.80	34,095	8.38	1,026	18,536	32.6	0.647	0.0008	814	7.07E-05	0.040	7.17E-06	11,743
100	3.30E+06	3.33E+06	7.81	34,067	8.36	1,026	18,517	32.6	0.648	0.0008	813	6.70E-05	0.040	7.25E-06	11,746
114	3.75E+06	3.78E+06	7.82	34,045	8.35	1,026	18,503	32.6	0.649	0.0008	813	6.41E-05	0.040	7.32E-06	11,747
128	4.20E+06	4.23E+06	7.82	34,028	8.34	1,026	18,492	32.6	0.649	0.0008	812	6.18E-05	0.040	7.37E-06	11,749
141	4.65E+06	4.68E+06	7.82	34,014	8.33	1,026	18,483	32.6	0.650	0.0008	812	6.00E-05	0.040	7.41E-06	11,750
155	5.10E+06	5.13E+06	7.83	34,003	8.32	1,026	18,476	32.5	0.650	0.0008	811	5.85E-05	0.040	7.45E-06	11,751
169	5.55E+06	5.58E+06	7.83	33,993	8.31	1,026	18,470	32.5	0.651	0.0008	811	5.72E-05	0.040	7.48E-06	11,751
182	6.00E+06	6.03E+06	7.83	33,985	8.31	1,026	18,465	32.5	0.651	0.0008	811	5.61E-05	0.040	7.50E-06	11,752
198	6.50E+06	6.53E+06	7.83	33,978	8.31	1,026	18,460	32.5	0.651	0.0008	811	5.51E-05	0.040	7.53E-06	11,753
482	1.59E+07	1.59E+07	7.84	33,923	8.27	1,026	18,425	32.5	0.653	0.0008	809	4.78E-05	0.040	7.71E-06	11,757
766	2.52E+07	2.52E+07	7.85	33,909	8.26	1,026	18,416	32.4	0.654	0.0008	809	4.59E-05	0.040	7.76E-06	11,758
1050	3.46E+07	3.46E+07	7.85	33,902	8.26	1,026	18,411	32.4	0.654	0.0008	808	4.50E-05	0.040	7.79E-06	11,759
1334	4.39E+07	4.39E+07	7.85	33,898	8.26	1,026	18,409	32.4	0.654	0.0008	808	4.45E-05	0.040	7.80E-06	11,759
1618	5.33E+07	5.33E+07	7.85	33,896	8.26	1,026	18,407	32.4	0.654	0.0008	808	4.42E-05	0.040	7.81E-06	11,759
1902	6.26E+07	6.26E+07	7.85	33,894	8.26	1,026	18,406	32.4	0.654	0.0008	808	4.40E-05	0.040	7.81E-06	11,759
2187	7.20E+07	7.20E+07	7.85	33,893	8.26	1,026	18,405	32.4	0.654	0.0008	808	4.38E-05	0.040	7.82E-06	11,759
2471	8.13E+07	8.13E+07	7.85	33,892	8.25	1,026	18,405	32.4	0.654	0.0008	808	4.37E-05	0.040	7.82E-06	11,759
2755	9.07E+07	9.07E+07	7.85	33,891	8.25	1,026	18,404	32.4	0.654	0.0008	808	4.36E-05	0.040	7.82E-06	11,760
3039	1.00E+08	1.00E+08	7.85	33,890	8.25	1,026	18,404	32.4	0.654	0.0008	808	4.35E-05	0.040	7.83E-06	11,760

Dilution Ratio	N(-3) Liq1	Mo(+6) Liq1	Mg(+2) Liq1	K(+1) Liq1	Hg(+2) Liq1	Co(+2) Liq1	Zn(+2) Liq1	Cd(+2) Liq1	Ca(+2) Liq1	Br(-1) Liq1	As(+5) Liq1	NiCr2O4 - Sol	NaAlCO3(OH)2 (Dawsonite) - Sol	CoCr2O4 - Sol	CaSO4.2H2O (Gypsum)	CaCO3 (Calcite) - Sol
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	1.79E-05	3,837	0	3.59E-04	0.0000	0.0012	9.98E-05	3,301	43.5	0.0206	0.0032	0	0.0001	1,114	145
2	0.0122	7.12E-06	1,800	199	1.43E-04	0.0025	0.0043	6.00E-05	1,591	48.6	0.0108	0.0021	0.48	0.0021	0	63.2
3	0.0152	4.44E-06	1,296	248	8.91E-05	0.0031	0.0051	5.01E-05	1,105	49.8	0.0083	0.0019	0.60	0.0026	0	41.5
5	0.0166	3.23E-06	1,067	271	6.48E-05	0.0034	0.0055	4.57E-05	884	50.4	0.0072	0.0017	0.66	0.0029	0	31.2
6	0.0173	2.53E-06	937	283	5.10E-05	0.0035	0.0057	4.31E-05	759	50.7	0.0066	0.0017	0.69	0.0030	0	25.2
8	0.0178	2.09E-06	853	292	4.20E-05	0.0036	0.0058	4.15E-05	677	50.9	0.0062	0.0016	0.71	0.0031	0	21.2
9	0.0182	1.77E-06	794	297	3.58E-05	0.0037	0.0059	4.03E-05	620	51.1	0.0059	0.0016	0.72	0.0031	0	18.4
11	0.0185	1.54E-06	750	302	3.11E-05	0.0038	0.0060	3.95E-05	579	51.2	0.0057	0.0016	0.73	0.0032	0	16.3
12	0.0187	1.36E-06	717	305	2.76E-05	0.0038	0.0060	3.88E-05	546	51.3	0.0055	0.0015	0.74	0.0032	0	14.6
14	0.0188	1.22E-06	690	308	2.48E-05	0.0038	0.0060	3.83E-05	521	51.3	0.0054	0.0015	0.75	0.0032	0	13.3
15	0.0189	1.11E-06	668	310	2.25E-05	0.0039	0.0061	3.79E-05	500	51.4	0.0053	0.0015	0.75	0.0032	0	12.2
17	0.0191	1.01E-06	651	311	2.06E-05	0.0039	0.0061	3.75E-05	483	51.4	0.0052	0.0015	0.76	0.0032	0	11.3
18	0.0191	9.32E-07	636	313	1.90E-05	0.0039	0.0061	3.72E-05	468	51.5	0.0052	0.0015	0.76	0.0033	0	10.5
20	0.0192	8.64E-07	623	314	1.76E-05	0.0039	0.0061	3.70E-05	456	51.5	0.0051	0.0015	0.76	0.0033	0	9.87
21	0.0193	8.05E-07	612	315	1.64E-05	0.0039	0.0062	3.68E-05	445	51.5	0.0050	0.0015	0.76	0.0033	0	9.30
23	0.0193	7.53E-07	602	316	1.54E-05	0.0039	0.0062	3.66E-05	436	51.5	0.0050	0.0015	0.77	0.0033	0	8.80
24	0.0194	7.08E-07	593	317	1.45E-05	0.0039	0.0062	3.64E-05	428	51.6	0.0049	0.0015	0.77	0.0033	0	8.35
26	0.0194	6.68E-07	586	318	1.37E-05	0.0040	0.0062	3.63E-05	420	51.6	0.0049	0.0015	0.77	0.0033	0	7.96
27	0.0195	6.32E-07	579	318	1.30E-05	0.0040	0.0062	3.61E-05	414	51.6	0.0049	0.0015	0.77	0.0033	0	7.61
29	0.0195	6.00E-07	573	319	1.23E-05	0.0040	0.0062	3.60E-05	408	51.6	0.0048	0.0015	0.77	0.0033	0	7.29
30	0.0195	5.71E-07	568	319	1.18E-05	0.0040	0.0062	3.59E-05	403	51.6	0.0048	0.0014	0.77	0.0033	0	7.00
46	0.0198	3.85E-07	532	323	8.04E-06	0.0040	0.0063	3.52E-05	369	51.7	0.0047	0.0014	0.78	0.0033	0	5.12
59	0.0199	2.97E-07	516	325	6.30E-06	0.0040	0.0063	3.49E-05	353	51.8	0.0046	0.0014	0.79	0.0034	0	4.22
73	0.0199	2.42E-07	506	326	5.20E-06	0.0041	0.0063	3.47E-05	343	51.8	0.0045	0.0014	0.79	0.0034	0	3.65
87	0.0200	2.05E-07	499	326	4.44E-06	0.0041	0.0063	3.46E-05	337	51.8	0.0045	0.0014	0.79	0.0034	0	3.26
100	0.0200	1.77E-07	493	327	3.89E-06	0.0041	0.0063	3.45E-05	332	51.8	0.0045	0.0014	0.79	0.0034	0	2.97
114	0.0200	1.56E-07	489	327	3.47E-06	0.0041	0.0064	3.44E-05	328	51.8	0.0044	0.0014	0.79	0.0034	0	2.74
128	0.0200	1.39E-07	486	327	3.14E-06	0.0041	0.0064	3.43E-05	325	51.8	0.0044	0.0014	0.79	0.0034	0	2.57
141	0.0200	1.26E-07	484	328	2.87E-06	0.0041	0.0064	3.43E-05	322	51.8	0.0044	0.0014	0.79	0.0034	0	2.43
155	0.0201	1.15E-07	482	328	2.65E-06	0.0041	0.0064	3.42E-05	320	51.8	0.0044	0.0014	0.80	0.0034	0	2.31
169	0.0201	1.06E-07	480	328	2.46E-06	0.0041	0.0064	3.42E-05	319	51.9	0.0044	0.0014	0.80	0.0034	0	2.21
182	0.0201	9.78E-08	478	328	2.30E-06	0.0041	0.0064	3.42E-05	317	51.9	0.0044	0.0014	0.80	0.0034	0	2.13
198	0.0201	9.03E-08	477	328	2.15E-06	0.0041	0.0064	3.41E-05	316	51.9	0.0044	0.0014	0.80	0.0034	0	2.05
482	0.0201	3.71E-08	467	329	1.09E-06	0.0041	0.0064	3.39E-05	306	51.9	0.0043	0.0014	0.80	0.0034	0	1.48
766	0.0202	2.34E-08	464	330	8.17E-07	0.0041	0.0064	3.39E-05	304	51.9	0.0043	0.0014	0.80	0.0034	0	1.33
1050	0.0202	1.71E-08	463	330	6.91E-07	0.0041	0.0064	3.39E-05	303	51.9	0.0043	0.0014	0.80	0.0034	0	1.26
1334	0.0202	0	463	330	6.18E-07	0.0041	0.0064	3.38E-05	302	51.9	0.0043	0.0014	0.80	0.0034	0	1.22
1618	0.0202	0	462	330	5.71E-07	0.0041	0.0064	3.38E-05	302	51.9	0.0043	0.0014	0.80	0.0034	0	1.19
1902	0.0202	0	462	330	5.38E-07	0.0041	0.0064	3.38E-05	301	51.9	0.0043	0.0014	0.80	0.0034	0	1.18
2187	0.0202	0	462	330	5.14E-07	0.0041	0.0064	3.38E-05	301	51.9	0.0043	0.0014	0.80	0.0034	0	1.16
2471	0.0202	0	461	330	4.95E-07	0.0041	0.0064	3.38E-05	301	51.9	0.0043	0.0014	0.80	0.0034	0	1.15
2755	0.0202	0	461	330	4.80E-07	0.0041	0.0064	3.38E-05	301	51.9	0.0043	0.0014	0.80	0.0034	0	1.14
3039	0.0202	0	461	330	4.68E-07	0.0041	0.0064	3.38E-05	301	51.9	0.0043	0.0014	0.80	0.0034	0	1.14

SCENARIO 5A

Dilution Ratio	Volume - PoPA	Volume - Total	pH	Total Dissolved Solids	Temperature	Density	Cl(-1)	Salinity	Ti(+4)	Si(+4)	Se(+4)	Sb(+5)	S(+6)	Pb(+2)	P(+5)	Ni(+2)	Na(+1)	N(-3)
	L/hr	L/hr		mg/L	°C	kg/m3	mg/L	g/Kg	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	39,036	9.84	45,209	20.4	1,037	25,119	43.8	5.58E-05	3.78E-04	5.43E-04	0	1,140	1.74E-03	0.0002	0.0096	15,268	0
1	50,000	89,018	10.2	42,750	13.6	1,031	21,345	37.4	5.51E-05	1.98E-04	6.78E-04	0.006	954	7.84E-04	0.0053	0.0059	13,298	0.0114
3	1.00E+05	1.39E+05	10.3	37,123	11.7	1,029	20,286	35.6	5.49E-05	1.66E-04	7.16E-04	0.007	901	5.17E-04	0.0066	0.0051	12,745	0.0145
4	1.50E+05	1.89E+05	10.3	36,307	10.8	1,028	19,787	34.8	5.47E-05	1.54E-04	7.34E-04	0.008	876	3.91E-04	0.0076	0.0047	12,485	0.0160
5	2.00E+05	2.39E+05	10.3	35,807	10.2	1,028	19,497	34.3	5.47E-05	1.47E-04	7.44E-04	0.008	862	3.18E-04	0.0084	0.0046	12,333	0.0169
6	2.50E+05	2.89E+05	10.4	35,439	9.90	1,027	19,307	34.0	5.46E-05	1.42E-04	7.51E-04	0.009	853	2.71E-04	0.0090	0.0044	12,234	0.0175
8	3.00E+05	3.39E+05	10.4	35,179	9.66	1,027	19,173	33.7	5.46E-05	1.39E-04	7.55E-04	0.009	846	2.37E-04	0.0094	0.0044	12,164	0.0179
9	3.50E+05	3.89E+05	10.4	34,986	9.49	1,027	19,074	33.6	5.46E-05	1.37E-04	7.59E-04	0.009	841	2.12E-04	0.0098	0.0043	12,112	0.0182
10	4.00E+05	4.39E+05	10.4	34,837	9.35	1,027	18,997	33.4	5.45E-05	1.36E-04	7.62E-04	0.009	837	1.93E-04	0.0101	0.0043	12,072	0.0184
12	4.50E+05	4.89E+05	10.4	34,719	9.24	1,027	18,936	33.3	5.45E-05	1.34E-04	7.64E-04	0.009	834	1.77E-04	0.0104	0.0042	12,040	0.0186
13	5.00E+05	5.39E+05	10.4	34,622	9.15	1,026	18,886	33.2	5.45E-05	1.33E-04	7.66E-04	0.009	832	1.65E-04	0.0106	0.0042	12,014	0.0187
14	5.50E+05	5.89E+05	10.4	34,542	9.08	1,026	18,845	33.2	5.45E-05	1.33E-04	7.67E-04	0.009	830	1.55E-04	0.0108	0.0042	11,993	0.0189
15	6.00E+05	6.39E+05	10.4	34,474	9.01	1,026	18,810	33.1	5.45E-05	1.32E-04	7.68E-04	0.009	828	1.46E-04	0.0110	0.0041	11,975	0.0190
17	6.50E+05	6.89E+05	10.4	34,416	8.96	1,026	18,781	33.1	5.45E-05	1.31E-04	7.69E-04	0.009	827	1.38E-04	0.0112	0.0041	11,959	0.0190
18	7.00E+05	7.39E+05	10.4	34,367	8.91	1,026	18,755	33.0	5.45E-05	1.31E-04	7.70E-04	0.009	825	1.32E-04	0.0113	0.0041	11,946	0.0191
19	7.50E+05	7.89E+05	10.4	34,323	8.87	1,026	18,732	33.0	5.45E-05	1.30E-04	7.71E-04	0.010	824	1.26E-04	0.0114	0.0041	11,934	0.0192
20	8.00E+05	8.39E+05	10.4	34,284	8.84	1,026	18,713	32.9	5.45E-05	1.30E-04	7.72E-04	0.010	823	1.21E-04	0.0116	0.0041	11,923	0.0193
22	8.50E+05	8.89E+05	10.4	34,250	8.81	1,026	18,695	32.9	5.45E-05	1.29E-04	7.72E-04	0.010	822	1.17E-04	0.0117	0.0041	11,914	0.0193
23	9.00E+05	9.39E+05	10.4	34,220	8.78	1,026	18,679	32.9	5.45E-05	1.29E-04	7.73E-04	0.010	822	1.13E-04	0.0117	0.0041	11,906	0.0194
24	9.50E+05	9.89E+05	10.4	34,192	8.75	1,026	18,665	32.9	5.45E-05	1.29E-04	7.73E-04	0.010	821	1.09E-04	0.0118	0.0041	11,899	0.0194
26	1.00E+06	1.04E+06	10.4	34,168	8.73	1,026	18,652	32.8	5.45E-05	1.29E-04	7.74E-04	0.010	820	1.06E-04	0.0119	0.0041	11,892	0.0194
38	1.50E+06	1.54E+06	10.4	34,009	8.58	1,026	18,570	32.7	5.44E-05	1.27E-04	7.77E-04	0.010	816	8.55E-05	0.0124	0.0040	11,849	0.0197
43	1.68E+06	1.72E+06	10.4	33,974	8.55	1,026	18,553	32.7	5.44E-05	1.27E-04	7.77E-04	0.010	815	8.10E-05	0.0125	0.0040	11,840	0.0197
48	1.86E+06	1.90E+06	10.4	33,946	8.53	1,026	18,538	32.6	5.44E-05	1.26E-04	7.78E-04	0.010	815	7.74E-05	0.0126	0.0040	11,832	0.0198
52	2.04E+06	2.08E+06	10.4	33,923	8.50	1,026	18,526	32.6	5.44E-05	1.26E-04	7.78E-04	0.010	814	7.44E-05	0.0127	0.0040	11,826	0.0198
57	2.22E+06	2.26E+06	10.4	33,903	8.49	1,026	18,516	32.6	5.44E-05	1.26E-04	7.79E-04	0.010	814	7.18E-05	0.0128	0.0040	11,821	0.0198
61	2.40E+06	2.44E+06	10.4	33,887	8.47	1,026	18,508	32.6	5.44E-05	1.26E-04	7.79E-04	0.010	813	6.97E-05	0.0129	0.0040	11,816	0.0199
66	2.58E+06	2.62E+06	10.4	33,872	8.46	1,026	18,500	32.6	5.44E-05	1.26E-04	7.79E-04	0.010	813	6.78E-05	0.0129	0.0040	11,813	0.0199
71	2.76E+06	2.80E+06	10.4	33,860	8.45	1,026	18,494	32.6	5.44E-05	1.26E-04	7.79E-04	0.010	812	6.62E-05	0.0130	0.0040	11,809	0.0199
75	2.94E+06	2.98E+06	10.4	33,849	8.44	1,026	18,488	32.6	5.44E-05	1.25E-04	7.80E-04	0.010	812	6.48E-05	0.0130	0.0040	11,806	0.0199
80	3.12E+06	3.16E+06	10.4	33,839	8.43	1,026	18,483	32.6	5.44E-05	1.25E-04	7.80E-04	0.010	812	6.35E-05	0.0130	0.0040	11,804	0.0199
85	3.30E+06	3.34E+06	10.4	33,830	8.42	1,026	18,479	32.5	5.44E-05	1.25E-04	7.80E-04	0.010	812	6.24E-05	0.0131	0.0040	11,801	0.0200
89	3.48E+06	3.52E+06	10.4	33,823	8.41	1,026	18,475	32.5	5.44E-05	1.25E-04	7.80E-04	0.010	811	6.14E-05	0.0131	0.0040	11,799	0.0200
94	3.66E+06	3.70E+06	10.4	33,816	8.41	1,026	18,471	32.5	5.44E-05	1.25E-04	7.80E-04	0.010	811	6.05E-05	0.0131	0.0040	11,797	0.0200
98	3.84E+06	3.88E+06	10.4	33,809	8.40	1,026	18,468	32.5	5.44E-05	1.64E-04	7.80E-04	0.010	811	5.97E-05	0.0145	0.0047	11,796	0.0200
103	4.02E+06	4.06E+06	9.95	33,800	8.39	1,026	18,465	32.5	5.44E-05	0.002	7.80E-04	0.010	811	5.89E-05	0.0348	0.0231	11,794	0.0200
108	4.20E+06	4.24E+06	9.41	33,796	8.39	1,026	18,462	32.5	8.54E-05	0.039	7.81E-04	0.010	811	5.82E-05	0.0381	0.0226	11,793	0.0200
112	4.38E+06	4.42E+06	9.15	33,793	8.38	1,026	18,459	32.5	8.20E-05	0.207	7.81E-04	0.010	811	5.76E-05	0.0387	0.0216	11,791	0.0200
117	4.56E+06	4.60E+06	9.01	33,791	8.38	1,026	18,457	32.5	7.88E-05	0.507	7.81E-04	0.010	811	5.70E-05	0.0393	0.0207	11,790	0.0200
121	4.74E+06	4.78E+06	8.91	33,788	8.37	1,026	18,455	32.5	7.58E-05	0.791	7.81E-04	0.010	811	5.65E-05	0.0398	0.0199	11,789	0.0200
126	4.92E+06	4.96E+06	8.80	33,787	8.37	1,026	18,453	32.5	7.30E-05	0.786	7.81E-04	0.010	810	5.60E-05	0.0398	0.0191	11,788	0.0200
131	5.10E+06	5.14E+06	8.72	33,785	8.36	1,026	18,451	32.5	7.05E-05	0.781	7.81E-04	0.010	810	5.55E-05	0.0399	0.0184	11,787	0.0200
135	5.28E+06	5.32E+06	8.65	33,784	8.36	1,026	18,449	32.5	6.81E-05	0.777	7.81E-04	0.010	810	5.51E-05	0.0399	0.0178	11,786	0.0200
140	5.46E+06	5.50E+06	8.59	33,782	8.36	1,026	18,448	32.5	6.59E-05	0.773	7.81E-04	0.010	810	5.47E-05	0.0399	0.0172	11,785	0.0200
144	5.64E+06	5.68E+06	8.55	33,781	8.35	1,026	18,446	32.5	6.38E-05	0.769	7.81E-04	0.010	810	5.43E-05	0.0399	0.0166	11,784	0.0201
149	5.82E+06	5.86E+06	8.51	33,780	8.35	1,026	18,445	32.5	6.18E-05	0.766	7.81E-04	0.010	810	5.39E-05	0.0399	0.0161	11,784	0.0201
154	6.00E+06	6.04E+06	8.47	33,778	8.35	1,026	18,444	32.5	6.00E-05	0.762	7.81E-04	0.010	810	5.36E-05	0.0399	0.0156	11,783	0.0201
167	6.50E+06	6.54E+06	8.39	33,776	8.34	1,026	18,440	32.5	5.54E-05	0.754	7.81E-04	0.010	810	5.28E-05	0.0399	0.0143	11,781	0.0201
326	1.27E+07	1.28E+07	8.07	33,758	8.30	1,026	18,421	32.4	2.84E-05	0.705	7.82E-04	0.010	809	4.79E-05	0.0399	0.0069	11,771	0.0201
486	1.90E+07	1.90E+07	7.99	33,752	8.28	1,026	18,414	32.4	1.91E-05	0.689	7.82E-04	0.010	808	4.62E-05	0.0400	0.0043	11,767	0.0201
646	2.52E+07	2.52E+07	7.95	33,749	8.27	1,026	18,410	32.4	1.43E-05	0.680	7.82E-04	0.010	808	4.53E-05	0.0400	0.0031	11,766	0.0202
805	3.14E+07	3.15E+07	7.93	33,747	8.27	1,026	18,408	32.4	1.15E-05	0.675	7.82E-04	0.010	808	4.48E-05	0.0400	0.0023	11,764	0.0202
965	3.77E+07	3.77E+07	7.92	33,746	8.27	1,026	18,407	32.4	9.61E-06	0.672	7.83E-04	0.010	808	4.44E-05	0.0400	0.0018	11,764	0.0202
1125	4.39E+07	4.39E+07	7.91	33,745	8.26	1,026	18,406	32.4	8.24E-06	0.669	7.83E-04	0.010	808	4.42E-05	0.0400	0.0014	11,763	0.0202
1284	5.01E+07	5.02E+07	7.90	33,744	8.26	1,026	18,405	32.4	7.22E-06	0.667	7.83E-04	0.010	808	4.40E-05	0.0400	0.0011	11,763	0.0202
1444	5.64E+07	5.64E+07	7.90	33,744	8.26	1,026	18,405	32.4	6.42E-06	0.666	7.83E-04	0.010	808	4.39E-05	0.0400	0.0009	11,762	0.0202
1604	6.26E+07	6.26E+07	7.89	33,743	8.26	1,026	18,404	32.4	5.78E-06	0.665	7.83E-04	0.010	808	4.38E-05	0.0400	0.0007	11,762	0.0202
1763	6.88E+07	6.89E+07	7.89	33,743	8.26	1,026	18,404	32.4	5.26E-06	0.664	7.83E-04	0.010	808	4.37E-05	0.0400	0.0006	11,762	0.0202
1923	7.51E+07	7.51E+07	7.89	33,743	8.26	1,026	18,404	32.4	4.82E-06	0.663	7.83E-04	0.010	808	4.36E-05	0.0400	0.0004	11,762	0.0202
2083	8.13E+07	8.13E+07	7.88	33,894	8.26	1,026	18,403	32.4	4.45E-06	0.662	7.83E-04	0.010	808	4.35E-05	0.0400	0.0003	11,762	0.0202
2242	8.75E+07	8.76E+07	7.88	33,742	8.26	1,026	18,403	32.4	4.14E-06	0.662	7.83E-04	0.010	808	4.35E-05	0.0400	0.0003	11,762	0.0202
2402	9.38E+07	9.38E+07	7.88	33,893	8.26	1,026	18,403	32.4	3.86E-06	0.661	7.83E-04	0.010	808	4.34E-05	0.0400	0.0002	11,762	0.0202
2562	1.00E+08	1.00E+08	7.88	33,893	8.26	1,026	18,403	32.4	3.62E-06	0.661	7.83E-04	0.010	808	4.34E-05	0.0400	0.0001	11,761	0.0202

Dilution Ratio	N(+5)	N(+3)	Mn(+2)	Mg(+2)	Zn(+2)	K(+1)	Hg(+2)	Fe(+3)	Fe(+2)	F(-1)	Cu(+2)	Cr(+6)	Cr(+3)	Co(+2)	Cd(+2)	Ca(+2)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	0	0	895	0.0010	0	4.51E-08	7.38E-10	0	0	7.81E-05	1.87E-04	5.10E-10	0.0722	5.41E-05	853
1	0.1589	0.0428	0.0028	670	0.0040	186	2.17E-07	4.13E-10	0.0084	1.41	7.88E-05	1.53E-04	2.87E-10	0.0039	4.27E-05	484
3	0.2033	0.0548	0.0036	606	0.0049	238	2.65E-07	3.52E-10	0.0108	1.80	8.18E-05	1.43E-04	2.42E-10	0.0031	3.95E-05	381
4	0.2243	0.0605	0.0040	577	0.0053	262	2.87E-07	3.27E-10	0.0119	1.99	8.37E-05	1.39E-04	2.23E-10	0.0027	3.80E-05	332
5	0.2364	0.0637	0.0042	559	0.0055	276	3.00E-07	3.14E-10	0.0126	2.09	8.50E-05	1.36E-04	2.13E-10	0.0025	3.71E-05	304
6	0.2444	0.0659	0.0043	548	0.0057	286	3.09E-07	3.05E-10	0.0130	2.16	8.59E-05	1.35E-04	2.07E-10	0.0024	3.65E-05	286
8	0.2500	0.0674	0.0044	540	0.0058	292	3.15E-07	2.99E-10	0.0133	2.21	8.65E-05	1.33E-04	2.02E-10	0.0023	3.61E-05	273
9	0.2542	0.0685	0.0045	534	0.0059	297	3.20E-07	2.95E-10	0.0135	2.25	8.70E-05	1.33E-04	1.99E-10	0.0022	3.58E-05	263
10	0.2574	0.0694	0.0046	530	0.0059	301	3.23E-07	2.92E-10	0.0137	2.28	8.74E-05	1.32E-04	1.96E-10	0.0022	3.56E-05	256
12	0.2599	0.0701	0.0046	526	0.0060	304	3.26E-07	2.89E-10	0.0138	2.30	8.78E-05	1.31E-04	1.94E-10	0.0021	3.54E-05	250
13	0.2620	0.0706	0.0046	523	0.0060	306	3.28E-07	2.87E-10	0.0139	2.32	8.80E-05	1.31E-04	1.93E-10	0.0021	3.53E-05	245
14	0.2637	0.0711	0.0047	521	0.0060	308	3.30E-07	2.85E-10	0.0140	2.34	8.83E-05	1.30E-04	1.91E-10	0.0021	3.51E-05	241
15	0.2652	0.0715	0.0047	518	0.0061	310	3.31E-07	2.84E-10	0.0141	2.35	8.84E-05	1.30E-04	1.90E-10	0.0021	3.50E-05	238
17	0.2664	0.0718	0.0047	517	0.0061	311	3.33E-07	2.83E-10	0.0142	2.36	8.86E-05	1.30E-04	1.89E-10	0.0020	3.49E-05	235
18	0.2675	0.0721	0.0047	515	0.0061	313	3.34E-07	2.82E-10	0.0142	2.37	8.88E-05	1.30E-04	1.89E-10	0.0020	3.49E-05	232
19	0.2685	0.0724	0.0048	514	0.0061	314	3.35E-07	2.81E-10	0.0143	2.38	8.89E-05	1.29E-04	1.88E-10	0.0020	3.48E-05	230
20	0.2693	0.0726	0.0048	513	0.0061	315	3.36E-07	2.80E-10	0.0143	2.38	8.90E-05	1.29E-04	1.87E-10	0.0020	3.47E-05	228
22	0.2700	0.0728	0.0048	512	0.0062	316	3.37E-07	2.79E-10	0.0143	2.39	8.91E-05	1.29E-04	1.87E-10	0.0020	3.47E-05	226
23	0.2707	0.0730	0.0048	511	0.0062	316	3.37E-07	2.79E-10	0.0144	2.40	8.92E-05	1.29E-04	1.86E-10	0.0020	3.46E-05	225
24	0.2713	0.0731	0.0048	510	0.0062	317	3.38E-07	2.78E-10	0.0144	2.40	8.93E-05	1.29E-04	1.86E-10	0.0020	3.46E-05	223
26	0.2718	0.0733	0.0048	509	0.0062	318	3.39E-07	2.78E-10	0.0144	2.41	8.94E-05	1.29E-04	1.85E-10	0.0019	3.46E-05	222
38	0.2752	0.0742	0.0049	504	0.0063	322	3.42E-07	2.74E-10	0.0146	2.44	8.98E-05	1.28E-04	1.83E-10	0.0019	3.43E-05	214
43	0.2760	0.0744	0.0049	503	0.0063	323	3.43E-07	2.74E-10	0.0147	2.44	9.00E-05	1.28E-04	1.82E-10	0.0019	3.43E-05	213
48	0.2766	0.0746	0.0049	502	0.0063	323	3.44E-07	2.73E-10	0.0147	2.45	9.00E-05	1.28E-04	1.82E-10	0.0019	3.42E-05	211
52	0.2771	0.0747	0.0049	502	0.0063	324	3.44E-07	2.73E-10	0.0147	2.45	9.01E-05	1.28E-04	1.81E-10	0.0019	3.42E-05	210
57	0.2775	0.0748	0.0049	501	0.0063	324	3.45E-07	2.72E-10	0.0147	2.46	9.02E-05	1.28E-04	1.81E-10	0.0019	3.41E-05	209
61	0.2779	0.0749	0.0049	500	0.0063	325	3.45E-07	2.72E-10	0.0148	2.46	9.02E-05	1.27E-04	1.81E-10	0.0018	3.41E-05	208
66	0.2782	0.0750	0.0049	500	0.0063	325	3.45E-07	2.72E-10	0.0148	2.46	9.03E-05	1.27E-04	1.81E-10	0.0018	3.41E-05	208
71	0.2785	0.0751	0.0049	500	0.0063	325	3.46E-07	2.71E-10	0.0148	2.47	9.03E-05	1.27E-04	1.81E-10	0.0018	3.41E-05	207
75	0.2787	0.0751	0.0049	499	0.0063	326	3.46E-07	2.71E-10	0.0148	2.47	9.04E-05	1.27E-04	1.80E-10	0.0018	3.41E-05	206
80	0.2789	0.0752	0.0049	499	0.0063	326	3.46E-07	2.71E-10	0.0148	2.47	9.04E-05	1.27E-04	1.80E-10	0.0018	3.41E-05	206
85	0.2791	0.0752	0.0049	499	0.0063	326	3.46E-07	2.71E-10	0.0148	2.47	9.04E-05	1.27E-04	1.80E-10	0.0018	3.40E-05	205
89	0.2793	0.0753	0.0049	498	0.0063	326	3.47E-07	2.71E-10	0.0148	2.47	9.04E-05	1.27E-04	1.80E-10	0.0018	3.40E-05	205
94	0.2794	0.0753	0.0049	498	0.0063	327	3.47E-07	2.70E-10	0.0148	2.47	9.05E-05	1.27E-04	1.80E-10	0.0018	3.40E-05	205
98	0.2795	0.0754	0.0049	498	0.0063	327	3.47E-07	2.43E-10	0.0148	2.47	8.31E-05	1.27E-04	1.80E-10	0.0015	3.40E-05	204
103	0.2797	0.0754	0.0050	496	0.0063	327	3.47E-07	1.09E-10	0.0149	2.48	6.35E-05	1.27E-04	1.78E-10	0.0004	3.40E-05	205
108	0.2798	0.0754	0.0050	495	0.0064	327	3.47E-07	1.70E-10	0.0149	2.48	1.54E-04	1.27E-04	5.41E-10	0.0011	3.40E-05	207
112	0.2799	0.0754	0.0050	493	0.0064	327	3.47E-07	2.57E-10	0.0149	2.48	3.17E-04	1.27E-04	9.91E-10	0.0028	3.40E-05	210
117	0.2800	0.0755	0.0050	492	0.0064	327	3.47E-07	3.33E-10	0.0149	2.48	4.82E-04	1.27E-04	1.38E-09	0.0045	3.40E-05	213
121	0.2801	0.0755	0.0050	492	0.0064	327	3.48E-07	4.08E-10	0.0149	2.48	6.60E-04	1.27E-04	1.76E-09	0.0060	3.40E-05	215
126	0.2802	0.0755	0.0050	490	0.0064	327	3.48E-07	5.15E-10	0.0149	2.48	9.52E-04	1.27E-04	2.31E-09	0.0060	3.40E-05	218
131	0.2802	0.0755	0.0050	489	0.0064	328	3.48E-07	6.22E-10	0.0149	2.48	1.27E-03	1.27E-04	2.86E-09	0.0059	3.40E-05	221
135	0.2803	0.0756	0.0050	488	0.0064	328	3.48E-07	7.29E-10	0.0149	2.48	1.61E-03	1.27E-04	3.43E-09	0.0059	3.39E-05	224
140	0.2804	0.0756	0.0050	487	0.0064	328	3.48E-07	8.36E-10	0.0149	2.48	1.85E-03	1.27E-04	3.99E-09	0.0059	3.39E-05	226
144	0.2804	0.0756	0.0050	487	0.0064	328	3.48E-07	9.42E-10	0.0149	2.48	1.85E-03	1.27E-04	4.56E-09	0.0059	3.39E-05	228
149	0.2805	0.0756	0.0050	486	0.0064	328	3.48E-07	1.05E-09	0.0149	2.48	1.85E-03	1.27E-04	5.13E-09	0.0058	3.39E-05	231
154	0.2806	0.0756	0.0050	485	0.0064	328	3.48E-07	1.15E-09	0.0149	2.48	1.85E-03	1.27E-04	5.70E-09	0.0058	3.39E-05	233
167	0.2807	0.0757	0.0050	483	0.0064	328	3.48E-07	1.43E-09	0.0149	2.49	1.85E-03	1.27E-04	7.26E-09	0.0057	3.39E-05	238
326	0.2815	0.0759	0.0050	472	0.0064	329	3.49E-07	4.41E-09	0.0150	2.49	1.86E-03	1.27E-04	2.77E-08	0.0054	3.39E-05	268
486	0.2818	0.0760	0.0050	468	0.0064	329	3.49E-07	6.76E-09	0.0150	2.49	1.86E-03	1.27E-04	4.68E-08	0.0053	3.38E-05	279
646	0.2819	0.0760	0.0050	466	0.0064	329	3.50E-07	8.83E-09	0.0150	2.50	1.86E-03	1.27E-04	6.45E-08	0.0052	3.38E-05	284
805	0.2820	0.0760	0.0050	465	0.0064	330	3.50E-07	1.08E-08	0.0150	2.50	1.86E-03	1.27E-04	8.15E-08	0.0052	3.38E-05	287
965	0.2821	0.0760	0.0050	464	0.0064	330	3.50E-07	1.27E-08	0.0150	2.50	1.86E-03	1.27E-04	9.82E-08	0.0051	3.38E-05	289
1125	0.2821	0.0760	0.0050	463	0.0064	330	3.50E-07	1.47E-08	0.0150	2.50	1.86E-03	1.27E-04	1.15E-07	0.0051	3.38E-05	291
1284	0.2822	0.0761	0.0050	463	0.0064	330	3.50E-07	1.68E-08	0.0150	2.50	1.86E-03	1.27E-04	1.33E-07	0.0051	3.38E-05	292
1444	0.2822	0.0761	0.0050	463	0.0064	330	3.50E-07	1.90E-08	0.0150	2.50	1.86E-03	1.27E-04	1.52E-07	0.0051	3.38E-05	293
1604	0.2822	0.0761	0.0050	462	0.0064	330	3.50E-07	2.14E-08	0.0150	2.50	1.86E-03	1.27E-04	1.73E-07	0.0051	3.38E-05	293
1763	0.2822	0.0761	0.0050	462	0.0064	330	3.50E-07	2.42E-08	0.0150	2.50	1.86E-03	1.27E-04	1.97E-07	0.0051	3.38E-05	294
1923	0.2822	0.0761	0.0050	462	0.0064	330	3.50E-07	2.74E-08	0.0150	2.50	1.86E-03	1.27E-04	2.25E-07	0.0051	3.38E-05	294
2083	0.2822	0.0761	0.0050	462	0.0064	330	3.50E-07	3.14E-08	0.0150	2.50	1.86E-03	1.27E-04	2.58E-07	0.0051	3.38E-05	295
2242	0.2822	0.0761	0.0050	462	0.0064	330	3.50E-07	3.65E-08	0.0150	2.50	1.86E-03	1.27E-04	3.01E-07	0.0051	3.38E-05	295
2402	0.2823	0.0761	0.0050	462	0.0064	330	3.50E-07	4.35E-08	0.0150	2.50	1.86E-03	1.27E-04	3.60E-07	0.0051	3.38E-05	295
2562	0.2823	0.0761	0.0050	462	0.0064	330	3.50E-07	5.46E-08	0.0150	2.50	1.86E-03	1.27E-04	4.53E-07	0.0050	3.38E-05	296

Dilution Ratio	Br(-1)	Be(+2)	Ba(+2)	As(+5)	Al(+3)	NiTiO3	NiFe2O4 (Trevorite)	NiCr2O4	Ni(OH)2 (Theophrastite)	NaAlCO3(OH)2 (Dawsonite)	Mg3Si2O5(OH)4 (Poor-crystalline Antigorite)	Mg(OH)2 (Brucite)	CuO	Co3(PO4) 2.8H2O	CaCO3 (Calcite)	Ca3(PO4)2	Be2(OH)2CO3	Al(OH)3 (Gibbsite)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	36.8	0	0	0.00	0.04	0.03	0.77	0.02	4.00	0	85.9	8,197	0.0002	0.1654	263	0	0	0.37
1	45.3	0.0028	0.0028	0.0034	0.0465	0.0130	0.3383	0.0115	1.75	0	39.4	3,540	0.0014	0.1604	260	0.033	0.000	0.33
3	47.7	0.0036	0.0036	0.0037	0.0480	0.0082	0.2165	0.0091	1.12	0	26.4	2,236	0.0017	0.1063	259	0.075	0.000	0.31
4	48.8	0.0038	0.0040	0.0039	0.0488	0.0060	0.1592	0.0080	0.82	0	20.2	1,622	0.0018	0.0806	258	0.093	0.001	0.31
5	49.4	0.0040	0.0042	0.0040	0.0494	0.0047	0.1259	0.0073	0.65	0	16.7	1,265	0.0019	0.0657	257	0.102	0.001	0.30
6	49.9	0.0041	0.0043	0.0040	0.0497	0.0039	0.1041	0.0069	0.53	0	14.4	1,031	0.0020	0.0560	257	0.108	0.002	0.30
8	50.2	0.0041	0.0044	0.0041	0.0500	0.0033	0.0887	0.0066	0.45	0	12.7	867	0.0020	0.0491	257	0.112	0.002	0.30
9	50.4	0.0042	0.0045	0.0041	0.0502	0.0028	0.0773	0.0063	0.39	0	11.5	745	0.0020	0.0440	257	0.115	0.002	0.29
10	50.6	0.0042	0.0046	0.0041	0.0503	0.0025	0.0685	0.0062	0.35	0	10.6	650	0.0020	0.0400	256	0.116	0.002	0.29
12	50.7	0.0043	0.0046	0.0041	0.0505	0.0022	0.0615	0.0060	0.31	0	9.80	575	0.0021	0.0369	256	0.118	0.002	0.29
13	50.8	0.0043	0.0046	0.0042	0.0506	0.0020	0.0558	0.0059	0.28	0	9.19	514	0.0021	0.0343	256	0.119	0.002	0.29
14	50.9	0.0043	0.0047	0.0042	0.0507	0.0018	0.0511	0.0058	0.26	0	8.69	463	0.0021	0.0322	256	0.120	0.002	0.29
15	51.0	0.0044	0.0047	0.0042	0.0507	0.0017	0.0471	0.0057	0.24	0	8.26	420	0.0021	0.0304	256	0.121	0.002	0.29
17	51.0	0.0044	0.0047	0.0042	0.0508	0.0015	0.0436	0.0057	0.22	0	7.89	384	0.0021	0.0289	256	0.121	0.002	0.29
18	51.1	0.0044	0.0047	0.0042	0.0509	0.0014	0.0407	0.0056	0.20	0	7.58	352	0.0021	0.0276	256	0.122	0.002	0.29
19	51.2	0.0044	0.0048	0.0042	0.0509	0.0013	0.0381	0.0056	0.19	0	7.30	325	0.0021	0.0264	256	0.122	0.002	0.29
20	51.2	0.0044	0.0048	0.0042	0.0510	0.0012	0.0358	0.0055	0.18	0	7.06	300	0.0021	0.0254	256	0.122	0.002	0.29
22	51.2	0.0044	0.0048	0.0042	0.0510	0.0011	0.0338	0.0055	0.17	0	6.84	279	0.0021	0.0245	256	0.123	0.002	0.29
23	51.3	0.0044	0.0048	0.0042	0.0510	0.0011	0.0320	0.0054	0.16	0	6.65	259	0.0021	0.0237	256	0.123	0.002	0.29
24	51.3	0.0045	0.0048	0.0042	0.0511	0.0010	0.0304	0.0054	0.15	0	6.48	242	0.0021	0.0229	256	0.123	0.002	0.29
26	51.3	0.0045	0.0048	0.0042	0.0511	0.0009	0.0289	0.0054	0.14	0	6.32	226	0.0021	0.0223	256	0.123	0.002	0.29
38	51.5	0.0045	0.0049	0.0043	0.0513	0.0006	0.0195	0.0052	0.09	0	5.32	126	0.0022	0.0181	255	0.125	0.002	0.29
43	51.6	0.0045	0.0049	0.0043	0.0513	0.0005	0.0175	0.0051	0.08	0	5.10	104	0.0022	0.0172	255	0.125	0.002	0.29
48	51.6	0.0046	0.0049	0.0043	0.0514	0.0004	0.0158	0.0051	0.07	0	4.92	85.9	0.0022	0.0164	255	0.125	0.002	0.29
52	51.6	0.0046	0.0049	0.0043	0.0514	0.0004	0.0145	0.0051	0.07	0	4.77	71.2	0.0022	0.0158	255	0.125	0.002	0.29
57	51.6	0.0046	0.0049	0.0043	0.0514	0.0003	0.0133	0.0051	0.06	0	4.65	58.9	0.0022	0.0153	255	0.125	0.002	0.29
61	51.7	0.0046	0.0049	0.0043	0.0514	0.0003	0.0123	0.0050	0.06	0	4.55	48.3	0.0022	0.0148	255	0.125	0.002	0.29
66	51.7	0.0046	0.0049	0.0043	0.0515	0.0003	0.0115	0.0050	0.05	0	4.46	39.3	0.0022	0.0145	255	0.125	0.002	0.29
71	51.7	0.0046	0.0049	0.0043	0.0515	0.0002	0.0107	0.0050	0.05	0	4.38	31.4	0.0022	0.0141	255	0.125	0.002	0.29
75	51.7	0.0046	0.0049	0.0043	0.0515	0.0002	0.0101	0.0050	0.04	0	4.31	24.4	0.0022	0.0138	255	0.126	0.002	0.29
80	51.7	0.0046	0.0049	0.0043	0.0515	0.0002	0.0095	0.0050	0.04	0	4.25	18.2	0.0022	0.0136	255	0.126	0.002	0.29
85	51.7	0.0046	0.0049	0.0043	0.0515	0.0002	0.0090	0.0050	0.04	0	4.19	12.8	0.0022	0.0134	255	0.126	0.002	0.29
89	51.7	0.0046	0.0049	0.0043	0.0515	0.0002	0.0085	0.0050	0.04	0	4.14	7.82	0.0022	0.0131	255	0.126	0.002	0.29
94	51.7	0.0046	0.0049	0.0043	0.0515	0.0001	0.0081	0.0050	0.03	0	4.10	3.36	0.0022	0.0130	255	0.126	0.002	0.29
98	51.7	0.0049	0.0049	0.0043	0.0455	0.0001	0.0078	0.0049	0.03	0	4.06	0	0.0022	0.0138	255	0.118	0.000	0.30
103	51.8	0.0050	0.0050	0.0043	0.0162	0.0001	0.0074	0.0049	6.64E-04	0	4.01	0	0.0022	0.0166	253	0.015	0.000	0.39
108	51.8	0.0050	0.0050	0.0043	0.0047	0.0000	0.0071	0.0049	0	0	3.80	0	0.0021	0.0145	246	0	0	0.42
112	51.8	0.0050	0.0050	0.0043	0.0026	0.0000	0.0068	0.0049	0	0	2.93	0	0.0019	0.0096	238	0	0	0.43
117	51.8	0.0050	0.0050	0.0043	0.0019	0.0000	0.0065	0.0049	0	0	1.43	0	0.0017	0.0043	232	0	0	0.43
121	51.8	0.0050	0.0050	0.0043	0.0015	0.0000	0.0063	0.0049	0	0	0	0	0.0015	0	226	0	0	0.43
126	51.8	0.0050	0.0050	0.0043	0.0012	0.0000	0.0061	0.0049	0	0	0	0	0.0011	0	218	0	0	0.43
131	51.8	0.0050	0.0050	0.0043	0.0010	0.0000	0.0059	0.0049	0	0	0	0	0.0007	0	210	0	0	0.43
135	51.8	0.0050	0.0050	0.0043	0.0008	0.0000	0.0057	0.0049	0	0	0	0	0.0003	0	203	0	0	0.43
140	51.8	0.0050	0.0050	0.0043	0.0007	0.0000	0.0055	0.0049	0	0	0	0	0	0	196	0	0	0.43
144	51.8	0.0050	0.0050	0.0043	0.0007	0.0000	0.0053	0.0049	0	0	0	0	0	0	190	0	0	0.43
149	51.8	0.0050	0.0050	0.0043	0.0006	0.0000	0.0051	0.0049	0	0	0	0	0	0	184	0	0	0.43
154	51.8	0.0050	0.0050	0.0043	0.0006	0.0000	0.0050	0.0049	0	0	0	0	0	0	179	0	0	0.43
167	51.8	0.0050	0.0050	0.0043	0.0005	0.0000	0.0046	0.0049	0	0.799	0	0	0	0	165	0	0	0
326	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0024	0.0048	0	0.800	0	0	0	0	84.3	0	0	0
486	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0016	0.0048	0	0.800	0	0	0	0	56.8	0	0	0
646	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0012	0.0048	0	0.800	0	0	0	0	43.0	0	0	0
805	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0010	0.0048	0	0.800	0	0	0	0	34.7	0	0	0
965	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0008	0.0048	0	0.800	0	0	0	0	29.1	0	0	0
1125	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0007	0.0048	0	0.800	0	0	0	0	25.1	0	0	0
1284	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0006	0.0048	0	0.800	0	0	0	0	22.1	0	0	0
1444	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0005	0.0048	0	0.800	0	0	0	0	19.8	0	0	0
1604	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0005	0.0048	0	0.800	0	0	0	0	17.9	0	0	0
1763	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0004	0.0048	0	0.800	0	0	0	0	16.4	0	0	0
1923	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0004	0.0048	0	0.800	0	0	0	0	15.1	0	0	0
2083	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0004	0.0048	0	0.800	0	0	0	0	14.0	0	0	0
2242	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0003	0.0048	0	0.800	0	0	0	0	13.1	0	0	0
2402	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0003	0.0048	0	0.800	0	0	0	0	12.3	0	0	0
2562	51.9	0.0050	0.0050	0.0043	0.0001	0.0000	0.0003	0.0048	0	0.800	0	0	0	0	11.6	0	0	0

SCENARIO 5B

Dilution Ratio	Volume - PoPA	Volume - Total	pH	Total Dissolved Solids	Temperature	Density	Cl(-1)	Zn(+2)	Si(+4)	Se(+4)	Sb(+5)	S(+6)	Pb(+2)	P(+5)	Ni(+2)	Na(+1)	N(-3)	N(+5)	N(+3)	Mo(+6)	Mn(+2)	Mg(+2)	K(+1)	Hg(+2)	Fe(+2)	F(-1)	Cu(+2)	Cr(+6)	Cr(+3)	Co(+2)	Cd(+2)	Ca(+2)	Br(-1)	Be(+2)	Ba(+2)	As(+5)	Al(+3)	NiCr2O4	NaAlCO3(OH)2 (Dawsonite)	Mg3Si2O5(OH)4 (Poor-crystalline Antigorite)	Mg(OH)2 (Brucite)	CuO	CoCr2O4	Co3(PO4)2.8H2O	CaSO4.2H2O (Gypsum)	CaCO3 (Calcite)	Ca3(PO4)2	Be2(OH)2CO3	Al(OH)3 (Gibbsite)
	L/hr	L/hr		mg/L	°C	kg/m3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0	0	39,029	12.1	46,456	20.4	1,038	25,607	0.001	0.000	0.003	0.000	877	2.12E-03	0	8.08E-16	15,293	0	0	0	1.52E-05	0.0000	0.04	0	3.04E-04	0	0	2.60E-04	1.87E-04	1.94E-04	1.58E-12	8.45E-05	2,596	36.8	0	0	0.017	0.000	2.73E-03	0	0.00	7,789	0	1.75E-04	0	1,417	336	0	0	0
1	50,000	89,017	10.5	39,242	13.6	1,031	21,553	0.004	0.000	0.002	0.006	954	9.49E-04	0.0005	7.51E-05	13,306	0.0114	0.1589	0.0428	6.64E-06	0.0028	188	186	1.33E-04	0.0084	1.41	1.21E-04	1.53E-04	1.61E-09	2.19E-03	5.60E-05	1,390	45.3	0.0028	0.0028	0.0101	0.084	1.70E-03	0	1.81	3,577	0.0013	0.0025	0	0	293	0.110	0	0
3	1.00E+05	1.39E+05	10.4	37,206	11.7	1,029	20,419	0.005	0.000	0.002	0.007	901	6.23E-04	0.0010	1.12E-04	12,750	0.0145	0.2033	0.0548	4.25E-06	0.0036	298	238	8.52E-05	0.0108	1.80	1.04E-04	1.43E-04	1.26E-09	2.82E-03	4.80E-05	960	47.7	0.0036	0.0036	0.0080	0.068	1.35E-03	0	2.32	2,259	0.0016	0.0030	0	0	281	0.139	0	0.114
4	1.50E+05	1.89E+05	10.4	38,354	10.8	1,028	19,885	0.005	0.000	0.001	0.008	876	4.69E-04	0.0016	1.28E-04	12,488	0.0160	0.2243	0.0605	3.12E-06	0.0040	350	262	6.28E-05	0.0119	1.99	9.95E-05	1.39E-04	1.14E-09	3.12E-03	4.42E-05	758	48.8	0.0036	0.0040	0.0070	0.063	1.19E-03	0	2.56	1,639	0.0018	0.0033	0	0	275	0.151	0.0026	0.163
5	2.00E+05	2.39E+05	10.4	35,880	10.2	1,028	19,574	0.006	0.000	0.001	0.008	862	3.80E-04	0.0021	1.38E-04	12,336	0.0169	0.2364	0.0637	2.47E-06	0.0042	380	276	4.97E-05	0.0126	2.09	9.72E-05	1.36E-04	1.07E-09	3.29E-03	4.20E-05	641	49.4	0.0036	0.0042	0.0064	0.060	1.10E-03	0	2.70	1,278	0.0019	0.0035	0	0	271	0.157	0.0038	0.190
6	2.50E+05	2.89E+05	10.4	35,555	9.90	1,027	19,371	0.006	0.000	0.001	0.009	853	3.22E-04	0.0026	1.43E-04	12,236	0.0175	0.2444	0.0659	2.04E-06	0.0043	400	286	4.12E-05	0.0130	2.16	9.59E-05	1.35E-04	1.03E-09	3.41E-03	4.06E-05	564	49.9	0.0036	0.0043	0.0061	0.058	1.04E-03	0	2.79	1,043	0.0019	0.0036	0	0	269	0.160	0.0045	0.207
8	3.00E+05	3.39E+05	10.4	35,278	9.66	1,027	19,228	0.006	0.000	0.001	0.009	846	2.81E-04	0.0031	1.48E-04	12,166	0.0179	0.2500	0.0674	1.74E-06	0.0044	414	292	3.51E-05	0.0133	2.21	9.50E-05	1.33E-04	9.98E-10	3.49E-03	3.96E-05	510	50.2	0.0037	0.0044	0.0058	0.057	9.95E-04	0	2.86	876	0.0020	0.0036	0	0	267	0.162	0.0048	0.219
9	3.50E+05	3.89E+05	10.4	35,072	9.48	1,027	19,121	0.006	0.000	0.001	0.009	841	2.50E-04	0.0035	1.51E-04	12,114	0.0182	0.2542	0.0685	1.52E-06	0.0045	424	297	3.07E-05	0.0135	2.25	9.44E-05	1.33E-04	9.78E-10	3.55E-03	3.89E-05	469	50.4	0.0037	0.0045	0.0056	0.056	9.64E-04	0	2.91	753	0.0020	0.0037	0	0	266	0.163	0.0049	0.227
10	4.00E+05	4.39E+05	10.4	34,913	9.34	1,027	19,039	0.006	0.000	0.001	0.009	837	2.26E-04	0.0039	1.53E-04	12,074	0.0184	0.2574	0.0694	1.34E-06	0.0046	432	301	2.72E-05	0.0137	2.28	9.40E-05	1.32E-04	9.63E-10	3.59E-03	3.83E-05	438	50.6	0.0038	0.0046	0.0055	0.056	9.40E-04	0	2.94	658	0.0020	0.0037	0	0	265	0.163	0.0050	0.234
12	4.50E+05	4.89E+05	10.4	34,787	9.24	1,027	18,974	0.006	0.000	0.001	0.009	834	2.08E-04	0.0043	1.55E-04	12,042	0.0186	0.2599	0.0701	1.21E-06	0.0046	438	304	2.45E-05	0.0138	2.30	9.36E-05	1.31E-04	9.51E-10	3.63E-03	3.78E-05	414	50.7	0.0038	0.0046	0.0053	0.055	9.22E-04	0	2.97	582	0.0021	0.0038	0	0	264	0.163	0.0050	0.239
13	5.00E+05	5.39E+05	10.4	34,684	9.15	1,027	18,921	0.006	0.000	0.001	0.009	832	1.92E-04	0.0047	1.56E-04	12,016	0.0187	0.2620	0.0706	1.09E-06	0.0046	444	306	2.22E-05	0.0139	2.32	9.33E-05	1.31E-04	9.41E-10	3.66E-03	3.75E-05	394	50.8	0.0038	0.0046	0.0053	0.055	9.06E-04	0	2.99	520	0.0021	0.0038	0	0	263	0.162	0.0050	0.244
14	5.50E+05	5.89E+05	10.4	34,599	9.07	1,026	18,877	0.006	0.000	0.001	0.009	830	1.80E-04	0.0050	1.57E-04	11,994	0.0189	0.2637	0.0711	1.00E-06	0.0047	448	308	2.04E-05	0.0140	2.34	9.31E-05	1.30E-04	9.34E-10	3.68E-03	3.71E-05	377	50.9	0.0039	0.0047	0.0052	0.055	8.94E-04	0	3.01	469	0.0021	0.0038	7.97E-06	0	263	0.162	0.0050	0.247
15	6.00E+05	6.39E+05	10.4	34,527	9.01	1,026	18,839	0.006	0.000	0.001	0.009	828	1.69E-04	0.0053	1.50E-04	11,976	0.0190	0.2652	0.0715	9.23E-07	0.0047	451	310	1.88E-05	0.0141	2.35	9.29E-05	1.30E-04	9.51E-10	3.52E-03	3.69E-05	363	51.0	0.0039	0.0047	0.0051	0.054	9.14E-04	0	3.03	426	0.0021	0.0038	0.0006	0	262	0.161	0.0049	0.250
17	6.50E+05	6.89E+05	10.4	34,465	8.96	1,026	18,807	0.006	0.000	0.001	0.009	827	1.60E-04	0.0056	1.45E-04	11,960	0.0190	0.2664	0.0718	8.56E-07	0.0047	455	311	1.75E-05	0.0142	2.36	9.27E-05	1.30E-04	9.67E-10	3.38E-03	3.67E-05	351	51.1	0.0039	0.0047	0.0050	0.054	9.30E-04	0	3.05	389	0.0021	0.0038	0.0010	0	262	0.160	0.0048	0.253
18	7.00E+05	7.39E+05	10.4	34,412	8.91	1,026	18,780	0.006	0.000	0.001	0.009	825	1.52E-04	0.0059	1.40E-04	11,946	0.0191	0.2675	0.0721	7.98E-07	0.0047	457	313	1.63E-05	0.0142	2.37	9.26E-05	1.30E-04	9.81E-10	3.26E-03	3.65E-05	341	51.1	0.0040	0.0047	0.0050	0.054	9.44E-04	0	3.06	357	0.0021	0.0038	0.0014	0	261	0.159	0.0048	0.255
19	7.50E+05	7.89E+05	10.4	34,365	8.87	1,026	18,756	0.006	0.000	0.001	0.010	824	1.45E-04	0.0061	1.35E-04	11,935	0.0192	0.2685	0.0724	7.48E-07	0.0048	460	314	1.53E-05	0.0143	2.38	9.25E-05	1.29E-04	9.94E-10	3.16E-03	3.63E-05	331	51.2	0.0040	0.0048	0.0050	0.054	9.56E-04	0	3.07	329	0.0021	0.0038	0.0018	0	261	0.159	0.0047	0.257
20	8.00E+05	8.39E+05	10.4	34,324	8.84	1,026	18,735	0.006	0.000	0.001	0.010	823	1.39E-04	0.0064	1.32E-04	11,924	0.0193	0.2693	0.0726	7.03E-07	0.0048	462	315	1.44E-05	0.0143	2.38	9.24E-05	1.29E-04	1.01E-09	3.07E-03	3.61E-05	323	51.2	0.0040	0.0048	0.0049	0.054	9.67E-04	0	3.08	304	0.0021	0.0038	0.0021	0	261	0.158	0.0047	0.258
22	8.50E+05	8.89E+05	10.4	34,288	8.80	1,026	18,716	0.006	0.000	0.001	0.010	822	1.33E-04	0.0066	1.28E-04	11,915	0.0193	0.2700	0.0728	6.64E-07	0.0048	463	316	1.36E-05	0.0143	2.39	9.23E-05	1.29E-04	1.02E-09	3.00E-03	3.60E-05	316	51.2	0.0040	0.0048	0.0049	0.054	9.76E-04	0	3.09	282	0.0021	0.0038	0.0023	0	261	0.157	0.0046	0.260
23	9.00E+05	9.39E+05	10.4	34,255	8.78	1,026	18,699	0.006	0.000	0.001	0.010	822	1.29E-04	0.0068	1.25E-04	11,907	0.0194	0.2707	0.0730	6.28E-07	0.0048	465	316	1.29E-05	0.0144	2.40	9.22E-05	1.29E-04	1.03E-09	2.93E-03	3.59E-05	310	51.3	0.0041	0.0048	0.0048	0.053	9.85E-04	0	3.09	263	0.0021	0.0038	0.0026	0	260	0.156	0.0045	0.261
24	9.50E+05	9.89E+05	10.4	34,226	8.75	1,026	18,684	0.006	0.000	0.001	0.010	821	1.24E-04	0.0070	1.23E-04	11,899	0.0194	0.2713	0.0731	5.97E-07	0.0048	467	317	1.23E-05	0.0144	2.40	9.21E-05	1.29E-04	1.04E-09	2.87E-03	3.58E-05	304	51.3	0.0041	0.0048	0.0048	0.053	9.92E-04	0	3.10	245	0.0021	0.0037	0.0028	0	260	0.156	0.0045	0.262
26	1.00E+06	1.04E+06	10.4	34,200	8.73	1,026	18,670	0.006	0.000	0.001	0.010	820	1.20E-04	0.0072	1.20E-04	11,893	0.0194	0.2718	0.0733	5.68E-07	0.0048	468	318	1.17E-05	0.0144	2.41	9.21E-05	1.29E-04	1.04E-09	2.81E-03	3.57E-05	299	51.3	0.0041	0.0048	0.0048	0.053	9.99E-04	0	3.11	229	0.0021	0.0037	0.0030	0	260	0.155	0.0044	0.263
38	1.50E+06	1.54E+06	10.5	34,030	8.58	1,026	18,582	0.006	0.000	0.001	0.010	816	9.51E-05	0.0086	1.05E-04	11,850	0.0197	0.2752	0.0742	3.83E-07	0.0049	476	322	8.01E-06	0.0146	2.44	9.17E-05	1.28E-04	1.10E-09	2.46E-03	3.51E-05	266	51.5	0.0042	0.0049	0.0046	0.053	0.001	0	3.15	128	0.0022	0.0037	0.0042	0	258	0.149	0.0039	0.270
43	1.68E+06	1.72E+06	10.5	33,993	8.55	1,026	18,563	0.006	0.000	0.001	0.010	815	8.96E-05	0.0090	1.02E-04	11,840	0.0197	0.2760	0.0744	3.43E-07	0.0049	478	323	7.21E-06	0.0147	2.44	9.16E-05	1.28E-04	1.12E-09	2.39E-03	3.49E-05	259	51.6	0.0043	0.0049	0.0046	0.053	0.001	0	3.15	106	0.0022	0.0037	0.0044	0	258	0.148	0.0038	0.272
48	1.86E+06	1.90E+06	10.5	33,963	8.52	1,026	18,548	0.006	0.000	0.001	0.010	815	8.51E-05	0.0093	9.97E-05	11,833	0.0198	0.2766	0.0746	3.11E-07	0.0049	480	323	6.56E-06	0.0147	2.45	9.15E-05	1.28E-04	1.13E-09	2.33E-03	3.48E-05	253	51.6	0.0043	0.0049	0.0046	0.053	0.001	0	3.16	88	0.0022	0.0037	0.0046	0	258	0.147	0.0037	0.273
52	2.04E+06	2.08E+06	10.5	33,939	8.50	1,026	18,535	0.006	0.000	0.001	0.010	814	8.15E-05	0.0096	9.76E-05	11,826	0.0198	0.2771	0.0747	2.84E-07	0.0049	481	324	6.02E-06	0.0147	2.45	9.15E-05	1.28E-04	1.14E-09	2.28E-03	3.47E-05	248	51.6	0.0043	0.0049	0.0045	0.052	0.001	0	3.17	73	0.0022	0.0037	0.0048	0	258	0.145	0.0036	0.274
57	2.22E+06	2.26E+06	10.5	33,918	8.49	1,026	18,524	0.006	0.000	0.001	0.010	814	7.84E-05	0.0099	9.58E-05	11,821	0.0198	0.2775	0.0748	2.61E-07	0.0049	482	324	5.57E-06	0.0147	2.46	9.14E-05	1.28E-04	1.15E-09	2.24E-03	3.47E-05	244	51.6	0.0044	0.0049	0.0045	0.052	0.001	0	3.17	60	0.0022	0.0037	0.0050	0	257	0.144	0.0035	0.275
61	2.40E+06	2.44E+06	10.5	33,900	8.47	1,026	18,515	0.006	0.000	0.001	0.010	813	7.57E-05	0.0101	9.43E-05	11,817	0.0199	0.2779	0.0749	2.42E-07	0.0049	483	325	5.18E-06	0.0148	2.46	9.14E-05	1.27E-04	1.16E-09	2.20E-03	3.46E-05	241	51.7	0.0044	0.0049	0.0045	0.052	0.001	0	3.18	50	0.0022	0.0037	0.0051	0	257	0.144	0.0034	0.275
66	2.58E+06	2.62E+06	10.5	33,885	8.46	1,026	18,507	0.006	0.000	0.001	0.010	813	7.35E-05	0.0103	9.30E-05	11,813	0.0199	0.2782	0.0750	2.25E-07	0.0049	484	325	4.85E-06	0.0148	2.46	9.13E-05	1.27E-04	1.17E-09	2.17E-03	3.46E-05	238	51.7	0.0044	0.0049	0.0045	0.052	0.001	0	3.18	40	0.0022	0.0037	0.0052	0	257	0.143	0.0033	0.276
71	2.76E+06	2.80E+06	10.5	33,872	8.45	1,026	18,500	0.006	0.000	0.001	0.010	812	7.15E-05	0.0105	9.19E-05	11,809	0.0199	0.2785	0.0751	2.11E-07	0.0049	484	325	4.56E-06	0.0148	2.47	9.13E-05	1.27E-04	1.17E-09	2.15E-03	3.45E-05	235	51.7	0.0044	0.0049	0.0045	0.052	0.001	0	3.18	33	0.0022	0.0037	0.0053	0	257	0.142	0.0033	0.277
75	2.94E+06	2.98E+06	10.5	33,860	8.44	1,026	18,494	0.006	0.000	0.001	0.010	812	6.98E-05	0.0106	9.09E-05	11,806	0.0199	0.2787	0.0751	1.98E-07	0.0049	485	326	4.31E-06	0.0148	2.47	9.13E-05	1.27E-04	1.18E-09	2.12E-03	3.45E-05	233	51.7	0.0044	0.0049	0.0045	0.052	0.001	0	3.19	25	0.0022	0.0037	0.0053	0	257	0.141	0.0032	0.277
80	3.12E+06	3.16E+06	10.5	33,850	8.43	1,026	18,489	0.006	0.000	0.001	0.010	812	6.82E-05	0.0108	9.01E-05	11,804	0.0199	0.2789	0.0752	1.87E-07	0.0049	485	326	4.08E-06	0.0148	2.47	9.13E-05	1.27E-04	1.18E-09	2.10E-03	3.44E-05	231	51.7	0.0044	0.0049	0.0045	0.052	0.001	0	3.19	19	0.0022	0.0037	0.0054	0	257	0.141	0.0031	0.277
85	3.30E+06	3.34E+06	10.5	33,840	8.42	1,026	18,484	0.006	0.000	0.001	0.010	812	6.68E-05	0.0109	8.93E-05	11,801	0.0200	0.2791	0.0752	1.77E-07	0.0049	486	326	3.88E-06	0.0148	2.47	9.12E-05	1.27E-04	1.19E-09	2.08E-03	3.44E-05	229	51.7	0.0044	0.0049	0.0045	0.052	0.001	0	3.19	14	0.0022	0.0037	0.0055	0	257	0.140	0.0031	0.278
89	3.48E+06	3.52E+06	10.5	33,832	8.41	1,026	18,480	0.006	0.000	0.001	0.010	811	6.56E-05	0.0110	8.86E-05	11,799	0.0200	0.2793	0.0753	1.68E-07	0.0049	486	326	3.70E-06	0.0148	2.47	9.12E-05	1.27E-04	1.19E-09	2.07E-03	3.44E-05	228	51.7	0.0045	0.0049	0.0044	0.052	0.001	0	3.19	8.72361	0.0022	0.0037	0.0055	0	257	0.140	0.0031	0.278
94	3.66E+06	3.70E+06	10.5	33,825	8.41	1,026	18,476	0.006	0.000	0.001	0.010	811	6.45E-05	0.0111	8.80E-05	11,797	0.0200	0.2794	0.0753	1.59E-07	0.0049	487	327	3.54E-06	0.0148	2.47	9.12E-05	1.27E-04	1.20E-09	2.05E-03	3.43E-05	226	51.7	0.0045	0.0049	0.0044	0.052	0.001	0	3.19	4.22478	0.0022	0.0037	0.0056	0	256	0.139	0.0030	0.278
98	3.84E+06	3.88E+06	10.5	33,818	8.40	1,026	18,473	0.006	0.000	0.001	0.010	811	6.35E-05	0.0112	8.74E-05	11,796	0.0200	0.2795	0.0754	1.52E-07	0.0049	487	327	3.39E-06	0.0148	2.47	9.12E-05	1.27E-04	1.20E-09	2.04E-03	3.43E-05	225	51.7	0.0045	0.0049	0.0044	0.052	0.001	0	3.20	0.14352	0.0022	0.0037	0.0056	0	256	0.139	0.0030	0.279
103	4.02E+06	4.06E+06	10.1	33,809	8.39	1,026	18,469	0.006	0.001	0.001	0.010	811	6.26E-05	0.0235	5.56E-05	11,794	0.0200	0.2797	0.0754	1.45E-07	0.0050	486	327	3.25E-06	0.0149	2.48	6.20E-05	1.27E-04	2.89E-09	5.67E-04	3.43E-05	224	51.8	0.0050	0.0050	0.0044	0.022	0.001	0	3.19	0	0.0022	0.0036	0.0100	0	255	0.075	0	0.367
108	4.20E+06	4.24E+06	9.49	33,803	8.39	1,026	18,466	0.006	0.025	0.001	0.010	811	6.17E-05	0.0385	6.54E-05	11,793	0.0200	0.2798	0.0754	1.39E-07	0.0050	485	327	3.13E-06	0.0149	2.48	1.27E-04	1.27E-04	8.54E-09	8.97E-04	3.43E-05	225	51.8	0.0050	0.0050	0.0044	0.006	0.001	0	3.07	0	0.0022	0.0036	0.0090	0	250	0	0	0.413
112	4.38E+06	4.42E+06	9.17	33,800	8.38	1,026	18,464	0.006	0.182	0.001	0.010	811	6.09E-05	0.0391	9.75E-05	11,791	0.0200	0.2799	0.0754	1.33E-07	0.0050	484	327	3.02E-06	0.0149	2.48	2.89E-04	1.27E-04	1.40E-08	2.55E-03	3.42E-05	228	51.8	0.0050	0.0050	0.0044	0.003	0.001	0	2.30	0	0.0019	0.0037	0.0041	0	241	0	0	0.422
117	4.56E+06	4.60E+06	9.02	33,797	8.38	1,026	18,461	0.006	0.488	0.001	0.010	811	6.02E-05	0.0397	1.09E-04	11,790	0.0200	0.2800	0.0755	1.28E-07	0.0050	483	327	2.91E-06	0.0149	2.48	4.56E-04	1.27E-04	1.86E-08	3.98E-03	3.42E-05	229	51.8	0.0050	0.0050	0.0044	0.002	0.001	0	0.79	0	0.0017	0.0038	0	0	235	0	0	0.424
121	4.74E+06	4.78E+06	8.89	33,795	8.37	1,026	18,459	0.006	0.649	0.001	0.010	811	5.96E-05	0.0397	8.21E-05	11,789	0.0200	0.2801	0.0755	1.23E-07	0.0050	483	327	2.82E-06	0.0149	2.48	6.81E-04	1.27E-04	2.85E-08	4.00E-03	3.42E-05	231	51.8	0.0050	0.0050	0.0044	0.001	0.001	0	0	0	0.0015	0.0037	0	0	228	0	0	0.426
126	4.92E+06	4.96E+06	8.78	33,793	8.37	1,026	18,457	0.006	0.649	0.001	0.010	810	5.90E-05	0.0397	6.39E-05	11,788	0.0200	0.2802	0.0755	1.19E-07	0.0050	482	327	2.73E-06	0.0149	2.48	9.89E-04	1.27E-04	4.18E-08	4.02E-03	3.42E-05	234	51.8	0.0050	0.0050	0.0044	0.001	0.001	0	0	0	0.0011	0.0036	0	0	220	0	0	0.427
131	5.10E+06	5.14E+06	8.70	33,791	8.36	1,026	18,455	0.006	0.649	0.001	0.010	810	5.84E-05	0.0397	5.27E-05	11,787	0.0200	0.2802	0.0755	1.15E-07	0.0050	481	328	2.64E-06	0.0149	2.48	1.33E-03	1.27E-04	5.62E-08	4.04E-03	3.42E-05	236	51.8	0.0050	0.0050	0.0044	9.29E-04	0.001	0	0	0	0.0007	0.0036	0	0	212	0	0	0.428
135	5.28E+06	5.32E+06	8.63	33,789	8.36	1,026	18,453	0.006	0.650	0.001	0.010	810	5.79E-05	0.0397	4.52E-05	11,786	0.0200	0.2803	0.0756	1.11E-07	0.0050	480	328	2.57E-06	0.0149	2.48	1.69E-03	1.27E-04	7.13E-08	4.04E-03	3.42E-05	238	51.8	0.0050	0.0050	0.0044	7.98E-04	0.001	0	0	0	0.0002	0.0035	0	0	205	0	0	0.428
140	5.46E+06	5.50E+06	8.57	33,788	8.36	1,026	18,451	0.006	0.650	0.001	0.010	810	5.74E-05	0.0397	3.98E-05	11,785	0.0200	0.2804	0.0756	1.07E-07	0.0050	480	328	2.49E-06	0.0149	2.48	1.85E-03	1.27E-04	8.70E-08	4.05E-03	3.42E-05	240	51.8	0.0050	0.0050	0.0044	7.04E-04	0.001	0	0	0	0	3.52E-03	0	0	198	0	0	0.429
145	5.64E+06	5.68E+06	8.53	33,786	8.35	1,026	18,450	0.006	0.650	0.001	0.010	810	5.69E-05	0.0397	3.58E-05	11,784	0.0201	0.2804	0.0756	1.04E-07	0.0050	479	328	2.43E-06	0.0149	2.48	1.85E-03	1.27E-04	1.03E-07	4.06E-03	3.41E-05	242	51.8	0.0050	0.0050	0.0044	6.34E-04	0.001	0	0	0	0	3.50E-03	0	0	192	0	0	0.429
149	5.82E+06	5.86E+06	8.49	33,785	8.35	1,026	18,448	0.006	0.650	0.001	0.010	810	5.65E-05	0.0397	3.26E-05	11,784	0.0201	0.2805	0.0756	1.01E-07	0.0050	478	328	2.36E-06	0.0149	2.48	1.85E-03	1.27E-04	1.19E-07	4.06E-03	3.41E-05	244	51.8	0.0050	0.0050	0.0044	5.79E-04	0.001	0	0	0	0	3.49E-03	0	0	186	0	0	0.429
154	6.00E+06	6.04E+06	8.45	33,784	8.35	1,026	18,447	0.006	0.650	0.001	0.010	810	5.60E-05	0.0397	3.01E-05	11,783	0.0201	0.2806	0.0756	9.77E-08	0.0050	478	328	2.30E-06	0.0149	2.48	1.85E-03	1.27E-04	1.36E-07	4.06E-03	3.41E-05	246	51.8	0.0050	0.0050	0.0044	5.35E-04	0.001	0	0	0	0	3.48E-03	0	0	180	0	0	0.429
167	6.50E+06	6.54E+06	8.37	33,780	8.34	1,026	18,443	0.006	0.651	0.001	0.010	810	5.50E-05	0.0398	2.54E-05	11,781	0.0201	0.2807	0.0757	9.02E-08	0.0050	477	328	2.15E-06	0.0149	2.49	1.85E-03	1.27E-04	1.81E-07	4.07E-03	3.41E-05	250	51.8	0.0050	0.0050	0.0044	4.43E-04	0.001	0.7934	0	0	0	3.47E-03	0	0	166	0	0	0
326	1.27E+07	1.28E+07	8.06	33,761	8.30	1,026	18,422	0.006	0.652	0.001	0.010	809	4.90E-05	0.0399	1.24E-05	11,771	0.0201	0.2815	0.0759	4.62E-08	0.0050	468	329	1.27E-06	0.0150	2.49	1.86E-03	1.27E-04	6.74E-07	4.10E-03	3.40E-05	274	51.9	0.0050	0.0050	0.0043	1.20E-04	0.001	0.79745	0	0	0	3.42E-03	0	0	85	0	0	0
486	1.90E+07	1.90E+07	7.98	33,754	8.28	1,026	18,415	0.006	0.653	0.001	0.010	808	4.69E-05	0.0399	1.05E-05	11,767	0.0201	0.2818	0.0760	3.10E-08	0.0050	466	329	9.70E-07	0.0150	2.49	1.86E-03	1.27E-04	9.75E-07	4.10E-03	3.39E-05	283	51.9	0.0050	0.0050	0.0043	8.88E-05	0.001	0.79841	0	0	0	3.42E-03	0	0	57	0	0	0
646	2.52E+07	2.52E+07	7.95	33,750	8.27	1,026	18,411	0.006	0.653	0.001	0.010	808	4.59E-05	0.0399	9.69E-06	11,766	0.0202	0.2819	0.0760	2.34E-08	0.0050	464	329	8.17E-07	0.0150	2.50	1.86E-03	1.27E-04	1.17E-06	4.11E-03	3.39E-05	287	51.9	0.0050	0.0050	0.0043	7.76E-05	0.001	0.79888	0	0	0	3.42E-03	0	0	43	0	0	0
805	3.14E+07	3.15E+07	7.93	33,748	8.27	1,026	18,409	0.006	0.654	0.001	0.010	808	4.53E-05	0.0400	9.27E-06	11,764	0.0202	0.2820	0.0760	1.87E-08	0.0050	463	330	7.25E-07	0.0150	2.50	1.86E-03	1.27E-04	1.30E-06	4.11E-03	3.39E-05	289	51.9	0.0050	0.0050	0.0043	7.19E-05	0.001	0.79915	0	0	0	3.41E-03	0	0	35	0	0	0
965	3.77E+07	3.77E+07	7.92	33,747	8.27	1,026	18,408	0.006	0.654	0.001	0.010	808	4.48E-05	0.0400	9.00E-06	11,764	0.0202	0.2821	0.0760	0.00E+00	0.0050	463	330	6.63E-07	0.0150	2.50	1.86E-03	1.27E-04	1.39E-06	4.11E-03	3.39E-05	291	51.9	0.0050	0.0050	0.0043	6.84E-05	0.001	0.79933	0	0	0	3.41E-03	0	0	29	0	0	0
1125	4.39E+07	4.39E+07	7.91	33,746	8.26	1,026	18,406	0.006	0.654	0.001	0.010	808	4.45E-05	0.0400	8.82E-06	11,763	0.0202	0.2821	0.0760	0.00E+00	0.0050	462	330	6.18E-07	0.0150	2.50	1.86E-03	1.27E-04	1.46E-06	4.11E-03	3.38E-05	292	51.9	0.0050	0.0050	0.0043	6.61E-05	0.001	0.79946	0	0	0	3.41E-03	0	0	25	0	0	0
1285	5.01E+07	5.02E+07	7.90	33,745	8.26	1,026	18,406	0.006	0.654	0.001	0.010	808	4.43E-05	0.0400	8.69E-06	11,763	0.0202	0.2822	0.0761	0.00E+00	0.0050	462	330	5.85E-07	0.0150	2.50	1.86E-03	1.27E-04	1.51E-06	4.11E-03	3.38E-05	293	51.9	0.0050	0.0050	0.0043	6.44E-05	0.001	0.79956	0	0	0	3.41E-03	0	0	22	0	0	0
1444	5.64E+07	5.64E+07	7.89	33,744	8.26	1,026	18,405	0.006	0.654	0.001	0.010	808	4.41E-05	0.0400	8.59E-06	11,763	0.0202	0.2822	0.0761	0.00E+00	0.0050	462	330	5.59E-07	0.0150	2.50	1.86E-03	1.27E-04	1.56E-06	4.11E-03	3.38E-05	294	51.9	0.0050	0.0050	0.0043	6.32E-05	0.001	0.79963	0	0	0	3.41E-03	0	0	20	0	0	0
1604	6.26E+07	6.26E+07	7.89	33,744	8.26	1,026	18,405	0.006	0.654	0.001	0.010	808	4.40E-05	0.0400	8.51E-06	11,762	0.0202	0.2822	0.0761	0.00E+00	0.0050	462	330	5.38E-07	0.0150	2.50	1.86E-03	1.27E-04	1.59E-06	4.11E-03	3.38E-05	294	51.9	0.0050	0.0050	0.0043	6.22E-05	0.001	0.79969	0	0	0	3.41E-03	0	0	18	0	0	0
1764	6.88E+07	6.89E+07	7.89	33,744	8.26	1,026	18,404	0.006	0.654	0.001	0.010	808	4.39E-05	0.0400	8.44E-06	11,762	0.0202	0.2822	0.0761	0.00E+00	0.0050	462	330	5.21E-07	0.0150	2.50	1.86E-03	1.27E-04	1.62E-06	4.11E-03	3.38E-05	295	51.9	0.0050	0.0050	0.0043	6.14E-05	0.001	0.79974	0	0	0	3.41E-03	0	0	17	0	0	0
1923	7.51E+07	7.51E+07	7.88	33,743	8.26	1,026	18,404	0.006	0.654	0.001	0.010	808	4.38E-05	0.0400	8.39E-06	11,762	0.0202	0.2822	0.0761	0.00E+00	0.0050	461	330	5.07E-07	0.0150	2.50	1.86E-03	1.27E-04	1.65E-06	4.11E-03	3.38E-05	295	51.9	0.0050	0.0050	0.0043	6.08E-05	0.001	0.79978	0	0	0	3.41E-03	0	0	15	0	0	0
2083	8.13E+07	8.13E+07	7.88	33,743	8.26	1,026	18,404	0.006	0.654	0.001	0.010	808	4.37E-05	0.0400	8.35E-06	11,762	0.0202	0.2822	0.0761	0.00E+00	0.0050	461	330	4.95E-07	0.0150	2.50	1.86E-03	1.27E-04	1.67E-06	4.11E-03	3.38E-05	296	51.9	0.0050	0.0050	0.0043	6.03E-05	0.001	0.79982	0	0	0	3.41E-03	0	0	14	0	0	0
2243	8.75E+07	8.76E+07	7.88	33,743	8.26	1,026	18,403	0.006	0.654	0.001	0.010	808	4.36E-05	0.0400	8.31E-06	11,762	0.0202	0.2822	0.0761	0.00E+00	0.0050	461	330	4.85E-07	0.0150	2.50	1.86E-03	1.27E-04	1.69E-06	4.11E-03	3.38E-05	296	51.9	0.0050	0.0050	0.0043	5.98E-05	0.001	0.79985	0	0	0	3.41E-03	0	0	13	0	0	0
2402	9.38E+07	9.38E+07	7.88	33,742	8.26	1,026	18,403	0.006	0.654	0.001	0.010	808	4.36E-05	0.0400	8.28E-06	11,762	0.0202	0.2823	0.0761	0.00E+00	0.0050	461	330	4.76E-07	0.0150	2.50	1.86E-03	1.27E-04	1.71E-06	4.11E-03	3.38E-05	296	51.9	0.0050	0.0050	0.0043	5.94E-05	0.001	0.79987	0	0	0	3.41E-03	0	0	12	0	0	0
2562	1.00E+08	1.00E+08	7.88	33,893	8.26	1,026	18,403	0.006	0.654	0.001	0.010	808	4.35E-05	0.0400	8.25E-06	11,761	0.0202	0.2823	0.0761	0.00E+00	0.0050	461	330	4.68E-07	0.0150	2.50	1.86E-03	1.27E-04	1.72E-06	4.11E-03	3.38E-05	296	51.9	0.0050	0.0050	0.0043	5.91E-05	0.001	0.7999	0	0	0	3.41E-03	0	0	12	0	0	0

Attachment D: Reasonable Potential Analysis Spreadsheet Calculations - Temperature

Marine Temperature Reasonable Potential and Limit Calculation

Based on WAC 173-201A-200(1)(c)(i)--(ii) and Water Quality Program Guidance. All Data inputs must meet WQ guidelines. The Water Quality temperature guidance document may be found at: http://www.ecy.wa.gov/biblio/0610100.html

INPUT	May-Sep	Oct-Apr
1. Chronic Dilution Factor at Mixing Zone Boundary	195.0	195.0
2. Annual max 1DADMax Ambient Temperature (Background 90th percentile)	11.4 °C	10.0 °C
3. 1DADMax Effluent Temperature (95th percentile)	30.0 °C	30.0 °C
4. Aquatic Life Temperature WQ Criterion	16.0 °C	16.0 °C
OUTPUT		
5. Temperature at Chronic Mixing Zone Boundary:	11.50 °C	10.10 °C
6. Incremental Temperature Increase or decrease:	0.10 °C	0.10 °C
7. Incremental Temperature Increase 12/(T-2) if T≤ crit:	1.28 °C	1.50 °C
8. Maximum Allowable Temperature at Mixing Zone Boundary:	12.68 °C	11.50 °C
A. If ambient temp is warmer than WQ criterion		
9. Does temp fall within this warmer temp range?	NO	NO
10. Temp increase allowed at mixing zone boundary, if required:	---	---
B. If ambient temp is cooler than WQ criterion but within 12/(T_{amb}-2) and within 0.3 °C of the criterion		
11. Does temp fall within this incremental temp. range?	NO	NO
12. Temp increase allowed at mixing zone boundary, if required:	---	---
C. If ambient temp is cooler than (WQ criterion-0.3) but within 12/(T_{amb}-2) of the criterion		
13. Does temp fall within this Incremental temp. range?	NO	NO
14. Temp increase allowed at mixing zone boundary, if required:	---	---
D. If ambient temp is cooler than (WQ criterion - 12/(T_{amb}-2))		
15. Does temp fall within this Incremental temp. range?	YES	YES
16. Temp increase allowed at mixing zone boundary, if required:	NO LIMIT	NO LIMIT
RESULTS		
17. Do any of the above cells show a temp increase?	**NO**	**NO**
18. Temperature Limit if Required?	**NO LIMIT**	**NO LIMIT**

Notes:

Appendix B
Ecological Safety Methodology

Ecological Safety Methodology

1 Introduction

Note that this is a working document that will continue to be refined prior to and throughout operation of the project.

Project Macoma, LLC, a wholly owned subsidiary of Ebb Carbon, proposes to deploy a temporary small-scale pilot project of Ebb Carbon's marine carbon dioxide removal (mCDR) technology at Terminal 7 of the Port of Port Angeles (Port) in Port Angeles, Washington (pilot project or Project Macoma). Ebb Carbon's mCDR technology is designed to remove carbon dioxide (CO_2) safely and permanently from the atmosphere while reducing seawater acidity locally.

Ebb Carbon is developing an Ecological Safety Methodology (ESM)—a robust monitoring, modeling, and reporting tool designed to measure any positive impacts to water quality and marine life and ensure no adverse impacts to the environment from operation of its mCDR technology—with various experts. These experts include the scientific community (e.g., the Pacific Northwest National Laboratory-Sequim and the University of Washington), federal and state resource agencies. Project Macoma, LLC, and the Lower Elwha Klallam Tribe are also discussing the potential for partnership on this pilot project.

The ESM will describe intended data collection and analysis associated with this field trial of Ebb Carbon's mCDR technology. In pertinent part here, the ESM is also an adaptive management tool that will help ensure discharges of alkaline-enhanced seawater to Port Angeles Harbor do not result in adverse environmental effects by identifying circumstances when pilot project operations might need to be paused or modified for the protection of the marine environment. Project Macoma, LLC, will follow the ESM throughout the pilot project. The ESM will be refined over time as this emerging field and the science behind it further develops.

This document sets forth an initial framework for the ESM primarily from a regulatory compliance perspective, which includes initial considerations for establishing baseline conditions, describing initiation of project operations, identifying parameters that will be regularly monitored, and determining exceedance thresholds for modifying Project Macoma, LLC's discharge of higher alkaline seawater, if a need to do so is indicated. The initial version of the ESM will be released prior to commencement of pilot project operations, including obtaining any required permits or approvals needed to begin implementation. Ebb Carbon will continue to build upon this structure with input from its expert partners.

2 Background

2.1 Environmental Setting

This section describes the environmental conditions anticipated at the proposed location of the pilot project at Terminal 7 at the Port. This site is located adjacent to and within marine waters in the Port Angeles Harbor along the Strait of Juan de Fuca. The potential for impacts from the pilot project is related mainly to changes in water quality at and in the vicinity of the discharge location; therefore, the ESM focuses on aquatic resources.

2.1.1 Area of Interest

The area of interest for ESM implementation has been informed in part by mixing zone studies (Brown and Caldwell 2024). It extends from the point of discharge at the 25 proposed outfall ports spaced 2 feet apart along the 50-foot length of the barge, which would be moored near the Terminal 7 dock in Port Angeles Harbor. Preliminary mixing analyses indicate that surrounding pH would return to ambient within the nearfield mixing zone, approximately 21 feet from the discharge point at the barge. Water quality would return to ambient approximately 40 feet around the discharge, well within the allowable chronic mixing zone (approximately 207 feet). During operations, the mixing zone will be maintained within permitted limits. The standard Washington State Department of Ecology (Ecology)-required mixing zone distance is 207 feet from the point of discharge. Water quality monitoring and ecological monitoring would be conducted within both zones to ensure safe operations of the pilot study and to collect data to help inform further development and deployment of this technology. Water quality monitoring would occur to assess for potential acute and chronic mixing zone exceedances at proposed distances of 15 and 150 feet, respectively. The specific area for evaluation may be refined based on the mixing zone modeling and through further discussions with Ebb Carbon's expert partners and Tribal and stakeholder engagement.

2.1.2 Aquatic Habitat

The project would be located in marine waters in Port Angeles Harbor. This area has the potential to include important aquatic habitat, such as areas designated under the Endangered Species Act (ESA) including Habitat Areas of Particular Concern (HAPCs), Essential Fish Habitat (EFH), or other important aquatic environmental features. These areas were preliminarily identified through desktop analysis (NOAA Fisheries 2023a, 2023b; NMFS 2023; WDFW 2023a, 2023b) but should be further verified through site surveys as noted in Section 4. Desktop analysis identifies the potential for the following habitats:

- Estuary HAPC
- Canopy kelp HAPC

- Groundfish EFH
- Salmon (pink, Chinook, and coho) EFH
- Coastal pelagic species EFH
- Forage fish (sand lance and smelt) spawning areas
- Critical habitat protected under the ESA

2.1.3 Aquatic Species

Several important aquatic species are likely to be present in the area of interest. These species are listed in Table 1 and were determined through a review of the following databases and input from the Lower Elwha Klallam Tribe and the Port:

- Protected Resources App (NOAA Fisheries 2023b)
- ESA Critical Habitat Mapper (NMFS 2023)
- Priority Habitats and Species on the Web (WDFW 2023a)
- iPaC – Information for Planning and Consultation (USFWS 2023)

It is assumed that species could be present if specific habitat characteristics are also present. Proposed baseline studies are described further in Section 4.1.1.

2.1.4 Site Contamination

The pilot project is located within an uplands area of Terminal 7 that is a part of Agreed Order DE 21560 and within a portion of Western Port Angeles Harbor that is under Agreed Order DE 9781, both issued under the Washington State Model Toxics Control Act. The site of the pilot project is also near sediments that are a part of the Rayonier Mill Cleanup Site.

Since the early 1900s, effluent discharged into the area from industrial facilities operating in Port Angeles Harbor. The distribution of hazardous substances corresponds with the locations of historical industrial activities and wastewater discharge sites identified within Port Angeles Harbor. Discharges resulted in harbor sediments contaminated by petrochemicals, polychlorinated biphenyls (PCBs), dioxins, and heavy metals (NOAA 2023).

The resulting contamination is in intertidal and subtidal sediments over the entirety of Port Angeles Harbor. Eleven sediment studies between 2002 and 2013 revealed hazardous substances at concentrations above state and federal standards, indicating potential injuries to benthic organisms, fish, shellfish, and birds (NOAA 2023). The pilot project is designed to be temporary and modular to allow future cleanup activities to occur, if and as required. The design of the intake and outfall system would be located near the surface of the water column and would not cause potentially contaminated sediments to be resuspended.

Table 1
Aquatic Species Assumed to be Present in the Area of Interest

Species	Population	Status	Critical Habitat	Presence/Timing	Habitat Preference in Project Area	Source
Mammals						
Gray whale (*Eschrichtius robustus*)	Eastern North Pacific DPS	SS	None designated	Year-round	Nearshore habitat for foraging, deeper offshore habitat for migration	WDFW 2022
Humpback whale (*Megaptera novaeangliae*)	Mexico DPS and Central America DPS	FE (CA DPS), FT (Mexico DPS), SE	Designated, not present in project area	Year-round; most frequent sightings in spring and fall	Migration and foraging in offshore waters; unlikely to be present in project area	NMFS 2023
Killer whale (*Orcinus orca*)	Southern Resident DPS	FE, SE	Designated, present in project area	Year-round; most frequent sightings in summer	Migration and foraging in nearshore and offshore waters; unlikely to be present in project area	NMFS 2023
Birds						
Marbled murrelet (*Brachyramphus marmoratus*)	USA (California, Oregon, Washington)	FT, SE	Designated, not present in project area	Year-round; breeding season May–September	Old-growth forest nesting sites, marine foraging areas within 1.2 to 3 miles offshore less than 100 feet deep; foraging habitat present in project area	USFWS 2023
Northern spotted owl (*Strix occidentalis*)	--	FT, SE	Designated, not present in project area	Not present	Older forest habitat; not present in project area	WDFW 2023a
Short-tailed albatross (*Phoebastria albatrus*)	--	FE, SC	None designated	Not present	Coastal shoreline and open ocean; not present in project area	USFWS 2023
Yellow-billed cuckoo (*Coccyzus americanus*)	Western DPS	FT, SE	Designated, not present in project area	Not present	Deciduous woodlands; not present in project area	USFWS 2023

Species	Population	Status	Critical Habitat	Presence/Timing	Habitat Preference in Project Area	Source
Fish						
Bocaccio (*Sebastes paucispinis*)	Puget Sound/Georgia Basin DPS	FE	Designated, not present in project area	Year-round offshore presence Larvae: January–July	Kelp, rocky subtidal habitat	NMFS 2023
Bull trout (*Salvelinus confluentus*)	Coastal Recovery Unit	FT, SC	Designated, present in project area (from mean lower low water to 10-meter depth)	Adult: fall (September–December) Juvenile: year-round, nearshore	Marine waters and shorelines, including estuaries, bays, inlets, shallow subtidal areas, and intertidal flats	USFWS 2023
Chinook salmon (*Oncorhynchus tshawytscha*)	Puget Sound ESU	FT, CI	Designated, present in project area (nearshore marine)	Adult: summer and fall (July–December) Juvenile: year-round, nearshore	Marine waters and shorelines, including estuaries, bays, inlets, shallow subtidal areas, and intertidal flats	NMFS 2023
Coho salmon (*O. kisutch*)	Olympic Peninsula ESU	CI	None designated	Adult: summer (July–August) Juvenile: year-round, nearshore	Marine waters and shorelines, including estuaries, bays, inlets, shallow subtidal areas, and intertidal flats	NMFS 2023
Chum salmon (*O. keta*)	Hood Canal Summer-Run ESU	FT	Designated, not present in project area	Adult: summer (June–August) Juvenile: year-round, nearshore	Marine waters and shorelines, including estuaries, bays, inlets, shallow subtidal areas, and intertidal flats	NMFS 2023
Dolly varden (*Salvelinus malma*)	Native char	FPT	None designated	Adult: fall (September–December) Juvenile: year-round, nearshore	Marine waters and shorelines, including estuaries, bays, inlets, shallow subtidal areas, and intertidal flats	USFWS 2023

Species	Population	Status	Critical Habitat	Presence/Timing	Habitat Preference in Project Area	Source
Eulachon (*Thaleichthys pacificus*)	Southern DPS	FT	Designated, not present in project area	Adult: spring (February–April) Juvenile: year-round, nearshore	Marine waters and shorelines, including estuaries, bays, inlets, shallow subtidal areas, and intertidal flats	NMFS 2023
Green sturgeon (*Acipenser medirostris*)	Southern DPS	FT	Designated, not present in project area	Summer and fall in estuaries and bays; winter off Vancouver Island	Marine waters and shorelines, including estuaries, bays, inlets, shallow subtidal areas, and intertidal flats	NMFS 2023
Pink salmon (*O. gorbuscha*)	Odd-year ESU	CI	None designated	Adult: summer (July–August) Juvenile: year-round, nearshore	Marine waters and shorelines, including estuaries, bays, inlets, shallow subtidal areas, and intertidal flats	NMFS 2023
Steelhead (*O. mykiss*)	Puget Sound DPS	FT	Designated, present in freshwater adjacent to project area	Adult: winter (December–April) Juvenile: year-round, nearshore	Marine waters and shorelines, including estuaries, bays, inlets, shallow subtidal areas, and intertidal flats	NMFS 2023
Yelloweye rockfish (*Sebastes ruberrimus*)	Puget Sound/Georgia Basin DPS	FT	Designated, not present in project area	Year-round offshore presence Larvae: April–December	Kelp, rocky subtidal habitat	NMFS 2023
Invertebrates						
Dungeness crab (*Cancer magister*)	--	CI	None designated	Breeding season: October–December Adult: year-round Larvae: December–March	Adult: coastal waters Larvae: current drift Megalopae: nearshore and estuarine Juvenile: oyster beds, gravel/rocky habitats	WDFW 2023
Pinto abalone (*Haliotis kamtschatkana*)	--	SE	None designated	Year-round	Rocky reefs and kelp forests in nearshore coastal habitats	Sowul et al. 2022

Species	Population	Status	Critical Habitat	Presence/Timing	Habitat Preference in Project Area	Source
Sunflower sea star (*Pycnopodia helianthoides*)	--	FPT	None designated	Year-round	Intertidal and subtidal coastal waters on various substrate types	88 Fed. Reg. 16212; March 16, 2023
Monarch butterfly (*Danaus plexippus*)	--	FC	None designated	Not present	Grasslands and prairies; not present in project area	USFWS 2023
Taylor's checkerspot (*Euphydryas editha taylori*)	--	FE, SE	Designated, not present in project area	Not present	Grasslands and prairies; not present in project area	USFWS 2023

Note:
--: no population assigned

2.2 Potential Effects of the Pilot Project

This section describes the anticipated impact mechanisms that could affect aquatic resources during operation of the pilot project. Environmental permitting for the pilot project is being conducted separately to ensure adverse effects are adequately addressed as part of obtaining the necessary approvals for construction and operation; however, operational information is presented here to provide context for the development and implementation of the ESM. Additional detail on potential impacts to species of concern and their habitat are more fully described in the Biological Assessment (Anchor QEA 2024a) and Critical Areas Report (Anchor QEA 2024b).

The purpose of the pilot project is to combat ocean acidification and ameliorate human-driven climate change by removing excess CO_2 from the atmosphere. Because the pilot project will potentially deacidify seawater locally, temporary changes in water quality are expected (Brown and Caldwell 2024). Preliminary analysis indicates these temporary changes would include increases in pH, temperature, and turbidity and decreases in dissolved oxygen levels. Significant or longer lasting increases in turbidity may indicate that the system is releasing CO_2, which is counter to the pilot project goal. The pilot project would not be operating effectively in this scenario, and operations would need to be ceased temporarily to address the issue. The long-term benefits from carbon storage are anticipated to outweigh any potential short-term adverse impacts from the pilot project. The potential benefits and operational impacts to aquatic resources will be monitored and evaluated as part of the ESM.

Table 2 presents potential impacts to species and life stages potentially present in the project area. Initial monitoring and adaptive management strategies are described in Section 4.

Table 2
Potential Pilot Operation Impacts to Species

Operation Impact	Description	Potentially Affected Species/Life Stages
Turbidity	Reduced light transmission through water column, decreasing visibility for organisms and reducing photosynthesis processes for aquatic vegetation	Juvenile fish species: clogging gills, increased predation, decreased foraging success, reduced habitat Benthic invertebrates (Dungeness crab, pinto abalone, sunflower sea star, shellfish): reduced habitat Mammal and bird species: reduced prey
pH	Increased pH associated with discharge from outfall, affecting aquatic species present	Fish: damage to gills, eyes, and skin; reduced habitat Benthic invertebrates (Dungeness crab, pinto abalone, sunflower sea star, shellfish): reduced diversity and biomass; increased susceptibility to disease; reduced habitat Mammal and bird species: reduced prey
Temperature	Increases in temperatures, affecting the distance and location of changes in water quality (e.g., pH, dissolved oxygen), and affecting aquatic species present	Fish: reduced presence due to area avoidance, increased metabolic needs Benthic invertebrates (Dungeness crab, pinto abalone, sunflower sea star, shellfish): reduced diversity and biomass, increased susceptibility to disease, reduced habitat Mammal and bird species: reduced prey
Dissolved oxygen	Decreases in dissolved oxygen, affecting aquatic species present	Fish: reduced growth, altered behavior, increased mortality, reduced reproduction Benthic invertebrates (Dungeness crab, pinto abalone, sunflower sea star, shellfish): reduced diversity and biomass prey, increased susceptibility to disease, reduced habitat Mammal and bird species: reduced

3 Tribal and Stakeholder Engagement

Ebb Carbon is committed to engaging its expert partners and other Indian Tribes, the Port, resource agency representatives and regulators, and scientists in the development and implementation of the ESM. Input from the community surrounding the pilot project will be solicited as well. It is understood that these entities may have important input on topics related to the pilot study, including the following:

- Identification of important habitat characteristics and species of concern
- Surveys and studies relevant to the execution of the pilot project
- Potential information about presence and absence of important aquatic resources
- Concerns over impact pathways
- Feedback on baseline data collection and monitoring
- Protocols for modifying higher-alkaline water discharge

The timeline for engagement will begin in early 2024 and will include the following three main touchpoints:

- Early 2024: presenting project/preliminary framework and receiving input, such as on aquatic resources of concern
- Mid-2024: sharing baseline data collection results, presenting refined monitoring and discharge protocols, and gathering additional input prior to beginning pilot-scale operations and data collection
- Mid-2025: presenting updates on implementation and discussing refinements

4 Baseline Data Collection

Baseline data will be collected to assess the ecological attributes of the project site prior to beginning operations. This information will be used to help inform development of the monitoring and discharge protocols. Data collection will focus on the following ecological attributes:

- Eelgrass
- Macroalgae
- Epibenthic and benthic sampling
- Forage fish spawning habitat
- Substrate characterization

These attributes were selected based on the potential presence of aquatic resources and the logistics of data collection and monitoring conditions anticipated at the site. These attributes are representative of key species of interest and would provide a solid basis for beginning field testing and evaluation but could be modified depending on site verification (since some attributes may not be present) and Tribal and stakeholder priorities.

Baseline studies will be conducted to confirm the presence or absence of important habitat features (i.e., eelgrass, macroalgae, macroinvertebrates, and fish habitat) and to establish baseline conditions prior to implementation of the pilot project. These studies will also identify a suitable reference site or sites to be sampled for comparison. Reference sites consist of locations with similar features in nearby locations that are not disturbed by human activity (e.g., harbor use or industrial activity along a shoreline) to provide a metric against which habitat conditions could be measured and emulated. Observations of fish will be documented, but it is not anticipated that fish data will be collected for the purposes of data analysis. The baseline studies could include transect/quadrant surveys to document aquatic vegetation, benthic organism presence, and habitat condition via snorkeling and video surveys.

5 Monitoring Protocol

The monitoring protocol will outline the specific attributes that will be monitored, how and at what frequency they will be monitored, and how the information will be documented and reported. Monitoring efforts of pilot project effects would include water quality sampling and biological monitoring, which would begin along with pilot project operations.

5.1 Water Quality Monitoring

Water quality monitoring would be accomplished by attaching sensors to existing piers to collect regular measurements of water temperature, salinity, dissolved oxygen, turbidity and suspended solids, chlorophyll, pH, and the partial pressure of CO_2. Data for water temperature, salinity, dissolved oxygen, turbidity, and pH would be collected continuously (recorded in increments up to 15 minutes). Less frequent (up to weekly) seawater samples would be collected and analyzed for total alkalinity and dissolved inorganic carbon.

Water quality parameters that exceed pre-set limits are to be determined in coordination with regulatory agencies and the Lower Elwha Klallam Tribe. Exceedances would alert the responsible party to determine and implement adaptive management actions (Table 3). During operations, the mixing zone will be maintained within permitted limits. The Ecology-required mixing zone distance is 207 feet from the point of discharge. Water quality monitoring would occur to assess for potential acute and chronic mixing zone exceedances at proposed distances of 15 and 150 feet, respectively.

5.2 Biological Monitoring

Biological monitoring would focus on assessing changes to aquatic habitat and species that may be present. The frequency and extent would be determined in coordination with Tribal and stakeholder input. Example methods could include recurring visual inspection by on-site staff for observable changes in habitat conditions, such as the development of algae or changes in aquatic vegetation that are visible from the surface at low tide. Additional surveys using submerged cameras could be used to look for changing vegetation boundaries and identify presence/absence of benthic invertebrate communities.

6 Discharge Protocol

This section describes the initial strategies that could be employed to safely adjust the pilot project's ongoing operations based on monitoring data. Table 3 describes the alkalinity releases planned for pre-operation and preliminary operations.

Table 3
Alkalinity Release Activities During Operational Phases

Operational Phase	Estimated Duration	Alkalinity Release	Description of Key Activities
Pre-operation	6 months	None	• Finalize system design. • Develop ocean models. • Obtain permits. • Collect baseline ocean chemistry and ecological data. • Test system safety, alarms and controls.
Preliminary operations	2 months	Yes – operations during normal business hours, monitored by Ebb team members.	• Verify system safety, alarms and controls. • Establish precipitate thresholds by collecting site-specific data that will more accurately correlate calcite concentrations to turbidity values. • Conduct field measurements after controlled alkalinity release and compare measurements to models. • WET testing to assess alkalinity discharge.

Note:
WET: whole effluent toxicity

Table 3 addresses potential issues that may arise during operation and suggests actions to reduce adverse impacts. It is expected that this protocol would be further developed through Tribal and stakeholder engagement. This would include the development of specific thresholds where corrective actions would be required, the timeline within which decisions would be made, and who would be responsible for making decisions and taking corrective actions.

Table 4
Adaptive Management Strategies During Operations

Potential Issue	Indicator	Adaptive Management Strategy
Water quality changes	Remote monitoring from moored sensors indicates unanticipated changes more than anticipated from baseline levels.	• Test and recalibrate moored sensors to ensure accurate readings. • Temporarily shut down operation to determine if all equipment is functioning properly. • Meet with partners to discuss changes to design prior to resuming operation.
	Recurring grab sample results document changes more than anticipated from baseline levels.	• Follow monitoring plan to include duplicate samples for collection and laboratory quality assurance/quality control. • Resample to ensure accurate results and identify problems. • Temporarily shut down operation to determine if all equipment is functioning properly. • Meet with partners to discuss changes to design prior to resuming operation.
Observations of aquatic vegetation changes	Weekly visual inspections document algal growth or changes in visible aquatic vegetation.	• Determine possible reason for observation and the role (if any) Project Macoma operation played in development of algal growth or changes in visible aquatic vegetation. • Conduct additional water quality sampling to measure changes in nutrient levels and other water quality triggers to unexpected changes in aquatic vegetation. • Temporarily shut down operation to determine if all equipment is functioning properly. • Meet with partners to discuss changes to design prior to resuming operation.
Observations of aquatic organism behavioral changes	Collect additional water quality grab samples and review moored sensor readings leading up to and during observation.	• Determine possible reason for observation and the role (if any) Project Macoma operation played in behavioral change. • Temporarily shut down operation if unexpected behavioral change occurs to determine if all equipment is functioning properly. • Meet with partners to discuss changes to design prior to resuming operation.
Observations of deceased aquatic organisms	Collect additional water quality grab samples and review moored sensor readings leading up to and during observation.	• Determine possible reason for observation and the role (if any) Project Macoma operation played in the die-off. • Temporarily shut down operation to determine if all equipment is functioning properly. • Meet with partners to discuss changes to design prior to resuming operation.

7 References

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