Portland Metro Levee System Feasibility Study

1948 Vanport flood (Photo courtesy of Oregon Historical Society, Lot 131_010)

Draft Integrated Feasibility Report and Environmental Assessment

US Army Corps of Engineers ®
Portland District

CCDD
Columbia Corridor Drainage Districts

January 2020

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Executive Summary

Introduction

The Portland Metro Levee System (PMLS) Feasibility Study (study) is a flood risk management general investigations feasibility study being conducted by the Portland District U.S. Army Corps of Engineers (Corps) in partnership with the Columbia Corridor Drainage Districts Joint Contracting Authority (CCDD), which includes Peninsula Drainage District #1, Peninsula Drainage District #2, Multnomah County Drainage District #1, and Sandy Drainage Improvement Company.

Authority

Initial Corps involvement in construction of the levee system began with the Flood Control Act of June 22, 1936. After the 1948 flood event, additional construction was authorized in the Flood Control Act of May 17, 1950. The study authority for this project is Section 216 of the Flood Control Act of 1970, as amended. Title IV, Division B of the Bipartisan Budget Act of 2018, Public Law 115-123, enacted February 9, 2018 authorizes the government to conduct the study at full Federal expense.

Study Area

The study area lies along the Columbia River within the cities of Portland, Gresham, Fairview, and Troutdale in Multnomah County, Oregon and has a population at risk of approximately 30,000. The study area includes 27 miles of levees along the lower Columbia River, running from the Columbia River Crossing of the Burlington Northern Santa Fe (BNSF) railroad in North Portland to the Sandy River (River Mile (RM) 105.9 to RM 121.8). Large portions of north and northeast Portland, City of Gresham, City of Fairview, and City of Troutdale are natural floodplains. Beginning in 1917, a system of levees and pump stations has been constructed to provide critical flood protection and stormwater management for the Columbia Corridor Drainage Districts (CCDD).

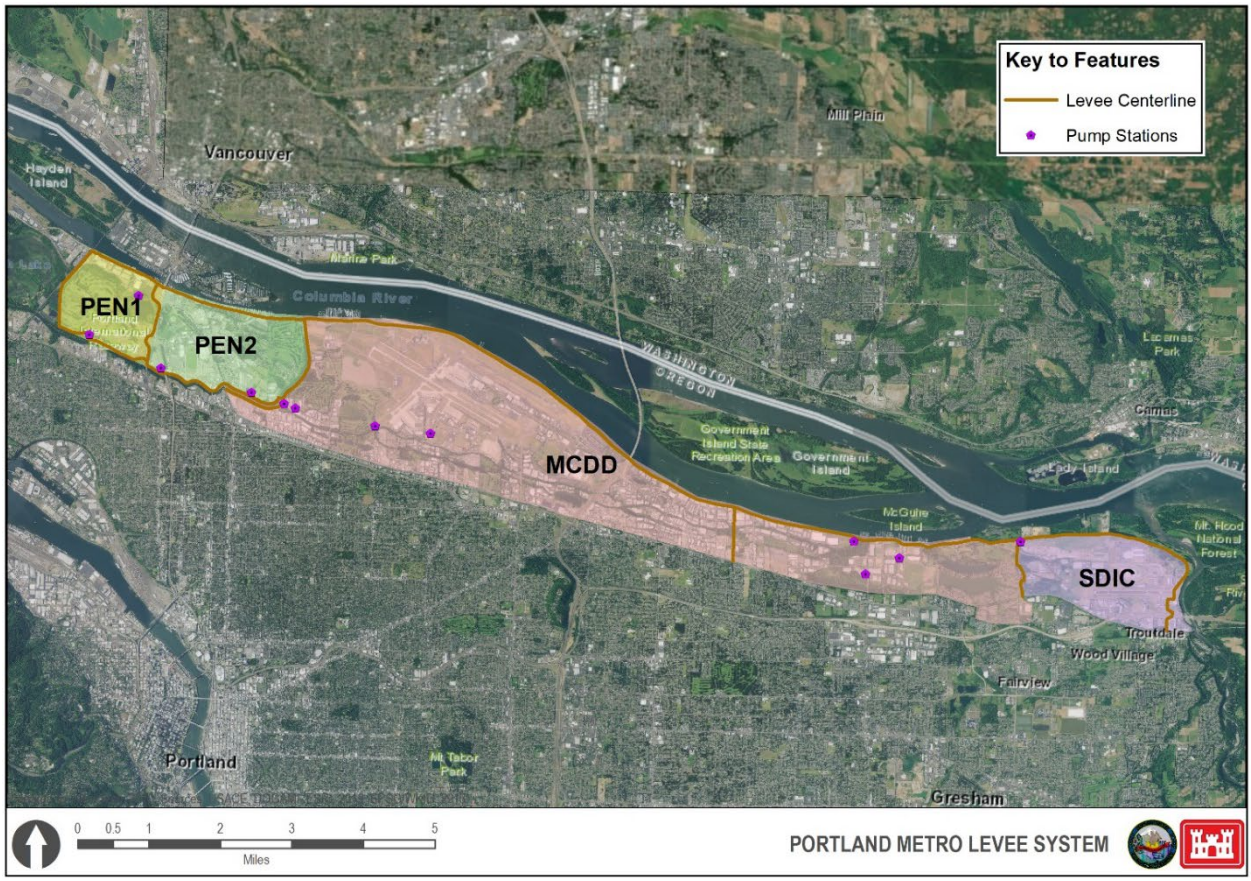
The study area includes the entire Portland Metro Levee System (PMLS), which consists of four integrated and contiguous levee systems: Peninsula Drainage District #1 (PEN 1), Peninsula Drainage District #2 (PEN 2), Multnomah County Drainage District # 1 (MCDD), and Sandy Drainage Improvement Company (SDIC). The PMLS encompasses approximately 12,500 acres. These four districts are responsible for managing the 27 miles of Federally authorized levees, 45 miles of ditches and sloughs, and 12 pump stations.

The PMLS protects significant and essential assets including portions of the region's water supply, power, and natural gas infrastructure, critical commercial and industrial properties driving over $16 billion in economic benefits and $7.2 billion in property values, the Portland International Airport, three interstate highways, two transit and Class I freight rail lines, a

Metropolitan Area Express (MAX) light rail and power station, an Air National Guard base, an Air Force Reserve Rescue Squadron, and thousands of businesses and residences protected by the PMLS system.

Purpose

The purpose of the study is to assess alternatives for Federal interest with a focus on improving levee performance, incorporating resilience, and reducing flood risk to a 27-mile levee system that has seen significant land-use changes since it was originally authorized. A need has been identified for reducing the flood risk in the study area.



Objectives

The impact of a levee failure at PMLS would have extreme consequences due to the significance of the people, property, and infrastructure at risk. The system has failed once before, in the 1948 flood event. The railroad embankment failure resulted in at least 15 deaths and the displacement of over 18,500 residents. The primary planning objective of this feasibility study is to reduce flood risk in the PMLS in an acceptable manner that minimizes impacts on resources and is acceptable to the public and stakeholders. Specific planning objectives are documented in the main report, focusing on flood risk, life safety, resiliency, operability, and opportunities to support recreation and cultural and natural resources.

Plan Formulation

Evaluation of the future without project condition included detailed engineering and economic evaluations to quantify flood risk and prepare for the evaluation of alternatives. System-wide, the analysis of National Economic Development (NED) flood risk damages estimated $22.3 million in Expected Equivalent Annual Damage (EEAD). LifeSim modeling estimated a population at risk of nearly 30,000 during the daytime and 12,000 overnight, resulting in life loss estimates ranging 9 to 33 for the Overtopping with 72-Hour Warning scenario (25^{th} to 75^{th} percentile estimates). The chance of these flood scenarios occurring is low, but it is not negligible. Life loss during an overtopping event is generally lower than a failure prior to overtopping, since there is more warning time in an overtopping scenario. If a levee breaches before it is overtopped, the life loss consequences are much higher, but the probability of this occurring is lower.

Through several iterations of strategy development, measure identification, and screening, a focused array of three alternatives were identified that focused on different strategies for achieving planning objectives, including Alternative 3 – Prioritize Public Health and Safety Alternative Strategy; Alternative 4 – Maximize Resilience/Reliability Alternative Strategy; and Alternative 5 – Uniform Annual Exceedance Probability Alternative Strategy. The table below summarizes the measures included in each alternative.

No.	Measure	Alternative 3	Alternative 4	Alternative 5
5	Improve Levee Performance and Reliability	•	•	•
6	Flood Warning in Residential/PAR areas	•	•	•
7	Increase Levee Heights	•	•	•
10	Add Pump Capacity		•	•
14	Improve Flood Fight		•	•
15	Automate Systems		•	
20A	Add Redundant power source; Replace SDIC PS		•	•
20B	Replace SDIC Pump Station	•	•	•
22	Debris Removal (trash in water and trees/limbs)		•	•
30	Build Additional Levee/Floodwall		•	•
32	Rehab/Replace Mechanical Structures (gates, etc.)		•	
36	Education	•	•	•
37	Signage for Evacuation	•	•	•
41	Safe Zones	•	•	•

Identification of the Tentatively Selected Plan

The NED costs and benefits of each alternative are summarized in the table below. All of the alternatives have net benefits above unity. While Alternative 3 has the highest benefit-cost ratio and Alternative 5 has the lowest, Alternative 5 maximizes net benefits. Alternative 5 is the NED Plan.

Item Description	Alternative 3	Alternative 4	Alternative 5
Total Annualized Investment Cost ($1,000s)	$1,866	$2,883	$6,149
Annual Benefits ($1,000s)	$6,038	$8,448	$13,777
Annual Net Benefits ($1,000s)	**$4,172**	**$5,565**	**$7,628**
Benefit-Cost Ratio	3.24	2.93	2.24

Notes: Cost figures shown at FY2020 Price Level. All figures are in $1,000s. Total Annualized Investment cost reflects total economic project cost, including interest during construction and operation and maintenance, and reflects the FY2020 Federal Discount Rate of 2.75% and a 50-year period of analysis.

Alternative 5 seeks to address inconsistencies within the levee system to provide more uniform flood risk throughout the study area. This alternative focuses on both the internal and external sources of flooding. It includes a levee raise and other improvements to the levees in PEN 1 and PEN 2 to address both fragility and overtopping risks. A new floodwall would be added along the Columbia River segments of the PEN 1 and PEN 2 levees, including under the I-5 bridge. The alternative includes a new levee parallel to the existing railroad embankment on the west edge of PEN 1. The alternative increases levee heights at locations with low spots in MCDD and SDIC. Pump station measures are included to ensure more consistent performance between the interior drainage systems. Improvements include capacity increases at three pump stations, better debris control at three locations, and elevating/replacing the Sandy pump station. Measures in this alternative include both structural and non-structural measures

The PDT evaluated the alternatives to identify the Tentatively Selected Plan (TSP). The evaluation included a comparison of how well the alternatives meet the planning objectives and of how well they address the four Principles & Guidelines (P&G) evaluation criteria and additional criteria relevant to this study.

Considering the planning objectives, Alternative 5 was rated highest in terms of the extent to which the objectives were met for four of the six objectives. Alternative 4 was rated better than Alternative 5 only for the objective related to system resilience due to cross-levees improvements that serve as a secondary line of defense, as well as additional features related to interior drainage and pump stations. Alternative 5 opts to increase system capacity. Alternative 4 rated higher or was judged to have the same rating as Alternative 3 across all the objectives.

Considering the P&G and other criteria, Alternative 5 was judged to be more efficient than Alternative 4 and Alternative 3, and it provided the greatest reduction in Life Safety risk among the three alternatives. Regarding completeness, effectiveness, and acceptability, Alternative 5 and Alternative 4 ranked the same, and both ranked higher than Alternative 3. Regarding impacts to natural resources, Alternative 3 was judged to have the least impacts, though Alternative 4 and Alternative 5 were judged to have lower to medium adverse impacts. Regarding implementation risks, all the alternatives were judged to have risks for real estate requirements. Finally, both Alternative 4 and Alternative 5 were judged to maximize reduction in uncertainty related to managing flood risk in the study area.

While the risk of life loss can never be eliminated, all alternatives provide improved life safety compared to the future without project scenario. Alternative 3 and 4 improve levee segments that currently have an appreciable chance of breaching before overtopping, particularly in PEN 1 and the Peninsula Canal cross-levee. Alternatives 4 and 5 include improvements to the SDIC embankment, reducing the chance of failure prior to overtopping. Overtopping at PEN2 is the failure mode that poses the highest life safety risk when considering both the probability of inundation and the lives lost in the event of a flood. Alternatives 3 and 4 include filling isolated low spots in PEN 2, which has only a small improvement to life safety in PEN 2. Alternative 5 adds a more significant levee raise in PEN 2, which substantially reduces the chance of an overtopping event in this area (about 80% reduction in probability).

Based on these comparisons and in consideration of the NED analysis, Alternative 5 is identified as the TSP. It provides the greatest economic and life safety benefits consistent with protecting the environment, better meets the selection criteria, and the relative risks or uncertainty are comparable to the other two alternatives.

MCACES Cost for TSP

Following the alternatives analysis, a more detailed Micro-Computer Aided Cost Estimating System (MCACES) cost estimate was prepared for the TSP (Alternative 5). This table includes construction costs, Preconstruction Engineering and Design (PED), Construction Management (CM) which includes Engineering and Design (EDC) and Supervision and Administration (S&A) during construction, and Land, Easements, Rights-of-Way, Relocation, and Disposal Areas (LERRDs). A risk-based contingency has been applied to construction cost estimates. Based upon the MCACES estimate, total Estimated Cost of the TSP is $123,407,000 (FY 2020 price level). Escalated to the expected Program Year of 2021, Project First Cost is $130,710,000 (FY 2021 price level).

Item	Cost (FY21) in $1,000s
Construction Costs	$62,083
Preconstruction Engineering/Design (PED)	$7,567
Construction Management (EDC, S&A)	$6,306
Contingency	$34,653
Real Estate (LERRDs)	$20,100
Total Project First Cost	**$130,710**

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Note: *Chapter and Section headings in this report that are noted with an asterisk (*) are compliant with and required by NEPA.*

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List of Acronyms

Acronym/Abbreviation	Definition
AADT	Average Annual Daily Traffic
ADT	Average Daily Traffic
AEP	Annual Exceedance Probability
AQCR	Air Quality Control Regions
AQI	Air Quality Index
AQMA	Air Quality Maintenance Area
BMPs	best management practices
BNSF	Burlington Northern Santa Fe Railroad
CCDD	Columbia Corridor Drainage Districts
COA	Conservation Opportunity Area
Corps	U.S. Army Corps of Engineers
CSWC	Columbia Slough Watershed Council
CT	Census Tract
CWA	Clean Water Act
dBA	Decibels
DDE	dichlorodiphenyldichloroethylene
DNL	Day Night Level
DOGAMI	Oregon Department of Geology and Mineral Industries
EDC	Engineering During Construction
EEAD	Expected Equivalent Annual Damages
EPA	U.S. Environmental Protection Agency
EQ	Environmental Quality
FHWA	Federal Highway Administration
FY	fiscal year
GIS	Geographic Information System
GWMA	Groundwater management area
HHS	U.S. Department of Health and Human Services
HTRW	Hazardous, Toxic and Radioactive Waste
HUD	U.S. Department of Housing and Urban Development
IEPR	Independent External Peer Review
IPaC	Information for Planning and Conservation
Leq	Average Sound Level
LERRD	Lands, Easements, Rights of Way, Relocations, and Disposal Sites
Lmax	Maximum Sound Level
LRC	Levee Ready Columbia
MAX	Metropolitan Area Express Light Rail System
MBTA	Migratory Bird Treaty Act
MCDD	Multnomah County Drainage District
MP	Mile post
MS4	Municipal Separate Storm Sewer Systems
NAAQS	National Ambient Air Quality Standards

Acronym/Abbreviation	Definition
NAVD88	North American Vertical Datum of 1988
NED	National Economic Development
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NWI	National Wetland Inventory
OARRA	Oregon Archaeological Records Remote Access
OCS	Oregon Conservation Strategy
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OSE	Other Social Effects
OSWB	Oregon State Weed Board
OWQI	Oregon Water Quality Index
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
PAR	Populations at risk
PCBs	Polychlorinated biphenyls
PDT	Project Delivery Team
PDX	Portland International Airport
PEN 1	Peninsula 1 Drainage District
PEN 2	Peninsula 2 Drainage District
PIR	Portland International Raceway
PM_{10}	Particulate matter less than 10 micrometers in diameter
$PM_{2.5}$	Particulate matter less than 2.5 micrometers in diameter
PMLS	Portland Metro Levee System
PRD	Portland Parks and Recreation Department
RED	Regional Economic Development
SDIC	Sandy Drainage Improvement Company
SHPO	State Historic Preservation Office
SIP	Oregon Clean Air Act State Implementation Plan
SLC	Sea Level Change
TMDL	total maximum daily load
TSP	Tentatively Selected Plan
UGB	Urban Growth Boundary
USACE	U.S. Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
WDOE	Washington Department of Ecology
WWQI	Washington Water Quality Index

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1. Introduction

The Portland Metro Levee System (PMLS) Feasibility Study (study) is a flood risk management general investigations feasibility study being conducted by the Portland District U.S. Army Corps of Engineers (Corps) in partnership with the Columbia Corridor Drainage Districts Joint Contracting Authority (CCDD), which includes Peninsula Drainage District #1, Peninsula Drainage District #2, Multnomah County Drainage District #1, and Sandy Drainage Improvement Company. The purpose of the study is to analyze current flood risks in the system, develop projections of future without-project conditions, and identify flood risk management options that could meet current and future needs within the policies and regulations of the Corps. Implementation of this study could lead to a Federally supported construction component if a solution is found to be in the Federal interest. This feasibility report and integrated environmental assessment documents technical analyses and plan formulation and evaluation conducted during the feasibility study.

1.1. Study Purpose, Need and Scope

The purpose of the study is to assess alternatives for Federal interest with a focus on improving levee performance, incorporating resilience, and reducing flood risk to a 27-mile levee system that has seen significant land-use changes since it was originally authorized. A need has been identified for improving flood risk management in the study area.

The scope of the study includes the entire levee system, which consists of four integrated and contiguous levee systems operated and maintained by four local drainage districts: Peninsula Drainage District #1 (PEN 1), Peninsula Drainage District #2 (PEN 2), Multnomah County Drainage District # 1 (MCDD), and Sandy Drainage Improvement Company (SDIC).

The study area lies within portions of four cities and has a population at risk of approximately 30,000. The PMLS protects significant and essential assets:

- Backup drinking water supply serving approximately 1 million people
- Critical infrastructure driving over $16 billion in economic benefits and $7.2 billion in property values
- A major natural gas pipeline that serves two states, and Bonneville Power Authority substation.
- Two airports including Portland International Airport (19,882,788 passengers in 2018 or 54,473 daily) over (Port of Portland, 2019b)
- Three interstate highways (I-5, I-205, I-84)
- Two transit and Class I freight rail lines, Max light rail and power station
- A US Air National Guard Base that houses the 142nd Fighter Wing and the Air Force's 304th Reserve Rescue Squadron which serve the Pacific Northwest region and the nation.

- Thousands of businesses and residences protected by the PMLS system.

1.1.1. Original Authorized Purpose

Initial Corps involvement in construction of the levee system began with the Flood Control Act of June 22, 1936. After the 1948 flood event, additional construction was authorized in the Flood Control Act of May 17, 1950. The Flood Control Acts authorize the PMLS levees to heights based on the water surface profiles of historic floods. The 1936 Flood Control Act authorized SDIC and MCDD to the 1894 flood, and PEN 1 and PEN 2 to the smaller 1876 flood. The 1950 Flood Control Act authorized improvements to the Levee Design Flood, which is a modeled design flood based on the 1894 flood with some upstream reservoir storage accounted for. The sections below describe the original authorized purpose for each levee district.

1.1.1.1. Peninsula Drainage District #1 (PEN 1)

Local interests originally constructed the system in 1918. The Federal project was originally authorized by the 1936 Flood Control Act provided for the construction of about 0.9 miles of new levee along the Oregon Slough; construction of 0.3 miles of reinforced concrete-steel sheet pile flood wall and three emergency stoplog structures along the Oregon Slough, and one stoplog structure at the railroad embankment's underpass along North Portland Road; improvement of 1.4 miles of existing levee along Columbia Slough; and construction of a pumping plant. The 1950 Flood Control Act modified the project to provide for raising and strengthening of the existing levees along the district side of the railroad and highway embankment and to provide necessary closure structures and sheet pile cut-offs. No construction has been done on the improvements authorized by the Flood Control Act of 1950 due to lack of local cooperation and the proposed improvements were deauthorized in 1977 (USACE, 1996). Therefore, the authorized levee height is currently based on the 1876 event as specified in the 1936 Flood Control Act. Construction work by the Corps occurred along the railroad embankment (western edge of the district) in both 1972 ("Operation Foresight" via Public Law 84-99) and 1997 (PEN 1 Section 205 project).

1.1.1.2. Peninsula Drainage District #2 (PEN 2)

The system was organized in 1917 and the original levee on the Columbia Slough was completed in 1921. The Federal project originally authorized by the 1936 Flood Control Act provided for enlargement and strengthening of 3.9 miles of existing levee; construction of two reinforced concrete flood walls, 856 feet in length; construction of 1.2 miles of stone revetment; and construction of a pumping plant. The 1950 Flood Control Act modified the project to provide for raising and strengthening portions of the existing levee, installing toe drains, and reinforcing a reach of highway embankment. Only a portion of the improvements authorized by the 1950 Flood Control Act was completed, due to lack of local cooperation.

1.1.1.3. Multnomah County Drainage District # 1 (MCDD)

In 1917 local interests began construction of levees and pump stations within parts of the floodplain (Cornforth, 2018). The Federal project originally authorized by the 1936 Flood Control Act was completed in 1950, enlarging and strengthening 11.85 miles of existing levee; constructing 0.7 miles of stone revetment; and reconstructing the existing pumping plant. The 1950 Flood Control Act modified the project to provide strengthening of the main levee; construction of a cross levee to divide the district into two areas that minimize and localize damage resulting from failure at any point in the main levee, thereby increasing resiliency; construction of a pumping plant in the east area of the district; and installation, at the main slough crossings, of drainage structures equipped with gates at both ends. Closure of the Peninsula Drainage Canal was completed March 1959.

1.1.1.4. Sandy Drainage Improvement Company (SDIC)

SDIC was originally organized as a private enterprise in 1915, and initial levee construction occurred shortly thereafter. The Federal project originally authorized by the 1936 Flood Control Act provided for reconstruction of 2.4 miles of the existing levee; construction of 1.2 miles of new levee; construction of a pumping plant; and installation of a tide box. The 1950 Flood Control Act modified the project to provide strengthening of the existing levee and the installation of toe drains along the existing levee at various locations. Construction was completed by SDIC (at the time called Sandy Drainage District) with private capital, including a cross levee between SDIC and MCDD that was authorized as part of the MCDD. Improvements authorized by the 1950 Flood Control Act were completed in April 1960.

1.1.2. Previous Studies

In 1990 the Portland District conducted a reconnaissance study evaluating flood risks in the Rivergate area (USACE, 1990). The study area included the vicinity of PEN 1 and industrial and commercial development to the West of PEN 1 along the Columbia River. Findings of the study were that filling in the study area already eliminated the flood risks and there are no plans that warrant detailed study.

In 1996 the Portland District completed a Section 205 study for PEN 1. The recommended plan included reinforcing 2,000 lineal feet of the Union Pacific Railroad embankment in the southwest corner of PEN 1, raising the outlet of the existing pump station, and encasing the portion of the outlet within the levee in concrete. Construction was completed in 1997.

In 2008 an Environmental Impact Statement was completed by Washington DOT addressing Interstate 5 Columbia River Crossing.

On June 11th, 2015 Northwestern Division approved the Portland District's Section 216 Initial Appraisal Report for the PMLS recommending a new start feasibility study under the General Investigations program and concluding federal interest in conducting additional studies.

In 2019 a joint study conducted by USGS and Portland District in support of Levee Ready Columbia titled "Assessment of the Columbia and Willamette River Flood Stage on the Columbia Corridor Levee System at Portland, Oregon, in a Future Climate". The study provides information on an extreme but plausible winter-time climate scenario in order to inform how well the system would perform under that scenario.

The Corps has completed periodic levee inspections on the levee system. The non-federal sponsor has completed additional conditions assessments in 2014 and 2018 by Cornforth Consultants.

1.2. Study Authority

Initial Corps involvement in construction of the levee system began with the 1936 Flood Control Act. After the 1948 flood event, additional construction was authorized in the 1950 Flood Control Act.

The study authority for this project is Section 216 of the Flood Control Act of 1970 (33 USC 426 et seq) as amended, which reads:

"The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."

Title IV, Division B of the Bipartisan Budget Act of 2018, Public Law 115-123, enacted February 9, 2018 authorizes the government to conduct the study at full Federal expense. "*For an additional amount for " Investigations" for necessary expenses related to the completion, or initiation and completion, of flood and storm damage reduction, including shore protection, studies which are currently authorized or which are authorized after the date of enactment of this subdivision, to reduce risk from future floods and hurricanes, at full Federal expense, $135,000,000, to remain available until expended…*"

Policy Guidance on Implementation of Supplemental Appropriations in the Bipartisan Budget Act of 2018 section 4.c. states that "*Feasibility studies that are predominantly for flood and storm damage reduction are eligible to be considered for Supplemental Investigations funds. In addition, comprehensive and watershed studies that are predominantly for flood and storm damage reduction, even if there are other ancillary purposes, are eligible for consideration. Both structural and non-structural measures will be considered. Studies may address long-range measures to reduce exposure to risks from floods and coastal storms."* (Army, 2018)

1.3. Lead Federal Agency, Non-Federal Sponsor and Stakeholders

The Corps Portland District is the lead Federal agency for this study. The feasibility study is being conducted in partnership with CCDD, which consists of the four drainage districts: PEN 1, PEN 2, MCDD and SDIC. The non-Federal sponsor on the project is CCDD. MCDD has been granted decision authority to act on behalf of the four drainage districts.

There are also several key stakeholder groups involved with the project, most of which are a part of the Levee Ready Columbia partnership. On July 17, 2015, the Levee Ready Columbia partners (Table 1-1), a group of public, private, nonprofit, and neighborhood organizations, signed a declaration of cooperation. This document signifies each organization's commitment to work proactively and collaboratively on the levee system and modernize the way operations and maintenance are funded and governed at the local level.

Table 1-1 Levee Ready Columbia Program Partners

Audubon Society	Jubitz Corporation
Bridgeton Neighborhood Association	Metro Regional Government
City of Fairview	Multnomah County
City of Gresham	Multnomah County Drainage District #1
City of Portland – Bureau of Environmental Services – Bureau of Parks and Recreation – Bureau of Development Services – Bureau of Transportation – Water Bureau	Peninsula Drainage District #1
	Peninsula Drainage District #2
	Port of Portland
	Sandy Drainage Improvement Company
	Sauvie Island Drainage Improvement Company
	State of Oregon – Department of Environmental Quality – Department of Land Conservation and Development - Governor's Regional Solutions Team
City of Troutdale	
Columbia Corridor Association	
Columbia Slough Watershed Council	US Army Corps of Engineers
East Columbia Neighborhood Association	
Federal Emergency Management Agency	

1.4. Cooperating Agencies*

No cooperating agencies are expected at this time. [1]

1.5. Study Area

The study area lies along the Columbia River within the cities of Portland, Gresham, Fairview, and Troutdale; in Multnomah County, Oregon. The study area includes 27 miles of levees along

[1] Chapter and Section headings in this report that are noted with an asterisk (*) are compliant with and required by NEPA.

the lower Columbia River, running from the Columbia River Crossing of the BNSF railroad in North Portland to the Sandy River (River Mile (RM) 105.9 to RM 121.8). Large portions of north and northeast Portland are natural floodplains. Beginning in 1917, a system of levees and pump stations has been constructed to provide critical flood risk management and stormwater management for the CCDD. Figure 1-1 shows the study area. The Portland Metro Levee System consists of four drainage districts: PEN 1, PEN 2, MCDD, and SDIC, encompassing approximately 12,500 acres. These four districts are responsible for managing the 27 miles of Federally authorized levees, 45 miles of ditches and sloughs, and 12 pump stations.

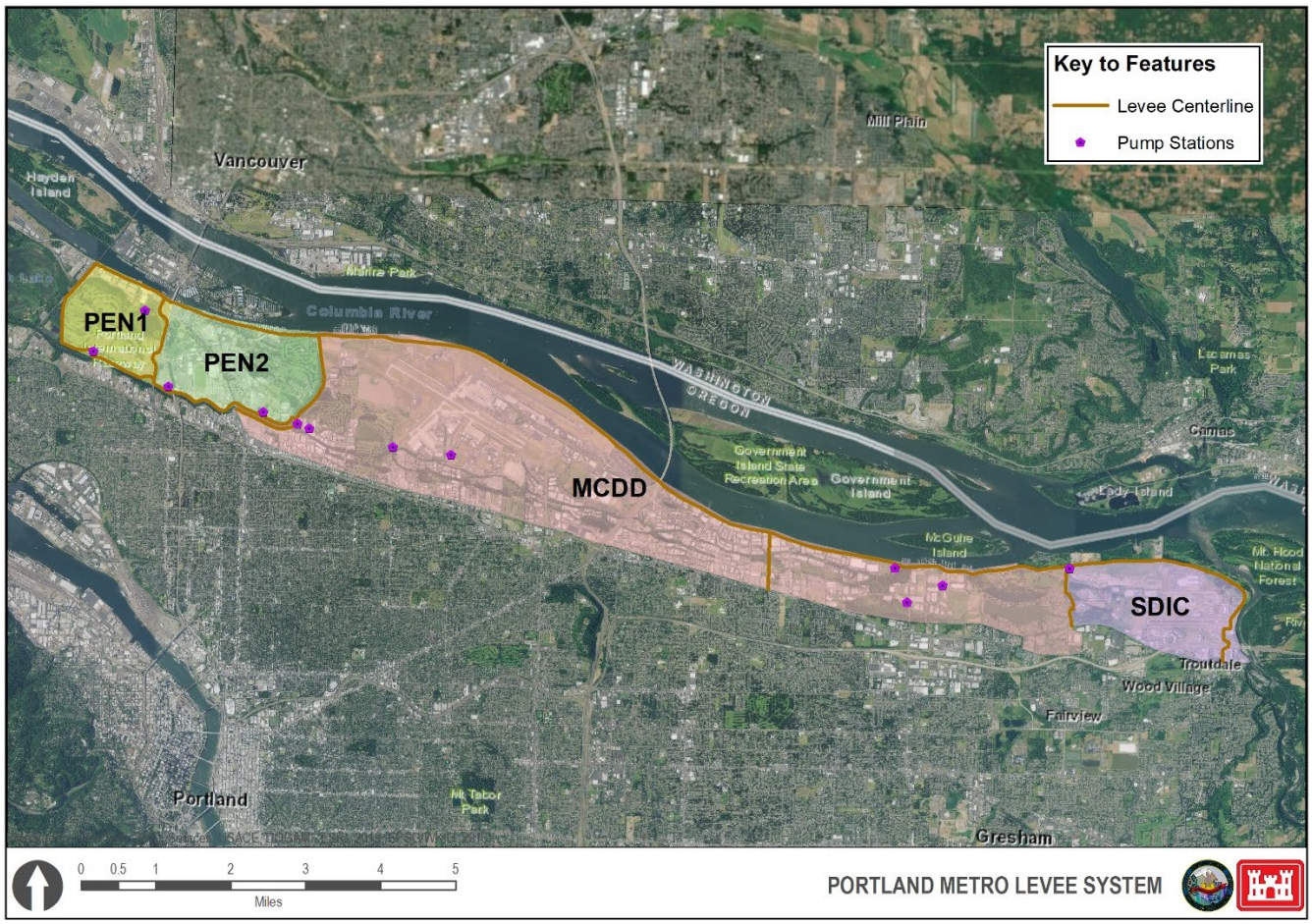

Figure 1-1 PMLS Study Area

1.5.1. PEN 1 Description

PEN 1 is located from RM 105.9 to RM 106.8 on the mainstem Columbia River (Figure 1-2). The Oregon Slough along the Columbia River is the northern boundary of the district. The district protects an area of approximately 901 acres, including 116 acres that are improved and utilized for commercial and industrial purposes. Other significant property uses include I-5 and the bridge over the Columbia River connecting a major North/South transportation corridor running from California to Canada, the Yellow Line MAX transit system, Expo Center, Portland

International Raceway (PIR), Heron Lake Golf Course, Delta Park West, and the Port of Portland's Vanport Wetlands. There are no residential properties within the district. The PEN 1 system is 4.95 miles in length and includes levees and floodwalls as well as highway and railroad embankments and a closure structure. The PEN 1 levee system is bordered by I-5 to the east, embankments of the Union Pacific Railroad and Burlington Northern Santa Fe Railroad to the west, and the Columbia Slough to the south.

1.5.2. PEN 2 Description

PEN 2 is located from RM 106.8 to RM 108.7 on the mainstem Columbia River (see Figure 1-3). The district protects an area of approximately 1,600 acres, including 1,300 acres that are improved, and 20 acres of sloughs and drainage canals.

Land use in the district is divided among commercial, residential, industrial, recreation, and agriculture. Developments within the district include Columbia Edgewater Golf and Country Club, Delta Park Sports Complex, Portland Meadows racetrack, several hundred commercial and retail businesses, small industrial buildings, and nearly 900 residences with approximately 2500 residents. Residential areas make up approximately 35 percent of PEN 2. PEN 2 is bounded to the west by the I-5 embankment, to the east by the Peninsula Drainage Canal cross levee, to the north by the Bridgeton Road and N Marine Drive levee, and to the south by the Columbia Slough levee. The I-5 embankment is a shared boundary with PEN 1 to the west. The east side of the Peninsula Drainage Canal is referred to as the "PEN 2 Cross levee" or "Peninsula Canal Cross Levee"; it is a shared boundary with MCDD to the east. The PEN 2 levee system is 6.5 miles in length, including the inactive portion of the Peninsula Drainage Canal and the I-5 embankment.

1.5.3. MCDD Description

The MCDD levee system includes 14.7 miles of levee along the left banks of the Columbia River from RM 108.7 to RM 119.2, the Peninsula Drainage Canal, and the Columbia Slough, (Figure 1-4 and Figure 1-5). It contains no floodwalls or closure structures. In addition to the primary levee, the district contains two cross levees, at 142nd Avenue and 223rd Avenue. The 223rd Avenue cross levee separates the MCDD levee system from the SDIC levee system to the east. The 142nd Avenue cross levee divides the district into two smaller levee systems, which are commonly referred to as MCDD East and MCDD West. Both cross levees are redundant measures designed to limit damage in the event of a breach during a flood event.

At the western end, the MCDD levee system connects with Martin Luther King Jr. Boulevard at the Peninsula Drainage Canal crossing, which separates the PEN 2 and MCDD levee systems. The leveed area is 10.5 miles long, and averages one mile in width from north to south, though certain areas are significantly wider, particularly in MCDD West. It reduces the risk of flooding to approximately 8,590 acres of residential, industrial, commercial, agricultural, and open space land. The area includes over 1800 businesses and approximately 1,100 residential structures. Many of these properties are of vital importance to the region, including the Portland International Airport (PDX), Air and Army National Guard Facilities, the Columbia South Shore

Well Fields (backup drinking water), Columbia River Correctional Institution and the Inverness Jail.

1.5.4. SDIC Description

SDIC includes a levee system and one interior drainage pump station. It is located from (RM 119.2 to RM 121.5) and along the west shoreline of the lower Sandy River, near the confluence of the Sandy and Columbia Rivers (Figure 1-6). The levee reduces flood risk to approximately 1,556 acres of industrial, commercial, and undeveloped public and private properties within the Cities of Fairview and Troutdale, and unincorporated Multnomah County. The area also includes critical utility and transportation infrastructure including two Interstate Highways (I-205 and I-84), a Williams Company natural gas pipeline, substations for the Bonneville Power Administration, Portland General Electric and PacifiCorp, portions of NE Marine Drive, and the Port of Portland's Troutdale Regional Airport. The Port has also developed the Troutdale Reynolds Industrial Park in SDIC, which includes private industry and distribution centers, such as FedEx and Amazon.

The SDIC levee embankment is 3.28 miles in length. At the downstream end of the primary levee embankment, a secondary, cross levee segment of 0.91 miles divides the SDIC protected area from MCDD to the west.

Figure 1-2 Vicinity of Peninsula Drainage District #1 (PEN 1)

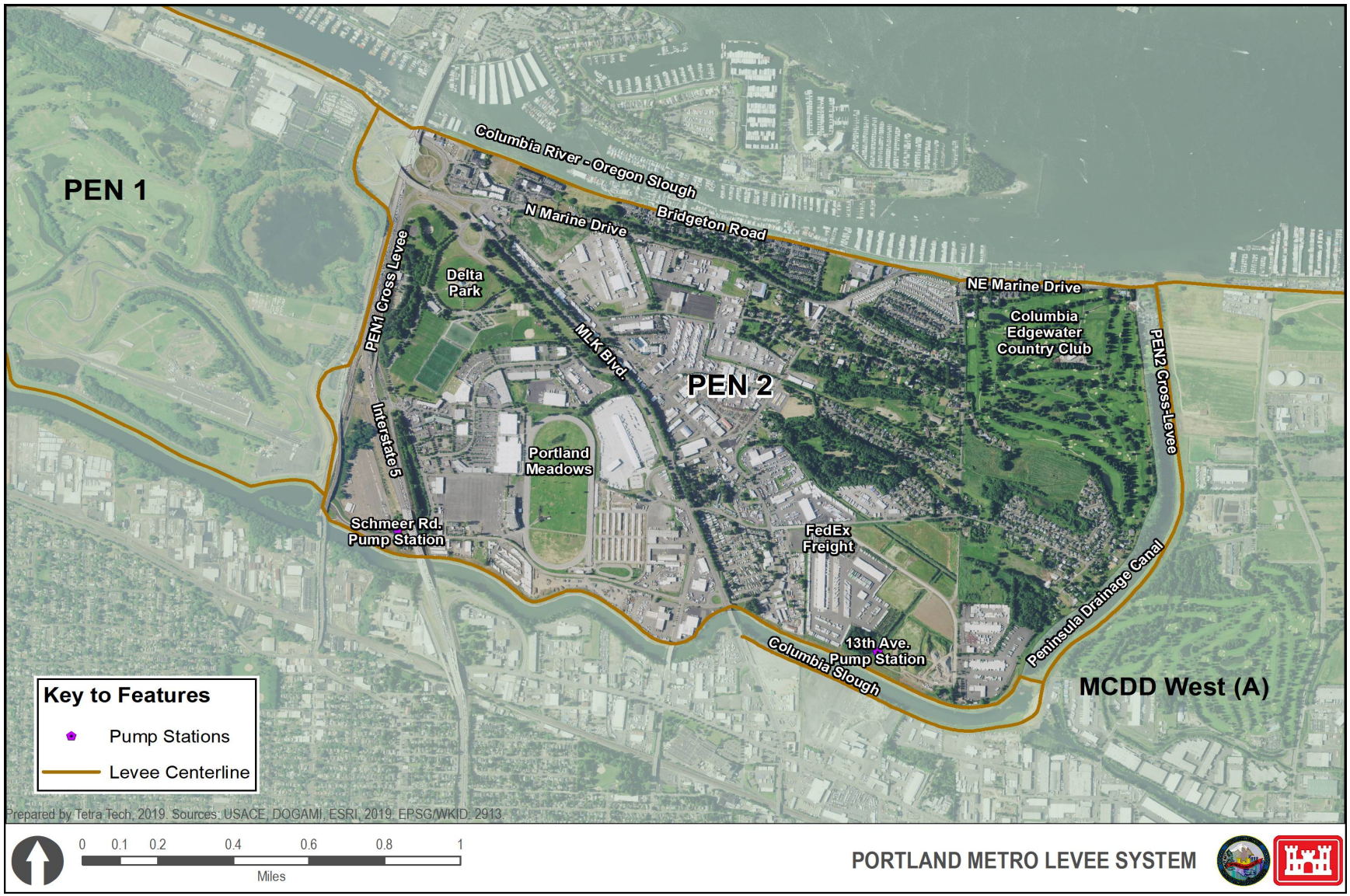

Figure 1-3 Vicinity of Peninsula Drainage District #2 (PEN 2)

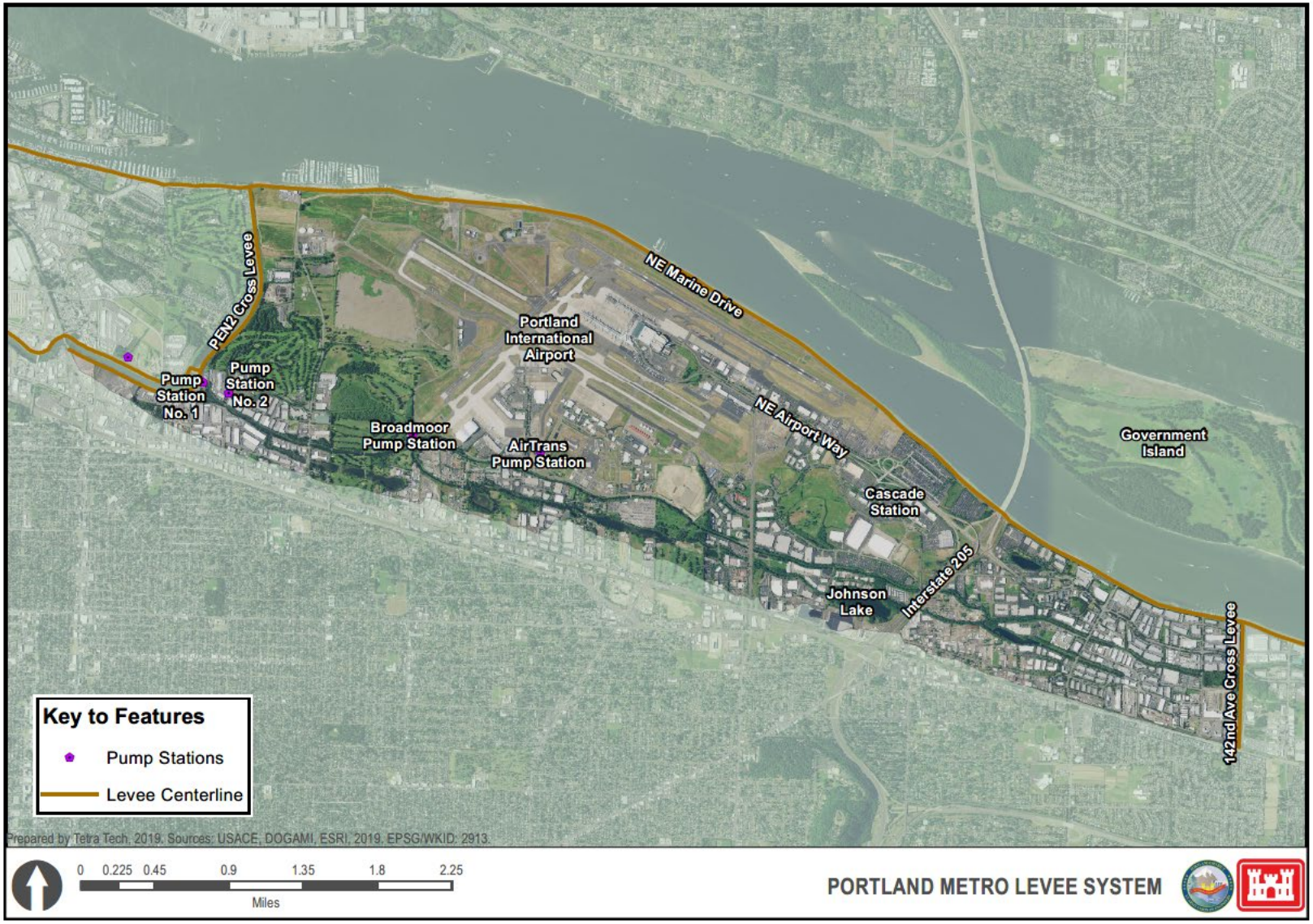

Figure 1-4 Vicinity of Multnomah County Drainage District #1 (MCDD) West

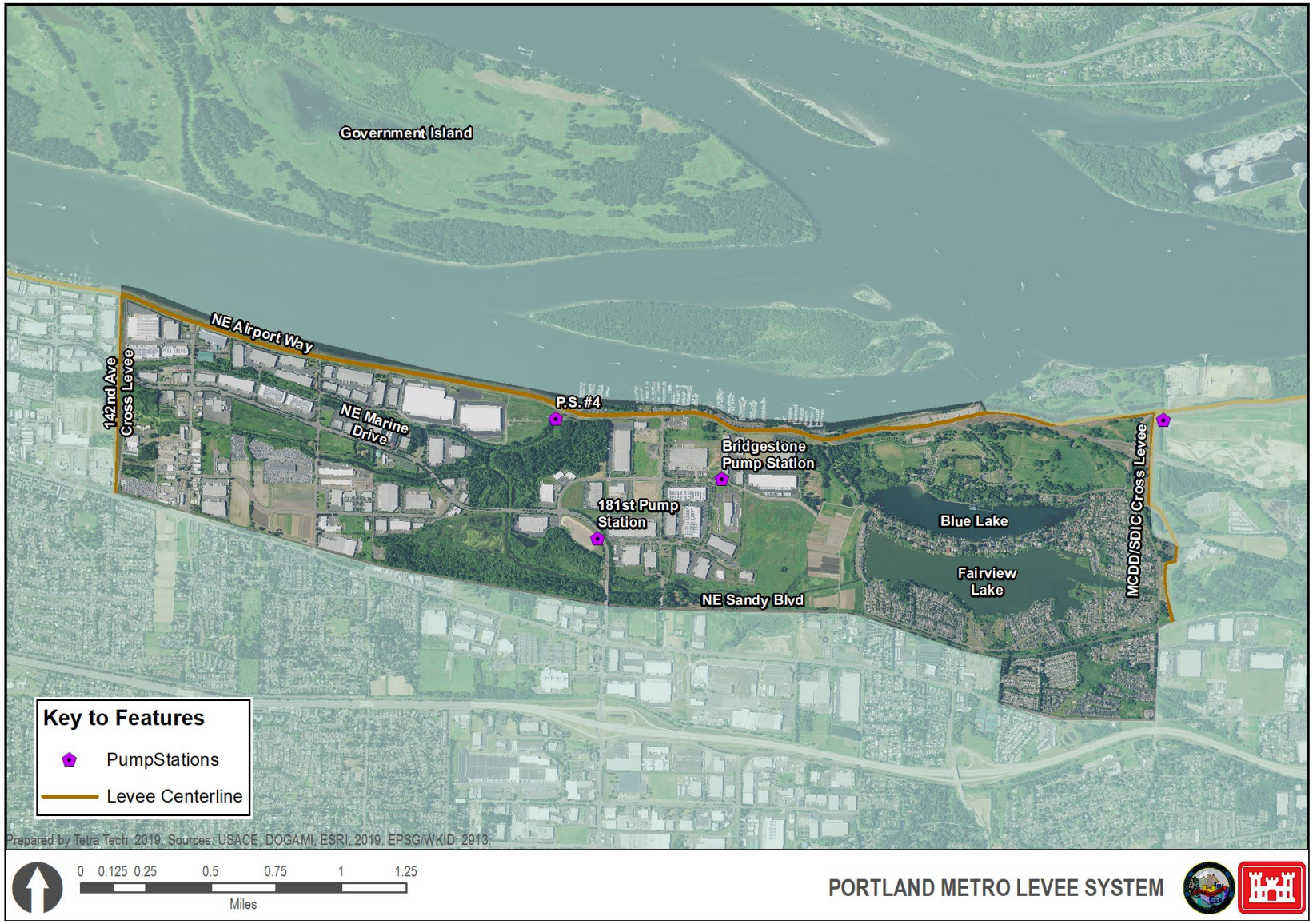

Figure 1-5 Vicinity of Multnomah County Drainage District #1 (MCDD) East

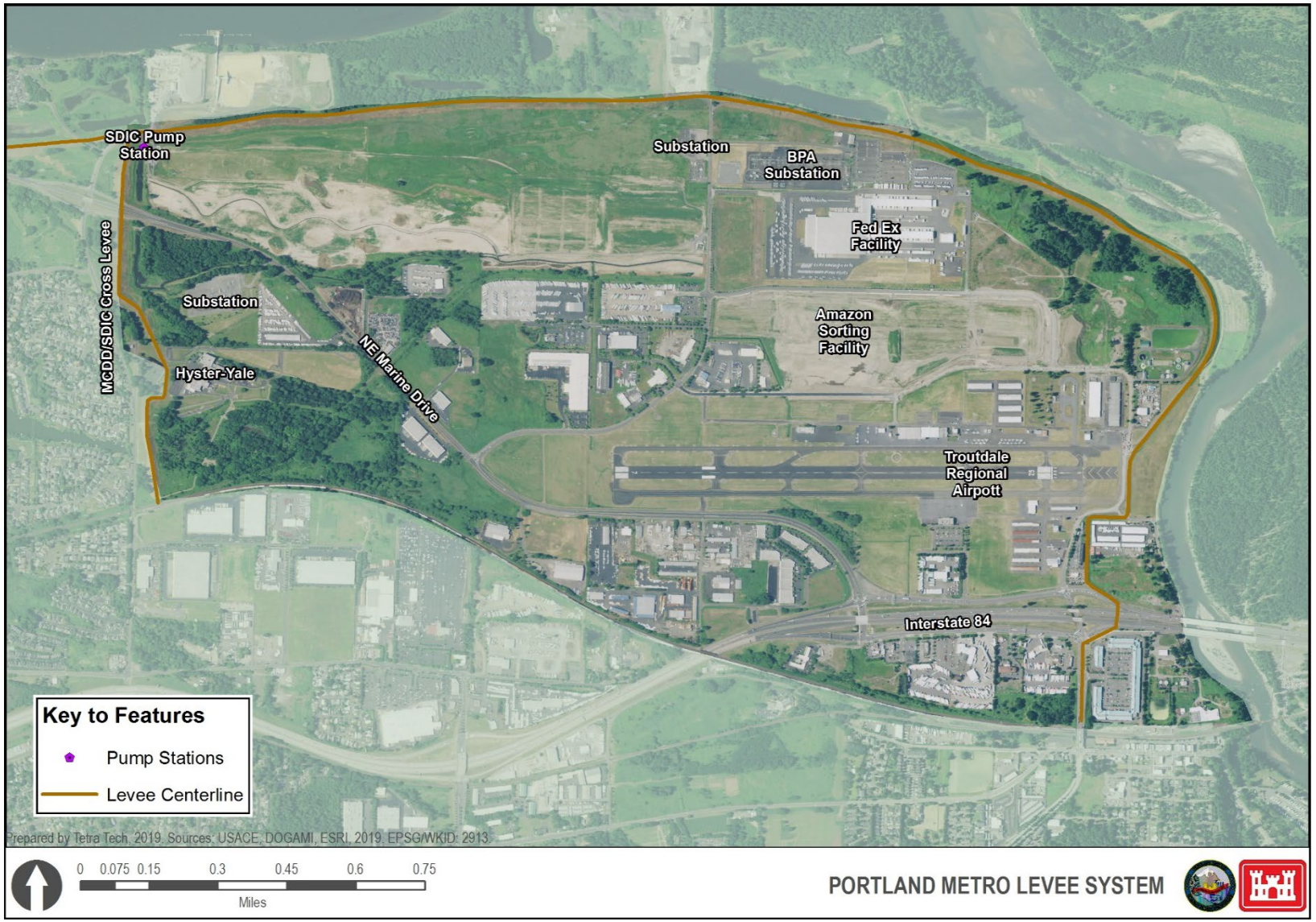

Figure 1-6 Vicinity of Sandy Drainage Improvement Company (SDIC)

1.6. Proposal for Federal Action

The primary purpose for the project is to improve levee performance, incorporate resilience, and provide improved flood risk management to the 27-mile levee system that has seen significant land-use changes since it was originally authorized, designed, and constructed.

The PMLS provides relatively better performance than most other levee systems in the Lower Columbia River. However, the impact of a levee failure at PMLS would have extreme consequences, as discussed in the previous descriptions of the leveed areas. The system has failed once before, in the 1948 flood event. The railroad embankment failure resulted in at least 15 deaths and left over 18,000 people without homes. The quality and construction of the current embankment is unknown as the railroads have declined to allow access to obtain data to fully analyze the embankment. While the railroad embankment is a well-known vulnerability, other areas of the system also contribute risk to the system. Potential vulnerabilities include seepage and/or stability issues at the PEN 1 Columbia Slough levee, the Peninsula Drainage Canal cross-levee, and the northwest portion of SDIC. PEN 2 is most susceptible to overtopping, which could allow floodwaters to spread throughout the system if cross-levees fail, as they did in the 1948 event. In light of the extreme consequences of flooding, the proposed Federal action will develop a plan to address potential system failures and provide improvements to flood risk management in the study area.

1.7. History of the Investigation

On June 11, 2015, Northwestern Division approved the Portland District's Section 216 Initial Appraisal Report for the PMLS.

This general investigation was approved as a new start study on July 5, 2018, under the Long-Term Disaster Recovery Investment Program (Public Law 115-123, the Bipartisan Budget Act of 2018). On October 3, 2018, the Feasibility Cost-Share Agreement was executed for the project. The signing of the Feasibility Cost-Share Agreement is the official start of the study. All project milestone dates have been scheduled based on this start date.

The feasibility study timeline is shown in Table 1-2.

Table 1-2 Feasibility Study Timeline

Study Milestone	Date
Feasibility Cost Sharing Agreement Signed	October 3, 2018
Alternatives Milestone	January 9, 2019
Tentatively Selected Plan Milestone	October 3, 2019
Draft Integrated Feasibility/EA Review Complete	January 6, 2020
Agency Decision Milestone	April 3, 2020
Chief's Report for Signature	October 3, 2021

1.8. Overview of Integrated Feasibility Report and Environmental Assessment

This report is an integrated feasibility report and environmental assessment (IFR/EA). As an IFR/EA, it documents a six-step planning process that identifies problems and opportunities, considers objectives and constraints, formulates and evaluates alternatives, and tentatively selects a plan for recommendation. Both the alternative formulation process and IFR/EA must meet the requirements of the National Environmental Policy Act (NEPA; 42 United States Code 4321 et seq.), the Council on Environmental Quality's Regulations for Implementing NEPA (40 Code of Federal Regulations (CFR) Parts 1500 to 1508), and the Corps' regulations for implementing NEPA (33 CFR part 230 and ER 200-2-2). Chapter and section headings in this report that are noted with an asterisk (*) are compliant with and required by NEPA.

Table 1-3 provides an overview of the organization of the main body of the IFR/EA.

Table 1-3 Feasibility Report Organization

Report Heading	Overview of Contents
Executive Summary*	Summarizes the IFR/EA. It stresses the major conclusions, areas of controversy (including issues raised by agencies and the public), and the issues to be resolved (including the choice among alternatives).
Chapter 1 Introduction	Provides background information concerning the project, project authorization, project status, and the scope of the study. The chapter also notes other previous related reports.
Chapter 2* Need for and Objectives of the Action	Provides background information concerning the purpose and need, identifies problems and opportunities, study objectives, and planning constraints.
Chapter 3* Plan Formulation	Describes the planning process with respect to the selection of alternative plans. In this chapter, the future without project condition (No Action) is described. Formulation, analysis, and comparison of alternatives are described. Descriptions of the alternatives under consideration are also provided.
Chapter 4* Affected Environment and Environmental Consequences	Provides a detailed presentation of the existing environmental conditions within the study area. This chapter also includes a discussion of the environmental resources that may be affected by implementation of project alternatives and describes the potential environmental consequences.
Chapter 5* Description of the Tentatively Selected Plan	Describes the recommended alternative.
Chapter 6* Compliance with Environmental Statutes	Addresses compliance with applicable environmental laws, regulations, and policies.
Chapter 7* Summary of Public Involvement, Review Process, and Consultation	Summarizes the coordination with agencies and the public that has taken place during the study.

Report Heading	Overview of Contents
Chapter 8 Recommendation	Provides the cost sharing for the recommended plan, the steps for the study prior to project authorization, and the Federal and non-Federal responsibilities for the project. This
Chapter 9* List of Preparers	Provides a listing of the preparers of this report.
Chapter 10* References	Lists the references cited throughout the report.

** Chapter and section headings in this report that are noted with an asterisk (*) are compliant with and required by NEPA.*

1.9. Intended Audiences and Uses

This document is intended to provide a review of alternative selection for updating the PMLS to withstand future potential flooding and retrofit the system as needed to improve flood risk management. The document is designed to address Federal regulatory requirements, part of which is to provide a thorough review of the alternative selection process and justification to the populations that would be most affected by the project. These populations primarily include those living and working within the boundaries of the project area. It may also serve an interest to those who pass through the area regularly for air, vehicle, vessel, or train travel, or those who engage with the many commercial businesses in the area. As a comprehensive review of environmental conditions pursuant to NEPA, this document will be used by the Corps, CCDD and the separate drainage districts to inform future decision-making. Organizations with special interest in the levees, such as Levee Ready Columbia, will use the information within this document to identify existing environmental and safety conditions, and to identify groups to engage. Additionally, it will provide a starting point for NEPA compliance among other Federal interests for future projects that may be undertaken within the CCDD.

2. Need for and Objectives of the Action

In accordance with Corps EC 11-2-216 (Section C-7, Paragraph (1)(c)), an initial Federal Interest Determination (FID) was developed for the purpose of identifying that proceeding with the PMLS Feasibility Study is in the interest of U.S. taxpayers at this stage of project development. The initial FID found there is Federal interest and likelihood that there is at least one alternative that will maximize National Economic Development (NED) benefits and likely has a cost-benefit greater than 1:1 (USACE, 2018).

On January 17, 2019 an Alternatives Milestone Meeting was held at which time the Federal interest in proceeding with the feasibility study was affirmed. The meeting reviewed projected scope, schedule and budget for the study as well as future without project assumptions, alternative formulation strategies and project risks.

2.1. Problems and Opportunities

Problems and opportunities were identified in the study area. Their identification was informed by the evaluation of concerns and desires perceived by stakeholders and the public. Problems and opportunities are defined in the planning process to form the foundation of the planning process, and reflect the priorities of the Federal government, non-Federal sponsors, and stakeholders. Once they are defined, they guide efforts to develop solutions (USACE, 2000).

2.1.1. Problems

Identified problems are as follows:

- The four districts operate as a system, but there are varying levels of flood risk from upstream to downstream along the main Columbia River levees (27 miles) and the three cross levees within the study area.
- The railroad embankment at the downstream limit of the study area in PEN 1 is not considered a levee but is incorporated (i.e. “tied in”) into the levee system. It does function in some capacity to withhold water, but operation and maintenance and access for inspections on this portion of embankment are prohibited by the railroad.
- There are multiple low spots, missing or incomplete sections of floodwall, and clearance issues within the existing system. Moreover, portions of some cross levees do not meet design standard geotechnical factors of safety.
- There is a population at risk estimated at over 30,000 including two correctional facilities and a tiny-house project for homeless assistance. There are several distribution centers and businesses that run 24-hour operations, including a postal facility and the Air National Guard base that houses the 142nd Fighter Wing and the Air Force’s 304th Reserve Rescue Squadron which serve the Pacific Northwest region and the nation.

- There are high consequences from flooding. Extensive critical infrastructure exists within the PMLS project area, including: backup drinking water supply that services a population of nearly 1 million, two airports (Portland International Airport and Troutdale Regional Airport), a major interstate natural gas pipe line, a jet fuel line, three Interstate Highways, railroads, main landing substations for Columbia River hydropower transmission lines for the Bonneville Power Association, Pacific Power, and Portland General Electric (PGE) in the metro area, and a commuter rail line. In addition, there are hundreds of residences, businesses and vehicles, the Expo Center, and Portland International Raceway.
- There is a lack of redundancy in many components of the system. The existing pump stations do not all have backup pumps or power supplies. Gravity outfalls can no longer be used as another way to drain water due to environmental concerns (i.e. fish passage or entrapment). A defunct "gate tower" valve between two cross levees allows free flow between the leveed areas, negating the performance of the redundant cross levee at this location.
- There are portions of the system that are outdated and/or do not meet current standards, such as over-steepened levee slopes, lack of automation, lack of clearance for flood-fighting, and access issues.
- The non-Federal sponsor does not own most of the property; it operates and maintains the levee districts utilizing easements. Easements for all levee segments are not clear at this time. There are also levee encroachment issues within the PMLS. The most significant of these in PEN2 have been addressed in an encroachment study (refer to Appendix C (Levees)) that was coordinated with the Portland District Levee Safety Officer and the Levee Ready Columbia Technical Advisory Subcommittee. Other districts are expected to follow similar processes.

2.1.2. Opportunities

While a problem can be thought of as an undesirable condition, opportunities are areas where there is a chance for improvement. Identified opportunities are as follows:

- Improve reliability and resiliency to reduce risk and uncertainty within the system under existing and potential future conditions.
- Reduce level of flood risk.
- Reduce economic losses due to flood damages within the existing system.
- Improve ability to operate and maintain the flood risk management system.
- Reduce risk of loss of life from flooding.
- Increase access and the ability to flood fight.
- Reduce disruption to employment centers from flood events.
- Reduce future operation and maintenance costs.
- Increase recreation opportunities and maintain existing natural and cultural resources.

- Increase public awareness of flood risk, including transient populations using alternative communication strategies.

2.2. Purpose and Need for Action*

The purpose of the Corps action is to reduce the risk of flood damage occurring in the existing PMLS area during flood events by improving system performance, resilience, and management in a manner that maximizes economic and life safety benefits while considering environmental consequences.

The need for action is to reduce the risk of failure, vulnerabilities, and/or potential for overtopping of the existing PMLS and potential economic and life safety losses during flood events. There have been significant changes in national flood risk management policy, critical infrastructure, and land use since the system was originally authorized, requiring examination and determination of additional Federal investment.

2.3. National Objective

The national or Federal objective of water and related land resources planning is to contribute to NED consistent with protecting the nation's environment pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED include increases in the net value of the national output of goods and services, expressed in monetary units. These contributions are the direct net benefits that accrue in the study area and the rest of the nation.

2.4. Planning Objectives

The primary planning objective of this feasibility study is to reduce flood risk in the PMLS in an acceptable manner that minimizes impacts on resources, is acceptable to the public and stakeholders, and is in the Federal interest as demonstrated using NED standards as specified in ER 1105-2-100. Specific planning objectives include:

- Reduce flood risk, in particular to critical infrastructure, within the PMLS over the planning period of analysis.
- Reduce threats to life safety from flooding and increase awareness of flood risk in the PMLS over the period of analysis.
- Increase resiliency of the flood risk management system over the planning period of analysis.
- Increase reliability of the flood risk management system over the planning period of analysis.
- Improve operability of the flood risk management system and decrease flood response and recovery time.

- To the extent practicable, provide opportunities for recreation, natural resources, and cultural resources.

Some of the terminology used in the planning objectives is further defined here. The first objective is to reduce flood risk, which is focused on both the probability and economic consequence of floods. Reducing threats to life safety includes reducing the probability of life loss or reducing the expected life loss in the event of a flood. Resilience is defined in Engineer Pamphlet 1100-1-2 as the ability to anticipate, prepare for, and adapt to changing conditions and withstand and recover from disruptions. Reliability is defined in Engineer Manual 1110-2-1619 as the likelihood of successful performance of a given project element over a specified time period. Operability is defined in Engineer Regulation 415-1-11 as the ability to efficiently operate and maintain facilities over their life cycle when the facilities are built according to the project's plans and specifications.

2.5. Planning Constraints

Unlike planning objectives, which represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints considered to this point are as follows:

- Cross levees must stay in place, as required by the Portland District Levee Safety Officer, in order to retain redundancy in the system and ensure no future development in the current locations of the cross levees.
- The railroad embankment will not be considered a levee for purposes of analysis. This segment of the system has been a long-standing vulnerability for the system and an area for past levee failures since it has unknown/untested structure materials compounded by railroad ownership and an associated policy that will not allow for routine operation and maintenance consistent with Corps policies. It is assumed to offer some resistance to floodwaters, but the embankment materials are estimated to be relatively weak since little information is available.
- Existing road infrastructure remains unchanged. There are two major Interstate highways, both having bridge abutments which cross the Columbia River. This study will assume those bridges and their alignment remain unchanged during the planning period of analysis.

2.6. Considerations

Although not constraints, the following considerations have been identified to inform the planning process:

- The four levee districts operate as one consolidated system.
- Flood risk assumptions for this study related to outcomes of other major Federal activities currently occurring within the Columbia River Basin. Ongoing basin-wide projects, such

as the Columbia River Treaty (CRT) (Department of State, 2019) and Columbia River System Operations (CRSO) Environmental Impact Statement (USACE, 2019), have the potential to modify upstream reservoir operations.

2.7. Public Scoping Comments and Resources of Concern*

The Corps held meetings prior to the preparation of the IFR/EA to gather public input related to the proposed action. The Corps held open houses for the project on two consecutive nights: Wednesday December 12, 2018, and Thursday, December 13, 2018. The December 12 meeting was held from 5:30 p.m. to 7:00 p.m. at the Rockwood Public Safety Building, located at 675 NE 181st Avenue in Gresham, Oregon. The December 13 meeting was held from 5:30 p.m. to 7:00 p.m. at the MCDD headquarters, located at 1880 NE Elrod Drive, Portland, OR 97211. Nine members of the public signed in at the December 12 meeting, and 19 members of the public signed in at the December 13 meeting. Nine members of the Corps' project delivery team (PDT) attended each of the public open houses.

The purposes of the meetings were to provide an overview of the proposed action and the preliminary alternative formulation process, and to allow members of the public, stakeholders, and agency representatives to provide input, feedback, and share information. The open house included information tables for attendees to visit and discuss aspects of the project with the Corps' project staff. Flyers with information about the feasibility study were available at these information tables. In addition, the Corps presented an overview of the feasibility study process, the study authority and sponsor, Federal interest in the project, and potential problems with the current levee system. The Corps also discussed project objectives and initial alternative strategies and explained how those, and future alternatives would be evaluated. The presentation concluded with a timeline for the study and public involvement and information on how interested parties could be involved in the study, either by providing input or sending questions to the Corps.

The Corps also held two agency kickoff meetings in December 2018. The first of these was held on December 10 from 2:00 p.m. to 4:00 p.m. at the Portland District office building in downtown Portland, Oregon (333 SW 1st Avenue). In an email sent on November 30, 2018, The Corps invited the Federal resource agencies and state agencies with a regulatory role to this meeting. The second agency kickoff meeting was held on December 12 from 8:00a.m. to 10:00 a.m., also at the District's office in Portland. For this meeting, the Corps invited MCDD; Metro; the Port of Portland; representatives of the cities of Portland, Fairview, Gresham, and Troutdale; and representatives of tribal governments. Invitees who were unable to attend in person were able to join the meeting remotely via webinar or by phone.

For each of these meetings, the agenda focused on three areas of discussion: the feasibility study process, the study area and preliminary alternative strategies, and the environmental and cultural resources compliance process. The Corps provided an overview of each topic. Each overview was followed by a question-and-answer session specific to that topic. At the end of the meetings, representatives of agencies in attendance were given the opportunity to provide feedback.

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3. Plan Formulation

Plan formulation has been conducted with a focus on achieving the Federal objective of water and related land resources project planning: to contribute to National Economic Development (NED) consistent with protecting the Nation's environment pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements.

Plan formulation also considers all effects, beneficial or adverse, on each of the four evaluation accounts identified in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G); U.S. Water Resources Council (1983): National Economic Development, Environmental Quality, Regional Economic Development, and Other Social Effects. Alternative formulation, including development and screening of measures, is summarized below.

3.1. Future Without-Project Condition Description (No Action Alternative)*

Under the No Action Alternative (the future without-project condition), no Corps action would be taken with respect to addressing flood risk management in the PMLS system. A few improvements to the levee system that are planned to occur before the base year of the analysis (2023) are included in the Future Without-Project condition. The northeast corner of PEN 2 will be raised by the Port of Portland in the next few years. The levee sponsor will replace some pumps and pump station components, as detailed in Appendix E (Pump Station Risk Assessment). With respect to the No Action Alternative, the following assumptions were made:

- The levee districts would continue to operate and maintain the PMLS at a level similar to current conditions to include scheduled repair, rehabilitation and replacement when necessary.
- The drainage districts do not have the authority to issue general obligation bonds to help finance major system upgrades. The new governance structure does have this authority, however, there is uncertainty regarding whether such a measure would pass. Because of this uncertainty, major system upgrades that would require a voter-approved bond measure are not assumed to occur.
- For the governance structure, the four drainage districts will join together to create one district with one board of directors. The preferred governance structure was designed by Levee Ready Columbia and has been created by the Oregon State Legislature in June 2019. The work of establishing the district is currently being addressed as part of the Levee Ready Columbia process and it is anticipated that the new district will be up and running by 2025.
- The outcomes of the Columbia River Treaty and Columbia System Operations Projects would support a future condition in which the flood risks from the Columbia River would not increase for the PMLS.

- Planned flood emergency operations activities such as sandbagging in low spots, operating closure structures, and emergency response operations would continue to occur.
- Pump stations would not be operated to bail water out of the system if a levee breach or overtopping were to occur; this is because pump stations cannot reliably be operated remotely during an active flood, and safety concerns for on-site personnel override the objective of removing water from the system during an event. Similarly, emergency maintenance to repair levee breaches or to bring in temporary pumps during a flood event would not occur due to the potential threat to life if crews were dispatched to active flood areas. It is assumed that water will be drained from the system after the flood event using temporary pumps.
- Consistent with existing policies, a qualitative assessment will be conducted for addressing climate change, and alternatives will be formulated to be resilient to future climate scenarios; however, future climate scenarios will not be used to determine project benefits.
- Only development with a reasonable assurance of construction will be included in the economic structure inventory. New development will be sourced from construction that is already planned to occur as identified in municipal master plans. Zoning and building code requirements will persist, allowing structures to be built in the leveed area without requiring elevation to the 1 percent annual exceedance probability (AEP) event.
- The population at risk will continue to grow at rates based on projected development from master plans.
- The Sponsor will continue to exercise easements and will not extinguish them to private or public interests. The railroad will continue denying access to the railroad embankment in PEN 1. Periodic levee inspections will continue but inspectors will not have permissions to assess the railroad embankments.
- Current Corps design standards will be assumed to be applicable over the 50-year period of planning analysis.
- Wetlands are assumed to persist throughout the period of analysis. There are jurisdictional wetland areas in the levee system, including the Vanport wetlands and sites in SDIC.

Future Without-Project Conditions are assessed to determine the potential impacts of not implementing the Proposed Action. In this case, Future Without-Project Conditions would be based on no changes to the current level of flood risk management. This does not mean that flood-risk management would not occur under the Future Without-Project Conditions; rather, it means that the present course of action would continue until that action is changed. Therefore, the estimated Future Without-Project Conditions serve as a baseline against which the potential impacts of the action alternatives can be compared. The benefits are assumed to begin accruing in the year 2025, so the 50-year period of analysis ends in 2075.

3.2. Future Without-Project Flood Risk

Flood risk is a combination of flood probability, system performance and consequence (see Figure 3-1).

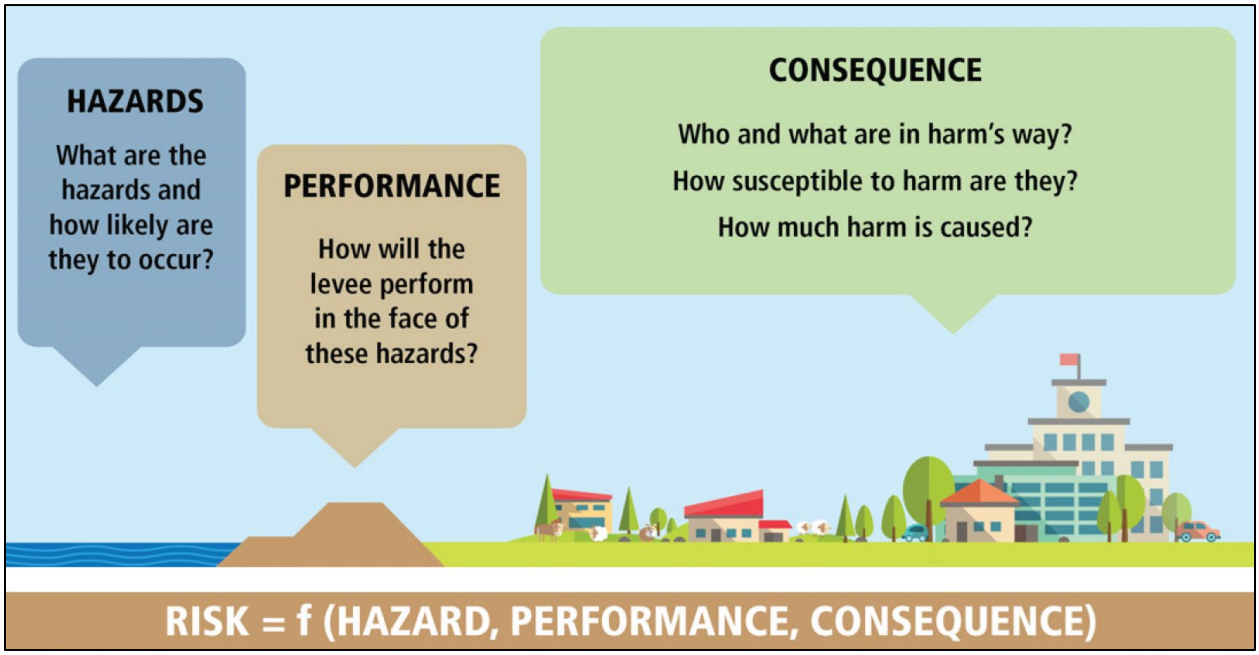

Figure 3-1 Depiction of Flood Risk within the Portland Metro Levee System

Flooding in the PMLS can occur from two basic mechanisms: high water from adjacent water bodies generating a levee failure (termed "riverine"), or ponding generated from inability to pump stormwater out of the system (termed "interior drainage"). For riverine flooding, there are three potential sources of floodwaters that can put pressure on the levee system: the Columbia River, the Columbia Slough, and the Sandy River. The Columbia River is a source of loading for all districts. The Columbia Slough is a source of loading for PEN 1, PEN 2, and MCDD. Columbia Slough connects to the Willamette River near the confluence of the Columbia and Willamette. It backwaters during flood events when the Columbia and Willamette are high. The third riverine source of flooding is the Sandy River, which loads the upstream end of SDIC. Cross levees divide the system on the inside of the levees, and are not regularly exposed to water. The cross levees between the systems provide redundancy—if one of the levee segments were to breach, the cross levees are intended to reduce the risk of floodwaters from entering adjacent districts. The cross-levees do not always perform as intended due to issues with seepage and stability, as well as low spots. Figure 3-2 depicts the study area and sources of flooding.

Appendix A (Hydrology and Hydraulics) documents the modeling and analysis of these flooding mechanisms upon the study area. Appendix C (Levees) includes assessment of the existing levee embankments, floodwalls, and closure structures. Summary of and documentation of the future without-project flood risks are included here, with detailed information found in Appendix A (Hydrology and Hydraulics).

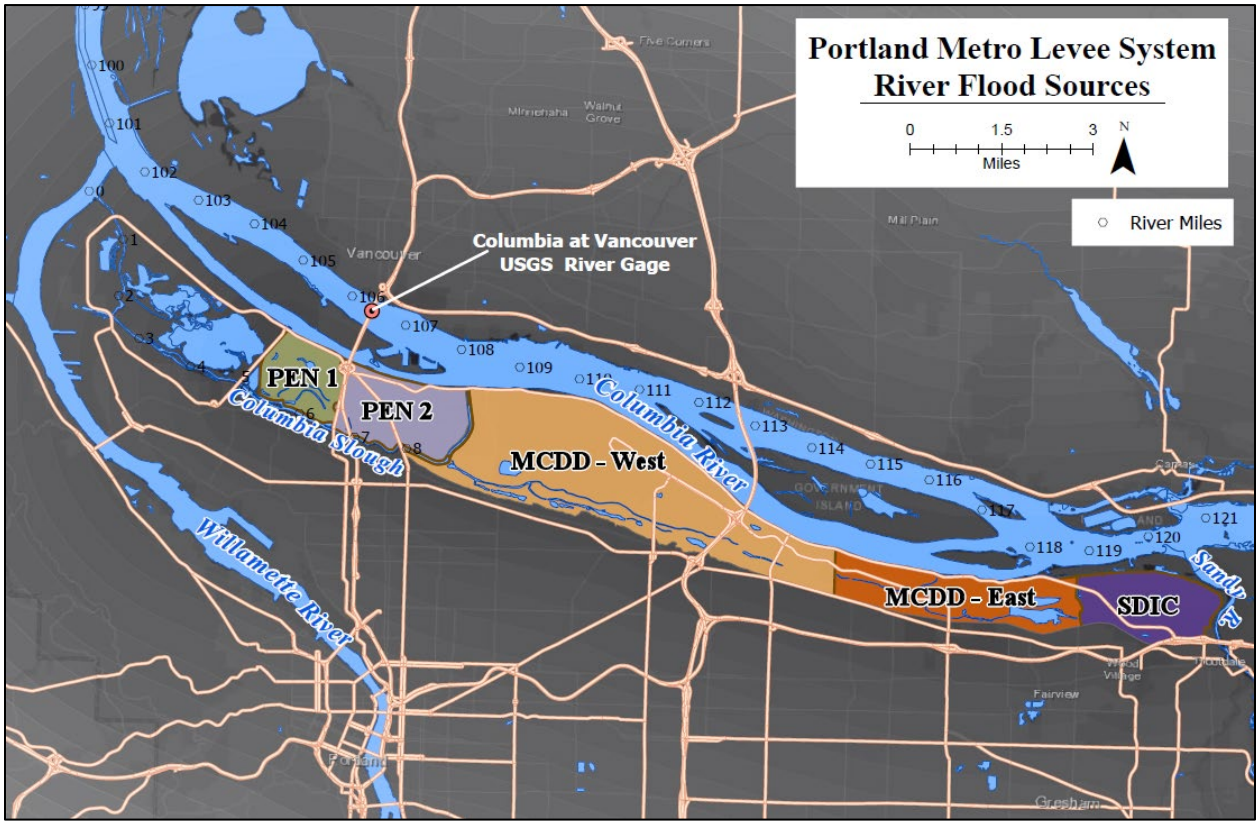

Figure 3-2 Overview of Flooding Sources

3.2.1. Seasonality

There are two distinct seasons of flooding in the PMLS system: winter and spring. Winter floods (typically rain on snow hydrologic events) are shorter-duration events (~3 days) caused by extreme precipitation. An example winter flood is the February 1996 event. Spring flood events are primarily caused by rapid melting of high-elevation snowpack, and generally have much longer durations of high water. An example of a spring flood is the June 1948 event. The system of reservoirs in the Columbia basin is more effective at managing spring floods than winter floods. Winter floods generate higher peak stages than spring floods, but the duration of high water is shorter.

3.2.2. Flooding History

With its location along the Columbia River floodplain and upstream of the confluence with the Willamette River, the study area has a history of flooding. This includes the catastrophic 1948 flood, in which several levee breaches occurred on Memorial Day, known as the Vanport Flood.

In 1942, a significant housing project was constructed on low-lying federally owned land along the Columbia River just outside of the city limits of Portland. This housing project was the brainchild of Henry J. Kaiser, owner of three large shipyards in the area that supplied ships to the

war effort. As World War II escalated, defense employment in the Portland metro area grew quickly. To find enough workers to keep up with demand, Kaiser promoted positions in his shipyards throughout the country, attracting many people to the region, including many people of color. To address the need for additional worker housing, Kaiser asked the City of Portland to help develop worker housing. As many of the incoming workers were African Americans, Portland officials in the Housing Authority of Portland (HAP) were slow to respond due to deep-seated systemic racism (Oregon Historical Society 2003). Kaiser needed housing for his workers and could not wait so he worked with the US Maritime Commission to secure funding to advance a large housing project on 650 acres of Columbia River floodplain (Oregon Historical Society 2019), which was surrounded by recently constructed levees. This land was in PEN 1 and PEN 2.

Although the housing units were built quickly, Vanport was a bustling community that had been developed to meet the needs of its residents with several schools, nurseries that provided 24-hour childcare, a hospital, shopping and recreation centers, and a large movie theater. While de facto racial segregation took place in Vanport, several vital services such as the schools and community center were integrated (Oregon Historical Society 2019). By the end of 1944, Vanport's population had reached approximately 42,000 residents, making it the second largest city in Oregon and the largest wartime housing project in the nation. Vanport was managed by the HAP. During this time, an adjacent property, the stockyards and exposition hall in PEN 1 were used as a transfer station during the World War II Japanese internment, adding to the turbulent and important history of the area.

The population of Vanport began to decline toward the end of the war and dropped significantly after the war as some families returned home and others moved into the city of Portland. The city became home to GIs returning from the war, and the Oregon University System opened the Vanport Extension School to help the GIs' education and job training (Portland State University 2019). As the population decreased, Vanport remained a vital place, especially for the African American families with limited options for moving due to racist housing policies in and around Portland, and for the African American families living in Vanport, these policies made it nearly impossible to secure housing in Portland (City of Portland 2019h).

After the war, the fate of the city of Vanport was uncertain, as civic leaders in Portland talked about tearing the community down to make way for industrial development and concerns were raised about the quickly constructed community becoming blighted as the population declined from its wartime high (Portland State University 2017).

Sadly, the question of the future of the city of Vanport was never answered. On May 30, 1948, the railroad embankment at the western end of the city, which served as a part of the flood protection system in the area, breached. Fortunately, students of the Vanport Extension Center saw the breach occur and ran into town to let people know that floodwaters were coming (Geiling 2015). As the floodwaters filled the sloughs and lowest areas, the community had about 35 minutes to evacuate the city. In less than two hours, the entirety of Vanport was inundated. At

least 15 people died, and another 18,500 residents were left without homes. This flood inundated all of the area that is now PEN 1 and PEN 2 for months.

The Vanport Flood of 1948 has left an indelible mark on Portland—especially the African American community. The day of the flood the HAP issued a notice to residents that read: "Remember. Dikes are safe present. You will be warned if necessary. You will have time to leave. Don't get excited." (Oregon Public Broadcasting 2016). In less than a day, Oregon's second largest city was wiped away. The initial breach flooded PEN 1, a subsequent breach of the Denver Avenue cross-levee led to the flooding of PEN 2. The force of the water in the Columbia Slough led to the breaching of the levee in MCDD which led to the flooding of the Portland Super Airport, today's Portland International Airport.

After the flood, the diaspora of Vanport residents was drawn largely on race lines. While displaced white residents distributed throughout Portland and beyond, the African American residents faced the choice of either moving to Portland's constrained and overpopulated Albina neighborhood—the only neighborhood Portland's discriminatory housing policies allowed African Americans to live, or the option to leave the region (City of Portland 2019h). It took some families years to find stable housing.

The Columbia River floods of 1948 and the destruction of Vanport were driving factors in the negotiation of the Columbia River Treaty between the United States and Canada. Signed in 1964, the treaty had two primary purposes: 1) to create hydroelectricity for the US and Canada, and 2) to provide flood safety benefits in the lower Columbia River basin.

The Vanport story remains vital to this day. It helps explain the African American experience in Oregon. It is a story of diaspora, that the community continues to feel as the lack of investment in the Albina community made it ripe for gentrification and continued displacement. The communication and lack of support experienced by the African American community in the lead up and aftermath of the flood has perpetuated conspiracy theories and rumors, echoes of which can be heard during the Hurricane Katrina levee failures and flood. The Portland community is still healing, and trust is still being rebuilt.

The Vanport Flood continues to be a dynamic component of today's Portland. The Vanport Mosaic non-profit organizes an annual festival to both celebrate and memorialize the stories of the survivors of the 1948 flood. These stories of flood survivors and their families are being cataloged so future generations can learn from their experiences. Historical markers for the Vanport community and flood are located within the district as well, with additional place marking efforts underway. For the local levee system managers, the lessons learned from the levee failures and failures of communication guide their work. Indeed, it is the clear pictures of Vanport's aftermath that have drawn and rallied community support for levee modernization efforts.

The water surface profiles of the Columbia River that load the PMLS are relatively flat, with only a few feet of difference from the downstream end at PEN1 to the upstream end at SDIC.

Because the interior topography is also fairly flat from upstream to downstream, the 1948 flood that inundated PEN1 also spread to the upstream portions of PMLS.

Historic records from the Vancouver gage (USGS gage 14144700) indicate that five floods since the 1894 flood of record have exceeded the current-day 1 percent AEP (100-year) flood elevation of 31.4 feet (see Appendix A (Hydrology and Hydraulics)). The current day 1% AEP flood elevation includes the beneficial flood risk management contributions from upstream reservoirs. Large flood events at PMLS were more common before upstream reservoirs were completed. The system of reservoirs upstream of the project area was completed in 1974 with the construction of Mica Dam in Canada. The river heights during flood events before 1974 would be significantly reduced if the current system of reservoirs was available to manage flows. Table 3-1 displays the peak water levels from these flood events.

Table 3-1 Historic Flooding in the Study Area Observed Elevations (USGS Gage 14144700)

Year	Observed Water Surface Elevation (feet, NAVD88)
June 1894	39.7
June 1948	36.3
June 1956	32.9
December 1964	33.0
February 1996	32.5

The PMLS experienced three large floods after 1948 without breaching (1956, 1964, and 1996). A landside slope failure initiated on the Columbia Slough levee segment during the 1996 flood but did not progress to breach.

3.2.3. Levee Analysis

Appendix C (Levees) includes a levee analysis that evaluated potential failure modes, performed seepage analysis, and developed fragility curves for the levee sections. Fragility curves provide the probability of levee failure before a flood overtops it for a range of water level loadings. The potential failure modes driving risk in the system are levee seepage and piping, levee landside slope instability, levee overtopping, and pump failures.

The following four sections were identified as potentially problematic and recommendations were developed for each.

Railroad Embankment: This embankment at the west end of PEN 1 is a known weak segment. Sand berms (also known as seepage berms) that were placed against the landside slope of the embankment provide a stable condition for flood levels up to their top elevations. If flood elevations are above the top of the berms, the probability of breach increases significantly. The railroad embankment above the seepage berm is assumed to provide some resistance to floodwaters, but the embankment materials are estimated to be relatively weak since little information is available.

PEN 1 Columbia Slough Levee: The section of levee evaluated shows potential problems with both piping and sliding. It is recommended that improvements be considered for the entire levee segment.

Peninsula Canal Levee: The levee between PEN 2 and MCDD West is susceptible to slope failure when loaded on either side. Risk of landside slope failure is significant for the 1 percent AEP flood elevation.

SDIC Columbia River Levee: A part of the levee segment on the west end is founded on a relatively soft clayey silt to silty clay. This foundation condition may cause slope instability issues when the river is at or near the top of the levee.

3.2.3.1. Levee Breach Characteristics

Since the levees are primarily sand/silt material, they are expected to progress from initiation to full breach relatively quickly, typically in the span of a few hours. The breach observed in 1948 was extremely rapid, widening to nearly 600 feet in a few minutes (USACE 1949). Overtopping of a levee is assumed to lead to breach, since the levees are not designed for managed overtopping and the levee embankments are not competent to withstand overtopping flows.

In the event of a levee failure, interior areas rapidly fill with water and equilibrate with the water levels of the river. In all of the levee systems (except MCDD West and SDIC), the interior water level equilibrates with the exterior within one day for events where the river water levels are more than 10 feet above the landward levee toe. MCDD West and SDIC are the only exceptions to this. The MCDD West area is relatively large, the bottom elevation of a breach is relatively high. These factors suggest a slower infill due to more storage capacity in the leveed area, less head during overtopping and time for overtopping to occur, and a lower overall breach flow capacity. The 1948 post-flood report (USACE 1949) offers supporting confirmation, noting that floodwaters from the levee breach at the southwest end of MCDD took 28.5 hours to reach the eastern end of the district. The other exception is SDIC: if overtopping occurs at the upstream end of SDIC where there is no well-defined levee prism but rather long stretches of high ground, the SDIC area is expected to fill more slowly.

When a levee breach occurs, nearly the entire interior area experiences some degree of flooding. There is not much high ground within the leveed areas, resulting in almost complete inundation. Depths are highest in PEN 1 and PEN 2, and lowest in SDIC. SDIC is the only district that shows some areas without inundation on the high ground of the eastern and southern portions of the district. Maps of modeled inundation extents and the time it takes for floodwaters to spread throughout an area can be found in Appendix A (Hydraulics and Hydrology). An example for the PEN2 system is given in Figure 3-3.

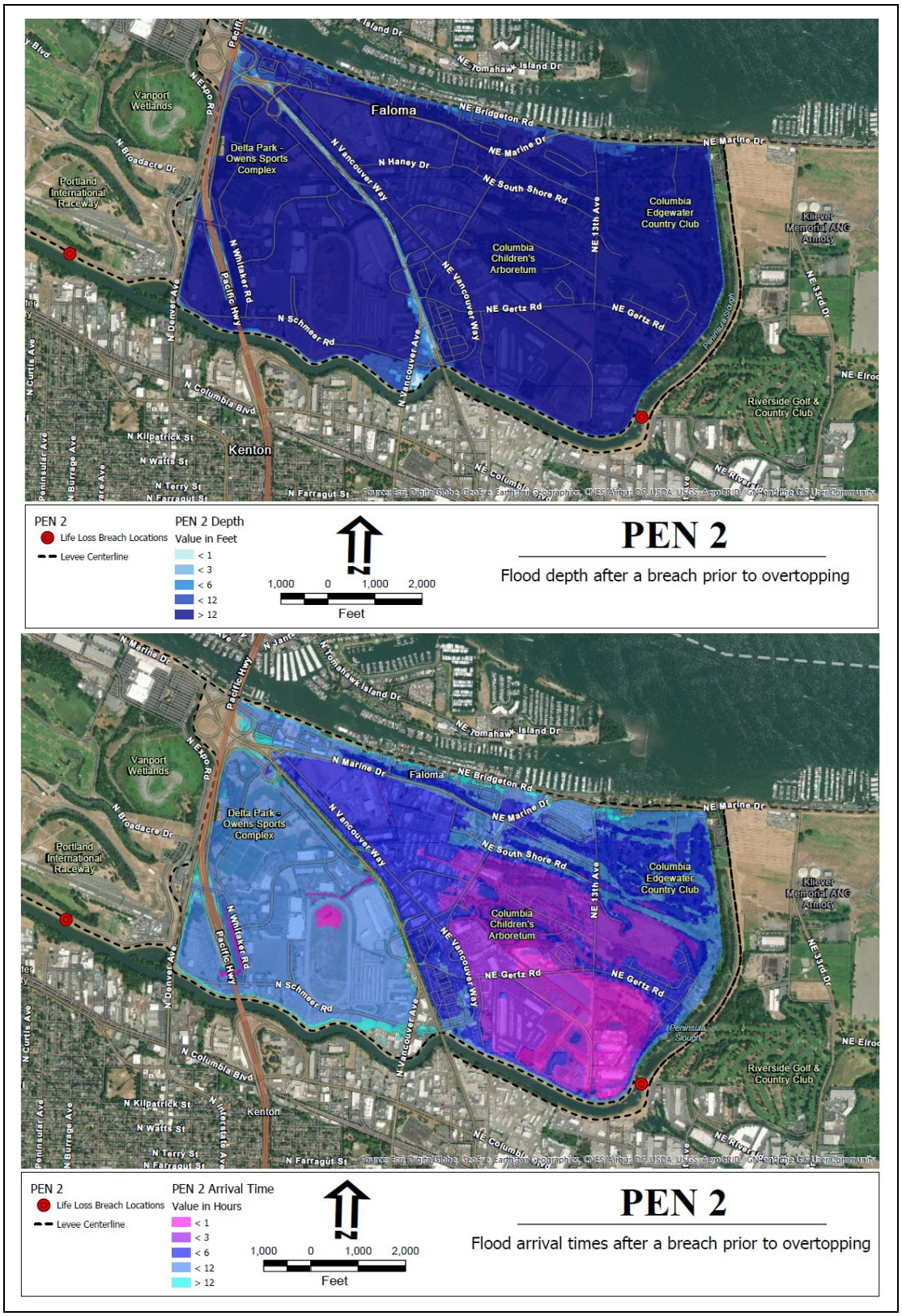

Figure 3-3 PEN 2 Example Flood Depth and Arrival Time Grids for Breach prior to Overtopping

3.2.4. Project Performance

Annual Exceedance Probability (AEP) is a measure of the chance of having a damaging flood (levee failure) in any given year. These estimates are calculated using a Monte Carlo modeling approach detailed in Appendix A (Hydraulics and Hydrology). The modeling combines the chance of a flood overtopping the levee with the chance of failure of the levee prior to being overtopped by a flood via fragility curves across a wide range of high water conditions. Fragility curves provide the probability of levee failure before a flood overtops it for a range of water level loadings. Cascading flood scenarios where one area fails, spurring failure of a cross-levee, are also included in these estimates. Table 3-2 provides modeled AEP results for the Future Without-Project condition. To provide context, the probability of other non-flood hazards are provided in the table, including the annual chance of a home experiencing fire damage and the chance of a Cascadia Subduction Zone earthquake occurring. A damaging flood to the levee system is more likely than these two reference events. MCDD East has the lowest probability of failure, while PEN 1 has the highest. The total system result is not the sum or average of each leveed area, since most of the flood events cause failures at multiple leveed areas. The total system result is only slightly higher than the PEN 1 result, indicating that nearly always when there is a failure somewhere in the system, there is a failure at PEN 1. The exceptions are a few events with overtopping at PEN 2 that do not trigger a fragility failure at PEN 1, nor rise high enough to overtop PEN 1. When one part of the system fails, the rest of the system experiences additional loading on the cross-levees, which do not always perform as intended. The failure of one area can affect the whole system when cross-levees fail.

Table 3-2 Future Without-Project AEP Results

Leveed Area	Annual Probability of Failure	Return Interval (years)
PEN 1	1.01%	100
PEN 2	0.36%	300
MCDD West	0.20%	500
MCDD East	0.04%	2400
SDIC	0.10%	1000
Total System	1.03%	100
Comparable Probability		
Fire Damage to a home[1]	0.3%	300
Cascade Subduction Zone Earthquake (magnitude 7.1+)[2]	1%	100

[1]Average 2002-2010 based on home structure fires from National Fire Protection Association and U.S. Census housing unit data (ER 1105-2-101)

[2]About a 37% chance that an earthquake of 7.1+ magnitude will occur in the Cascadia Subduction Zone in the next 50 years (OEM 2019)—converted to annual probability via a binomial distribution for illustration.

The second project performance metric is the long-term risk, which provides the probability of having one or more damaging floods over a period of time. Table 3-3 provides the long-term risk

results. While the probability of levee failure in any given year may appear small, the chances of experiencing a levee failure over a longer time horizon are more appreciable.

Table 3-3 Future Without-Project Long-Term Risk Results

Leveed Area	Long-Term Risk		
	10 years	**30 years**	**50 years**
PEN 1	9.7%	26.3%	39.8%
PEN 2	3.5%	10.2%	16.5%
MCDD West	2.0%	5.9%	9.6%
MCDD East	0.4%	1.2%	2.0%
SDIC	1.0%	3.0%	4.9%
Total System	**9.8%**	**26.6%**	**40.3%**

The third project performance metric is the assurance of levee performance. The assurance metric (also known as conditional non-exceedance probability) provides the likelihood that a levee will perform adequately during an event of some specified magnitude. The AEP metric provides the most likely estimate of levee performance, while the assurance metric provides information on the uncertainty of performance. Assurance results are given in Figure 3-4 and Table 3-4. In general, MCDD East has the highest levels of assurance, while PEN 1 has the lowest.

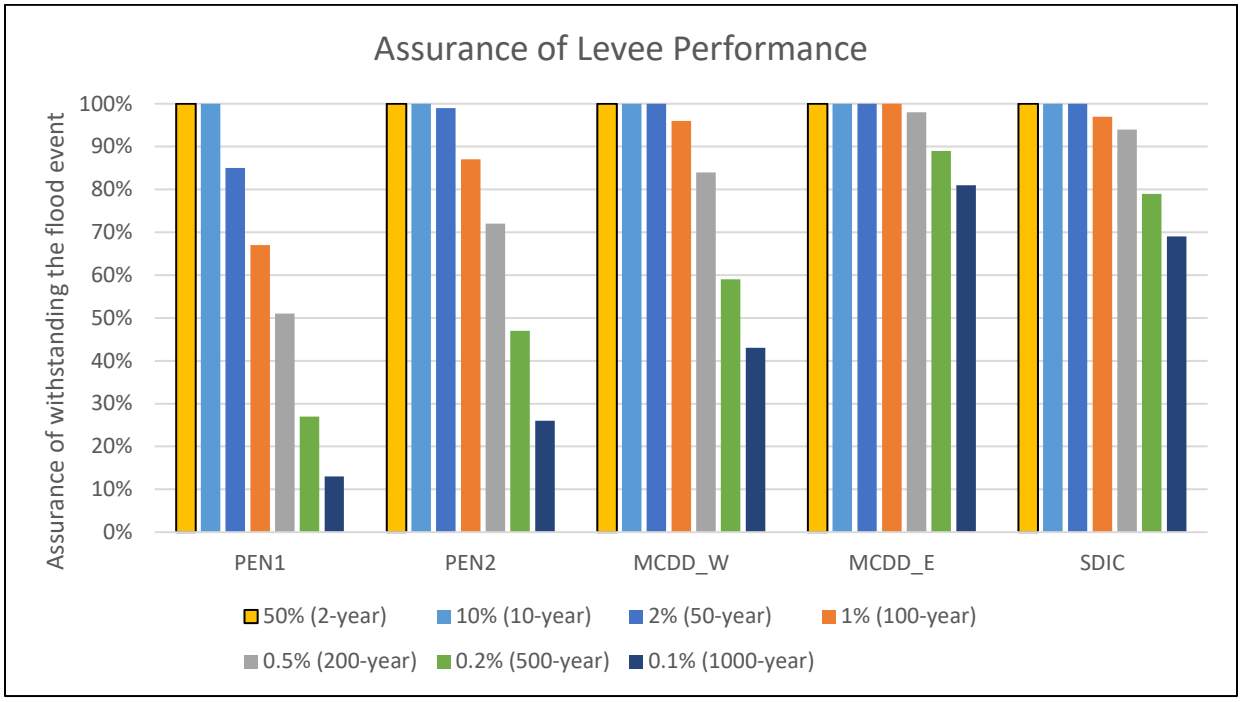

Figure 3-4 Future Without-Project Assurance Results

Table 3-4 Future Without-Project Assurance Results for Levee Performance

AEP	PEN 1	PEN 2	MCDD West	MCDD East	SDIC
50% (2-year)	100%	100%	100%	100%	100%
10% (10-year)	100%	100%	100%	100%	100%
2% (50-year)	85%	99%	100%	100%	100%
1% (100-year)	67%	87%	96%	100%	97%
0.5% (200-year)	51%	72%	84%	98%	94%
0.2% (500-year)	27%	47%	59%	89%	79%
0.1% (1000-year)	13%	26%	43%	81%	69%

3.2.4.1. Detailed Failure Results

The Monte Carlo simulation approach, detailed in Appendix A (Hydraulics and Hydrology), generates additional information about failure mechanisms aside from the standard project performance metrics. Whether the levee failures occur in winter or spring provides context to the results and is shown in Figure 3-5. As expected, the winter season poses the dominant risk to the PMLS system. Failures during the spring are still possible but are a much lower contributor to flood risk. This figure provides the number of failures in relative terms. In other words, results are shown only for those events that experienced a failure. The “Total” bar is not necessarily the sum of the winter and spring events, since a given year could experience a failure during the winter and the spring. For example, the SDIC “Total” bar is only around 10%, which means that for those events where there was a failure somewhere in PMLS, 10 percent of these events had a failure at SDIC.

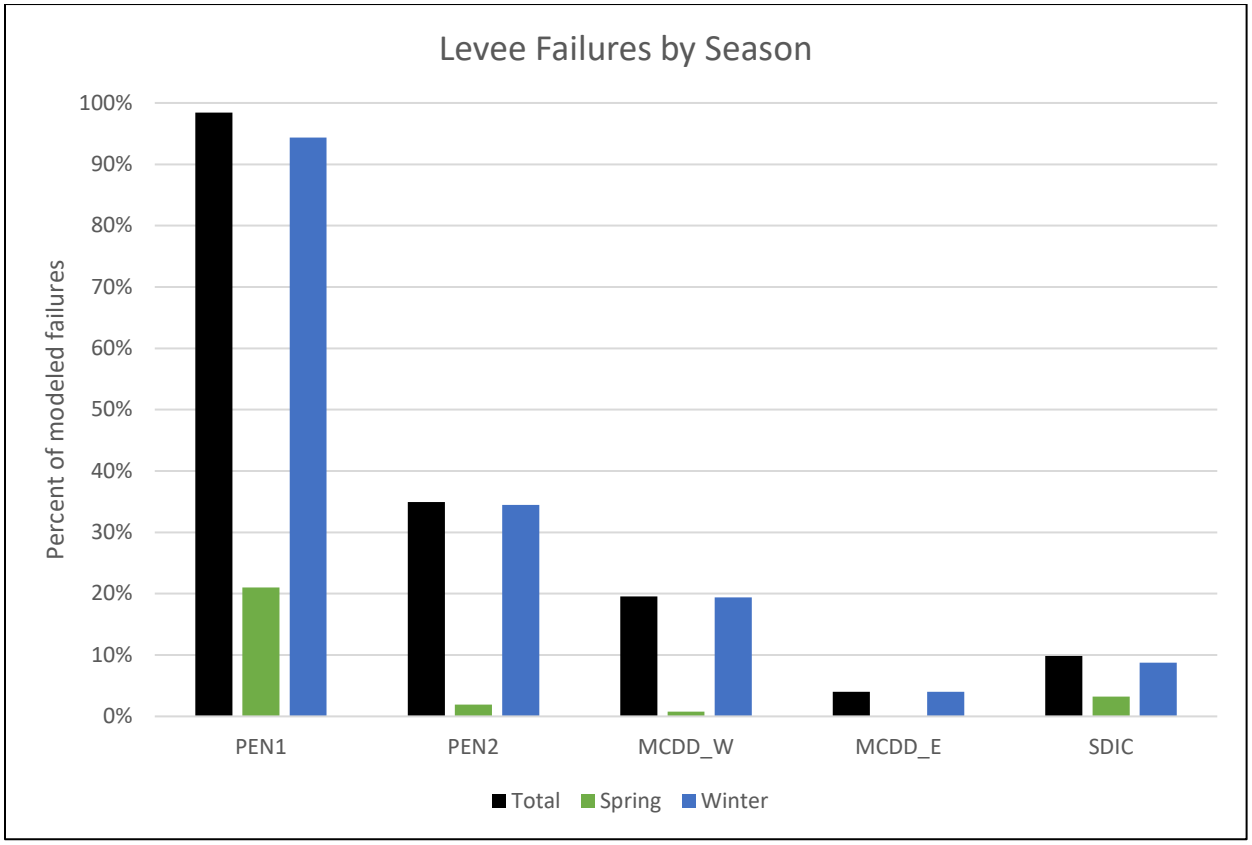

Figure 3-5 Future Without-Project Levee Failures by Season

Another way to look at the results is to see the contribution to failure by flooding mode. Figure 3-6 shows the relative failures broken down by whether the failure was overtopping or a fragility (including closure structures) failure. The results show that PEN 1 is most vulnerable to fragility failures at either the railroad embankment or Columbia Slough segment, while PEN 2 is more susceptible to overtopping. The dominant flooding path for MCDD West is a cascading failure, where PEN 2 overtops, and then the Peninsula Canal cross levee experiences a fragility failure. The cross levees with MCDD West and SDIC are the primary vulnerability to MCDD East. The dominant flooding path for SDIC is a fragility failure on the Columbia River near the pump station.

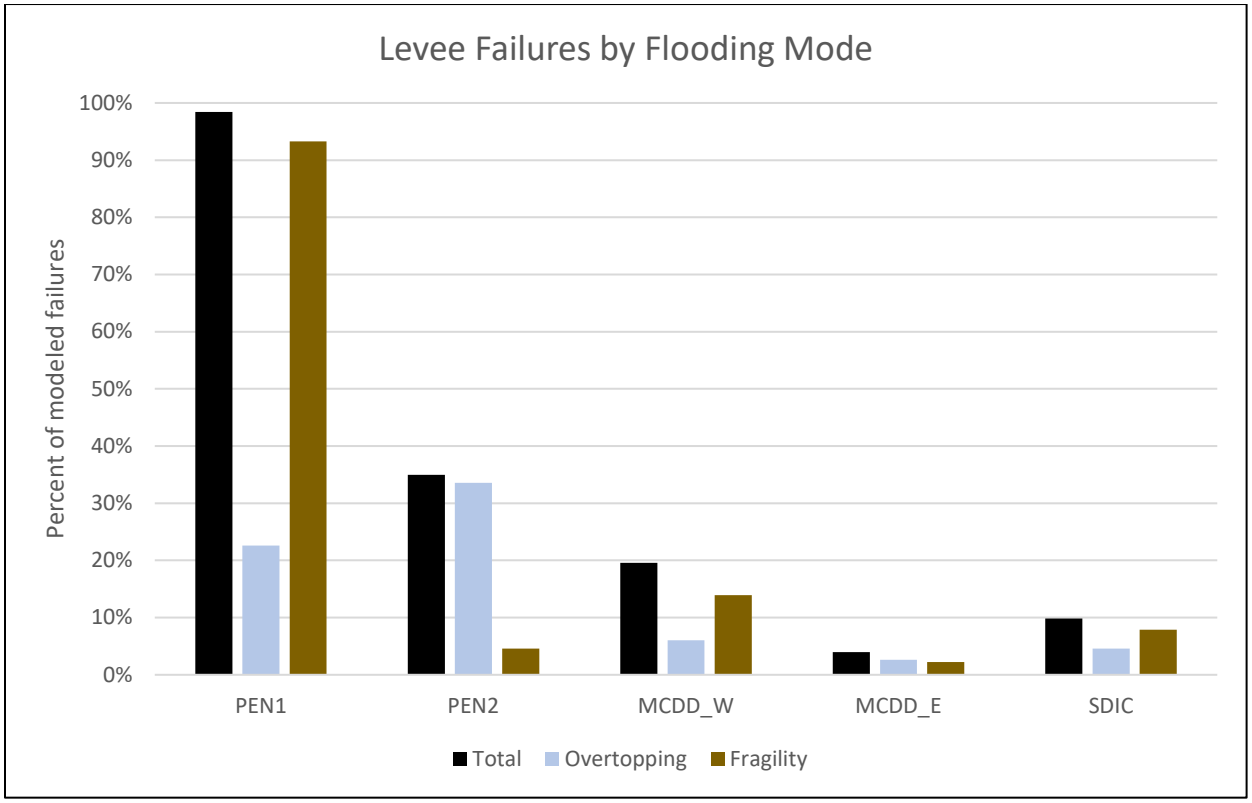

Figure 3-6 Future Without-Project Levee Failures by Flooding Mode

3.2.5. Interior Drainage and Pump Stations

In addition to flood risk posed by levee failure from riverine sources, the PMLS also faces a hazard from stormwater generated by large precipitation events. The interior drainage system includes the stormwater system that routes water inside the levee to pump stations, which then expel water from the system to the Columbia River or Columbia Slough. Many of the pump stations were designed for lesser flows prior to full development of the drainage area, and have difficulty managing relatively frequent storm events. In actual operations, temporary pumps are sometimes brought in to supplement the pump stations, but these emergency actions are unplanned and are not included in the future without-project analysis. In the event of a pump station failure, stormwater will pond inside the levee system, causing damages to low-lying structures. The interior drainage assessment evaluates the potential for high water levels and the damage they cause. Storms of varying magnitude are simulated using XPSWMM modeling software. This model converts storm rainfall into runoff that flows through the interior drainage system to the pump station, which is then modeled to pump water from the system. XPSWMM results include inundation levels from water that is not pumped out quickly enough to prevent damage. The probability of a pump station failure is incorporated into the analysis. Damaging events from interior drainage commence at relatively frequent events, sometimes as early as the 5 percent AEP (20-year) storm event. Refer to Appendix A (Hydraulics and Hydrology) for a full discussion of the interior drainage results and modeling details.

Six exterior pump stations and three interior pump stations were evaluated. Additional interior pump stations are present in the study area, but they are smaller scale and were not evaluated in this study. The pump stations are located in all four drainage districts. All pump stations are managed, maintained and operated by MCDD. The majority of the pump stations were constructed prior to the most recent revision of the Corps' pump station standards Engineer Manual (EM) 1110-2-3102 (USACE, 1995) and EM 1110-2-3105 (USACE, 1999). Table 3-5 summarizes the dominant potential failure modes identified in the pump station evaluation.

Table 3-5 Summary of Dominant Potential Failure Modes and Measures

Pump Station	Dominant Potential Failure Mode
PEN 1 PIR (Portland International Raceway)	Pump 2 operates outside of the pump curve.
PEN 2 13th Avenue	Intake is too small for the pump station capacity.
PEN 2 Schmeer Road	None Identified
MCDD AirTrans	Trash Rake has a high likelihood of jamming.
MCDD Broadmoor	Clogged trash rack
MCDD Pump Station 1	None Identified
MCDD Pump Station 2	Pumps cannot keep up in a storm event.
MCDD Pump Station 4	Clogged trash rack
SDIC Sandy Pump Station	Pumps cannot keep up in a storm event.

3.2.6. Climate Change

Climate change and possible implications are described in detail in Appendix A (Hydrology and Hydraulics). In summary there are three areas where climate change may affect the PMLS; temperature, precipitation, and streamflow.

Literature supports increasing temperature trends in the Columbia Basin. From 1916-2006, the basin-wide mean temperature increased by 0.19 °F per decade, or a total of 1.7 °F. By the 2070s, mean temperature in the Columbia Basin is projected to increase an additional 3 ºF to 10 °F, depending on emissions scenario. Maximum temperature extremes are also projected to increase.

Although there is some variation in precipitation trends, moderate consensus supports a trend of increasing annual precipitation in the Columbia Basin, with strong consensus for an increase in extreme precipitation. From 1916 to 2006, the basin-wide annual precipitation increased approximately 9 percent, and from 1901 to 2016, the amount of precipitation falling during the heaviest 1 percent of events increased by 22 percent in the region. The frequency and intensity of extreme events is projected to continue to increase, and by the end of the century a 20-year storm could increase by up to 19 percent. Projected trends vary by season, with decreasing precipitation in summer and increasing precipitation in winter.

Statistically significant decreases in annual and spring-summer flows were observed during the latter half of the 20th century in the Pacific Northwest, especially for already dry years. Despite the observed decreasing trend in the region, future projections in the Columbia Basin indicate an increase in annual streamflow volume. Streamflow projections indicate seasonal trends of higher

winter flows and earlier spring peak flows. These seasonal trends are consistent with observed and projected trends in decreasing snowpack. The analysis is primarily based on unregulated flow estimates that do not include the effect of reservoir regulation. The upcoming Phase II of the River Management Joint Operating Committee study will incorporate reservoir operations to project future trends in regulated streamflow and will be referenced when available.

Even under current climate conditions, winter rain flood events are a greater threat to PMLS than spring snowmelt events. Climate change effects are expected to exacerbate the threat of winter flooding. The largest risk posed to PMLS from climate change is likely the potential higher stages generated from increased winter-time flows on the Willamette and Columbia Rivers. If winter-time flows become more extreme, there are limited opportunities for adaptive management to re-operate the reservoirs in the Columbia basin to mitigate this increased risk.

While the Columbia River is tidally-influenced in the vicinity of PMLS, the potential for Sea Level Change (SLC) is a relatively small risk to the PMLS system since it is fairly far upstream. Four SLC scenarios were evaluated with a hydraulic model: no change, low, intermediate, and high. Under the most extreme SLC scenario in the year 2100, average water levels are expected to increase by 4.21 feet at Astoria. This translates upstream to an increase of 0.5 feet for the 1 percent AEP (100-year) winter flood at PMLS. While an increase of 0.5 feet is not negligible, it is relatively small for even the most extreme SLC scenario forecast in the year 2100. The intermediate and low SLC scenarios show a very limited impact on PMLS, with the maximum increase in peak stage around 0.1 feet for winter floods.

While SLC has a small effect on peak stages, it is expected to increase the duration of high water, creating additional stress on the levee system. SLC scenarios show a larger impact on the duration of high-water during spring snowmelt events due to the broader peak flows. SLC causes water levels to stay above an elevation that begins to place stress on the levee system for the 0.2 percent AEP (500-year) spring snowmelt flood for an additional week when compared to current average sea levels. In contrast, the duration increase for winter floods ranges from a few hours (intermediate scenario) to 20 hours (high scenario) for the 1 percent AEP event.

The primary climate variables that could pose a risk to the PMLS are summarized in Table 3-6. Only climate change variables that have an effect on flood risk management are included; other climate change effects are not explored.

Table 3-6 Summary of Climate Change Variables that Pose a Risk to PMLS

Climate Change Variable for PMLS	Risk Description
Sea Level Change	Analysis indicates that sea level change alone does not have a large effect on water surface elevation within the project area in comparison to other factors. For most of the modeled scenarios of interest, the increase in river levels in the year 2100 under the intermediate sea level rise scenario was around 0.1 feet for winter flood events and between 0.1-0.2 feet for spring flood events.
Interior Drainage Precipitation Increase	Studies have indicated that a 5% AEP (20-year) storm could increase precipitation over a 3 day period from the current value of 5.5 inches to 6-6.5 inches. This increase in magnitude means that under future climate conditions a 5% AEP (20-year) storm could look more like what is currently considered to be a 2%-3% AEP (30 to 50-year) storm.
Increased flows on Columbia and Willamette Rivers	Both Columbia and Willamette River peak flows are anticipated to increase during the winter and spring seasons, increasing the duration of levee loading. Climate projections agree on the direction of annual and seasonal trends, but the magnitude of the impact varies between projections and is difficult to quantify.

3.2.7. Inventory

The study area is home to approximately 8,900 people, with residential populations concentrated in PEN 2, MCDD West, and MCDD East. Daytime population is also greatly impacted by the density of business activity and transportation activity in the study area. A recent study by the Oregon Department of Geology and Mineral Industries (DOGAMI) estimated 59,000 total employees working within the study area, with MCDD West accounting for about two thirds of that total.

The study area is situated in an ideal location for commercial transportation, logistics, and distribution businesses due to its proximity to major transportation infrastructure in the Portland International Airport, I-5, I-84 and I-205, BNSF and Union Pacific railroad lines, and the Columbia River. For similar reasons, the study area is well-suited to industrial uses, from machining and fabrication to electronics manufacturing, to chemical and industrial ingredient supply. Proximity to major population centers in the Portland-Vancouver-Hillsboro area have also made the study area an attractive location for big box retail centers and shopping malls, hotels providing ready access to the airport, and recreational businesses with large land use requirements, such as sports complexes, golf courses, racetracks, and exposition centers.

The largest facility providing service to the region as well as the state is the Portland International Airport (PDX), located in MCDD West. In addition to serving approximately 20 million domestic passengers annually, the airport is also a major hub for air freight and related

intermodal services, with major fulfillment and distribution facilities for USPS, FedEx, Amazon, and others located in the study area. Proximity to PDX, and nearby Troutdale Regional Airport in SDIC, also supports Air and Army National Guard facilities in the study area.

A major piece of infrastructure within MCDD is the Columbia South Shore Well Field, which is part of the Portland Water Bureau's groundwater drinking water system and has been used to meet as much as 50 percent of daily demand for nearly 1 million area residents. This well field is available for use as a supplemental supply when the primary Bull Run source is either inadequate to meet demand or is experiencing some other issue. Given that the aquifers are beneath heavily developed commercial and industrial areas, the Portland Water Bureau administers a groundwater protection program in cooperation with area businesses to ensure that risk of contamination is minimized. The system is subject to impact from flooding via contamination of the supply, as well as from loss of power to run well pumps and distribution equipment.

The study area also contains other local and regional utility infrastructure. There are eight electrical substations between MCDD West/East and SDIC which are owned by Bonneville Power Administration, Portland General Electric, and PacifiCorp. There are also two natural gas facilities in MCDD West and a Williams Company gas line which runs through SDIC (DOGAMI 2018).

In PEN 1, the Expo Center is a major exhibit hall and convention space in the region. PEN 1 is also bordered on the west by a freight rail line. This line conveys traffic to and from the only railroad crossing of the Columbia River west of Wishram, Washington, 100 miles upstream.

I-5 sits just inside the western end of PEN 2 along its shared boundary with PEN 1, providing the one of two primary interstate highways for travel between Vancouver, WA and Portland, OR (Vancouver recently put out a publication that states there is 60,000+ commuters from Vancouver to Portland on a daily basis). While the Columbia Boulevard Wastewater Treatment plant main property is south of Columbia Slough and outside the study area, there is a parcel of settling ponds located in the southwest corner of PEN 2.

A critical input to the economic analysis is the development of a building (structure) inventory for the study area that captures the structure value and content value at risk of damage or loss. Appendix B (Economics) provides a detailed discussion of the development of this inventory. Table 3-7, below, summarizes the total number of buildings in the inventory. Table 3-8 summarizes the depreciated replacement value of the inventory by reach and building type, whose grand total amounts to approximately $6 billion dollars.

Table 3-7 Floodplain Structure Inventory Summary

Leveed Area	Structure Count by Occupancy Type						
	Agricultural	Commercial	Industrial	Public	Residential	Utility Buildings	Total
PEN 1	0	10	14	4	0	19	**47**
PEN 2	51	157	29	9	867	2	**1,115**
MCDD West	17	696	253	150	323	25	**1,464**
MCDD East	2	99	78	2	937	25	**1,143**
SDIC	1	86	63	5	4	10	**169**
Total	**71**	**1,048**	**437**	**170**	**2,131**	**81**	**3,938**

Table 3-8 Floodplain Structure Inventory Valuation Summary (With Depreciation)

PMLS HEC-FDA Structure Inventory - Replacement Value With Depreciation by Reach and Damage Category							
Reach	(All figures in $1,000s)						
	AGR	COM	IND	PUB	RES	UTL	Total
PEN 1	$0	$1,833	$111,200	$59,434	$0	$1,245	**$173,712**
PEN 2-13th Avenue PS	$2,168	$180,733	$31,354	$6,660	$179,317	$969	**$401,201**
PEN 2-Schmeer PS	$8,819	$139,061	$15,475	$24,498	$451	$0	**$188,304**
MCDD West-PS1	$437	$2,010,629	$550,435	$367,140	$42,631	$1,038	**$2,972,310**
MCDD West-AirTrans	$0	$26,435	$185	$127,350	$0	$272	**$154,242**
MCDD West-PS2	$291	$41,151	$67,169	$41,096	$1,706	$743	**$152,456**
MCDD West-Broadmoor	$125	$21,590	$105	$16,913	$0	$187	**$38,920**
MCDD_East-PS4	$57	$853,221	$288,740	$14,674	$237,883	$288	**$1,394,863**
Blue Lake	$0	$1,760	$0	$0	$36,202	$1,807	**$39,769**
SDIC	$58	$202,811	$333,254	$8,389	$0	$744	**$545,256**
Total	**$11,955**	**$3,479,224**	**$1,397,917**	**$666,154**	**$498,190**	**$7,293**	**$6,060,733**

Notes: AGR- Agricultural, COM-Commercial, IND-Industrial, PUB-Public, RES-Residential, UTL-Utility Building. Values determined by multiplying the structure footprint area in square feet by the 2019 RS Means Construction Cost per square foot. Price Level-2019

3.2.8. Economic Consequences

Future without-project NED consequences were modeled using the Corps certified HEC-FDA software, which integrates economic and engineering information to estimate damage as a function of flood depth. HEC-FDA results are in the form of Expected Equivalent Annual Damage (EEAD), which represents the average annual flood damages expected to occur over a long period of time, taking into consideration affected economic assets over the full range of probabilistic flood events and geotechnical failure possibilities.

Economic assets that are subject to damage are an input to the HEC-FDA model. Damage to structures (buildings) and their contents is a key consequence category. Other consequence

categories include damage to utility infrastructure, parked vehicles, and other infrastructure. NED damage also includes detour and delay impacts on passengers at Portland International Airport and Troutdale Airport, TriMet bus and light rail riders, freight trains, passenger trains, and roadway traffic. The study also considered the impacts on water delivery cost because of impact on the Portland Water Bureau's Groundwater Facility.

Table 3-9 summarizes the EEAD for the future without-project condition. As shown in the table, the largest three damage categories constitute 91 percent of the total EEAD, including Commercial structures (48 percent), Industrial structures (30 percent), and Public structures (13 percent).

Table 3-9 EEAD for the Future Without-Project Condition

	Building Damage Category						**Other Damage Category**				
	(All Figures in $1,000's)										
Damage Reach Name	**AGR**	**COM**	**IND**	**PUB**	**RES**	**UTL**	**VEH**	**INFRA**	**EMG**	**Total**	**Percent of Total**
Pen 1	$0	$22	$959	$379	$0	$23	$4	$0	$47	$1,435	6.4%
Pen 2-13th Ave PS	$149	$1,236	$749	$33	$747	$5	$177	$0	$20	$3,115	13.9%
PEN 2-Schmeer PS	$95	$1,386	$235	$258	$2	$0	$11	$0	$0	$1,988	8.9%
MCDD_West-PS1	$3	$5,063	$3,300	$1,539	$75	$4	$317	$0	$24	$10,325	46.2%
MCDD West-AirTrans	$0	$78	$1	$311	$0	$1	$0	$17	$0	$407	1.8%
MCDD West-PS2	$1	$144	$124	$194	$5	$6	$4	$0	$0	$479	2.1%
MCDD West-Broadmoor	$1	$114	$0	$103	$0	$1	$0	$0	$0	$219	1.0%
MCDD_East-PS4	$0	$2,404	$894	$16	$303	$1	$10	$0	$4	$3,632	16.3%
Blue Lake	$0	$1	$0	$0	$10	$2	$1	$0	$0	$14	0.1%
SDIC	$0	$232	$459	$9	$0	$3	$5	$0	$5	$714	3.2%
Total	$249	$10,681	$6,722	$2,842	$1,141	$45	$529	$18	$101	**$22,328**	
Percent of Total	1.1%	47.8%	30.1%	12.7%	5.1%	0.2%	2.4%	0.1%	0.5%		

Notes: AGR = Agricultural, COM = Commercial, IND = Industrial, INFRA = Public Transportation and Freight Railway Infrastructure, PUB = Public, RES = Residential, UTL = Utility Building, VEH = Domestic Vehicles, EMG –Emergency Response Costs

3.2.9. Life Safety

As previously shown in Figure 3-1, risks to life safety are a function of the probability of high water, the performance of the levee, and the consequences (lives lost) in the event of a failure. HEC-LifeSim produces estimates of life loss for given levee failure scenarios. The probability of these events actually occurring is an equally important component of the life safety risk.

Life safety was analyzed using HEC-LifeSim software for the future without project condition. Life safety analysis is described in more detail in Appendix B (Economics). The extent and rate of inundation in the event of levee breach serve as inputs to the HEC-Lifesim software. These maps were generated using the hydraulic model of the study area as described in more detail in Appendix A (H&H). In conducting the analysis, the Corps engaged with social scientists in the areas of warning and evacuation to better understand how flood warnings spread through a community and what causes an individual to delay a decision to take protective action based on those warnings. PDT members also conducted interviews with emergency managers from Multnomah County, the Portland Bureau of Emergency Management, and the Multnomah County Drainage District.

The LifeSim model includes levee overtopping and levee failure-prior-to-overtopping breach scenarios for the Future Without-Project condition. It was assumed for the overtopping scenario that industrial, commercial, and public entities would comply with a 72-hour advance warning to evacuate. This means that no one would be in those types of buildings when the levee overtopping flood hazard arrives. However, this assumption does not apply to residential structures where life loss estimates are dictated by warning and evacuation time series curves. Note that unsheltered communities that do not receive emergency warnings through traditional communication channels are accounted for in the LifeSim model warning issuance time vs. percent of population warned curves. The breach prior to overtopping scenarios assume the Columbia River is at the highest water surface elevation possible before the threshold to issue mandatory evacuation orders (river stage of 32.5 feet NAVD88 at the Vancouver gage).

HEC-LifeSim was used to estimate potential life loss for levee breach scenarios. Table 3-10 shows the range for life loss estimates for the Future Without-Project condition. These figures are the maximum of the life loss estimates between the daytime (2 p.m.) and nighttime (2 a.m.) model outputs. There is considerable uncertainty in the estimation of lives lost during a flood, and precise estimates of life loss are less useful than a range. The 25^{th} to 75^{th} percentile of the LifeSim estimates is shown in the table to capture the large uncertainty in estimating life loss.

The chance of these scenarios occurring is low, but it is not negligible. For instance, the probability of overtopping at PEN 2 is between 0.1% and 0.8% each year (5^{th} to 95^{th} percentile). Life loss consequences during an overtopping event is generally lower than a failure prior to overtopping, since there is more warning time for overtopping. If a levee breaches before it is overtopped, the life loss consequences are much higher, but the probability of this occurring is lower. For instance, the chance of breach prior to overtopping for PEN 2 is less than 0.0001%. In contrast, PEN 1 is the most susceptible to breach prior to overtopping. The probability of breach prior to overtopping occurring in any given year at PEN 1 is between 0.05% and 0.4%.

Table 3-10 Life Loss Modeling Summary Results – Future Without Project

Leveed Area	Modeled Range of Lives Lost in Scenario (25% – 75% Uncertainty)	Annual Probability of Scenario (5% – 95% Uncertainty)
Failure Prior to Overtopping (Columbia River level less than mandatory evacuation levels)		
MCDD East	0 - 0	< 0.001%
MCDD West	74 - 413	< 0.001%
PEN 1	1 - 6	0.08% – 0.3%
PEN 2	80 – 150	< 0.001%
SDIC	3 - 9	0.01% - 0.03%
Overtopping (72-hour warning)		
MCDD East	2 – 7	0.005% - 0.01%
MCDD West	0 – 9	0.01% - 0.2%
PEN 1	0 – 0	0.05% - 0.4%
PEN 2	7 – 17	0.1% - 0.8%
SDIC	0 - 0	0.01% - 0.1%
Total	**9 - 33**	

The table shows that the highest potential for life loss is in PEN 2 and MCDD-West. PEN 2 has the most residents of any of the leveed areas. Even in an overtopping scenario with days of warning, significant life loss is still expected at PEN 2. As previously shown in the modeling results, PEN 2 is also the area where overtopping is most likely in the system since it has the lowest levee elevations. Therefore, life loss at PEN 2 poses the highest risk in the system. Other areas also show high potential for life loss, but PEN 2 is the most critical area when considering both probability of a failure and the consequence of a flood together. MCDD-West has a large population in the leveed area, but the residential population is smaller than PEN 2. However, the uncertainty bounds are larger on MCDD-West since it is a much larger area. Non-residential populations are more likely to evacuate, reducing the life loss consequence in MCDD-West despite the large populations. The flooding pattern in MCDD-West is also less severe, allowing for more successful evacuation. The MCDD-West area is much larger than PEN 2 and a levee breach opening would be smaller, which means that floodwaters take longer to spread through MCDD-West than PEN 2.

Population at risk (PAR) estimations are also computed by LifeSim. The PAR is derived by estimating the number of people in structures would be exposed to any amount of flood water if they do not evacuate for the given scenario (overtopping and failure-prior-to-overtopping for this study). PAR estimates are shown in Table 3-11.

Table 3-11 Population at Risk in the Study Area

Leveed Area	Estimated Population at Risk			
	Day (2pm)		Night (2am)	
	PAR (under 65)	PAR (over 65)	PAR (under 65)	PAR (over 65)
MCDD East	826	47	317	21
MCDD West	20,359	1,955	7,513	759
PEN 1	158	9	61	3
PEN 2	3,905	422	2,794	354
SDIC	1,905	96	643	32
Total	**27,153**	**2,529**	**11,328**	**1,169**

3.2.10. Summary of Future Without-Project Conditions

In addition to the assessment of without-project flood risk, the feasibility study also assessed Future Without-Project conditions related to other resource categories identified in the study area. Table 3-12 provides an overview of the future without-project conditions for the evaluated resource categories. These are discussed in more detail in Chapter 4.

Table 3-12 Summary of Future Without-Project Conditions

Resource Category	Future Without-Project Conditions
Water Resources	Water resources in the study area would continue to be protected through Federal, state, and local water quality and pollution prevention programs and development requirements. Development or drainage district management could incrementally result in wetland losses, vegetation removal and more impervious surfaces. Increases in impervious surface due to development would continue to be offset through measures to reduce impervious surface effects. Climate change would accentuate existing seasonal variations in precipitation and water flows, though dams would continue to influence flows.
Physical Resources	Physical resources in the study area would not change substantially in the future. Terrestrial soils would continue to degrade from natural erosive processes and from impacts from future development. Aquatic sediment in the Columbia River mainstem would continue to increase in fine materials.
Air Quality	Air quality is closely regulated and expected to remain in compliance with Federal and state standards. Future standards are likely to become increasingly protective.
Noise	Noise conditions are regulated by state and local ordinance, but noise levels would likely increase incrementally if neighborhoods and transportation facilities are further developed.
Utilities	Utility demand in the area would increase as population increases, requiring upgraded or new infrastructure.
Biological Resources	Biological resources are expected to continue trends toward decline in quality and quantity due to continued urbanization. However, Federal, state, and local groups would also continue to protect, conserve, rehabilitate and restore the natural habitats, and fish and wildlife populations in the study area.

Resource Category	Future Without-Project Conditions
Cultural Resources	Over time, cultural artifacts may be discovered in the area. Existing cultural protection laws will ensure their preservation and proper use.
Hazardous, Toxic and Radioactive Waste (HTRW)	Hazardous materials will continue to be used for local industry and transported via truck, rail, and barge through the project area. Existing regulations will continue to control and address HTRW.
Land Use, Planning, and Zoning	Land use, planning and zoning would continue to be regulated by state and local municipalities. Future developments would be subject to standards and codes intended to prevent inconsistency or degradation of lands in the study area. Drainage district management would continue to pursue measures to protect land uses from flood events in the study area.
Socioeconomics and Environmental Justice	Socioeconomics are unlikely to change in the future, with no particular trends apparent for population composition, structure, or income. Similarly, environmental justice communities are unlikely to change. Drainage district management would continue to ensure flood risk management for these communities.
Visual Resources	Visual resources would change incrementally over time, as a result of infilling in neighborhoods, further development of commercial areas, or expansion of drainage district flood risk reduction measures. Natural areas would continue to be encroached upon, though local groups would continue to protect natural areas.
Recreation	Recreational resources would remain steady in terms of quality and quantity for recreation areas within the Portland-Vancouver Metro area over time. As the metro area increases in population, there would be increasing demand for recreation areas. City growth plans would continue to ensure the development of parks based on population growth. Local groups would continue to collaborate on recreation protections with drainage districts.
Public Health and Safety	Development of the area and an incrementally increasing population would require increased protection from local law enforcement and emergency response groups over time.
Transportation and Traffic	The transportation network is expected to expand with increasing population and development under the current multi-modal Transportation System Plan. PDX would continue to serve ever increasing numbers of travelers. Expansion and improvements of local surface streets, light rail, and pathways are also expected.

3.3. Alternative Development Process

Alternative Development Terms

Measure – *a feature or an activity that can be implemented at a specific geographic site to address one or more planning objectives.*

Alternative Strategy – *Strategy of combining measures in various ways to help the team think about how measures can solve identified problems in the PMLS.*

Alternative – *a set of one or more management measures functioning together to address one or more objectives.*

This section presents the process used in the development of alternatives. The Corps' six-step planning process specified in Engineer Regulation (ER) 1105-2-100 is used to develop, evaluate, and compare an array of candidate plans.

1. The specific problems and opportunities to be addressed in the study are identified, and the causes of the problems are discussed and documented. Planning goals are set, objectives are established, and constraints are identified.
2. Existing and future without-project conditions are identified, analyzed, and forecasted. The existing condition resources, problems, and opportunities critical to plan formulation, impact assessment, and evaluation are characterized and documented.
3. The study team formulates alternative plans that address the planning objectives. An initial set of alternatives is developed and is evaluated at a preliminary level of detail.
4. Each alternative plan is evaluated for its ability and extent of meeting the specified planning objectives and constraints, as well as efficiency, completeness, and acceptability. The impacts of alternative plans are evaluated using the system of accounts framework specified in the P&G and ER 1105-2-100.
5. Alternative plans are compared to each other. A benefit-cost analysis is conducted to prioritize and rank flood damage reduction alternatives. A public involvement program obtains public input to the alternative identification and evaluation process.
6. The plan with the greatest net benefits is selected for recommendation if at least one plan exists displaying Federal interest. A locally preferred plan may be recommended and approved if the non-Federal sponsor desires other acceptable project features than those in the National Economic Development (NED) Plan.

The steps above are presented sequentially, but iterations are conducted as necessary to formulate plans.

The feasibility study process involves successive iterations of alternative solutions to the defined problems. These solutions are based upon the study objectives and constraints, and address problems and opportunities that have been previously defined. Figure 3-7 shows the major steps taken in the process from the initial development of measures at a planning charrette though identification of the Tentatively Selected Plan (TSP). The following section describes the process and decisions during the processes. The iterative process of developing, evaluating, and refining alternatives is described below

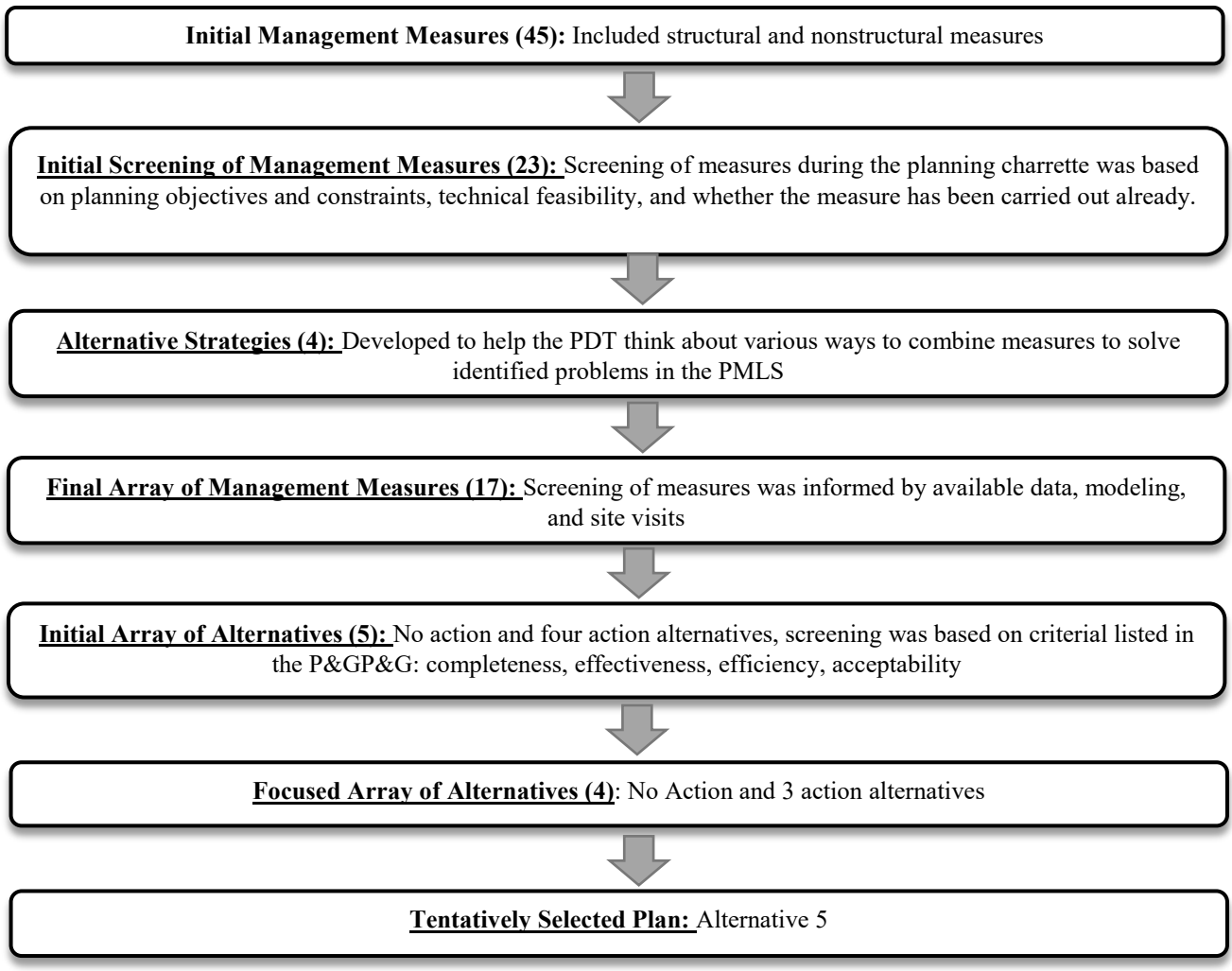

Figure 3-7 Alternative Development and Screening Diagram

3.3.1. Initial Iteration of Measures and Strategies (Planning Charrette)

A planning charrette was held in October 2018 during which the Project Delivery Team (PDT) discussed existing information, developed problems, opportunities, and study objectives, and developed flood risk reduction measures for the formulation of alternatives. The charrette occurred over a series of days and included a brainstorming session, study area site visit, and meeting to screen and develop strategies.

3.3.1.1. Measures

The initial array of measures is included in Table 3-13. Note that the measure numbering is maintained throughout the study; the numbers do not change as measures are screened.

Table 3-13 Initial Array of Flood Risk Reduction Measures

1. Elevate structures – Elevate individual structures and critical infrastructure to above flood elevations	**16. Improve permeability (e.g. paved parking lot replaced with grid and grass) –** Increase permeability infiltration to reduce stormwater runoff	**31. Remove existing levee (specific to PEN 1) –** Remove existing levee and allow area to flood
2. Flood proof buildings – Install floodproofing on buildings within area at risk	**17. Increase wetlands/retention ponds –** Add wetlands or retention ponds to reduce stormwater runoff	**32. Rehab or replace mechanical/structural features (gates, valves, pumps) -** These measures include the potential to replace the Gate Valve Tower (SDIC/MCDD cross-levee) and to replace/automate the 142nd Ave cross-levee valve.
3. Buy outs – Buy out and relocate residences and businesses from within the study area	**18. Complete seismic retrofits –** Retrofit structures to withstand seismic events	**33. Adjust/ensure levee slopes meet current standards –** Modify levee slopes where they do not meet current design standards
4. Relocation of residences/businesses/critical infrastructure	**19. Install large portable pumps similar to Brazil –** Install very large portable pump stations to be used when needed	**34. Relocate transportation corridors –** Relocate transportation infrastructure out of the study area
5. Widen levees (improve levee performance)- This measure addresses levee stability or seepage concerns through levee re-grading (width/slope) or the installation of drain or relief well systems.	**20. Add redundancy for pump system** - This measure provides for a back-up power source for pump stations to allow for increased reliability of pump operations	**35. Utilize setback levees-** Install setback levees and allow some areas to flood
6. Flood warning system - This measure revises and updates flood hazard and evacuation plans and develops expanded communication and evacuation plans when a flood warning is to be issued (e.g. sirens, reverse 911 calls). It provides early warning to those in the area when a flood risk is eminent, it could include sirens, reverse 911 calls, automated messages, or similar actions.	**21. Install submersible pump stations –** Modify pump stations to have submersible pumps, which operate when inundated	**36. Education on flood risk** - This measure is focused on education of flood risk and may be developed in several forms such as flyers, websites, information meetings, and updates to emergency plans among others.
7. Increase levee heights (this includes cross levees, mainstem, slough)- This measure provides a higher level of risk reduction from over-topping by increasing the height of the levee which may include small sections of raises in areas where there is a low spot or large sections	**22. Improve/increase debris control** - This measure addresses pump station trash rack performance/capacity.	**37. Install/improve signs for evacuation –** Evacuation route signage within the system

8. Maximize/increase flood storage capacity in the Willamette Basin Projects	**23. Relocate MCDD Headquarters out of floodplain (COOP plan) –** Move the HQ facility out of the floodplain	**38. Removal of levee vegetation –** Remove vegetation from along levees
9. Bigger facility—buy real estate to expand horizontal area of the floodplain	**24. Reroute water/floodwater -**Route floodwaters away from infrastructure	**39. Address existing erosion/control future erosion on levees -**
10. Add pump capacity – increase pump capacity through larger or additional pumps at pump stations	**25. Construct levee next to railway/highway to act as drainage seep –** additional levee added to control seepage	**40. Reduce area of protection –** Remove levee and reduce area protected
11. Add gates – new gravity outlet gates at the pump stations	**26. Aquatic invasive plants control/eradication-** aquatic vegetation control throughout study areas	**41. Establish "safe zones" for evacuation life/safety-** This measure entails the establishment and marking of areas or structures of higher elevation in the event of unforeseen levee failures prior to district evacuation protocols.
12. Add ring levees – Ring levees are constructed to protect individual structures or properties	**27. Recreation trails on top of levees** – Add recreation trails at the top of levees	**42. Stem wall** - concrete wall typically used in association with a foundation
13. Riprap (Bank Protection) – provide bank protection in areas where erosion may be an issue	**28. Install/Operate tide gates.** Operating tide gates at pump stations would provide a redundant way to expel interior drainage, also reducing demand on the pumps.	**43. Add relief or overflow areas-** includes managed overtopping in order for areas to fill more slowly in event of a flood
14. Improve flood fight—improve access roads, remove restrictions for equipment, improve mobility of flood fighters	**29. Improve/increase seepage berms** – add seepage berms within the levee system	**44. Zoning** – Change zoning regulations within the study area
15. Automate operations in the systems - This measure addresses automating time/labor intensive floodfighting efforts, such as the PEN1/Marine Drive flood panel installation.	**30. Build additional levees/floodwalls** - This measure converts temporary flood closure measures at cross-levees into permanent features by raising Airport Way and Marine Drive. Also includes a parallel levee at the PEN 1 railroad embankment.	**45. Secure floating homes** – Secure floating homes to reduce risk of damage during flood event.

These measures were evaluated during the charrette and initial screening was conducted to eliminate some from further consideration. Screening criteria applied to evaluate these measures include the following questions:

- Has it been already carried out by a non-Federal entity?
- Does it meet the planning objectives?
- Does it avoid the planning constraints?
- Is it technically feasible?

Table 3-14 describes the measures that were eliminated during the charrette screening, and the rationale for their elimination.

Table 3-14 Measures Eliminated and Rationale for Elimination in the First Plan Formulation Iteration

No.	Measure	Rationale for Elimination
8	Maximize/increase flood storage capacity in the Willamette Basin Projects	Only reduces flood effects in the PMLS system caused by the Willamette River. Eliminated because it is outside study authority and operational authority for Willamette Valley Project.
9	Bigger facility—buy real estate to expand horizontal area	Outside the study footprint, governance structure/sponsorship, and does not meet project objectives.
11	Add gates	Does not meet objectives of project, does not fit hydraulic conditions of this area (example: New Orleans system gates).
16	Improve permeability (e.g., paved parking lot replaced with grid and grass)	Would need to have a high percent of impermeable parking lots to make a difference in flood events, and groundwater table is high making this ineffective.
17	Increase wetlands/retention ponds	Groundwater is high and would prevent retention capability for flood events to make a measurable difference.
19	Install very large portable pumps	Cost prohibitive to install.
21	Install submersible pump stations	Not a viable measure to retrofit existing facilities. Cost prohibitive to construct entirely new stations.
24	Reroute water/floodwater	No opportunities to do bypass channel in this system.
25	Construct levee next to railway/highway to act as drainage seep	Other measures meet the intent of this measure.
28	Install/Operate tide gates	Would have negative endangered species implications, as operating tide gates regularly could strand fish in the degraded habitats of the stormwater drainage system on the interior of the levee.
31	Remove existing levee (specific to PEN1)	Does not meet objectives of the project. This measure would provide floodplain restoration but no significant flood attenuation is gained. It is also cost-prohibitive to remove a levee and relocate

No.	Measure	Rationale for Elimination
		residences and businesses from this area. Does not meet the governance structure objectives of levee system.
34	Relocate transportation corridors	Cost prohibitive. The Sponsor can continue to communicate/coordinate with transportation agencies as they develop future plans.
35	Utilize setback levees	Does not meet project purpose because of amount of existing infrastructure, no room for setbacks that would be effective in increasing the floodway/plain and reducing flood profile. Cost-prohibitive compared to utilizing existing levee system which achieves similar objectives.
39	Address existing erosion/control future erosion on levees	Not specific enough to evaluate—replaced by measures 13, 33.
40	Reduce area of protection	Does not meet objectives, would be cost prohibitive to implement this measure due to need for modifications to major transportation infrastructure
42	Stem wall	Redundant with other measures.
43	Add relief or overflow areas	Engineering and Construction Bulletin (ECB) 2019-8 calls for consideration of managed overtopping of levees (USACE, 2019a). In this system there is limited space available and it would provide minimal flood attenuation benefit. The evacuation threshold is well before overtopping would occur, managed overtopping is not anticipated to provide a life safety benefit and there is no economic benefit. Overtopping in one area does not affect exterior water levels.
23	Relocate MCDD HQ	This measure is a non-Federal action.
44	Zoning	This measure is a non-Federal action.
45	Secure floating homes	This measure is a non-Federal action.

Measures retained after the initial formulation and screening are listed in Table 3-15 these include non-structural and structural measures. As defined in USACE Planning Bulletin 2016-01, non-structural measures are those that reduce human exposure or vulnerability to a flood hazard without altering the nature or extent of that hazard. Non-structural measures can include activities that require construction, such as elevating homes or flood proofing buildings. They can also include measures that do not require construction, such as measures that increase evacuation effectiveness by improving flood warning plans and systems.

Table 3-15 Measures Retained Following First Round of Screening

Structural Measures	Non-Structural Measures
5 – Widen levees (improve levee performance)	4- Relocation of residences/businesses/critical infrastructure
7 – Increase levee heights	1 – Elevate structures
10 – Add pump capacity	2 – Flood proof buildings
12 – Add ring levees	3 – Buyouts
13 – Bank protection	14 – Improve flood fight (Four-season maintenance and flood fight access)
18 – Complete seismic retrofits	15 – Automate operations in the systems
20 – Add redundancy for pump system	22 – Improve/Increase debris control
29- Seepage control	23 – Relocate MCDD Headquarters out of floodplain
30 – Build additional levees/floodwalls	26 – Aquatic invasive plants control/eradication
32 – Rehab or replace mechanical/structural features (gates, valves, pumps)	36 – Education on flood risk
	37 – Install/Improve signs for evacuation
33 – Adjust/ensure levee slopes meet current standards	38 – Removal of levee vegetation
	41 – Establish “safe zones” for evacuation life/safety

3.3.2. Alternative Strategies

The Alternative Strategies were developed to help the PDT think about various ways to combine measures to solve identified problems in the PMLS. Table 3-16 includes a comparison of the measures that address the planning objectives, as well as their grouping into alternative strategy categories. Measures were combined using four alternative strategies plus the Future Without-Project condition (No Action) to develop an array of five initial alternative strategies.

The initial array of alternative strategies was defined based on review of other studies within the Columbia River System, discussions with the non-Federal sponsor, documented interests of the Levee Ready Columbia consortium of stakeholders, and input from other resource agencies and the public. These strategies are intended to focus on the various objectives and provide a framework to develop different solutions to the identified problems. Measures associated with these strategies were not developed at a specific level of detail but were generally sited throughout the study area.

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Table 3-16 Measures Compared to Objectives and Alternative Strategies

Measure No.	Measure	OBJECTIVES						ALTERNATIVE STRATEGIES			
		Reduce flood risk, in particular to critical infrastructure, within the PMLS over the period of analysis	Reduce threats to life safety from flooding and increase awareness of flood risk in the PMLS over the period of analysis	Increase resiliency of the flood risk management system over the planning period of analysis	Increase reliability of the flood risk management system over the planning period of analysis	To the extent practicable, provide opportunities for recreation, natural resources, and cultural resources	Improve operability of the flood risk management system and decrease flood response and recovery time	Non-Structural	Prioritize Public Health and Safety	Maximize Resilience/ Reliability	Uniform Annual Exceedance Probability
1	Elevate structures	**X**	**X**					X	X		
2	Flood proof buildings	**X**	**X**	**X**	**X**			X			
3	Buyouts	**X**	**X**			**X**		X			
4	Relocation of residences/businesses/critical infrastructure	**X**	**X**				**X**	X	X		
12	Add ring levees	**X**	**X**	**X**	**X**			X	X		
15	Automate operations in the systems	**X**			**X**		**X**			X	X
22	Improve/increase debris control	**X**	**X**		**X**		**X**	X		X	
23	Relocate MCDD Headquarters out of floodplain (COOP plan)	**X**	**X**				**X**	X			
26	Aquatic invasive plants control/eradication						**X**	X		X	
27	Recreation trails on top of levees					**X**	**X**	X		X	
36	Education on flood risk		**X**					X	X	X	
37	Install/Improve signs for evacuation		**X**					X	X	X	
38	Removal of levee vegetation			**X**	**X**		**X**	X	X		
41	Establish “safe zones” for evacuation life/safety		**X**					X	X		
14	Improve Flood fight—improve access roads, remove restrictions for equipment, improve mobility of flood fighters		**X**	**X**			**X**	**X**			
5	Widen levees	**X**	**X**	**X**	**X**				X	X	X
7	Increase Levee heights (this includes cross levees, mainstem, slough)	**X**	**X**	**X**	**X**	**X**	**X**		X	X	X
10	Add pump capacity	**X**	**X**	**X**	**X**		**X**			X	X
13	Riprap (Bank Protection)	**X**	**X**	**X**	**X**		**X**		X	X	
20	Add redundancy for pump system	**X**		**X**	**X**		**X**			X	X
30	build additional levees/floodwalls	**X**	**X**	**X**	**X**				X	X	X
32	Rehab or replace mechanical/structural features (gates, valves, pumps)				**X**		**X**			X	X
33	Adjust/ensure levee slopes meet current standards	**X**	**X**	**X**	**X**				X	X	X
18	Complete seismic retrofits	**X**	**X**	**X**	**X**		**X**		X	X	
29	Improve/Increase seepage berms (this was specific to railroad embankment but could be anywhere)	**X**	**X**	**X**	**X**				X	X	X

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3.3.2.1. Alternative Strategy 1: No Action

Alternative Strategy 1 is the No Action Alternative (Future Without-Project condition). Under this alternative strategy, no Corps action would be taken with respect to addressing flood risk in the existing PMLS system. MCDD would continue to perform operation and maintenance activities.

3.3.2.2. Alternative Strategy 2: Non-Structural

Under this strategy, the feasibility of applying non-structural measures to reduce flood risks within the PMLS were evaluated. Non-structural measures target reducing the economic or life loss consequences in the event of a flood, and do not alter the nature or extent of the flood hazard. Non-structural measures included in this alternative are:

- Raise structures to include the max line/power station in PEN 1
- Conduct real estate buyouts to include Portland International Raceway and Heron Golf Course
- Implement a flood evacuation plan
- Relocate the MCDD Headquarters (COOP) out of MCDD

To allow for retention of floodwaters, the floodplain of PEN 1 would be reconnected to the Columbia River. This measure is possible if non-structural measures are implemented in the PEN 1 area. Two structural measures would be utilized in order to open up the floodplain area and allow for protection in the rest of the system to be maintained:

- Locate a setback levee at the Expo Center area in PEN 1
- Provide ring levees for Population at Risk and for security reasons; these would be located at both correctional facilities, as well as at the Air National Guard facilities and the Bonneville Power Administration substation

Figure 3-8 shows the components of this alternative strategy.

Figure 3-8 Alternative Strategy 2—Non-Structural

3.3.2.3. Alternative Strategy 3: Prioritize Public Health and Safety

Under this strategy, measures were identified that would lead to the best solution for life and safety. Measures in this alternative include the following structural and non-structural measures:

- Elevate structures such as the correctional facilities that were identified as the highest risks for population at risk in the area due to the complications associated with evacuating inmates; this measure may include securing the rooftop of the buildings
- Conduct real estate buyout of the Right to Dream Facility for transitioning homeless who are a PMLS population at high risk of flood impacts due to a lack of transportation options and communication challenges
- Provide ring levees at the airport fuel tanks, de-icer tanks, sub-stations, and air National Guard facilities, as these facilities affect national security response.
- Institute new zoning regulations for hazardous material tanks or other structures that could cause hazards to life and safety during and after flooding occurs
- Develop a risk education program including seismic risk coordination with USGS
- Provide signs/evacuation routes throughout designated emergency evacuation routes
- Remove levee vegetation specifically in MCDD near SDIC to avoid degradation
- Provide safe zones at the Expo Center, Portland International Airport, 142nd/cross levee, FedEx and Amazon distribution facilities

- Secure floating homes on the outside of the levee area that have broken loose in previous flood events and thereby create a hazard for the levee
- Widen levee in area where slope stability is an issue to reduce the chance of a levee breach prior to overtopping with minimal warning time.
- Increase levee heights near the Expo Center, I-5 off ramp area, under the I-5 overpass where the flood wall ends abruptly without a tie to high ground, at Airport Way and 142nd, at the I-84 off ramp, at Marine Drive and at the SDIC cross levee
- Conduct seismic retrofits throughout the system
- Provide flood warning systems in residential and population at risk areas

Figure 3-9 shows the components of this alternative strategy.

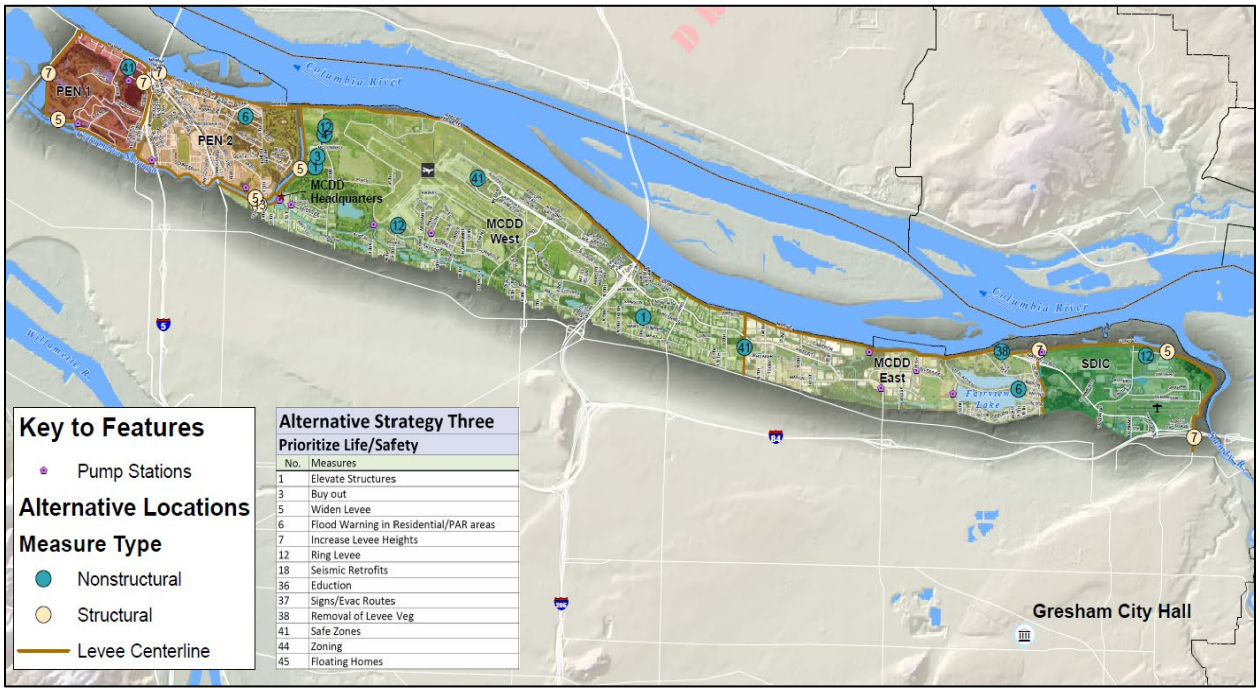

Figure 3-9 Alternative Strategy 3—Prioritize Life and Safety

3.3.2.4. Alternative Strategy 4: Maximize Resilience/Reliability

Under this strategy, measures are prioritized that lead to the best solution for maximizing resiliency and reliability in the system to address uncertain future conditions. Engineer Pamphlet 1100-1-2 defines resilience as the ability to anticipate, prepare for, and adapt to changing conditions and withstand and recover from disruptions. Engineer Manual 1110-2-1619 defines reliability as the likelihood of successful performance of a given project element over a specified time period. This alternative is comprised of both structural and non-structural measures including:

- Automate systems at the six pump plants with external discharge points and at the closure structures
- Improve debris removal, specifically trash racks/rakes (6 total). Trash racks/rakes can clog during large runoff events, which can cause pump stations to fail to evacuate water from the interior drainage system. Aquatic vegetation control throughout waterways to reduce this debris.
- Accommodate four-season maintenance road on levees, under I-205, cross levee at MCDD/PEN 2, and parallel levee to railroad to improve ability to inspect and flood fight during high water.
- Develop education program on flood risks, including sign installation
- Widen levee in areas where slope stability and/or seepage issues exist to improve reliability
- Increase levee heights to provide a higher level of risk reduction throughout or at targeted areas identified as weak areas, particularly at cross-levees to increase resilience of the system in the event of a failure at one location. Levee height increases include I-5 off ramp area, I-5 underpass, airport way at 142nd, I-84 off ramp, Marine Drive and SDIC cross levee
- Add pump capacity to the six pump stations with external discharge points and also the two pumps by the airport to increase the ability of a pump station to continue to marginally operate in the event of a failure of a single pump
- Supplement existing riprap to increase overall height of riprap on embankments to be resilient to potential more frequent high water events
- Add redundant power supply to pump stations
- Elevate structures, specifically the SDIC pump station
- Build additional levee/floodwall to include a parallel levee at the railroad embankment. Build additional cross-levee at I-205 to add redundancy.
- Rehabilitate or replace mechanical structures (gates)
- Automate floodwall closure in PEN 1. Replace and automate 142nd street valve and gate tower structure in MCDD/SDIC to prevent floodwaters from spreading in the event of a failure at MCDD-East or SDIC
- Re-shape levee slopes to meet current levee standards

Figure 3-10 shows the components of this alternative strategy.

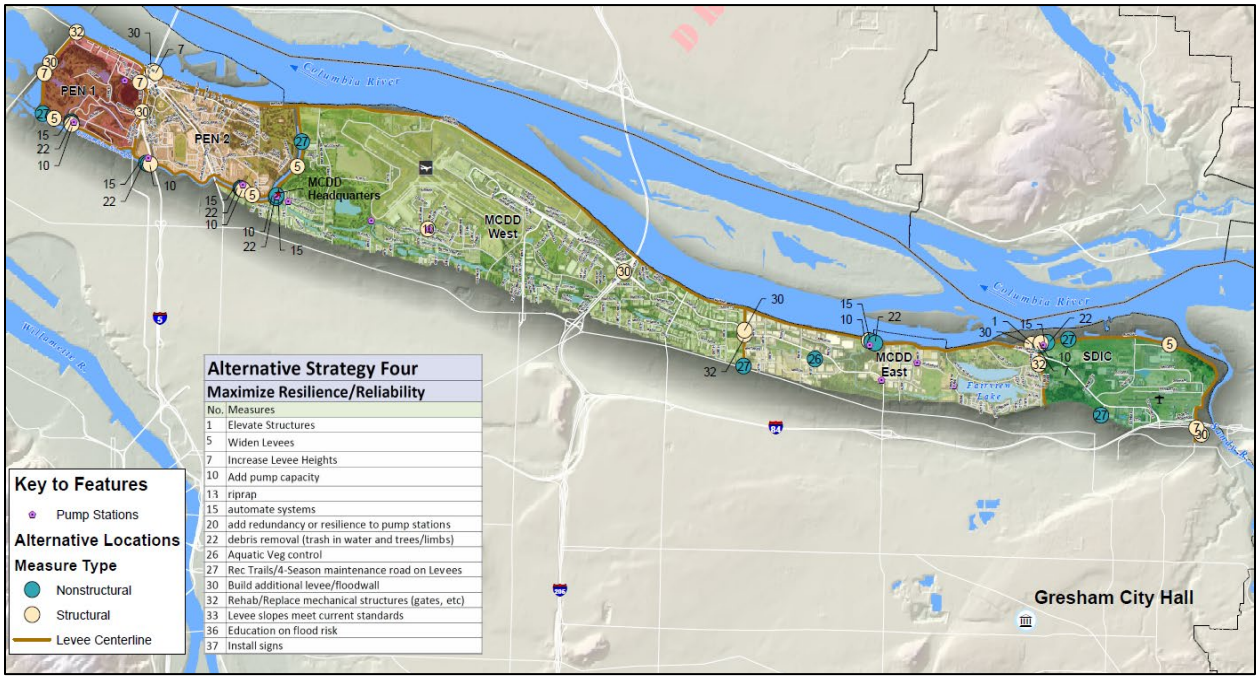

Figure 3-10 Alternative Strategy 4—Maximize Resilience/Reliability

3.3.2.5. Alternative Strategy 5: Uniform Annual Exceedance Probability (AEP)

This strategy formulates an alternative to address inconsistencies within the PMLS related to AEP and provide a more uniform AEP across the system. This alternative focuses more on the external sources of flooding rather than cross levees and resilience/redundancy measures. Measures include the following:

- Widen levees at Columbia Slough areas and construct a parallel levee at the railroad embankment to address the poorer performance of these areas relative to the rest of the system.
- Increase levee heights, including cross levees, up to the AEP of MCDD. PEN 1 and PEN 2 are at lower elevations than the rest of the system.
- Riprap in the Columbia Slough area of MCDD to ensure consistency of bank protection through the system.
- Build additional levees/floodwalls to extend the floodwall and close gap area under I-5 bridge
- Accommodate four-season maintenance road on levee under I-205
- Adjust/ensure levee slopes meet current levee standards

Figure 3-11 shows the components of this alternative strategy.

Figure 3-11 Alternative Strategy 5—Uniform Annual Exceedance Probability

3.3.3. Initial Array of Alternatives

The next iteration of plan formulation included a review of the measures making up the alternative strategies and a review and screening of the strategies themselves. This was completed during a Formulation Workshop in February 2019. The screening of these measures was informed by available data as modeling and assessment of the levees were underway and additional site visits had been conducted.

3.3.3.1. Measure Screening

During the workshop the measures were again reviewed, resulting in some of them being eliminated from further consideration. Rationale for eliminating the measures is included in Table 3-17. The remaining measures listed in Table 3-18 were reviewed as part of the array of alternatives.

Table 3-17 Measures Eliminated During Formulation Workshop

Measures	Screening Rationale
1 – Elevate structures	Prohibitive costs and difficulty in identifying assets to be protected. Measure is not a cost-effective means of protecting structures and population at risk within the PMLS.
2 – Flood proof buildings	Eliminated as a stand-alone measure due to cost and difficulty in selecting specific assets to include. Measure is not a cost-effective means of protecting structures and population at risk within the PMLS.
3 – Buyouts	Inclusion was based on potential for targeted approach, especially in PEN 1, associated with the potential for using buyouts to open up the floodplain; preliminary evaluation shows this is not likely to be effective and should be eliminated
4 – Relocation of residences/businesses/critical infrastructure	Not a standalone measure; relocations may be necessary in combination with construction of other measures. Measure is not a cost-effective means of protecting structures and population at risk within the PMLS.
18 – Complete seismic retrofits	High-consequence event associated with flood and earthquake concurrently (very low-probability); cost to address is expected to be very high; note that residual risk associated with seismic risk should be documented.
26 – Aquatic invasive plants control/eradication	Control and eradication of aquatic plants within the levee districts is a long-term task. Will be addressed within operation and maintenance but Measure #22 already addresses this at pump stations.
27 – Recreation trails	Deferred until after alternatives are developed and may be added later. Direction is to evaluate only flood risk at this time.
33 – Adjust/ensure levee slopes meet current standards	Adjusting levee slopes will be included as part of other measures (5 and 7), not stand-alone.
38 – Removal of levee vegetation	Removal of vegetation is a maintenance item, not a flood risk measure.

Table 3-18 Measures Carried Forward From Formulation Workshop

Measures	Notes
Levee Measures	
5 – (Widen levees) Improve levee performance and reliability	Targeting geotechnical needs could apply at any site where need is identified. Measure could be made up of several sub-measures depending on site: a. Widen levee, b. Install or rehab toe drains, c. Install relief wells.
7 – Increase levee heights (this includes cross levees, mainstem, slough)	Increase levee heights where low areas are identified by modeling. This may also include widening as necessary for construction.
13 – Bank protection	There may be reaches of levee where bank protection is a risk to the levee performance.
29 – Seepage control measures (e.g. improve/increase seepage berms)	Lower-elevation stability berms not necessarily limited to railroad berm and may include other types of seepage controls.
30 – Build additional levees/floodwalls	Add levees or floodwalls where necessary to reduce risk of overtopping.
Pump Station Measures	
10 – Add pump capacity	Add capacity to pump stations where the existing capacity is not capable of pumping the necessary volume.
20 – Add redundancy for pump system	Add redundancy to the pump system to improve reliability; could include redundant power source.
32 – Rehab or replace mechanical/structural features (gates, valves, pumps)	Rehabilitate or replace mechanical or structural feature within the system; could include liquefaction/seismic considerations for structural features (buildings and foundations).
Non-Structural Measures	
6 – Flood warning	This was previously eliminated, however flood warning time with a levee failure could be between 2 and 4 hours. Therefore, flood warning will be evaluated as a possible measure.
14 – Improve flood fight	All-seasons maintenance access to areas needed for flood fight.
15 – Automate operations in the systems	Automate pumps and closure structures where the need is identified to improve system operations.
22 – Improve/increase debris control	Control debris within the system with trash rakes, rake upgrades, other operational changes.
23 – Relocate MCDD Headquarters out of floodplain (COOP plan)	Relocate the HQ offices out of the floodplain.
36 – Education on flood risk	Provide education on the flood risks within the study area. This measure is to be included in all the alternatives.
37 – Install/improve signs for evacuation	Install signs on evacuation routes.
41 – Establish “safe zones” for evacuation life/safety	Establish safe zones to be associated with a flood warning and evacuation plan in the event of levee failure.

3.3.3.2. Alternative Strategy Screening

The PDT reviewed the initial array of alternative strategies and conducted a new round of screening. Analysis of the alternative strategies and associated measures following the charrette was conducted by applying criteria from Corps guidance and the P&G. The P&G suggests the use of four evaluation criteria in comparing alternative plans:

- **Completeness—**The extent to which the alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
- **Effectiveness—**The extent to which the alternative plan meets the objectives.
- **Efficiency—**The extent to which the alternative plan is the most cost-effective means of alleviating risk to the public.
- **Acceptability—**The workability and viability of the alternative plan with respect to acceptance by Federal and non-Federal entities and the public, and compatibility with existing laws, regulations, and public policies.

This comparison and screening resulted in the screening out of Alternative Strategy 2. This strategy evaluated the feasibility of applying non-structural measures to reduce flood risks within the PMLS. Non-structural measures included in this alternative were: raise structures to include the MAX line/power station in PEN 1; buyouts to include Portland International Raceway and Heron Golf Course; implement a flood evacuation plan; and relocate the MCDD headquarters out of MCDD. In addition, two structural measures were included (setback levee and ring levees). In order to open up the floodplain area, a setback levee would be located at the Expo Center area in PEN 1. For security reasons, ring levees would be utilized for population at risk (PAR) at both correctional facilities, Air National Guard facilities, and the Bonneville Power Administration substation. Table 3-19 shows the application of the P&G criteria to Alternative 2.

Table 3-19 Alternative Strategy 2 Compared to P&G Criteria

Completeness	Effectiveness	Efficiency	Acceptability
Incomplete, measures included in this alternative only reduce flood risk to some areas within the system, but the system as a whole has similar or high risks compared to without project conditions	Only partially meets planning objectives several structures would have increased flood risk especially within Pen 1	Setback levee, ring levee, and buyouts are not as efficient as other measures that address the same problem,	Ring levees were determined to not be technically feasible; setback levee and buyouts are not acceptable to affected parties

Based upon preliminary modeling results, it was found that Alternative 2 did not reduce the water surface profiles and therefore did not meet flood risk management objectives or the purpose and need for the project. Alternative Strategy 2 was therefore eliminated from further consideration as a standalone alternative based upon application of the criteria. However, the non-structural measures were carried forward and evaluated as part of the remaining alternatives.

3.3.4. Focused Array of Alternatives

The Alternative Strategies and associated measures were further refined through a focused Plan Formulation PDT Workshop (March 29, 2019) to develop a set of alternative plans for more detailed development and evaluation. These are listed in Table 3-20. This stage of alternative development relied upon modeling and analysis being conducted for the study to date including without-project levee assessments, hydraulic modeling, and pump station assessments. The results of these analyses and assessments contributed technical information that informed the PDT decisions for which measures were necessary to meet planning objectives.

Table 3-20 Alternatives that Resulted from Each Strategy

Alternative Strategy	Resultant Alternative Plan
Prioritize Public Health and Safety Alternative Strategy	Alternative 3
Maximize Resilience/Reliability Alternative Strategy	Alternative 4
Uniform Annual Exceedance Probability Alternative Strategy	Alternative 5

These data helped inform the further development of the focused array of alternatives. Measure were sited at specific locations where they would be appropriate to address levee fragility, overtopping, and pump station vulnerabilities as well as the population at risk. While the initial array was based on the identified problems and opportunities, the development of the focused array included physically identifying locations, extent and configuration of measures in areas to address the problems that have been identified based on levee analysis modeling results.

During the development and refinement of the focused array of alternatives several measures were evaluated and further screened. Ring levees and bank protection were eliminated from inclusion in the alternatives for the reasons listed Table 3-21. The scale of the levee raise at PEN 1 and PEN 2 in Alternative 5 was originally evaluated with approximately an 8 foot raise, but it was modified to a 3-4 foot raise at this time, as the costs and real estate requirements for an 8 foot raise were extreme in comparison to the associated benefits. Measures to increase levee height of the north end of the cross-levee between PEN 1 and PEN 2 were screened as model development matured. A seepage analysis was performed for the I-5 embankment just east of the Denver Avenue cross-levee at the north end. The I-5 embankment is very wide and is estimated to effectively serve as a barrier to floodwaters should the Denver Avenue cross-levee breach at the low spot near the on-ramp cloverleaf. The I-5 embankment serves as a barrier to flow up to elevation 35 feet NAVD88. Measures to increase heights of the cloverleaf were screened, since these measures would likely impact the nearby MAX station and adjacent wetlands without providing significant benefit.

Table 3-21 Measures Eliminated During Refinement of the Focused Array of Alternatives

Measure	Screening Rationale
Ring Levee	Conceptual alignments and quantities were developed for ring levees. The cost of implementation and possible impacts show that they are not viable measures; therefore, they were eliminated from further consideration.
Bank Protection	Erosion concerns were considered, and sites visited. There are not bank erosion issues that pose risk to the flood risk management system; therefore, this measure was not carried forward.

The focused array of alternatives was carried forward to evaluate their performance in addressing flood risks and potential for impacts to other resources in the study area. Alternatives 3, 4 and 5 are described in detail in the next sections.

3.3.5. Alternative Descriptions

The focused array of alternatives is described in the following pages including description of what measures they include, and maps showing locations of each measure. Maps for each alternative include an overview of the entire PMLS, as well as close-up maps of individual districts. For the close-up maps, MCDD West is divided into two areas: MCDD West (A) is the western portion and MCDD (B) is the eastern portion. Dividing MCDD West into these two areas was done to maintain a similar scale for all close-up maps: there is no actual physical boundary or cross-levee between the A and B areas. Designs are in included in Appendix D (Civil Design).

3.3.6. Alternative 3

This alternative includes measures that were identified to focus on solutions to reduce risks to life, public health and safety. This alternative includes both structural and non-structural measures as described in Table 3-22 and shown on the following maps (Figure 3-12 through Figure 3-17). This includes levee improvements within PEN 1 and PEN 2 in order to reduce risks associated with levee fragility and low spots in the existing system, replacement of the pump station in SDIC because this pump station was found to have an undersized intake and is potentially inundated by larger storm events. It also includes several non-structural measures throughout the study area to improve flood risk awareness, improve flood warning times, and better identify evacuation routes and safe zones.

Table 3-22 Alternative 3 Measures and Description

No.	Measures	Description
5	**Improve Levee Performance and Reliability**	Modifications in PEN 1 Columbia Slough areas include widening PEN 1 levee along the slough, railroad embankment seepage berm, and PEN 1 seepage controls. In MCDD West, includes widening and seepage controls at the Peninsula Slough cross levee.
6	**Flood Warning in Residential/PAR areas**	Revise and Update flood hazard and evacuation plans for Portland, Port of Portland, and Multnomah County Multi-Jurisdictional Natural Hazard Mitigation Plan NHMP (Multnomah County, 2017) to include flood risk information resulting from this feasibility study. Develop expanded communication and evacuation plans.
7	**Increase Levee Heights**	Extend the floodwall under I-5, raise levee elevation at the Columbia River homes along Marine Drive.
20	**Add Redundancy for Pump System**	Elevation and replacement of the SDIC Sandy Pump Station with a new pump station.
36	**Education**	Develop flood risk education materials for the population at risk and visitors within the study area. Materials will be based on flood risk information to be developed related to the levees. This effort will be coordinated with USGS to incorporate seismic aspects, as well as emergency responders and educators to meet a broad audience.
37	**Signage for Evacuation**	Install flood hazard and evacuation route signage throughout the study area including designated evacuation routes.
41	**Safe Zones**	Develop designated safe zones at high points within the PMLS for those that cannot evacuate from the floodplain. Would be implemented in conjunction with Measure 6.

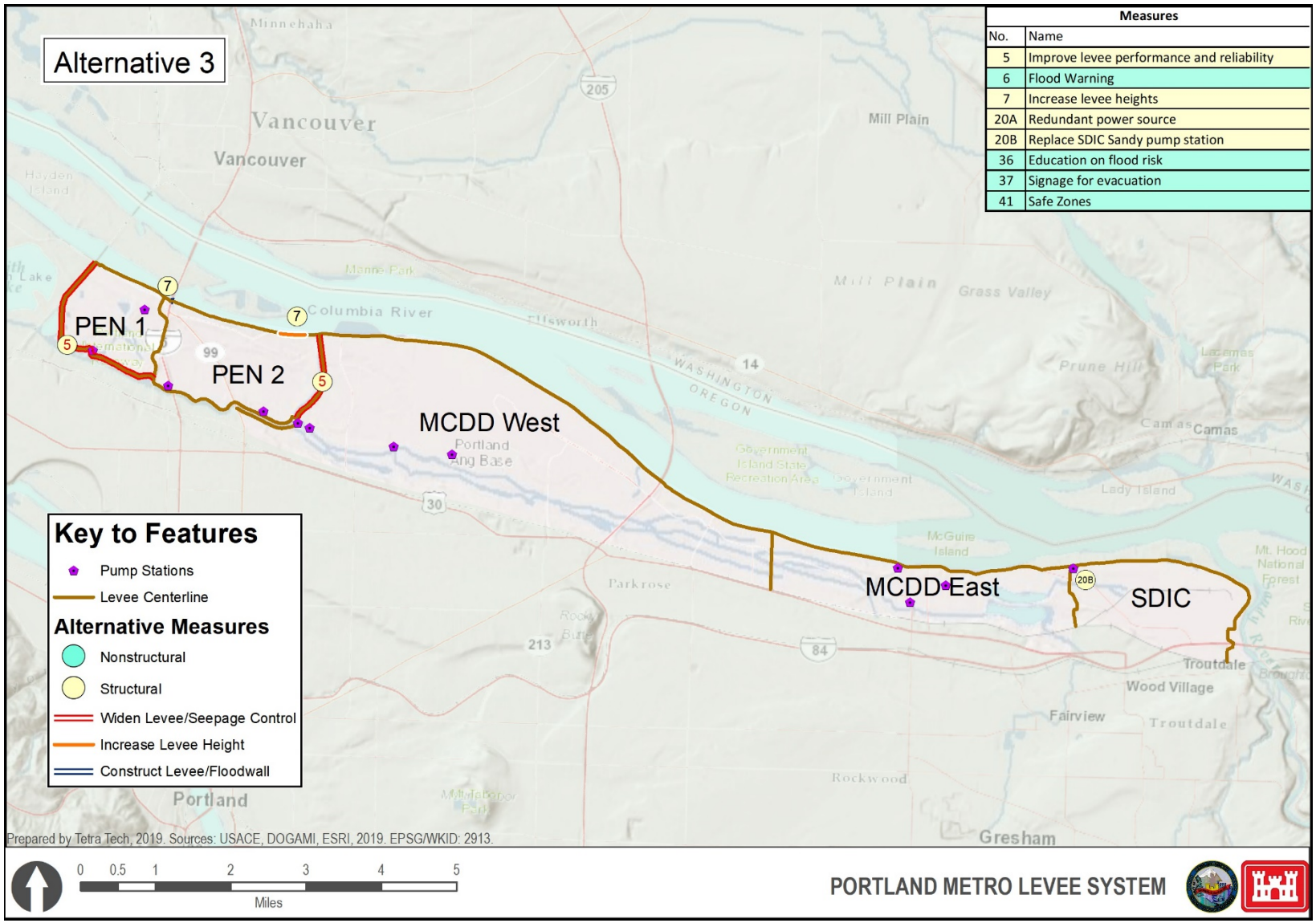

Figure 3-12 Alternative 3—Overview Map

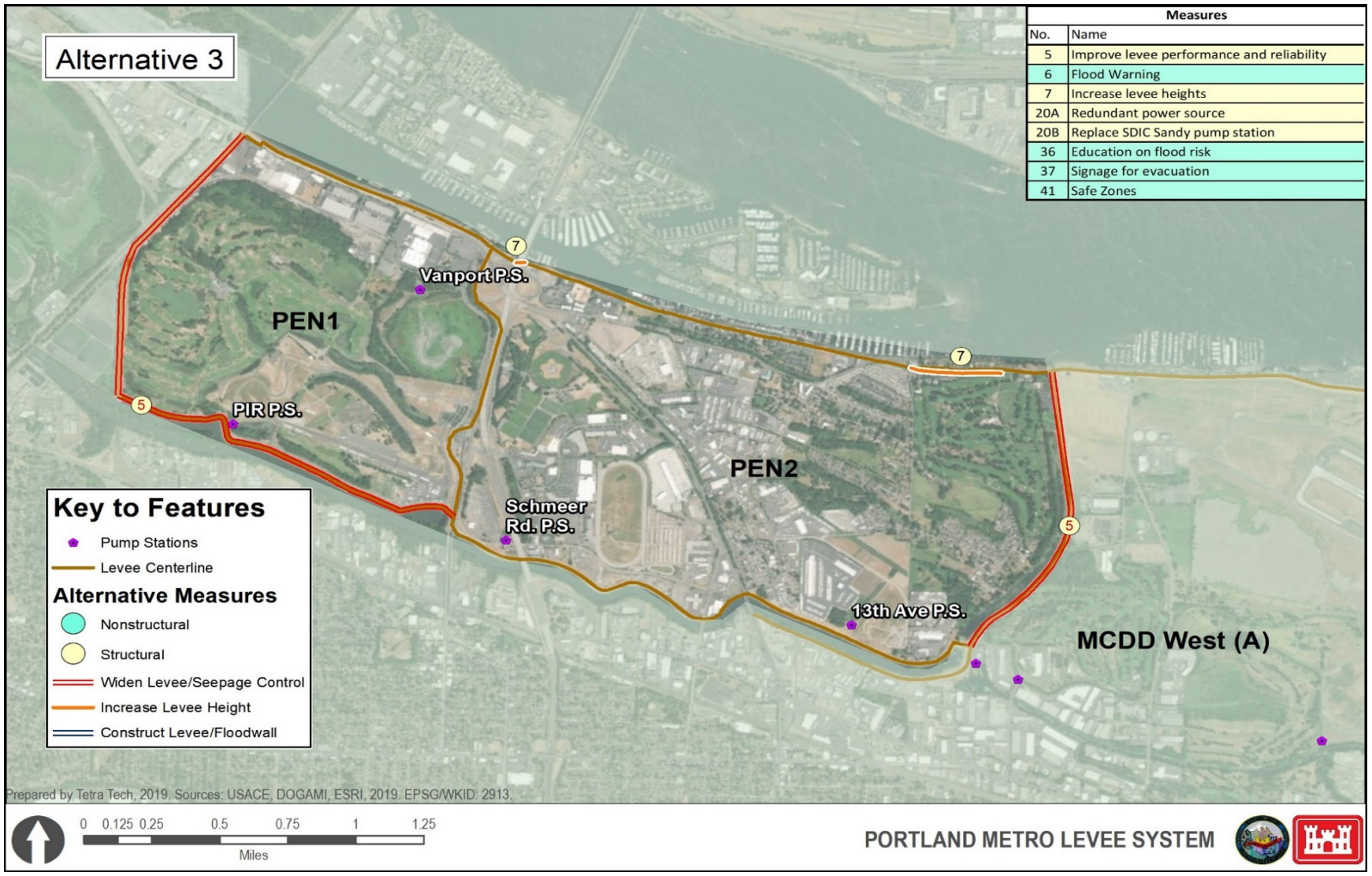

Figure 3-13 Alternative 3—PEN 1 and PEN 2

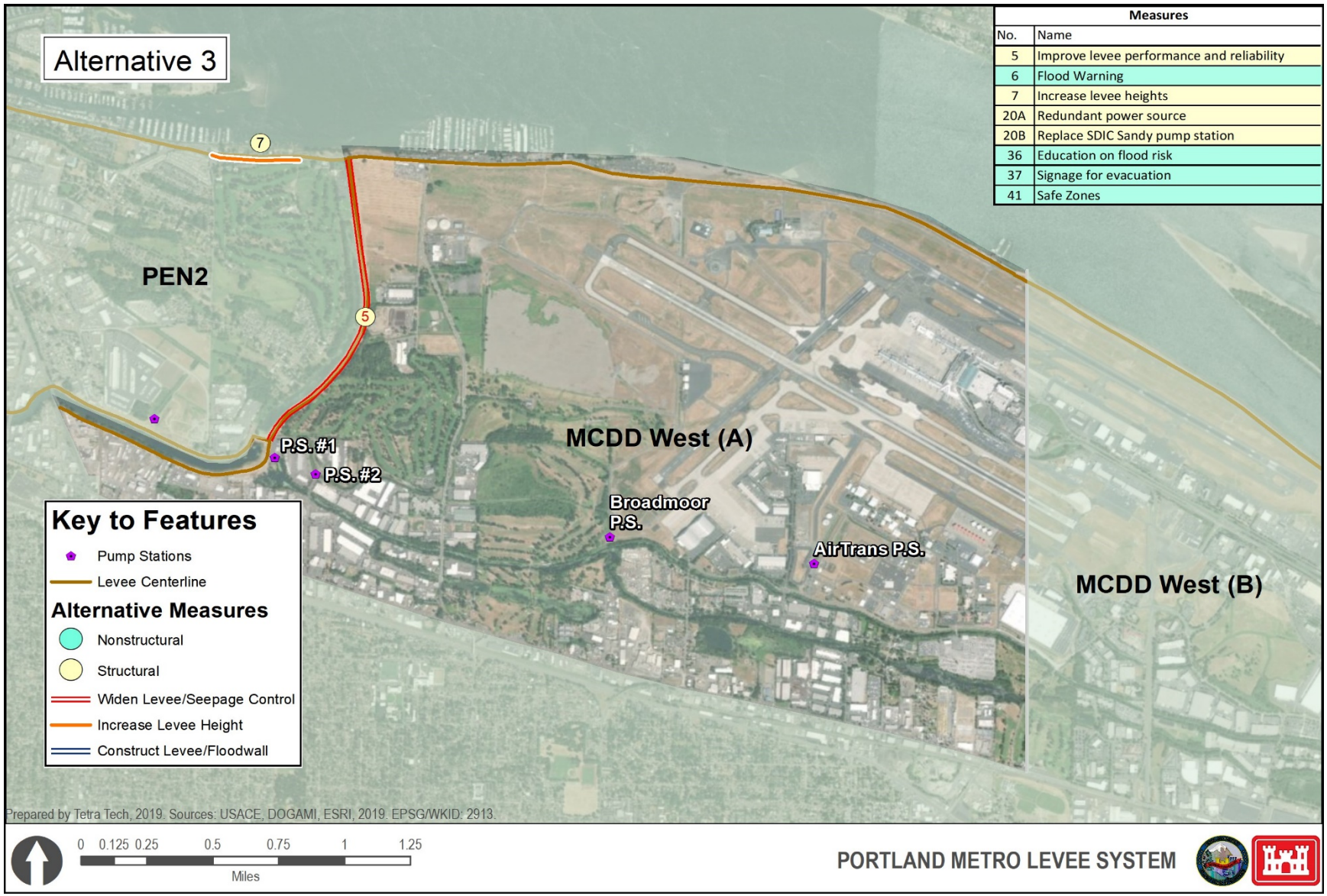

Figure 3-14 Alternative 3—MCDD West (A)

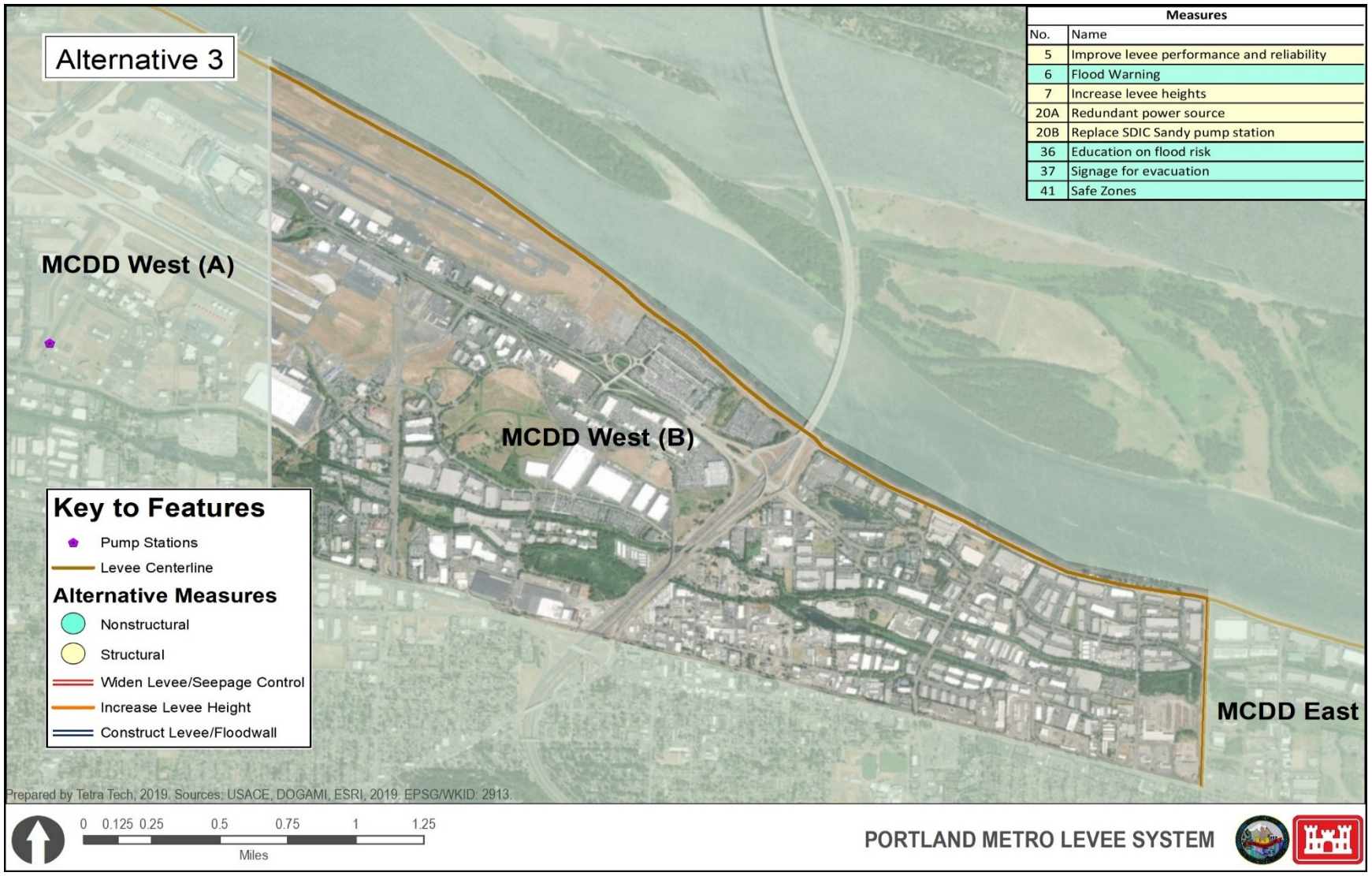

Figure 3-15 Alternative 3—MCDD West (B)

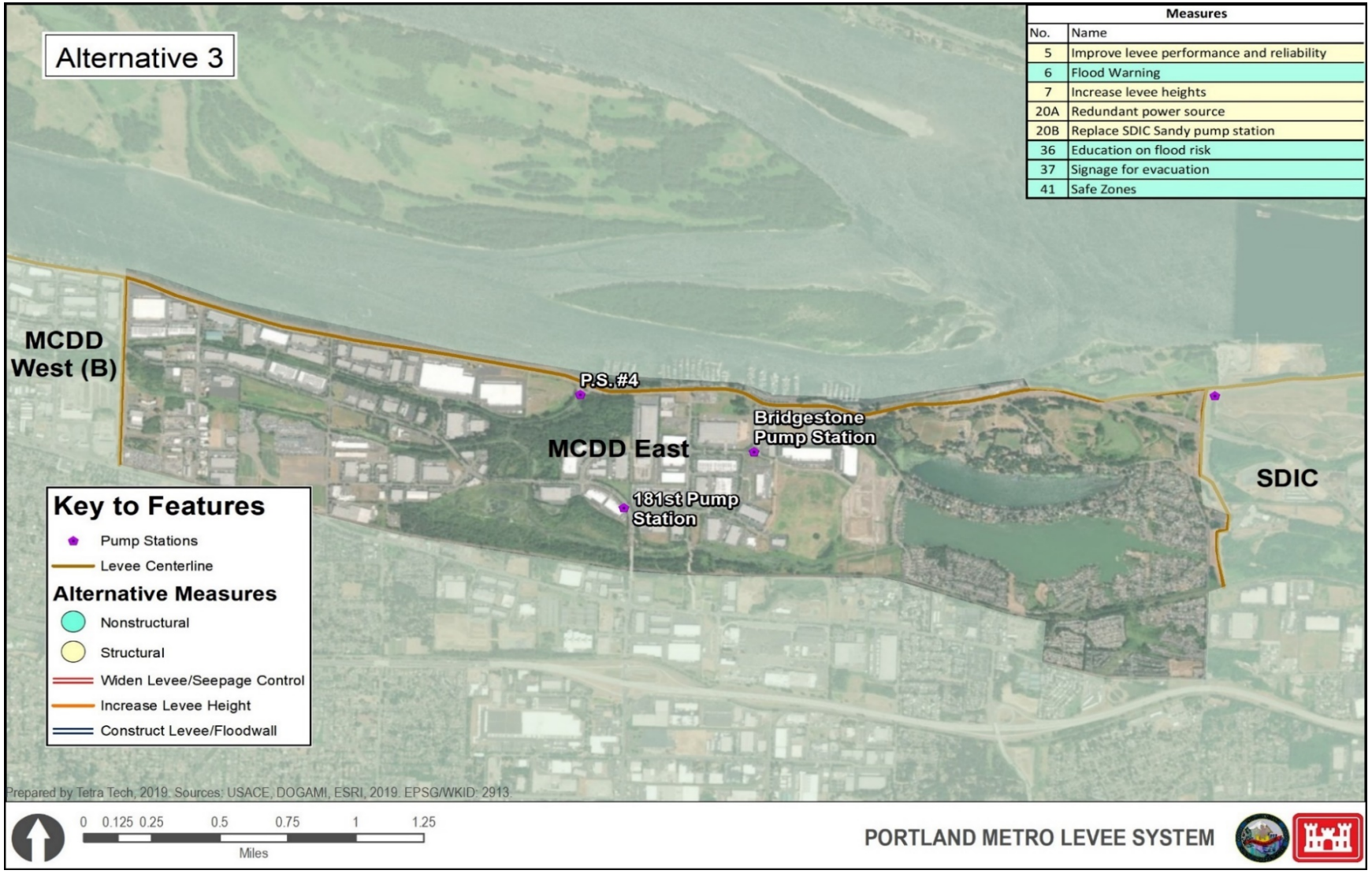

Figure 3-16 Alternative 3-MCDD East

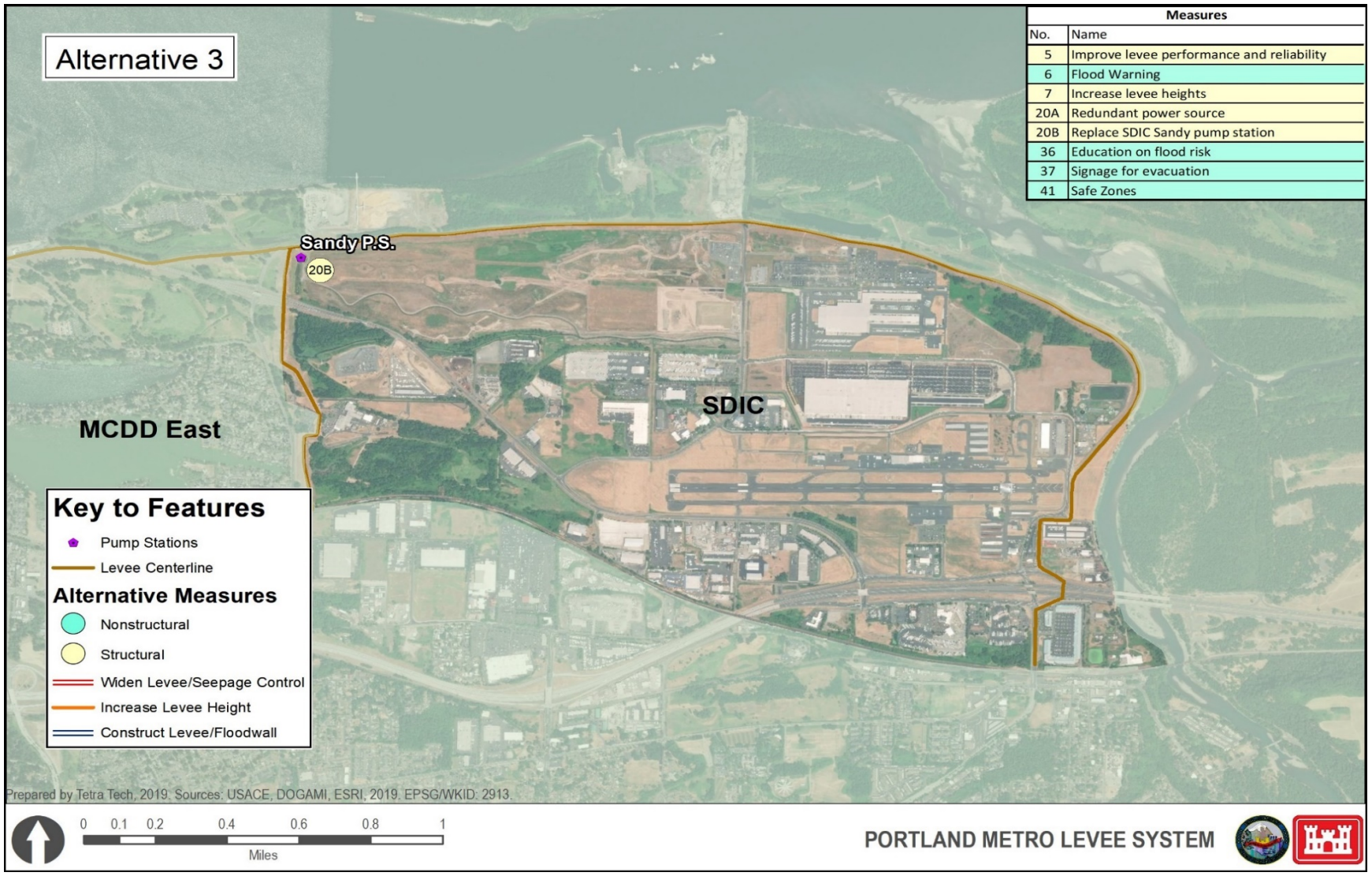

Figure 3-17 Alternative 3—SDIC

3.3.7. Alternative 4

This alternative prioritizes those measures that improve resiliency and reliability in the system in the event of failure in part of the system. Both structural and non-structural measures are included in this alternative. It includes measures to improve levees, raise levees in several locations and replace closure structures to increase resiliency and reliability by reducing risks from fragility and overtopping. It also includes measures to improve pump stations through additional capacity, add redundancy to the pumping system, and replace mechanical structures. Non-structural measures include improving flood fighting and maintenance roads to 4-season accessibility, adding signage for evacuation and flood risk education. Measures in this alternative include both structural and non-structural measures described in Table 3-23 and shown on the following maps (Figure 3-18 through Figure 3-23).

Table 3-23 Alternative 4 Measures and Description

No.	Measures	Description
5	**Improve Levee Performance and Reliability**	Modifications in PEN 1 Columbia Slough areas include widening PEN 1 levee along the slough, and PEN 1 seepage controls. A parallel levee is included at the railroad embankment as part of Measure 30. In MCDD West, includes widening and seepage controls at the Peninsula Slough cross levee. At SDIC, includes widening from the cross levee to Sundial Avenue.
6	**Flood Warning in Residential/ PAR areas**	Revise and Update flood hazard and evacuation plans for Portland, Port of Portland, and Multnomah County NHMP to include flood risk information resulting from this feasibility study. Develop expanded communication and evacuation plans.
7	**Increase Levee Heights**	Extend the floodwall under I-5. Raise levee elevation at the Columbia River homes along Marine Drive, along the 223rd Avenue/SDIC Cross levee, at the low spot in the Columbia River SDIC levee, and at the upstream end of SDIC south of I-84 near the Troutdale outlet mall.
10	**Add Pump Capacity**	Add capacity at pump stations where the need has been identified. (PEN 2 13th Avenue Intake, MCDD Pump Station 2 pumps and discharge lines, PEN 1 PIR replace pump 2).
14	**Improve Flood Fight**	Develop 4-season maintenance road on cross levee at MCDD/PEN 2, railroad parallel levee.
15	**Automate Systems**	Automate floodwall closure, 142nd street valve and culverts, SDIC gate tower.
20	**Add Redundancy to Pump Stations**	Elevation and replacement of SDIC Sandy Pump Station, and installation of redundant power sources within the system of pump stations.
22	**Debris Removal (trash in water and trees/limbs)**	Trash rakes replaced at MCDD-AirTrans, MCDD Pump Station 4, and MCDD Broadmoor.
30	**Build Additional Levee/Floodwall**	Raise Airport Way and Marine Drive so that closure structures are not required. Also includes a parallel levee at the PEN 1 railroad embankment.

No.	Measures	Description
32	**Rehab/Replace Mechanical Structures (gates, etc.)**	Rehab or replace mechanical structures (gates), SDIC gate tower, 142nd Avenue Valve (Between MCDD East and West).
36	**Education**	Develop flood risk education materials for the population at risk and visitors within the study area. Materials will be based on flood risk information to be developed related to the levees. This effort will be coordinated with USGS to incorporate seismic aspects, as well as emergency responders and educators to meet a broad audience.
37	**Signage for Evacuation**	Install flood hazard and evacuation route signage throughout the study area including designated evacuation routes.
41	**Safe Zones**	Develop designated safe zones at high points within the PMLS for those that cannot evacuate from the flood-plain. Would be implemented in conjunction with Measure 6.

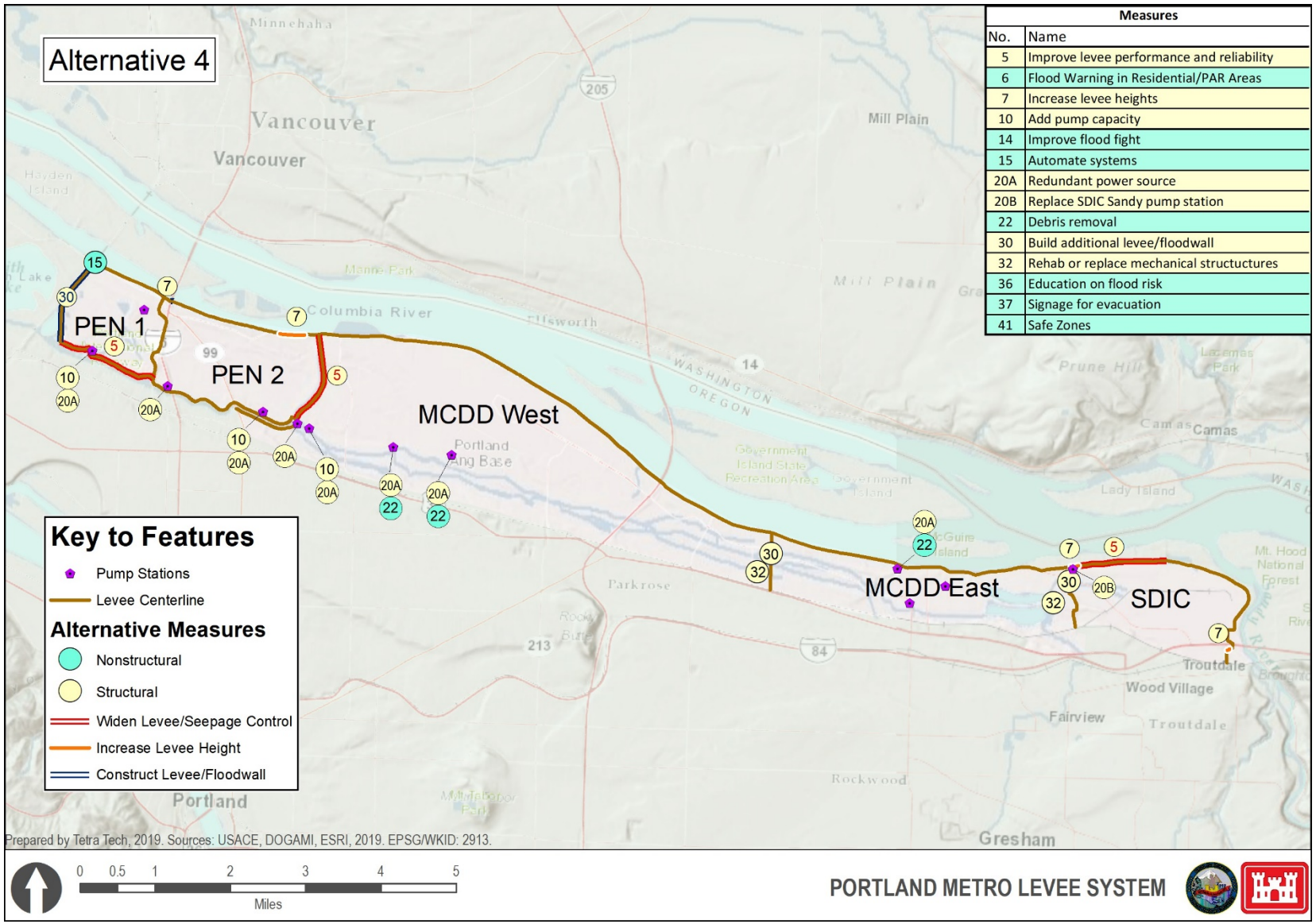

Figure 3-18 Alternative 4—Overview Map

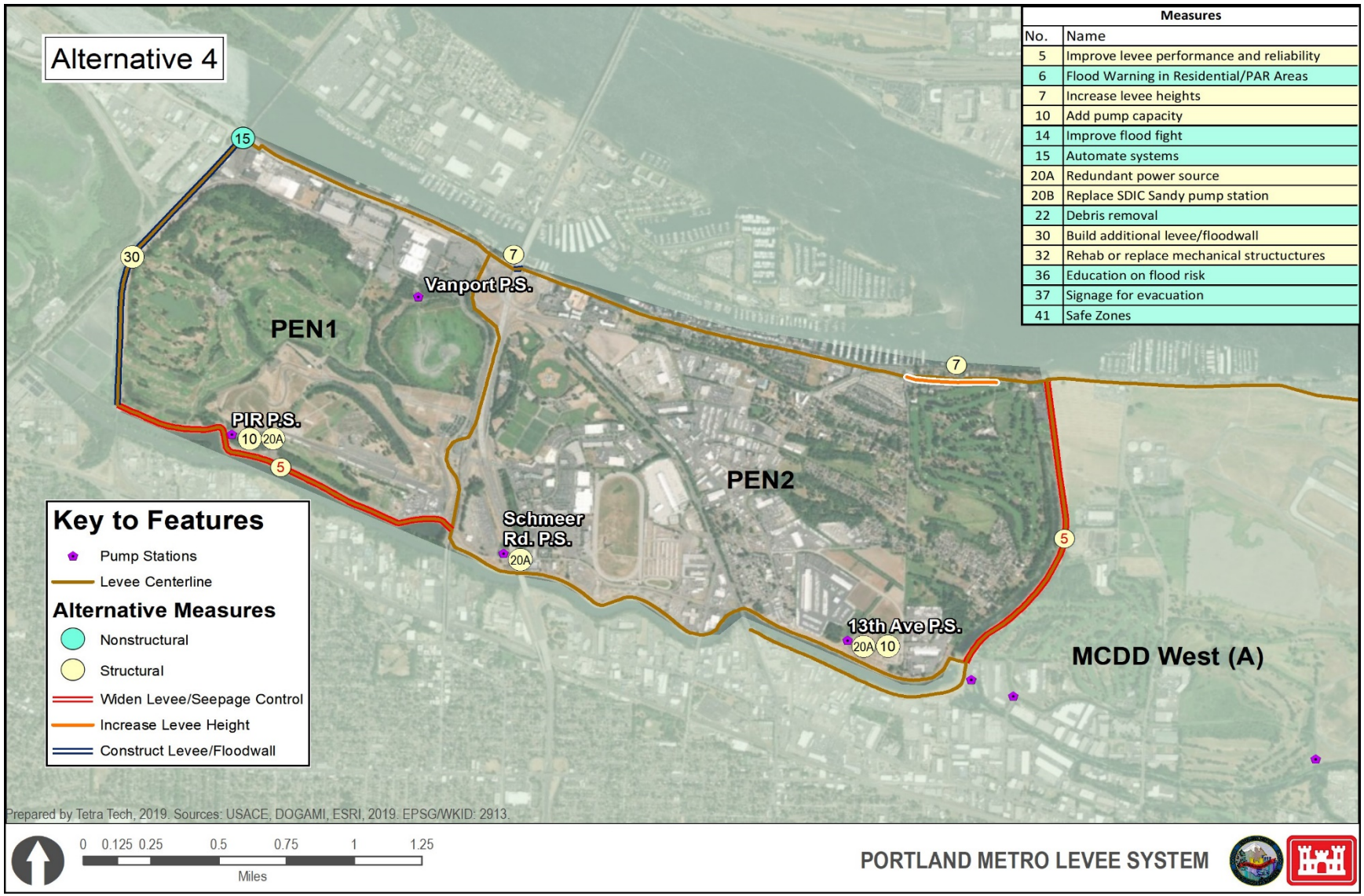

Figure 3-19 Alternative 4—PEN 1 and PEN 2

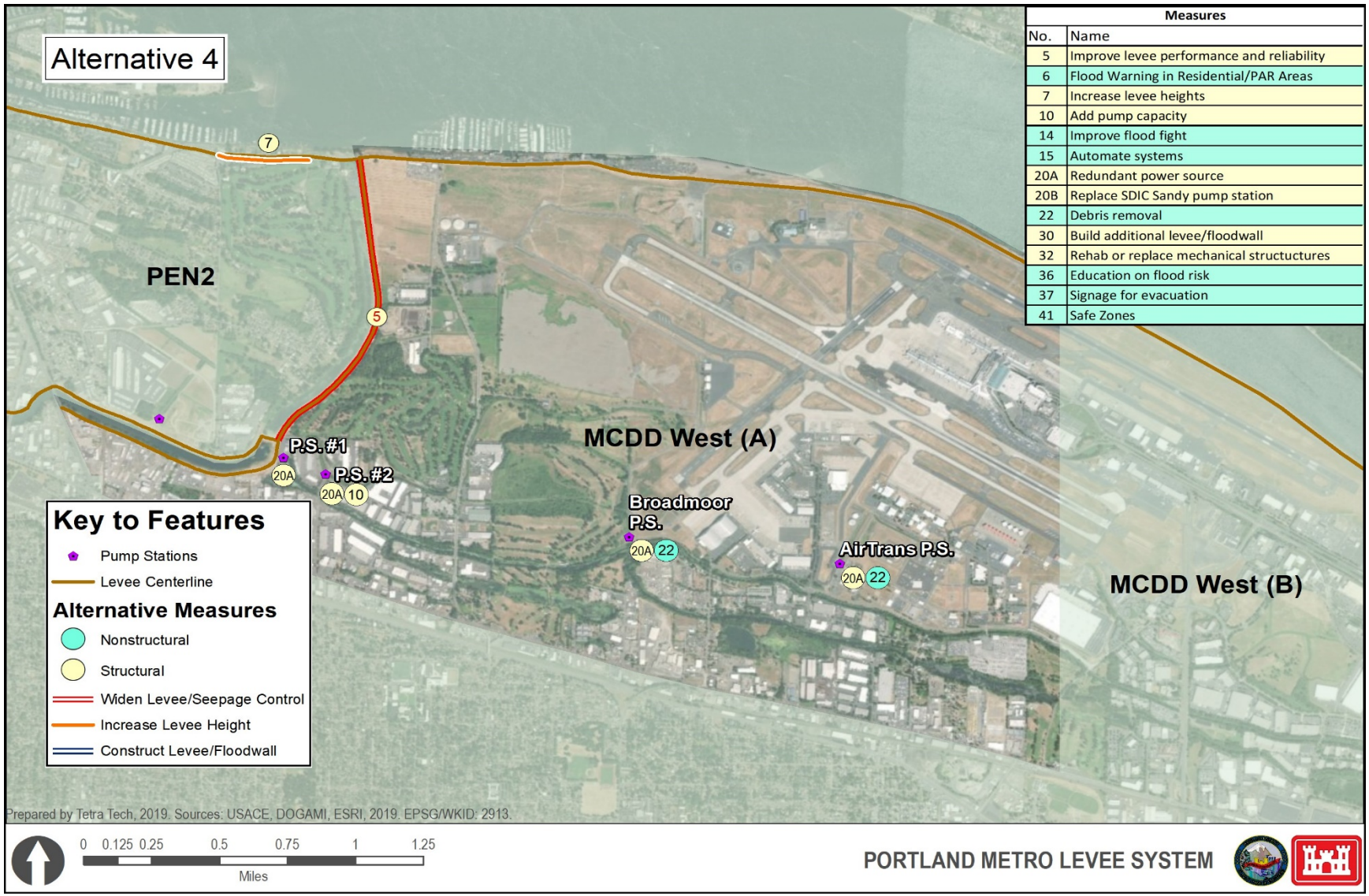

Figure 3-20 Alternative 4—MCDD West (A)

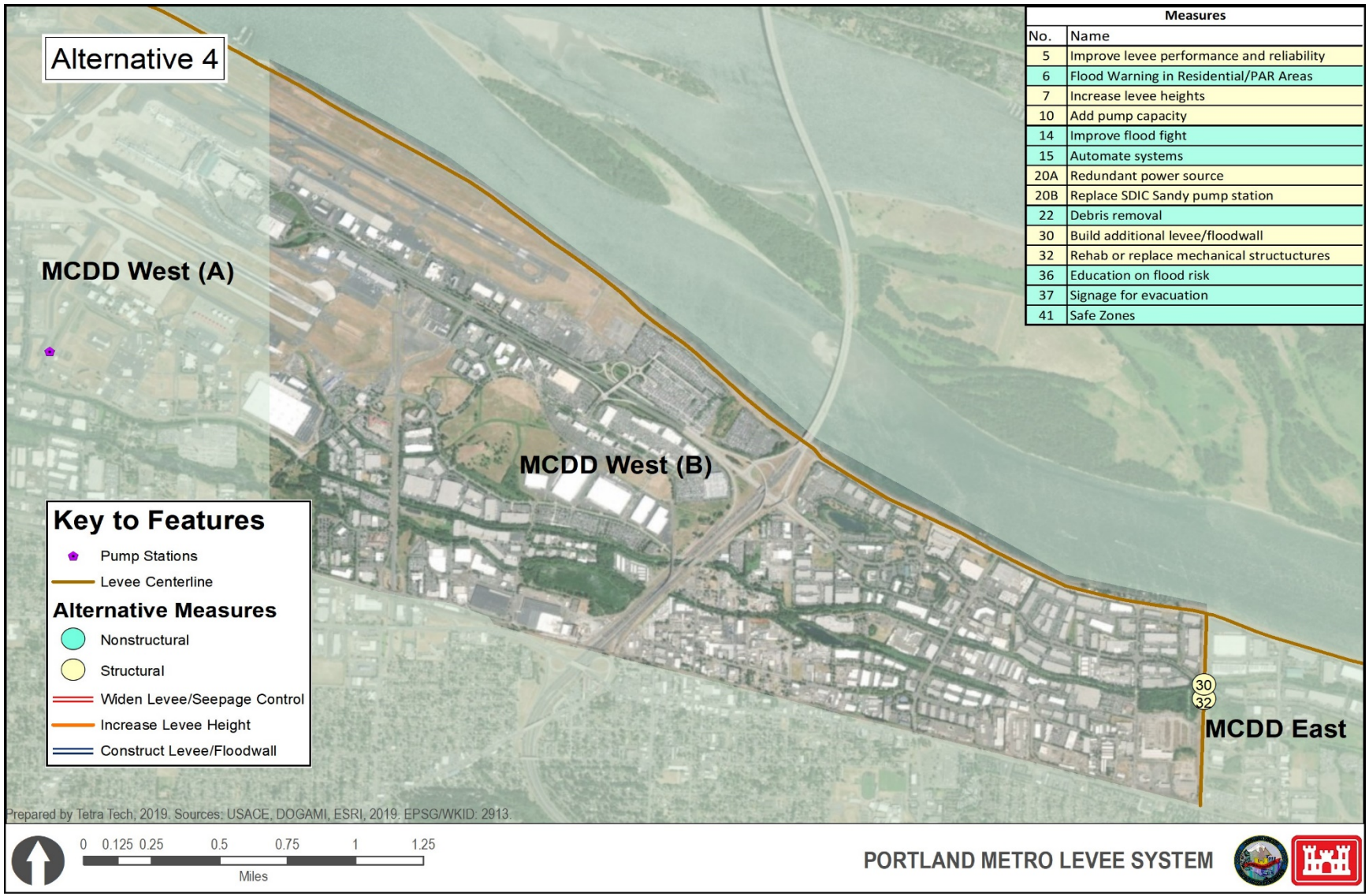

Figure 3-21 Alternative 4—MCDD West (B)

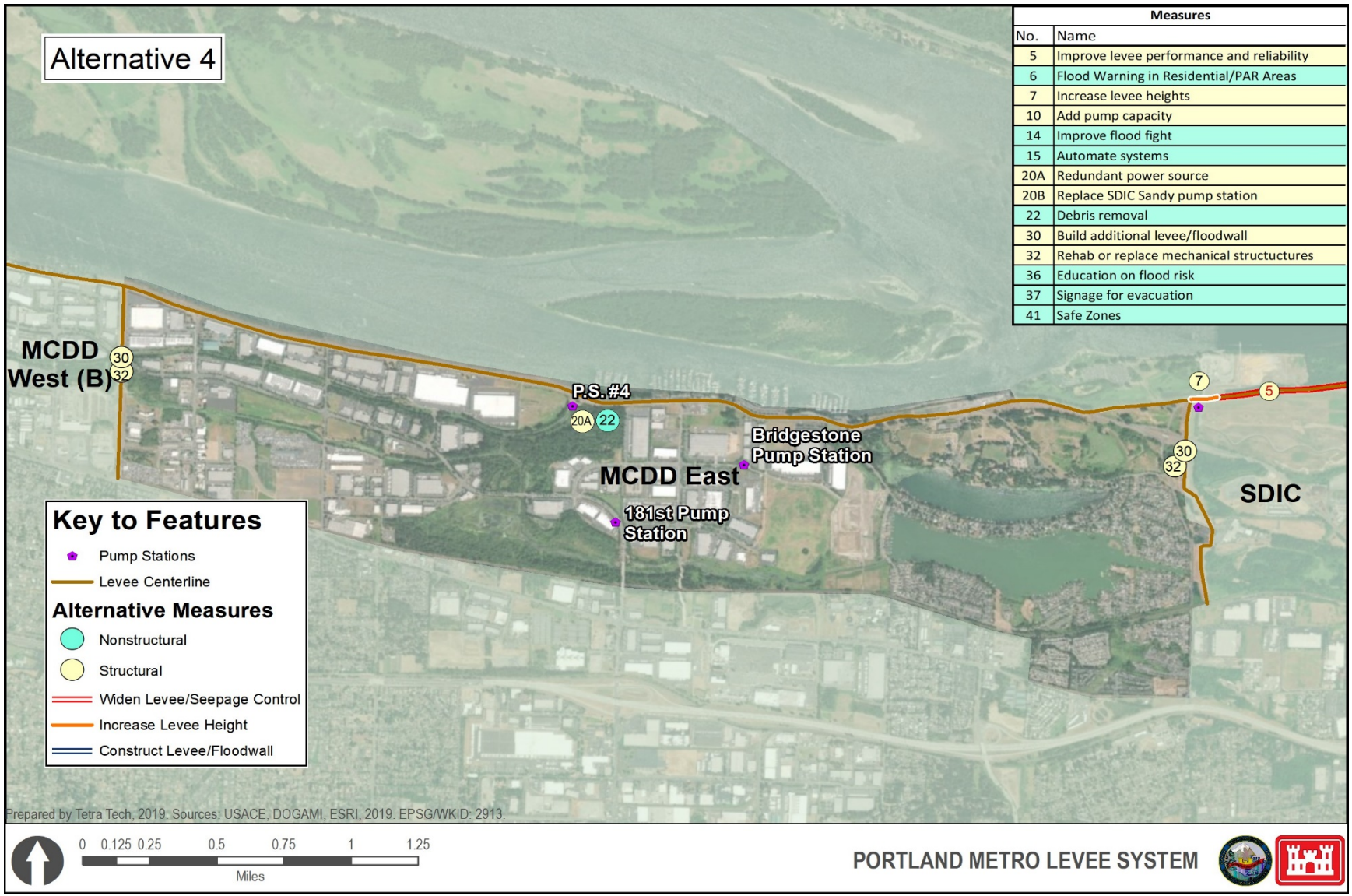

Figure 3-22 Alternative 4-MCDD East

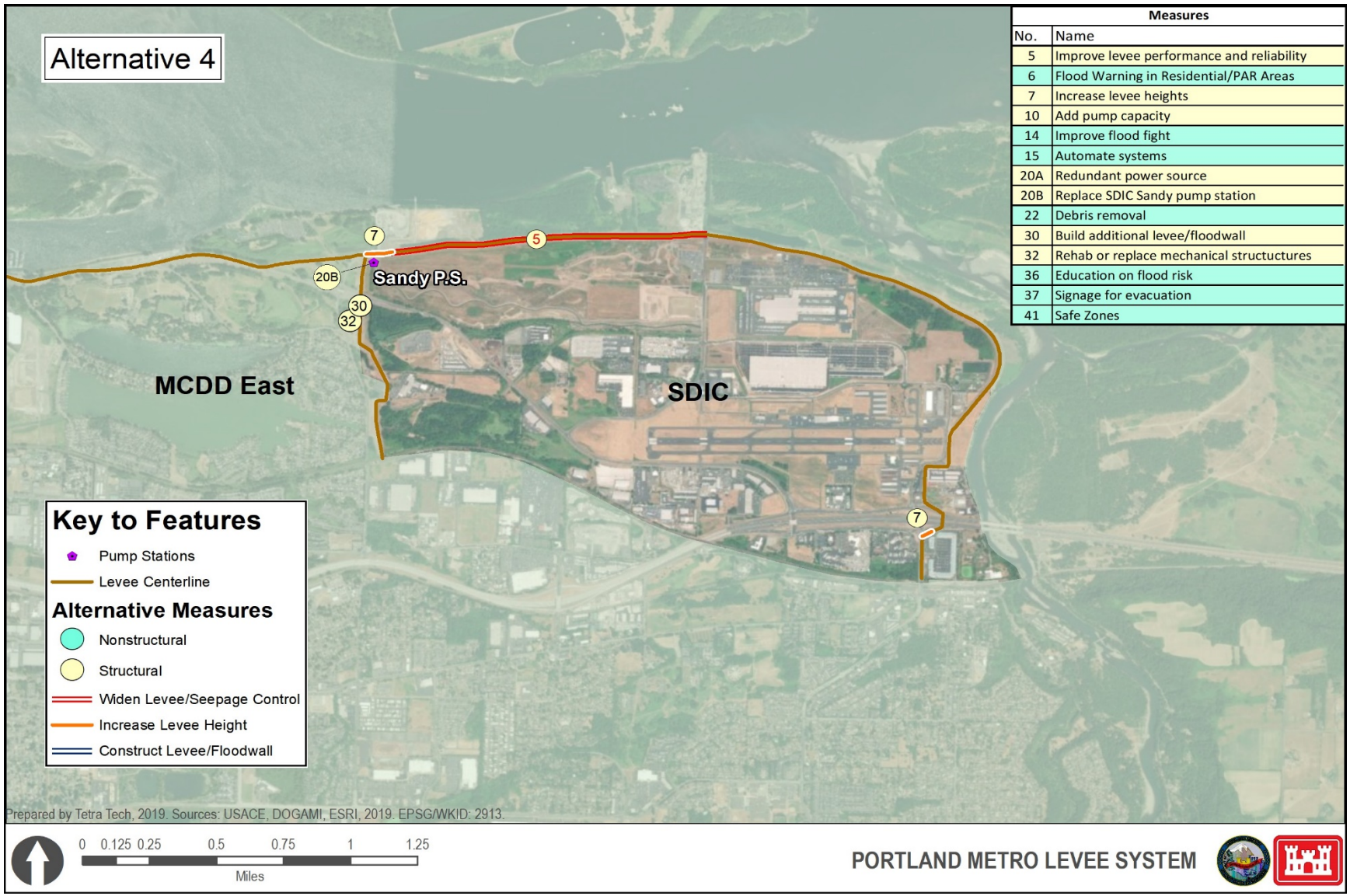

Figure 3-23 Alternative 4—SDIC

3.3.8. Alternative 5

This alternative seeks to address inconsistencies within the levee system to provide more uniform flood risk throughout the study area. This alternative focuses on both the internal and external sources of flooding. It includes a levee raise and other improvements to the levees in PEN 1 and PEN 2 to address both fragility and overtopping risks. A new floodwall would be added along the Columbia River segments of the PEN 1 and PEN 2 levees, including under the I-5 bridge. The alternative includes a new levee parallel to the existing railroad embankment on the west edge of PEN 1. The alternative increases levee heights at locations with low spots in MCDD and SDIC. Pump station measures are included to ensure more consistent performance between the interior drainage systems. Improvements include capacity increases at three pump stations, better debris control at three locations, and elevating/replacing the Sandy pump station. Measures in this alternative include both structural and non-structural measures described in Table 3-24 and shown on the following maps (Figure 3-24 through Figure 3-29). Since increasing levee heights (Measure 7) within PEN 1 and PEN 2 is included in this alternative, three measures (5, 7, and 30) are essentially combined. The alternative proposes a floodwall along the entire Columbia River mainstem, therefore Measures 30 and 7 are combined. On the other segments of levee, they will both be raised (Measure 7) and have improvements to performance and reliability (Measure 5).

Table 3-24 Alternative 5 Measures and Description

No.	Measures	Description
5	**Improve Levee Performance and Reliability**	Widen the PEN 1 Columbia Slough levee and add seepage controls (toe drains). In MCDD West, seepage controls (toe drains) at the Peninsula Slough cross levee are included. In SDIC, widening of the cross levee to Sundial Avenue is included.
6	**Flood Warning in Residential/ PAR areas**	Revise and update flood hazard and evacuation plans for Portland, Port of Portland, and Multnomah County NHMP to include flood risk information resulting from this feasibility study. Develop expanded communication and evacuation plans.
7	**Increase Levee Heights**	Increase levee heights up to three feet for PEN 1 and PEN 2 levees along Columbia mainstem and Columbia Slough. In MCDD West, includes filling in isolated low spots in the Peninsula Slough cross levee and Station 511+00 of the Columbia River levee (near Broughton Beach Park). Includes raising low spots near the Troutdale outlet mall and the Columbia River segment of SDIC.
10	**Add Pump Capacity**	Add capacity at pump stations where the need has been identified. (PEN 2 13th Avenue Intake, MCDD Pump Station 2 pumps and discharge lines).
14	**Improve Flood Fight**	Develop 4-season maintenance road on Peninsula Canal cross levee between MCDD and PEN 2, railroad parallel levee.
20	**Add Redundancy to Pump Stations**	Includes elevation and replacement of SDIC Sandy Pump Station, and installation of redundant power sources within the system of pump stations.

No.	Measures	Description
22	**Debris Removal (trash in water and trees/limbs)**	Trash Rakes replaced at MCDD-AirTrans, MCDD Pump Station 4, and MCDD Broadmoor.
30	**Build Additional Levees/ Floodwalls**	Construct a parallel levee at the PEN 1 railroad embankment. Install floodwalls along Marine Drive in PEN 1 and PEN 2.
36	**Education**	Develop flood risk education materials for the population at risk and visitors within the study area. Materials will be based up on flood risk information developed related to the levees and coordinated with USGS to incorporate seismic aspects, as well as emergency responders and educators to meet a broad audience.
37	**Signage for Evacuation**	Install flood hazard and evacuation route signage throughout the study area including designated evacuation routes.
41	**Safe Zones**	Develop designated safe zones at high points within the PMLS for those that cannot evacuate from the flood-plain. Would be implemented in conjunction with Measure 6.

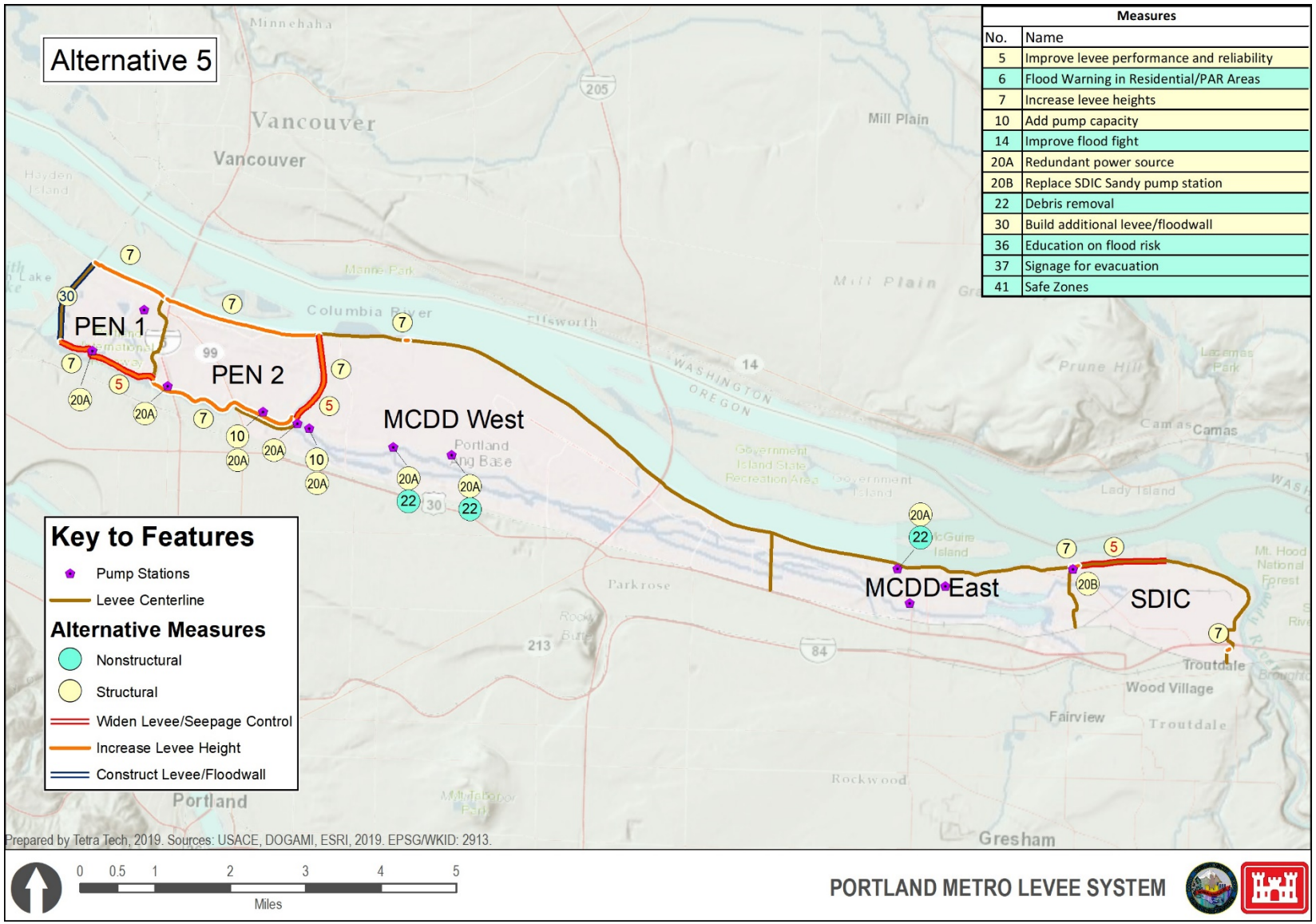

Figure 3-24 Alternative 5—Overview Map

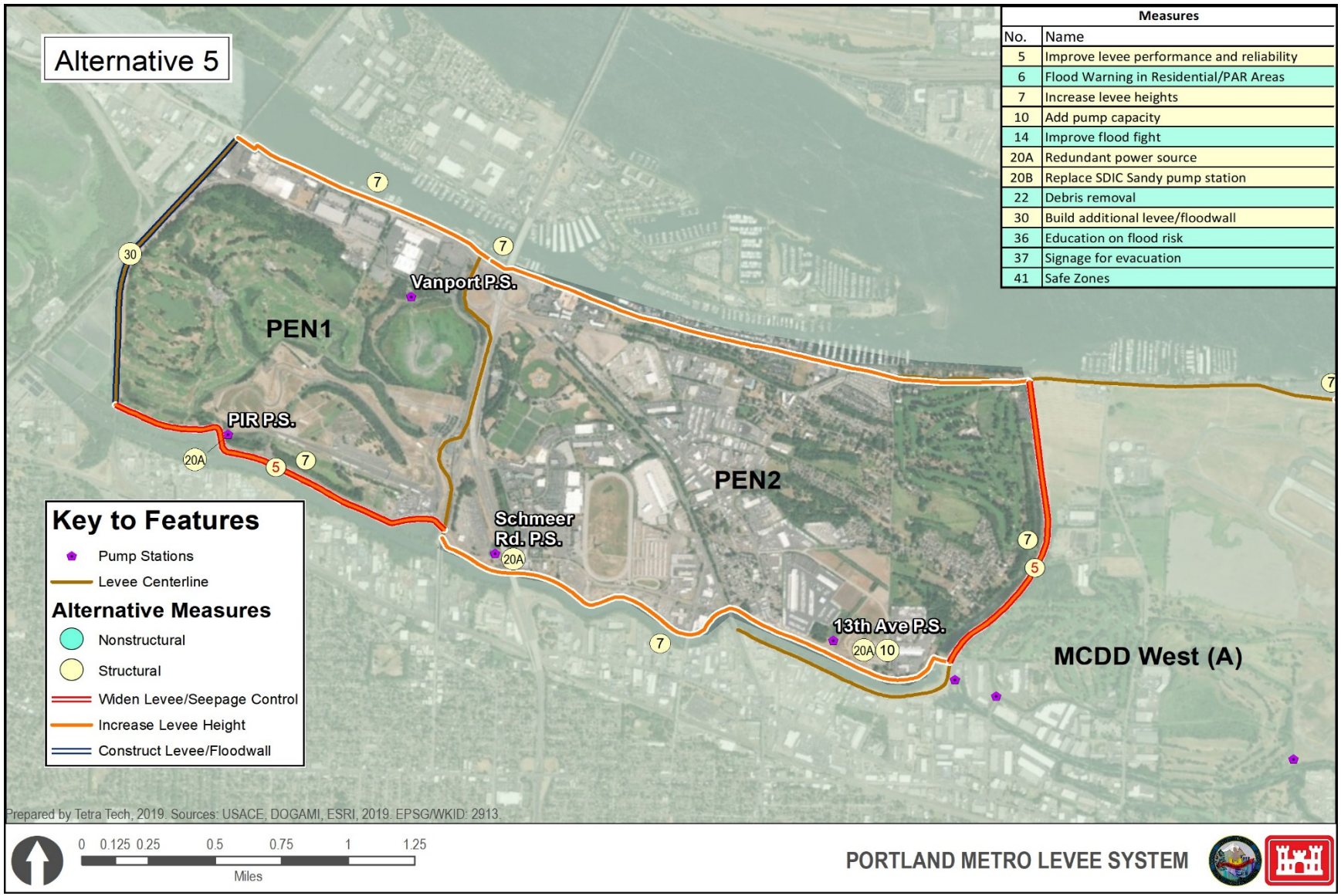

Figure 3-25 Alternative 5—PEN 1 and PEN 2

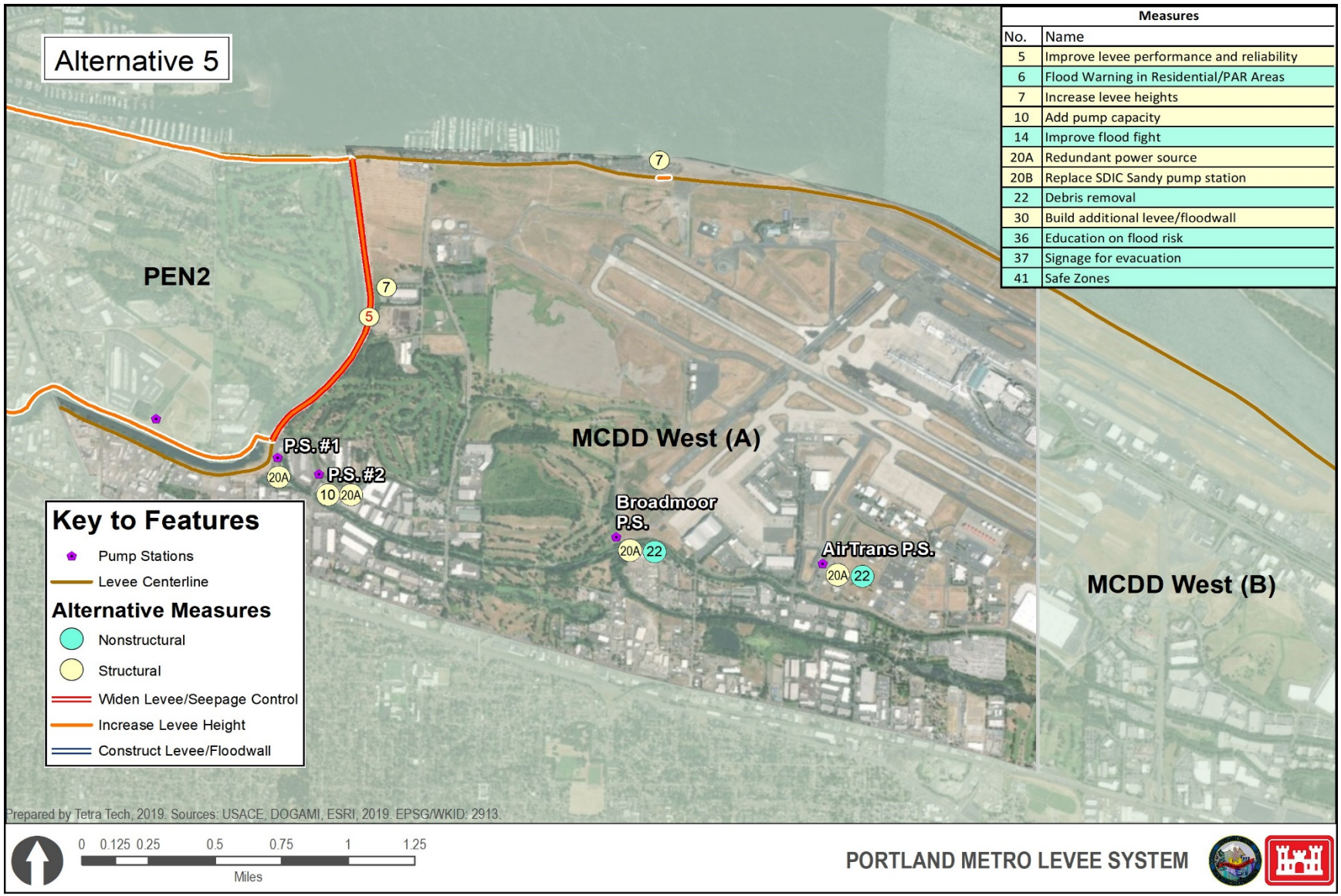

Figure 3-26 Alternative 5—MCDD West (A)

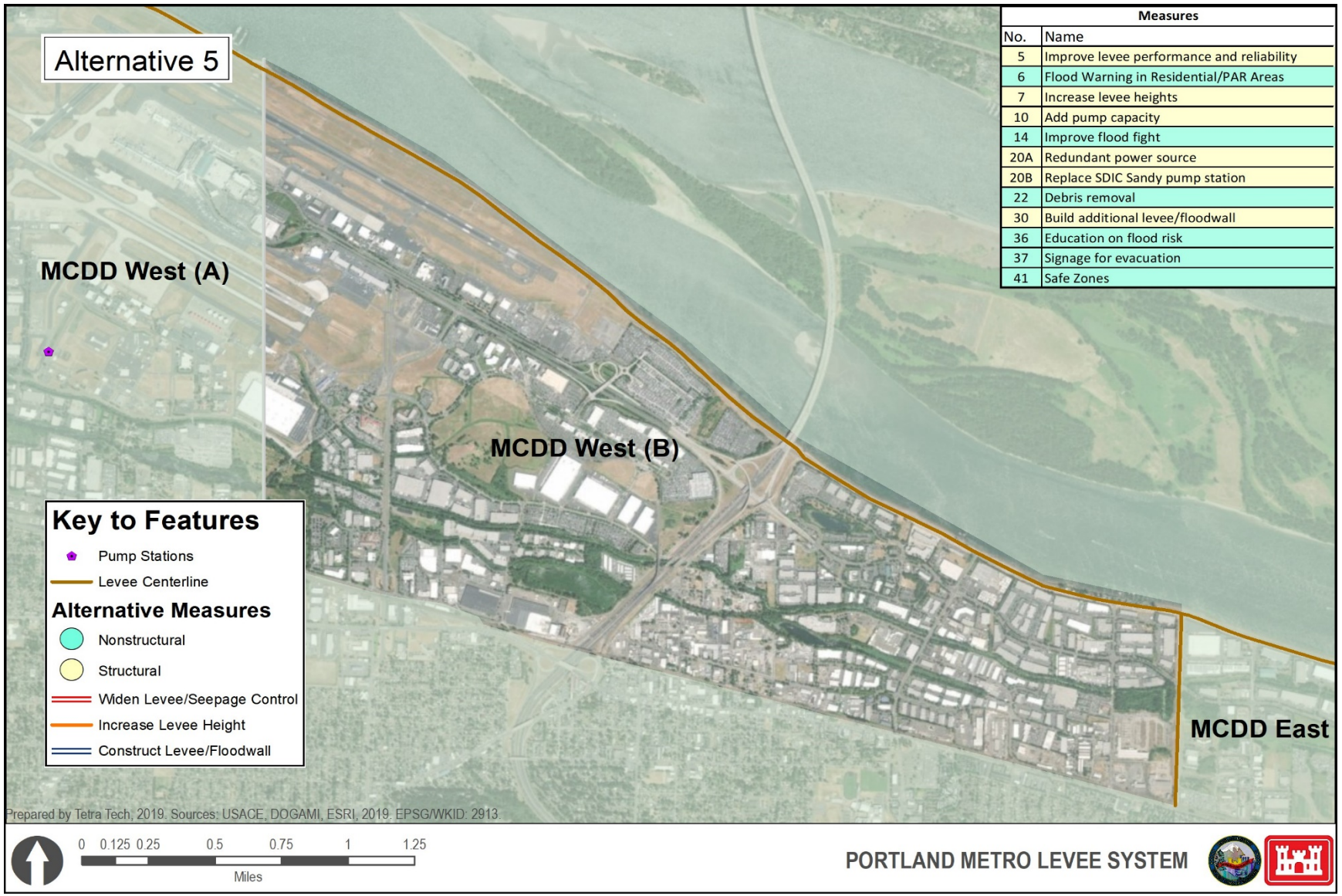

Figure 3-27 Alternative 5—MCDD West (B)

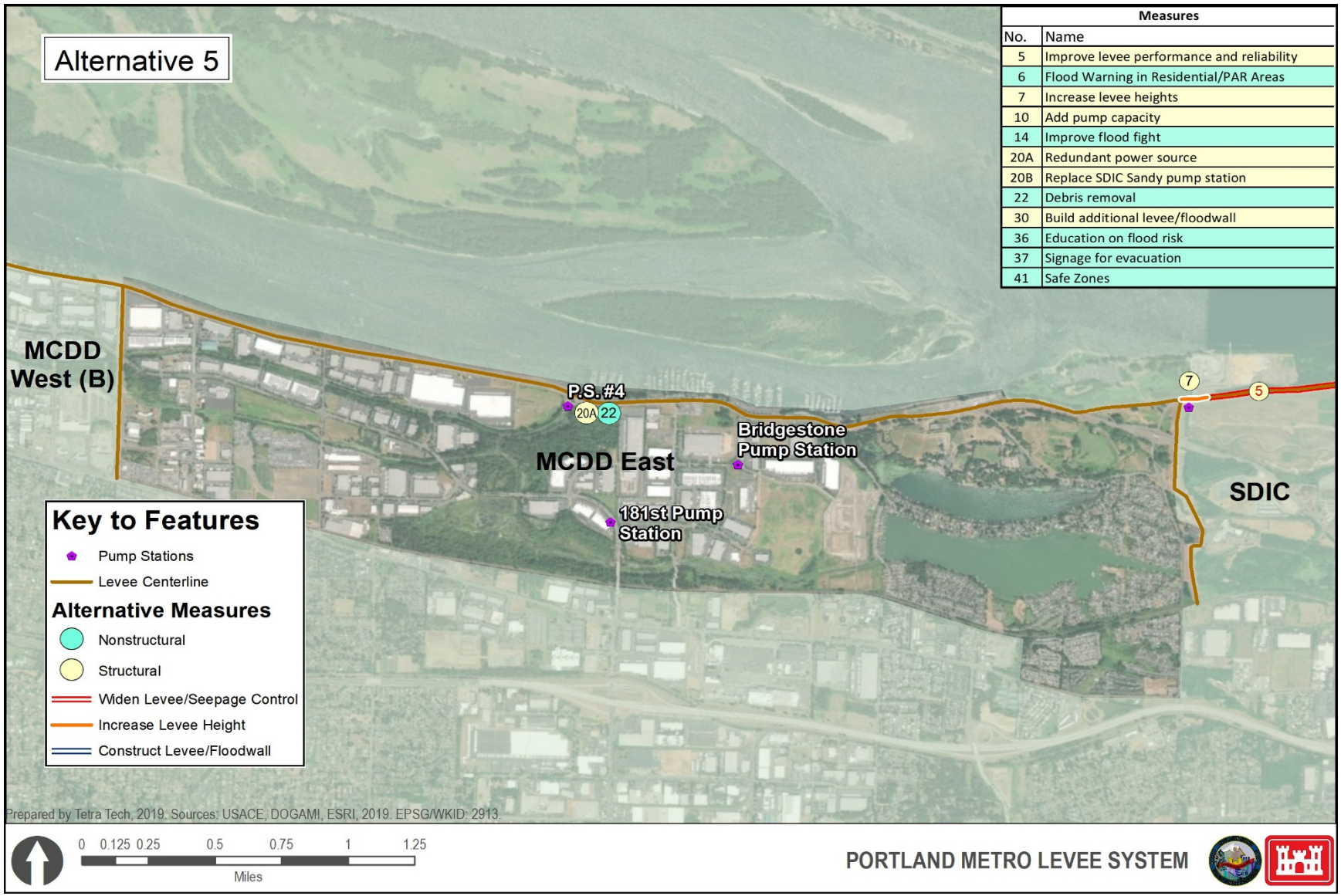

Figure 3-28 Alternative 5—MCDD East

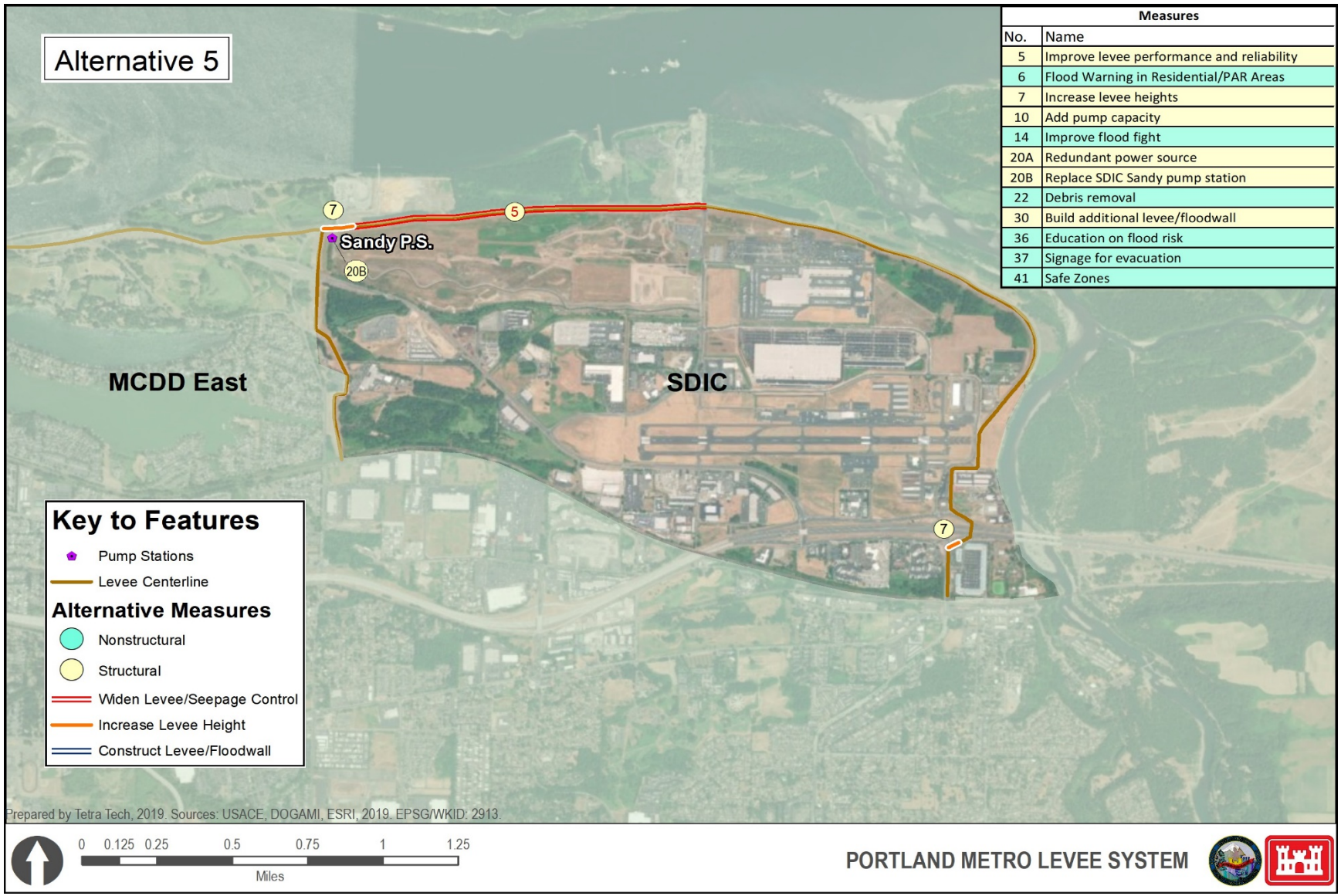

Figure 3-29 Alternative 5—SDIC

3.3.9. Recreation Measures

While the primary study objective focuses on flood risk reduction, a related study objective is, to the extent practicable, providing opportunities for recreation, natural resources, and cultural resources. One measure identified during the planning charrette is to provide recreation trails. The PDT considered areas within the alternatives where recreation elements could be added, and they identified several locations in conjunction with flood risk reduction measures. Recreation trails could be provided where access roads are included on levees along the parallel levee at the railroad embankment (PEN 1), Peninsula levee (PEN2/MCDD), and SDIC improvements from 223rd Ave to Sundial Road. These recreation trails would serve to add connectivity to the 40-mile loop. In addition, where the SDIC pump station is proposed to be elevated and replaced there is opportunity to add a viewing platform allowing for bird and wildlife viewing in the nearby wetlands. Additional recreation opportunities may be identified and evaluated as the study progresses. Areas for access to the river and the slough are lacking in the system and may be identified as more details are developed for the project.

3.3.10. Real Estate Requirements

Real estate estimated costs were derived using a rough order of magnitude, utilizing property values from the county assessor. An encumbrance factor was applied for the easements required. Single Family residences that may require a full taking were assigned full market value. The dollar figures reported are for planning purposes only and not to be mistaken as an appraisal on the parcels. Fair Market Valuations for each individual parcel will need to be formally appraised during feasibility design. Estimated costs of real estate for each alternative are included in Table 3-26 below.

3.3.11. Alternative Cost Estimates and Damages Reduced

Life cycle project costs were developed for the three alternatives for the purpose of comparing the costs to benefits. The implementation costs (referred to as first costs) including construction and real estate costs were amortized over the 50-year period of analysis using the fiscal year 2020 (FY 20) Federal discount rate of 2.75 percent. Assuming uniform expenditure over each construction period, interest during construction is based on the following construction periods:

- Alternative 3 – 24 months
- Alternative 4 – 36 months
- Alternative 5 – 42 months

The annualized investment costs were then combined with an estimate for annual operation, maintenance, repair, replacement and rehabilitation (OMRR&R) to arrive at a total annual cost for each alternative. The non-federal sponsor is responsible for the existing project features and have continuing operations and maintenance, repair, replacement, and rehabilitation (OMRR&R) obligations in accordance with established operations and maintenance manuals and agreements. Costs for this item account for the routine work that is expected to occur each year over the life

cycle of the project. Replacement and rehabilitation costs are often sourced from costs incurred under the Rehabilitation Assistance for Non-Federal Flood Control Projects program (Public Law 84-99, or PL 84-99). In the PMLS, levee failures are rare but cause extreme damages when they occur. The levee system has only failed once, in 1948. In other levee systems in the country, failure is a more common occurrence, triggering the PL 84-99 program to help rebuild levees and pump stations. In contrast to these systems, the PMLS has only minimally used the PL 84-99 program during high water events, and major infrastructure has not been replaced in the past. Therefore, the replacement and rehabilitation component of OMRR&R is expected to be minimal on an annualized basis in this system.

It is assumed that the sponsor's current OMRR&R costs for the existing project will continue. Therefore, the OMRR&R cost estimates only include the new (net) additional OMRR&R costs the sponsor would incur based on new features in the alternatives. The cost estimates are not the total OMRR&R costs for the system, but rather the relative increase or decrease from the FWOP. Costs for OMRR&R were estimated for the following categories:

- **Expanded levee and floodwall footprint**. Based on the sponsor's total 2018 expenditures for levee inspections and maintenance, the annual OMRR&R unit cost is approximately $0.01 per square foot of levee. This figure includes inspections and vegetation management. To estimate costs for alternatives, the area of expanded footprint is used in conjunction with the unit cost to calculate additional OMRR&R costs in this category.
- **Toe Drains**. From recent contract costs incurred by the sponsor, the unit cost of toe drain inspection and maintenance is approximately $4 per linear foot of toe drain. Inspections of toe drains are assumed to occur every 5 years. To estimate costs for alternatives, the unit cost is applied to any new linear footage of toe drains proposed and annualized over 50 years. New toe drains would not need to be replaced over the 50 year planning horizon.
- **Closure Structures**. Current flood closures are exercised by the Portland Bureau of Transportation at no cost to the non-federal sponsor. The primary OMRR&R cost for new closure structures is the cost to exercise the closures. An annual exercise for future closure structures would involve two field staff and associated heavy machinery to exercise the closures (pickup truck, trailer, truck-mounted crane). The daily cost for this field crew and equipment is approximately $2,750. It is assumed the new flood panels would not need to be replaced over the 50 year planning horizon.
- **Riverward bank protection**. The sponsor has incurred repair costs in recent years to address bank sloughing during high water events. These typically occurred in overbuild sections. Any rebuilt or new levee sections would be built at lower slopes and to higher standards. As such, they will not be subject to sloughing and not require any significant repairs or maintenance beyond what is budgeted for levee maintenance. Since no alternative proposes improvements to the riverward side of the existing levees, the net OMRR&R costs for all alternatives is zero.

- **Pump Stations**. Improvements to existing pump stations would serve to decrease OMRR&R costs, since they would include more reliable pumps and debris management systems. This potential decrease in OMRR&R costs is not quantified, and no OMRR&R costs are assumed for pump station improvements.
- **Relief Wells**. Relief wells are inspected and maintained every five years. Based on recent expenditure records from the sponsor, the cost is approximately $6,000 per relief well to inspect and maintain. This includes testing and inspection of the vertical component a well, as well as horizontal video inspection and cleaning. For any new relief wells proposed, an annual cost of $1,250 is assumed for OMRR&R. New relief wells would not need to be replaced over the 50 year planning horizon. No new relief wells are proposed by any alternatives, so there are no costs associated with this item.

OMRR&R costs by alternative are summarized in Table 3-25.

Table 3-25 OMRR&R Costs above FWOP by Alternative

Item	Alternative 3	Alternative 4	Alternative 5
Additional levee/floodwall footprint	688,000 ft^2	1,386,000 ft^2	1,948,000 ft^2
Additional Toe Drains	1,430 ft	1,430 ft	1,430 ft
New Closure Structures	None	None	30
Total Annual OMRR&R Cost	**$18,778**	**$25,758**	**$34,128**

In addition to construction and OMRR&R costs, the implementation costs include Preconstruction Engineering and Design and Construction Management. Real estate costs are referred to as lands, easements, rights of way, relocations, and disposal sites (LERRD). Table 3-26 presents the projects costs, benefits, and benefit-to-cost ratios for each alternative.

Annualized economic benefit estimates are calculated by comparing the flood Expected Equivalent Annual Damages (EEAD) of the Future Without Project Condition and each alternative Future With Project Condition. In other words, the benefits of an alternative are the annualized reduction in flood damages from the proposed system improvements. Refer to Appendix B (Economics) for more details. Annual net benefits are defined as the difference between the annual benefits and the annual costs of an alternative. For an alternative or increment thereof to be economically feasible, its benefits must exceed the costs. The alternative that offers the greatest net benefits is referred to as the NED Plan. The table below shows project cost and benefit estimations used during the initial alternatives selection process. This evaluation process was done using simplified parametric cost estimates. These cost estimates are approximate, but have enough detail to be suitable for comparing alternatives. Later, the

tentatively selected plan is evaluated with a more detailed Micro-Computer Aided Cost Estimating System (MCACES) estimate. Cost figures in the table will vary from the more detailed estimates shown for the TSP in Section 5.2 and 5.3 of this report.

Table 3-26 Alternative-Level Annual Costs and Benefits (FY 20 Price Levels and 2.75% Discount Rate)

Item Description	Alternative 3	Alternative 4	Alternative 5
Construction Costs	$21,636	$35,172	$75,562
Preconstruction Engineering/Design	$2,597	$4,221	$9,068
Construction Management	$2,164	$3,518	$7,557
Contingency	$13,265	$21,693	$46,352
Real Estate (LERRDs)	$8,904	$9,513	$19,018
Total Alternative Cost	$48,566	$74,117	$157,557
Interest During Construction [1]	$1,285	$3,012	$7,536
Total Investment Cost	**$49,851**	**$77,129**	**$165,093**
Annualized Investment Cost [2]	$1,847	$2,857	$6,115
Annual O&M[3]	$19	$26	$34
Total Annualized Investment Cost	**$1,866**	**$2,883**	**$6,149**
Annual Benefits	$6,038	$8,448	$13,777
Annual Net Benefits	**$4,169**	**$5,455**	**$7,628**
Benefit-Cost Ratio	**3.24**	**2.93**	**2.24**

Notes: Cost figures shown at FY2020 Price Level. All figures are in $1,000s.
1) Interest During Construction assumes equal annual outlays for construction periods of 24, 36, and 42 months for Alternatives 3, 4, and 5, respectively.
2) Total Investment Cost is annualized using the FY2020 Federal Discount Rate of 2.75% and 50-year period of analysis
3) O&M costs account for the additional routine work between the with-project and without-project conditions that is expected to occur each year over the life cycle of the project.

3.3.12. Life Safety

In addition to economic benefits, improvements to the levee system also provide benefits to life safety. Life safety was estimated using HEC-LifeSim software for the future without project condition, as discussed in Section 3.2.9. In addition to the FWOP simulations, HEC-LifeSim was used to evaluate the effectiveness of the nonphysical nonstructural measures that are included in all alternatives. Because the elicitation interview showed that study area emergency management entities are well-prepared for the most part, the implementation of nonstructural measures in the LifeSim model showed minimal positive impacts on life loss estimates compared to the without project condition. These positive impacts are shown in the table below.

Table 3-27 Life Loss Modeling Summary Results – With Nonstructural Measures

Leveed Area	Modeled Reduction in Life Loss Estimate from Nonstructural Measures
Failure Prior to Overtopping (Columbia River level less than mandatory evacuation levels)	
MCDD East	0
MCDD West	24
PEN 1	0
PEN 2	8
SDIC	1
Overtopping (72-hour warning)	
MCDD East	1
MCDD West	1
PEN 1	0
PEN 2	1
SDIC	0

Life loss if a breach were to occur (consequence) is only a component of life safety risk. As previously shown in Figure 3-1, life safety risk is a function of the probability of high water, the performance of the levee, and the consequences (lives lost) in the event of a failure. The probability of high water is not affected by the alternatives, and the non-structural measures have only a minor effect on the consequences of a breach between alternatives. However, the performance of the levee is different between alternatives. Since risk combines both the probability of flooding and the life loss consequence, the alternatives have different levels of life safety improvements.

All alternatives provide improved life safety compared to the future without project scenario. Table 3-28 shows the reduced probability of life loss events that improvements to the levee system provide. Alternative 3 and 4 improve levee segments that currently have an appreciable chance of breaching before overtopping, particularly in PEN 1 and the Peninsula Canal cross-levee. Alternatives 4 and 5 include improvements to the SDIC embankment, reducing the chance of failure prior to overtopping. As previously discussed, overtopping at PEN2 is the failure mode that poses the highest life safety risk. Alternatives 3 and 4 include filling isolated low spots in PEN 2, which has a small improvement to life safety in PEN 2. These improvements reduce the chance of overtopping by around 30% compared to FWOP. Alternative 5 adds a more significant levee raise in PEN 2, which reduces the probability of an overtopping event in this area. The improvements proposed by Alternative 5 decrease chance of an overtopping life loss event by about 80% compared to FWOP—nearly an order of magnitude. PEN 2 is the most critical area for life loss in the system, and the reduction in the chance of overtopping in PEN 2 has the largest effect on total life loss risk in the system.

Table 3-28 Life Safety improvements by alternative

		Annual Probability of Scenario by Alternative (5% – 95% Uncertainty)			
Leveed Area	**Life Loss Estimates With Non-structural Measures (25% – 75% Uncertainty)**	**FWOP**	**Alternative 3**	**Alternative 4**	**Alternative 5**
Failure Prior to Overtopping (Columbia River level less than mandatory evacuation levels)					
MCDD East	0 - 0	< 0.001%	No change	No change	No change
MCDD West	62 - 377	< 0.001%	No change	No change	No change
PEN 1	1 - 5	0.08% – 0.3%	< 0.001%	< 0.001%	< 0.001%
PEN 2	72 - 143	< 0.001%	No change	No change	No change
SDIC	2 - 8	0.01% - 0.03%	No change	< 0.001%	< 0.001%
Overtopping (72-hour warning)					
MCDD East	1 - 6	0.005% - 0.01%	No change	No change	No change
MCDD West	0 - 9	0.01% - 0.2%	No change	No change	0.01% - 0.1%
PEN 1	0 - 0	0.05% - 0.4%	No change	No change	0.02% - 0.2%
PEN 2	6 - 15	0.1% - 0.8%	0.07% - 0.6%	0.07% - 0.6%	0.02% - 0.2%
SDIC	0-0	0.01% - 0.1%	No change	0.001% - 0.04%	0.001% - 0.04%

3.4. Identification of the National Economic Development Plan

The alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment is defined as the NED Plan. As can be seen in Table 3-26, all of the alternatives have positive net benefits. While Alternative 3 has the highest benefit-cost ratio and Alternative 5 has the lowest, Alternative 5 has the highest net benefits. Per Corps policy, the plan that maximizes net benefits is the NED Plan, and Alternative 5 has the highest net benefits of the three. Therefore Alternative 5 is the NED Plan.

3.5. Identification of the Tentatively Selected Plan

The PDT evaluated the alternatives to identify the Tentatively Selected Plan (TSP). The evaluation included a comparison of how well the alternatives meet the planning objectives and of how well they address the four P&G evaluation criteria and additional criteria relevant to this study.

3.5.1. Planning Objectives Comparison

Table 3-29 summarizes the review of the alternatives relative to the planning objectives. The number of plus signs (+) signify the extent to which the PDT estimates each alternative would meet each objective. This represents the effectiveness criterion defined in the P&G. Additional plus signs signify that the alternative meets the objective more fully.

Table 3-29 Extent to Which the Focused Array of Alternatives Meet the Planning Objectives

Planning Objective	Number of + = Extent to Which Met		
	Alternative 3	Alternative 4	Alternative 5
Reduce flood damages, in particular to critical infrastructure, within the Portland Metro Levee System over the period of analysis	+	++	+++[1]
Reduce threats to life safety from flooding and increase awareness of flood risk in the Portland Metro Levee System over the period of analysis (this is a significant nonmonetary category, and has therefore been discussed both under planning objectives and comparison criteria)	++	++	+++[2]
Increase resiliency of the flood risk management system over the planning period of analysis	+	+++	++[3]
Increase reliability of the flood risk management system over the planning period of analysis	+	+++	+++[4]
Improve operability of the flood risk management system and decrease flood response and recovery time	++	+++	+++[5]
To the extent practicable, provide opportunities for recreation, natural resources, and cultural resources	+	+	+[6]

1. Alternative 5 has the highest annual net benefit, followed by Alternative 4 and 3.
2. Alternative 5 addresses overtopping in PEN 2, which is the most significant driver of life loss risk. Life loss consequences are similar between alternatives, but the reduction in probability of overtopping in Alternative 5 reduces life loss risk.
3. Alternative 4 includes more measures to replace closure structures on cross-levees. If a failure occurs in one area, these improvements increase the ability of the system to absorb some flood damages without failing other areas. Alternative 5 includes an increase in levee height, which better prepares the system for potential climate change impacts.
4. Alternatives 4 and 5 include more pump station improvements to increase the chance of successful operation during a flood. Alternative 4 and 5 include levee measures in SDIC that increase reliability of the levees beyond Alternative 3.
5. Alternatives 4 and 5 include 4-season maintenance roads. All alternatives include improvements to flood emergency and evacuation plans.
6. No significant differences between alternatives in this area.

3.5.2. Evaluation Criteria Comparison

Alternatives were also compared with the criteria shown in Table 3-30. These include the four criteria from P&G that were described previously, as well as added criteria important to the study objectives.

Table 3-30 TSP Comparison Criteria

Comparison Criteria	Alternative 3	Alternative 4	Alternative 5
Completeness—The extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.	Low—railroad alignment, seepage berm is a less complete solution as opposed to levee. Includes SDIC pump station replacement.	High—This includes all pump measures.	High—Includes levee raises and also adds pump station measures for consistent level of risk reduction, with exception of PIR.
Effectiveness—The extent that the plan meets the objectives. ***See Table 3-29***	Low/Medium	High	High
Efficiency—The extent to which an alternative plan is the most cost-effective means of alleviating risk to the public. (Table shows the annual net benefits.)	Medium—$4,172	Medium—$5,565	High—$7,628
Acceptability—The workability and viability of the alternative plan with respect to acceptance by Federal and non-Federal entities and the public, and compatibility with existing laws, regulations, and public policies.	Medium	Medium	Medium
Life Safety—Reduction in LifeSim values at risk compared to Future Without-Project	Medium	Medium	High
Impacts to Natural Resources—Area of potential impacts to natural resources	High—Lowest negative impacts (See Chapter 4)	H/M—Low to Medium negative impacts (See Chapter 4)	H/M—Low to Medium negative impacts (See Chapter 4)
Relative Risk—Implementation risk, real estate risks	High—requires railroad easements to replace entire embankment in PEN 1	High—off railroad but will still require easement at crossing of spur line, not as much private property but requires public properties	High— off railroad but will still require easement at crossing of spur line, most private property and also public properties

Comparison Criteria	Alternative 3	Alternative 4	Alternative 5
Uncertainty—Discuss technical uncertainties, Modeling, etc.	Medium	High Addresses more frequent flood events Reduces uncertainty with emergency flood fighting	High Higher level of risk reduction accounts for climate change Lesser extent—reduces uncertainty with emergency flood fighting

3.5.3. Results and Comparison

Based on these comparisons Alternative 5 is the TSP. The TSP is also the preferred alternative for purposes of NEPA. It provides the greatest net benefits consistent with protecting the environment, better meets the selection criteria, and the relative risks or uncertainty are comparable to the other two alternatives.

3.6. Four Accounts

The *Economic and Environmental Principles for Water and Related Land Resources Implementation Studies,* established by the Water Resources Council in 1983, created four criteria known as "accounts" to facilitate evaluation and effects of alternative plans.

- The NED account displays changes in the economic value of the national output of goods and services.
- The Environmental Quality (EQ) account displays non-monetary effects on significant natural and cultural resources.
- The Regional Economic Development (RED) account registers changes in the distribution of regional economic activity that result from each alternative plan.
- The Other Social Effects (OSE) account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

3.6.1. National Economic Development

The intent of comparing alternative plans in terms of NED is to evaluate the beneficial and adverse effects that the plans may have on the national economy. Beneficial effects are considered to be increases in the economic value of the national output of goods and services attributable to a plan. Increases in NED are expressed as the plan's economic benefits, and the adverse NED effects are the investment opportunities lost by committing funds to the implementation of a plan. In this case, NED benefits are the reduction in flood risk achieved by expending NED costs to implement a project, and net benefits are the difference between these NED benefits and NED costs. The HEC-FDA model was employed to estimate future without project and future with project NED benefits for each alternative. These benefits were then

compared to cost. Table 3-26 displays the NED benefits and shows that Alternative 5 has the greatest annual net benefits.

3.6.2. Environmental Quality

The EQ account is intended to indicate the long-term effects that the alternative plans may have on significant environmental resources. Significant environmental resources are defined by the Water Resources Council as those components of the ecological, cultural, and aesthetic environments which, if affected by the alternative plans, could have a material bearing on the decision-making process. Significance is derived from institutional, public, or technical recognition that a resource or an effect is significant. All alternatives were formulated to first avoid impacts to significant resources in particular those resources protected on the Endangered Species Act and critical habitat. If avoidance was not possible then minimization was utilized in order to have the least impacts on regulated resources occurring in the system. As alternatives continue to be refined, impacts to resources will continue to be considered, evaluated, and avoided or minimized to the extent possible. Table 4-2 at the beginning of Chapter 4 describes the effects that alternative plans have on environmental resources.

3.6.3. Regional Economic Development

The Regional Economic Development account is intended to illustrate the effects that the proposed plans would have on regional economic activity, specifically, regional income and regional employment. As described in Appendix B (Economics) the RED analysis considered two components: adverse business interruption losses from flooding and potential beneficial effects of plan implementation as a function of construction and OMRR&R expenditures which would accrue to businesses within the regional economy.

3.6.3.1. Business Interruption Losses

The No Action alternative would not reduce the risk of regional economic impacts from business disruption. Alternative 3 would likely reduce risk of levee breach through its targeted structural fixes. However, Alternative 3's emphasis on maximizing life, public health and safety may not maximize the reduction in risk of regional economic losses. Alternatives 4 and 5, however, include additional structural measures which would likely achieve greater reduction in the likelihood of levee failures, thereby maximizing regional economic benefits.

3.6.3.2. Beneficial Effects of Construction Spending

Regional income and employment are commonly applied measures of regional economic activity. The positive effects of a plan on regional employment are directly parallel to the positive effects on regional income. The primary types of positive regional impacts associated with the final alternatives involve short term employment and income gains associated with project construction

The RECONS model is utilized to analyze the economic impacts of project construction and OMRR&R expenditures. RECONS is a Corps-certified regional economic impact modeling tool that was developed to provide estimates of regional economic impacts associated with Corps spending. The model presents results at the regional level (typically a county or metropolitan statistical area), the state level (may include multiple states), and the national level.

Depending on the alternative, construction expenditures would support between 855 and 2,687 local jobs, provide between $47 million and $149 million in local labor income, and provide between $63 million and $199 million in gross regional product, and between $96 million and $302 million economic output (gross sales) in the regional impact area. Model results are found in Appendix B (Economics). With the largest construction cost, Alternative 5 provides the greatest increase in RED benefits, including jobs and labor income.

3.6.4. Other Social Effects

The purpose of the OSE analysis is to show the beneficial and adverse effects of a flood risk management alternative on the social wellbeing of the plan area. The OSE account typically includes long-term community impacts in the areas of public facilities and services, recreational opportunities, transportation and traffic, and manmade and natural resources. The OSE account also integrates information into the planning process that is not reflected in the other three accounts used by the Corps to evaluate projects and alternative plans.

Evaluation and comparison of alternatives in terms of OSE requires a relative scoring of outputs by social factor and metric. There are a variety of potential social effects from flooding that if present in the study area under a given alternative, should be considered in the assignment of relative scores. Based on the measures included in each alternative and the PDT's assessment of the expected effects of these measures on OSE resources, the PDT assigned a score for each *metric* for each alternative. Scoring uses a 7-point scale, from -3 to +3, allowing assignment of a score for each alternative relative to the Future Without-Project condition. Negative scores indicate adverse OSE impacts relative to the without-project condition, and positive scores indicate beneficial OSE impacts relative to the without-project condition. Table 3-30 includes the scoring rubric described above and Table 3-31 the OSE scoring table.

Score	In Relation to the Without Project Alternative, the With Project Alternative Has …
-3	Significant negative effects (showstopper)
-2	Moderate negative effects
-1	Minor negative effects
0	Negligible effects (no impact)
1	Minor beneficial effects
2	Moderate beneficial effects
3	Significant beneficial effects

***Figure 3-30 Scoring Rubric (*Source: USACE 2013a)**

Table 3-31 presents a summary of the assigned scores by alternative. Appendix B (Economics) documents the rationale for these assignments. By adding the final scores across all the metrics, the OSE performance of the alternatives may be compared in total. While all alternatives have beneficial effects, Alternative 5 scores highest.

Table 3-31 OSE Evaluation Scoring Table

Factor (metric)	**Without Project**	**Alternative 3**	**Alternative 4**	**Alternative 5**
Health and Safety (Expected annual life loss)	0	2	2	3
Economic Vitality (Employment impacts)	0	1	2	3
Social Connectedness (Risk to community institutions)	0	0	2	3
Identity (Support for sources of community pride and engagement)	0	3	1	1
Social Vulnerability and Resiliency (Effects of response and recovery)	0	3	2	3
Participation (Perception of planning process success)	0	2	2	2
Leisure and Recreation (Closure frequency)	0	0	2	2
Total	**0**	**11**	**13**	**17**

4. Affected Environment and Environmental Consequences*

4.1. Project History

This chapter provides a review of the affected environment and the environmental consequences that are anticipated to result from implementation of each of the proposed alternatives (Alternatives 3, 4, and 5, and the No Action Alternative). The history of the project and the need for action are described above (Chapter 1), along with a description of the alternatives and the process through which they were developed (Chapters 2 and 3). This project was initiated by the Corps in coordination with the CCDD in order to address deficiencies in the PMLS that may result from a flood event resulting from levee overtopping or levee failure. The initial construction of the PMLS was instigated by the 1948 flood that devastated the area. The drainage districts engineered a levee and pumping system prior to the passage of NEPA. This document has been prepared in compliance with NEPA and provides a current evaluation of the baseline and future without and with project conditions for the entire PMLS.

4.2. Resources Analyzed and Resources Screened from Detailed Analysis

Resources that may be impacted by implementation of the selected alternative must be evaluated for their existing condition, future without-project condition, and future with-project condition. Resources evaluated under this Environmental Assessment include air and climate, geophysical resources, groundwater, surface water, biological resources, socioeconomic conditions, public health and safety, utilities, noise, visual resources and recreation. In each case, the conditions warranted analysis. Due to the extent of the proposed project and the potential for environmental impacts across all resources, no resources were screened from a detailed analysis.

4.3. Summary of Environmental Consequences

Potential environmental consequences of each alternative are evaluated for each of the resource types described in Sections 4.5 through 4.19 according to Council on Environmental Quality (CEQ) guidance (Title 40 Part 1500). Impacts from the alternatives can be either direct or indirect. Direct impacts are those that are caused by the action and occur at the same time and place. Indirect impacts are caused by the action but occur later in time or are farther removed in distance, but are still reasonably foreseeable.

Impact levels are characterized as significant, less than significant (insignificant as a result of mitigation), minimal (insignificant), or no impact (resource is unaffected by the action). Impacts that were determined to be insignificant or barely noticeable were characterized as “minimal”, those that were moderate but reduced in intensity by mitigation were characterized as “less than

significant", and those characterized as "significant" were those considered to be highly noticeable or clearly over the threshold of the significance criteria.

Impacts are also described in terms of duration. Temporary impacts are those that would generally last no more than the period construction, such as noise impacts occurring during construction or the time it takes for a revegetated area to stabilize. Long-term, or permanent, impacts are those that would last beyond the construction period, and result from permanent changes such as bank armoring or changing the levee footprint.

The Corps has developed avoidance and minimization measures to reduce the intensity of impacts resulting from the action alternatives. A summary of these avoidance and minimization measures applicable for protection of each resource evaluated in this EA is provided in Table 4-1. The potential environmental consequences of implementing each action alternative are summarized in Table 4-2.

Table 4-1 Avoidance and Minimization Measures

Resource Category	**Avoidance and Minimization Measures**
Water Resources	• Sediments for re-contouring and restoration activities would be obtained on-site to the degree possible. • Staging areas, storage sites (fuel, chemical, equipment, and materials), and potentially polluting activities would occur in existing parking lots or open areas. These sites would be identified and secured and would be located 150 ft. or more from any natural water body or wetland, or on an adjacent, established road area in a location and manner that would preclude erosion into or contamination of the stream or floodplain. • A Spill Prevention Control and Countermeasures (SPCC) Plan would be developed. • Only use hydraulic fluids approved for work in aquatic environments. • Heavy equipment would be washed before delivery to project site to remove oils, fluids, grease, weed seeds, etc. • Heavy equipment would be regularly inspected and cleaned. • All non-emergency maintenance of equipment would be performed off-site. • All waste (solid waste, hazardous materials, etc.) would be disposed off-site. • All equipment, materials, supplies, and waste would be removed from project site when complete. • Activities would be scheduled during low flows or periods of no flow, as feasible. • Prepare and implement an erosion control plan, consistent with NPDES requirements and Section 401 consultation. • CWA permit-specific protection measures would be applied. • Erosion control measures would be applied to construction, staging, and access areas (e.g., silt fence or straw wattle and turbidity curtains installed where needed). If in-water work is required at pump stations, areas of impact would be isolated from aquatic areas to protect water quality and biological resources. • In-water work with machinery will not be required, work can be completed from machinery located on top of levees or within pump stations.

Resource Category	Avoidance and Minimization Measures
Physical Resources	• Prepare and implement an erosion control plan, consistent with National Pollutant Discharge Elimination System (NPDES) requirements and Section 401 consultation. • Use sediment barriers, such as silt fences, straw matting, and straw wattles. • Minimize the area of disturbance, use minimum areas for staging, clearing, and grubbing. • Use water trucks to apply water to control dust, as needed. • Apply mulch or straw, or reseed exposed soil areas to reduce erosion and dust after completing work within a given area. • Sequence construction to minimize soil exposure and erosion potential. • Decompact decommissioned access roads through disking and replanting.
Air Quality/Climate Change	• Apply water from water trucks to excavation areas, access and haul roads, and staging areas as needed to control fugitive dust. • Set a low speed limit on access roads to reduce dust mobilization.
Noise	• Construction near residences would be limited to daylight hours, as applicable. • Additional methods of sound dampening or shielding such as noise barriers would be evaluated during construction planning and implemented to the extent practicable. • Construction phasing would be reviewed to minimize the duration of particularly noisy activities and the overall duration of construction near residences.
Utilities	• During the project design phase, the designers will coordinate with utility providers to identify the locations of conveyance pipelines, communications cables, and other utility infrastructure at all locations where ground-disturbing actions will occur. • Design plans will show the locations of all utility infrastructure and specify measures to ensure that they are protected in place or relocated.
Biological Resources	• Staging and refueling areas would be established at least 150 ft. away from wetlands and other water bodies to the extent possible. • To control spread of non-native species, construction equipment would be washed before it was mobilized, and clean fill or dredged material would be used. • Replanting with native seed mix would occur as rapidly as possible following the completion of construction. Plantings would be mulched upon completion if needed. • Trees removed during construction would be evaluated for replacement as feasible. • Pre-construction biological surveys may be conducted if determined to be necessary for ESA and MBTA species (e.g., during nesting season). Avoidance training would be provided to construction teams. • If present, active bald eagle nests would be avoided during the nesting season, per coordination with USFWS. • Avoid riparian vegetation to the extent practicable during construction.

Resource Category	Avoidance and Minimization Measures
Cultural Resources	• Avoid known cultural resource sites during construction. • Protect any unanticipated cultural resources discovered during construction as follows: -Stop all work; cover and protect the cultural resource in place. -Notify Project Manager and Corps cultural resources specialist immediately. -Implement protection or other measures as instructed by Corps cultural resource specialist.
Hazardous Materials	• A description of hazardous materials to be used, and handling procedures would be available on-site. • Written procedures for notifying environmental response agencies would be posted at the work site. • Spill containment kits with written instructions for cleanup and disposal adequate for the types and quantities of materials used at the site would be available at the work site. • Workers would be trained in spill containment procedures and would be informed of the location of spill containment kits. • Workers would wear protective clothing when working with potentially hazardous materials. • Any waste liquids generated at the staging areas would be temporarily stored under an impervious cover until they could be properly transported to and disposed of at a facility that is approved for receipt of hazardous materials.
Land Use, Planning and Zoning	• Consider reconfiguring golf courses affected by levee expansion to allow full use of remaining area
Socioeconomics/ Environmental Justice	• To the extent practicable, design selected alternative to avoid disproportionate effect on low-income communities found in Census Tract 73. • Design traffic control plan to protect residents' access to uninterrupted transportation services. • Apply water to dirt surfaces as needed to control fugitive dust.
Aesthetics/Visual Resources	• Reseed and plant disturbed areas with appropriate native species and control weeds immediately following construction. • Use water trucks to apply water, as needed, to the construction area for dust control. • Protect and retain native riparian/wetland vegetation, to the extent practicable, by avoiding construction activities in these areas. • Minimize machinery present and the size of the disturbance area, to the extent practicable. • Clean-up site and remove equipment, as practical, during non-construction periods.
Recreation	• Maintain access to as many recreation features as possible during construction. • Incorporate recreation access information and any needed closures in the traffic control plan. • Install signs to inform the public of the lengths of closures and alternate routes for bicycles, or locations of birdwatching, hiking, or river access.

Resource Category	Avoidance and Minimization Measures
	• Ensure that levee widening construction is closely coordinated with adjacent businesses such as golf course management to avoid or minimize closures
Public Health and Safety	• The traffic control plan will identify measures to ensure uninterrupted access of emergency response entities to the study area.
Transportation and Infrastructure	• Coordinate with local transportation agencies as appropriate to develop a traffic control plan. • Include information regarding closures, detours, and traffic control measures in traffic control plan. • Use traffic controls such as flagging, reduced speed limits, signage, and barriers to route traffic through affected areas and at truck entry/exit points. • Coordination with utility providers to locate pipelines, communications cables, and other utility infrastructure in the study area.

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Table 4-2 Summary of Environmental Consequences of Proposed Alternatives

Resource	Alternative 1 (No Action)	Alternative 3	Alternative 4	Alternative 5
Water Resources and Climate Change	Water quality, quantity, and habitat will continue to be degraded through urbanization and disconnection from the floodplain. Local improvements will be managed through Federal, state, and local groups.	*Construction*: Temporary minor erosion and turbidity, or minor release of hazardous construction materials, offset by avoidance and minimization measures (AMMs). *Operation*: $5.26 million in equivalent annual flood risk reduction benefits.	*Construction*: Temporary minor erosion and turbidity, or minor release of hazardous construction materials, offset by AMM. *Operation*: Equivalent annual flood risk reduction benefits of $6.91 million (32% increase over Alternative 3).	*Construction*: Temporary minor erosion and turbidity, or minor release of hazardous construction materials, offset by AMM. *Operation*: Equivalent annual flood risk reduction benefits of $11.2 million (62% increase over Alternative 4, and 115% increase over Alternative 3).
Physical Resources	Natural soil erosion and aquatic sediment increasingly transitioning to fines over time. Increase in impervious surfaces with development.	*Construction*: Temporary minor erosion and dust generation at staging, clearing, grubbing, and work sites, particularly along Marine Drive, offset by AMMs. *Operation*: Widening levee with 90,000 cy of permanent fill in PEN 1, 120,000 cy in SDIC, and 110,000 cy in MCDD. Minor increase in impervious surfaces will not affect runoff.	*Construction*: Temporary minor erosion and dust generation at staging, clearing, grubbing, and work sites, particularly along Marine Drive, and offset by AMMs. *Operation*: Widening levee with 240,000 cy of permanent fill in PEN 1, 131,000 cy in SDIC, and 112,000 cy in MCDD. Minor increase in impervious surfaces will not affect runoff.	*Construction*: Temporary minor erosion and dust generation at staging, clearing, grubbing, and work sites, particularly along Marine Drive, offset by AMMs. *Operation*: Widening levee with 365,000 cy of fill in in PEN 1, 100,000 cy in PEN 2, 124,400 cy in SDIC, and 135,000 cy in MCDD. Up to ½ acre of new impervious surfaces will have minor effects to stormwater runoff.
Air Quality and Greenhouse Gases	Air quality may incrementally increase with new emissions restrictions of the next 25-30 years. The area is likely to remain in compliance with air quality criteria.	*Construction*: Temporary minor emissions to PEN 1/2, MCDD, and SDIC will not alter AQMA attainment status. *Operation*: No change to existing conditions.	*Construction*: Temporary minor emissions to PEN 1, PEN 2, MCDD, and SDIC will not alter AQMA attainment status. *Operation*: No change to existing conditions.	*Construction*: Temporary minor emissions to PEN 1, PEN 2, MCDD, and SDIC will not alter AQMA attainment status. *Operation*: No change to existing conditions.
Noise	Infilling of neighborhoods will increase population density and commercial uses. Increased residential and truck traffic may lead to increased noise levels.	*Construction*: Temporary moderate increases in noise over construction period of 24 months in golf courses and near homes along Marine Drive in PEN 1/PEN 2. *Operation*: No increase in operational noise.	*Construction*: Temporary moderate increases in noise over construction period of 36 months. *Operation*: No increase in operational noise.	*Construction*: Temporary moderate increases in noise over construction period of 42 months, primarily in PEN 1 and PEN 2, along Marine Drive. *Operation*: No increase in operational noise.
Utilities	Increasing population will require commensurate development of stormwater, landfill, and service utilities.	*Construction*: Ground disturbance and floodwall raising beneath I-5 may intersect with known utilities, coordination with companies will ensure no damage or interruption to service. *Operation*: No change to existing conditions.	*Construction*: Ground disturbance and floodwall raising beneath I-5 may intersect with known utilities, coordination with companies will ensure no damage or interruption to service. *Operation*: No change to existing conditions.	*Construction*: Ground disturbance may intersect with known utilities, coordination with companies will ensure no damage or interruption to service. *Operation*: No change to existing conditions.
Biological Resources	Increasing development will further reduce quantity of, and degrade remaining natural habitat. Federal and local efforts will incrementally address habitat losses through restoration activities and promoting conservation.	*Construction*: Temporary minor disturbance to terrestrial wildlife in golf courses and near SDIC pump station, offset with AMMs. No in-water work. *Operation*: Permanent fill of 0.08 acre of aquatic resources and removal of trees.	*Construction*: Temporary minor disturbance to terrestrial wildlife in golf courses and along Marine Drive, offset with AMMs. Pre-construction surveys to protect streaked horned lark. No in-water work. *Operation*: Permanent fill of 0.25 acre of aquatic resources and removal of trees.	*Construction*: Temporary minor disturbance to terrestrial wildlife at golf course and along Marine Drive, offset with AMMs. Pre-construction surveys to protect streaked horned lark. No in-water work. *Operation*: Permanent fill of 0.75 acre of aquatic resources and removal of trees.
Cultural Resources	Over time, cultural artifacts may be discovered in the area. Existing cultural protection laws will ensure their preservation and proper use.	*Construction*: Potential disturbance during ground work. Impacts avoided through AMMs or mitigation through coordination with SHPO and tribes. *Operation*: No change from existing conditions.	*Construction*: Potential disturbance during ground work. Impacts avoided through AMMs or mitigation through coordination with SHPO and tribes. *Operation*: No change from existing conditions.	*Construction*: Potential disturbance during ground work. Impacts avoided through AMMs or mitigation through coordination with SHPO and tribes. *Operation*: No change from existing conditions.

Resource	Alternative 1 (No Action)	Alternative 3	Alternative 4	Alternative 5
HTRW	Hazardous wastes will continue to be used for local industry and transported through the project area. Existing regulations will continue to control and address HTRW.	*Construction*: No construction initiated until all hazardous waste sites within construction footprint (PEN1/PEN2 and MCCD) are evaluated and remediated, as needed. Potential release of hazardous construction materials or waste, offset by AMMs. *Operation*: No change from existing conditions.	*Construction*: No construction initiated until all hazardous waste sites in project footprint (PEN1/PEN2, MCDD, and SDIC) are evaluated and remediated, as needed. Potential release of hazardous construction materials or waste, offset by AMMs. *Operation*: No change from existing conditions.	*Construction*: No construction initiated until all hazardous waste sites in project footprint (PEN1/PEN2, MCDD) are evaluated and remediated, as needed. Potential release of hazardous construction materials or waste, offset by AMMs. *Operation*: No change from existing conditions.
Land Use, Planning and Zoning	Increasing population density and commercial development will require ongoing zoning and land use control and management. Urban growth boundaries and management plans may require modification to accept growing population.	*Construction*: Transition of portions of golf courses to levee infrastructure. *Operation*: Permanent loss of 10 acres of fairways at greens at Heron Lakes Golf Course and 2 acres at Riverside Golf and Country Club.	*Construction*: Transition of portions of golf courses to levee infrastructure. *Operation*: Permanent loss of 12 acres of fairways at greens at Heron Lakes Golf Course and 2 acres at Riverside Golf and Country Club.	*Construction*: Transition of portions of golf courses to levee infrastructure. *Operation*: Permanent loss of 16 acres of fairways at greens at Heron Lakes Golf Course and 2 acres at Riverside Golf and Country Club.
Socioeconomics	Population density will increase. Jobs, incomes, and most demographics will continue along their current trajectory. Flooding with levee breach will result in billions in damage and potential casualties to an increasing population.	*Construction*: Temporary increase in construction workers in the area, along with incremental and temporary rise in economy. *Operation*: No permanent rise in housing needed. Flood risk reduced to all neighborhoods.	*Construction*: Temporary increase in construction workers in the area, along with incremental and temporary rise in economy. *Operation*: No permanent rise in housing needed. Flood risk reduced to all neighborhoods.	*Construction*: Temporary increase in construction workers in the area, along with incremental and temporary rise in economy. *Operation*: No permanent rise in housing needed. Flood risk reduced to all neighborhoods.
Environmental Justice	No future changes to demographics of low income or minority populations. At least half of all residents at risk from a 100-year flood plus levee breach. In particular, the majority or all of PEN 2 and MCDD homes would remain at risk.	*Construction*: Duration and scope of construction will not disproportionately affect low-income populations in CT 73 (MCDD). *Operation*: Flood risk reduction will benefit low-income populations.	*Construction*: Duration and scope of construction will not disproportionately affect low-income populations in CT 73 (MCDD). *Operation*: Flood risk reduction will benefit low-income populations.	*Construction*: Duration and scope of construction will not disproportionately affect low-income populations in CT 73 (MCDD). *Operation*: Flood risk reduction will benefit low-income populations.
Aesthetics	Continued development will increase number of homes and businesses, while removing green space and increasing impervious surfaces. Local groups will restore natural areas as much as possible and beautify with landscaping.	*Construction*: Temporary minor changes to natural areas, levees, and staging/work sites, particularly at golf courses and along Marine Drive. Offset by AMMs. *Operation*: Permanent fill of 0.08 acre of aquatic resources and removal of trees.	*Construction*: Temporary minor changes to natural areas, levees, and staging/work sites particularly at golf courses and along Marine Drive in PEN 1/2. Offset by AMMs. *Operation*: Permanent loss of 0.25 acre of aquatic resource and removal of trees.	*Construction*: Temporary minor changes to natural areas, levees, and staging/work sites, particularly at golf courses and along Marine Drive. Offset by AMMs. *Operation*: Permanent loss of 0.75 acre of aquatic resource and removal of trees. Raised floodwall and levees along Marine Drive will result in minor changes to existing aesthetics.
Recreation	Recreational facilities and features will be maintained by the cities and local interest groups. Without increased flood protection, parks and trails will be damaged by a flood event.	*Construction*: Temporary access interruptions to recreational facilities at Gleason Boat Ramp, Chinook Landing, and golf courses. Offset with AMMs to minimize interruptions. *Operation*: Permanent loss of 10 acres of Heron Lakes Golf Course and 2 acres at Riverside Golf and Country Club.	*Construction*: Temporary access interruptions to recreational facilities at Gleason Boat Ramp, Chinook Landing, and golf courses. Offset with AMMs to minimize interruptions. *Operation*: Permanent loss of 12 acres of Heron Lakes Golf Course and 2 acres at Riverside Golf and Country Club.	*Construction*: Temporary access interruptions to recreational facilities at Gleason Boat Ramp, Chinook Landing, and golf courses. Offset with AMMs to minimize interruptions. *Operation*: Permanent loss of 16 acres of Heron Lakes Golf Course and 2 acres at Riverside Golf and Country Club.
Public Health and Safety	Addressing potential flood damage will be piecemeal and not a comprehensive and holistic approach. A 100-year flood with levee breach will threaten 65-75% of structures.	*Construction*: Temporary minor increase in heavy machinery and traffic patterns, particularly along Marine Drive, dangers offset with AMMs. No reduction in emergency response access. *Operation*: Flood risk reduction for all communities throughout PMLS protected area.	*Construction*: Temporary minor increase in heavy machinery and traffic patterns, dangers offset with AMMs. No reduction in emergency response access. *Operation*: Flood risk reduction for all communities throughout PMLS protected area.	*Construction*: Temporary minor increase in heavy machinery and traffic patterns, dangers offset with AMMs. No reduction in emergency response access. *Operation*: Flood risk reduction for all communities throughout PMLS protected area.

Resource	Alternative 1 (No Action)	Alternative 3	Alternative 4	Alternative 5
Transportation and Traffic	As population grows, the number of vehicle trips on roads will increase, potentially congesting evacuation routes in the event of a flood. Roadways, railways, and trails will remain at risk to a 100-year flood with levee breach.	*Construction*: Temporary changes to traffic flow and access, due to road closures, detours, and approximately 50 truck trips per day. Traffic circulation plan and other AMMs to offset road and rail delays, and ensure safety. Floodwall raise along Marine Drive may affect traffic in PEN 1. *Operation*: No changes to existing conditions.	*Construction*: Temporary changes to traffic flow and access, due to road closures, detours, and approximately 50 truck trips per day. Traffic circulation plan and other AMMs to offset road and rail delays, and ensure safety. Levee raise along Marine Drive and Airport Dr. may affect traffic. *Operation*: No changes to existing conditions.	*Construction*: Temporary changes to traffic flow and access, due to road closures, detours, and approximately 80 truck trips per day, particularly along Marine Dr. Traffic circulation plan and other AMMs to offset road and rail delays, and ensure safety. Floodwall raise and raising Airport Drive may affect traffic at these locations, and would result in loss of up to 74 parking spaces along north side of N. Bridgeton Dr. *Operation*: No changes to existing conditions.
Cumulative Effects	The population at risk will continue to grow at rates based on projected development from master plans as well as estimates by the U.S. Census Bureau. Zoning and building code requirements will persist, allowing structures to be built in the leveed area without requiring elevation to the 1% AEP event. Wetlands and riparian resources are assumed to persist throughout the period of analysis. Flood risk management performance of Canadian and U.S.-operated facilities will remain the same for the study period.	*Construction*: Phasing, planning, and coordination with ODOT and municipal groups will ensure that construction of any alternative does not overlap with other projects in a way that causes greater delay, closure, or detour than when considered alone. *Operation*: Each of the alternatives has been designed to reduce potential flood risk from an overtopping or levee breach event. Coupled with existing levees, each alternative will reduce danger and flood damages to residents and businesses.		

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4.4. Water Resources (including Climate Change and Sea Level Change)

This section describes water resources and water quality in the study area and nearby areas where the alternatives could affect hydrology or water quality, and discusses the potential impacts the alternatives could have on water resources. The area of analysis includes the study area, the nearshore areas of the Columbia River in the vicinity of the project, and the Columbia Slough and its tributaries.

This section also discusses the projected effects of climate change on hydrology and water quality in the study area. Streams within the study area are tidally influenced, so the effects of sea level change are discussed here on a qualitative basis. For a full discussion of climate change, refer to Appendix A (Hydrology and Hydraulics).

4.4.1. Affected Environment

4.4.1.1. Surface Water

In compliance with the Clean Water Act (CWA), the states of Oregon and Washington maintain lists of impaired water bodies that are approved by the U.S. Environmental Protection Agency (EPA). Both the Oregon Department of Environmental Quality (ODEQ) and the Washington Department of Ecology (WDOE) monitor water quality in the Columbia River along the border, and both agencies submit listings for this portion of the Columbia River. The Columbia Slough, the Sandy River, Osburn Creek (a tributary of the Columbia Slough), and other water bodies in the vicinity of the study area are monitored by ODEQ.

Oregon Department of Environmental Quality Water Quality Monitoring

ODEQ has developed the Oregon Water Quality Index (OWQI) to rate general water quality at distinct monitoring sites and to evaluate whether water quality is improving or deteriorating at a given site. The *2018 OWQI Data Summary Report* and the Willamette, Sandy, and Columbia River Basin OWQI summary table are available at ODEQ's Water Quality Index webpage (ODEQ 2019e). The Sandy River at the Troutdale bridge, near the confluence with the Columbia River, has an OWQI score of 86 and a status of 'Good.' At Landfill Road (also known as City Dump Road), downstream of the study area, the Columbia Slough has an OWQI score of 50 and a status of 'Very Poor.' This site ranks particularly poorly for the following water quality parameters: dissolved oxygen, biological oxygen demand, total solids, nitrogen, and phosphorus. However, ODEQ trend analysis for the site indicates that there was an improving trend in water quality between water years 2009 and 2018. This improvement is likely due to water quality control projects implemented by the City of Portland.

ODEQ develops water quality criteria based on designated beneficial uses (ODEQ 2019a, Oregon Secretary of State 2019). Beneficial uses for the rivers and streams in the vicinity of the study area are shown in Table 4-3 (ODEQ 2003a, ODEQ 2003b, ODEQ 2005a). Oregon also

designates specific fish uses for rivers and streams within each water basin. The Columbia River is designated as a salmon and steelhead migration corridor. Salmon and trout rearing and migration are designated fish uses in both the Columbia Slough and the Sandy River. The Sandy River is also designated for salmon and steelhead spawning use from October 15 to May 15 of each year (ODEQ 2019a).

Table 4-3 Oregon Designated Beneficial Uses for the Mainstem Columbia River, Sandy River, Columbia Slough, and Osburn Creek (a Tributary of the Columbia Slough)

Oregon Beneficial Uses	Columbia River		Sandy River	Columbia Slough[2]	Osburn Creek[3]
	Mouth to RM[1] 86	RM[1] 86 to 309			
Public Domestic Water Supply[4]	•	•	•	•	•
Private Domestic Water Supply[4]	•	•	•	•	•
Industrial Water Supply	•	•	•	•	•
Irrigation	•	•	•	•	•
Livestock Watering	•	•	•	•	•
Fish and Aquatic Life	•	•	•	•	•
Wildlife and Hunting	•	•	•	•	•
Fishing	•	•	•	•	•
Boating	•	•	•	•	•
Water Contact Recreation	•	•	•	•	•
Aesthetic Quality	•	•	•	•	•
Hydropower		•	•	•	•
Commercial Navigation and Transportation	•	•			

1 RM = river mile
2 As a tributary to the Willamette River
3 As a stream within the Willamette Basin (also referred to as Fairview Creek)
4 With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards
Source: ODEQ 2003a, ODEQ 2003b, ODEQ 2005a

4.4.1.2. Water Quality Assessment Results

Statewide water quality assessments are completed by ODEQ and WDOE approximately every two to four years, as mandated by the CWA (ODEQ 2019d). The assessments use available water quality data to evaluate the water quality within a given segment of a stream or river, or within a lake or reservoir. Within each segment, measured parameters are assigned to a specific category that indicates if the water segment meets water quality standards for that parameter. The categories used by ODEQ and WDOE are defined in Appendix G (Additional Affected Environment Data).

Per CWA Section 303(d), ODEQ and WDOE compile 303(d) lists of all water bodies for which one or more parameters are categorized as Category 5, indicating that state water quality criteria were exceeded and a total maximum daily load (TMDL) pollutant load limit needs to be

developed (ODEQ 2019a). TMDLs are developed for water bodies that are impaired for one or more parameters such as temperature, turbidity, bacteria, or other pollutants. A TMDL establishes how much of a given pollutant a stream, river, or lake can receive before water quality standards are exceeded. Under the CWA, EPA reviews and either approves or disapproves TMDLs that are proposed by the states (EPA 2019a). If EPA disapproves a state TMDL, EPA must develop a replacement TMDL.

Category 4 and 5 ODEQ and WDOE listings for the main stem Columbia River upstream of, adjacent to, and downstream of the study area are listed in Appendix G (Additional Affected Environment Data). The table also includes ODEQ listings for the Sandy River, the Columbia Slough, Osburn Creek, two lakes in the study area, and the Willamette River. The two lakes in the study area that have ODEQ listings are Fairview Lake and Blue Lake.

Fairview Lake, on Osburn Creek, has a Category 5 listing for aquatic weeds or algae. Upstream and downstream of Fairview Lake, Osburn Creek has a Category 5 listing for biological criteria. The hydrologically separate Blue Lake, just north of Fairview Lake, has Category 5 listings for aquatic weeds or algae, pH, chlorophyll a, ammonia, and dissolved oxygen (ODEQ 2018a); (see Appendix G (Additional Affected Environment Data).

Columbia Slough

The eastern portion of the Columbia Slough (within the MCDD, Figure 4-1), has an approved TMDL for temperature under the Willamette Basin TMDL (ODEQ 2006), as well as approved TMDLs for lead, dichlorodiphenyldichloroethylene (DDE), chlorophyll a, dioxin, fecal coliform, phosphorus, dissolved oxygen, polychlorinated biphenyls (PCBs), and pH (ODEQ 1998). It also has a Category 5 listing for iron. South Columbia Slough, a tributary to the eastern portion of the Columbia Slough (Figure 4-1), also has a Category 5 listing for iron (ODEQ 2018a). The western portion of the Columbia Slough (within and adjacent to PEN 1 and PEN 2, Figure 4-1) has a TMDL for pH (ODEQ 1998) and Category 5 listings for biological criteria, dissolved oxygen, and iron (ODEQ 2018a); (see Appendix G (Additional Affected Environment Data).

Although water quality in the slough is poor, it has improved substantially since the 1990s due to City of Portland projects to reduce combined sewer overflows to the slough and improvements to the methods used by the Port of Portland to manage runoff of de-icing chemicals from Portland International Airport. The City of Portland monitors water quality in the slough. Current City of Portland management priorities for the slough include improving stormwater treatment and restoring riparian vegetation (City of Portland 2019a, City of Portland and ODEQ 2018).

Columbia River

In the portion of the Columbia River adjacent to and north of the study area, TMDLs have been approved by the EPA for dioxin (EPA 1991) and total dissolved gas (ODEQ and WDOE 2002).

Sandy River

The Sandy River, just east of the study area, has an approved TMDL for temperature (ODEQ 2005b).

Willamette River

The lower portion of the Willamette River, downstream of the study area, has approved TMDLs for temperature, E. coli and dioxin (ODEQ 2006, ODEQ 2018a) and numerous Category 5 listings (see Appendix G (Additional Affected Environment Data)).

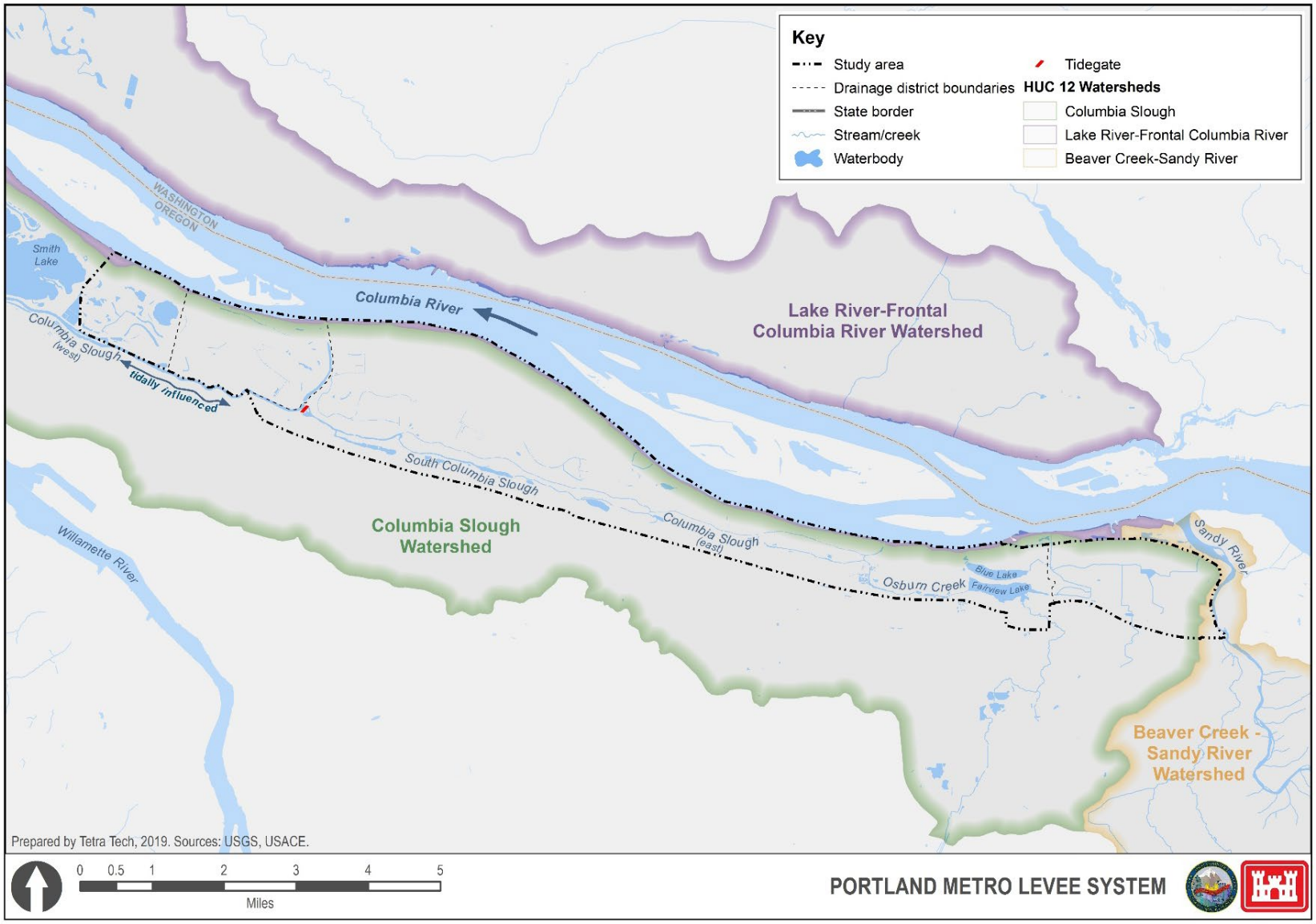

Figure 4-1 Watersheds in the Study Area

4.4.1.3. Groundwater

ODEQ Monitoring

ODEQ monitors and assesses groundwater quality in Oregon. Groundwater quality protection requirements for Oregon are codified in Oregon Administrative Rules Chapter 340, Division 40 (Oregon Secretary of State 2019). If groundwater in a specific area has elevated contaminant levels due to contamination from non-point sources, ODEQ has authority to designate that area to be a Groundwater Management Area (GWMA). This designation requires the formation of a local groundwater management committee and the development of an action plan to reduce groundwater contamination in the GWMA. There is no designated GWMA within or near the study area (ODEQ 2019b). ODEQ does not monitor groundwater quality in the study area.

Port of Portland Monitoring

The Port of Portland conducts groundwater quality monitoring where mandated by the EPA, such as at the Portland International Airport, located within the MCDD, and at the 800-acre Reynolds Metals Company Superfund Site that the Port is redeveloping, which is located within the SDIC portion of the study area.

Columbia South Shore Well Field

In areas where groundwater is used to supply drinking water, groundwater quality is monitored and protected. At the east end of the study area, a wellfield known as the Columbia South Shore Well Field is used as a source of drinking water for 966,000 people (City of Portland 2019b). The well field includes 26 active wells that tap into three aquifers. The wells are a secondary or alternative source of drinking water for the City of Portland, and are used when maintenance, turbidity, or low summer flows limit use of the primary Bull Run water supply (City of Portland 2018a). The upper range of measured pH and hardness values in the raw groundwater samples slightly exceeded the EPA standard (City of Portland 2018b). The raw groundwater is treated before distribution, and all treated groundwater that is distributed by the City of Portland meets EPA and state standards (City of Portland 2018a, City of Portland 2018b).

The City of Portland, City of Gresham, and City of Fairview jointly implement a groundwater protection program to protect the well field. The 7,567-acre designated protection area is known as the Columbia South Shore Well Field Wellhead Protection Area (City of Portland 2019b). 4,119 acres (or 48 percent) of the MCDD and 242 acres (16 percent) of the SDIC fall within the protection area. In total, the Columbia South Shore Wellfield Protection Area overlaps 34 percent of the 12,756-acre study area (ODEQ 2017). The groundwater protection program regulates halogenated solvents, carcinogenic materials, EPA-regulated hazardous substances and toxic chemicals, ODEQ-regulated hazardous wastes, petroleum products, and petroleum-based liquid fuels when these chemicals are used at concentrations greater than 10 percent and in quantities above designated thresholds. Businesses within the protected area that use these chemicals in amounts that exceed set thresholds are subject to regulation and must implement

spill prevention and containment plans and structural and operational best management practices (City of Portland 2019c).

4.4.1.4. Hydrology

Study Area

Hydrology within the study area has been substantially altered relative to historic conditions by construction of levees and dikes, use of pumps and canals, and the regulated hydrology of the Columbia River watersheds. Ongoing dredging of the Columbia River navigation channel alters the patterns of flow and circulation of deep water and shallow water. Channel modifications in the Columbia River, Columbia Slough, and the interior of the floodplain have altered sediment transport and deposition processes, erosion, and flooding patterns. Watershed characteristics by drainage district are shown in Table 4-4.

Table 4-4 Watershed Acreage and Percent Overlap with Drainage District

HUC 12 Name (Code)	Columbia Slough (170900120201)	Lake River-Frontal Columbia River (170800030104)	Beaver Creek—Sandy River (170800010703)
Total Acres in HUC 12	**36303.6**	**46965.7**	**22848**
PEN 1			
Acres in HUC 12	968.4	33	
Percent of District in HUC 12	95.50%	3.20%	
Percent of HUC 12 in District	2.70%	0.10%	
PEN 2			
Acres in HUC 12	1541	31	
Percent of District in HUC 12	95.50%	1.90%	
Percent of HUC 12 in District	4.20%	0.10%	
MCDD			
Acres in HUC 12	8310.4	199	
Percent of District in HUC 12	96.20%	2.30%	
Percent of HUC 12 in District	22.90%	0.40%	
SDIC			
Acres in HUC 12	1486.4	3.1	88
Percent of District in HUC 12	94.20%	0.20%	5.60%
Percent of HUC 12 in District	4.10%	0.01%	0.40%
Entire Study Area			
Acres in HUC 12	12306.1	266	88
Percent of Study Area in HUC 12	95.80%	2.10%	0.70%
Percent of HUC 12 in Study Area	33.90%	0.6	0.40%

Columbia River

Hydrology in the lower Columbia River is influenced primarily by seasonal discharges from the 12 mainstem dams upstream of the study area, and to a lesser extent by tidal influence. Development of the Federal Columbia River power system (FCRPS) has substantially affected

peak seasonal discharges as well as the velocity and timing of flows. The Columbia River estuary historically received annual spring freshet flows that were on average 75 to 100 percent higher than current flows (ISAB 2000 as cited in LRC 2017).

Tidal influence in the Columbia River extends to Bonneville Dam, and affects hydrology in Columbia Slough and the lower Willamette River as well as the mainstem Columbia River. Although the saltwater wedge stops well downstream of the study area, the tidal prism may fluctuate up to 2 feet in the study area.

Columbia Slough

Columbia Slough and the channels that connect to it form a branched, low-gradient waterway that is highly managed by pumps, levees, and impoundments. The slough's flat topography combined with the water management features results in slow water movements throughout the slough system. Stream flow velocities are low even during periods of high discharges from the slough's tributaries, and negative flow occurs on a daily basis due to tidal influence (NMFS 2005 as cited in LRC 2017).

Sandy River

Hydrology in the Sandy River is characterized by low flows in late summer and high flows associated with rainstorms and rain-on-snow events during winter and spring snowmelt (Metro 2012 as cited in LRC 2017).

4.4.1.5. Climate Change/Sea Level Change

A qualitative analysis of the potential impacts of climate change was performed for this feasibility study per the guidance in ECB 2018-14 (USACE 2018), ER 1100-2-8162 (USACE 2013), and ETL 1100-2-1 (USACE 2014) and provided in Appendix A (Hydrology and Hydraulics). The following paragraphs provide a brief summary of those findings.

Generally, climate change modeling shows variations in temperature, precipitation, snowpack, hydrology and streamflow trends throughout the region. Locally, observations in the Columbia Basin indicate a basin-wide mean temperature increase of 0.19°F per decade from 1916-2006, or a total increase of 1.7°F (RMJOC-I 2010). Precipitation data shows that the average trend in the Columbia Basin is an increase in annual precipitation of 0.34 inches per decade, or a total increase of 3 inches from 1916-2006 (RMJOC-I 2010). The amount of precipitation falling during the heaviest 1 percent of events increased by 22 percent% from 1901-2016, and the number of 5-year, 2-day events increased by 13 percent from 1901-2016 (USGCRP 2018). Similarly, snowpack has experienced a downward trend (Mote 2006). Despite the observed decreasing trend in the region, future projections in the Columbia Basin indicate an increase in annual streamflow volume. Streamflow projections indicate seasonal trends of higher winter flows and earlier spring peak flows. These seasonal trends are consistent with observed and projected trends in decreasing snowpack.

The effects of climate change may include sea level rise, which would affect tidal processes in the Columbia River and Columbia Slough. The average sea-level rise prediction based on numerical modeling by the International Panel on Climate Change and adjusted by the Climate Impacts Group is approximately 11 inches for the northern Oregon/southern Washington Pacific Ocean coasts by 2100 (Mote *et al.* 2008).

The Corps' Sea Level Change Curve Calculator (USACE 2017) presents sea level rise estimates by 2100 at the Astoria, Oregon gauge (Gauge 9439040) operated by the National Oceanic and Atmospheric Administration (NOAA), corresponding to three scenarios:

- Sea levels would decrease by 0.1 feet relative to the North American Vertical Datum of 1988 (NAVD88) under the low-rise scenario.
- Sea levels would increase by 0.93 feet NAVD88 under the intermediate scenario.
- Sea levels would increase by 4.21 feet NAVD88 under the high scenario.

Because the Lower Columbia River is tidally influenced, an analysis has also been completed to estimate the effect of sea level change in the project area. Overall, a rise in sea level could increase the peak stage (highest water surface elevation) of a flood by 0.09-0.47 feet on the Columbia River through the project area (see Appendix A (Hydrology and Hydraulics)) (USGS 2019). However, future predicted peak stage on the Columbia River is projected to increase by 4.13 feet in a potential future extreme but plausible event without sea level change, so the impact of sea level increase in peak stage is much smaller than the impact of extreme future storm conditions (see Appendix A). This means that the probability of a levee breach depends much more on the size of a precipitation event than on sea level rise. Rising sea level is projected to increase the duration of levee loading, as higher sea levels raise the overall surface water elevation, impeding the movement of flood waters out of the project area. This would result in an increased risk of levee failure due to seepage (see Appendix A). Predicted changes to sea level were modeled to result in delays in flood attenuation between a few hours to as many as 20 hours (see Appendix A).

4.4.2. Environmental Consequences

Potential impacts to water resources resulting from construction and operations could include:

- Alterations to hydrology and the floodplain,
- Long-term impacts to water quality parameters, and
- Impacts to designated beneficial uses, as described in the previous section.

4.4.2.1. Alternative 1 (No Action)

Climate models indicate that winter precipitation will increase, and summer precipitation will decrease, accentuating the existing seasonal variations in precipitation (Mote and Salathé 2009; IPCC 2013). Temperatures are expected to rise during the long term, with expected effects including more precipitation falling as rain rather than snow, diminished snowpack, increased

peak flows, reduced dry season (April to September) flows, altered timing of flows, and continued increases in water temperatures.

Continued development in the study area and operation of dams in the Columbia River Basin will affect hydrology in and adjacent to the study area into the foreseeable future. Federal, municipal, regional, state, and tribal agencies, as well as conservation organizations, have undertaken extensive restoration efforts throughout the project area and will continue working to reduce effects from hydromodification and urbanization of the watershed. While continued dam and reservoir operation within the Columbia River Basin will ultimately still regulate flows, comprehensive restoration efforts planned and currently implemented throughout the river network will help restore some hydrologic processes.

Water quality conditions and beneficial uses will continue to be addressed through Federal, state, and local legislation and efforts. Measures to address sediment quality in the Columbia Slough are expected to continue as needed, resulting in improvements of sediment and water quality over time. Small-scale restoration efforts proposed by the Columbia Slough Watershed Council will also add incrementally to the improvement of water quality (CSWC 2013). Overall, concerted efforts by a wide variety of agencies and local groups will ensure that water quality will remain as is or continue to improve into the future. However, improvements will continue to be slow and may not result in improved WQI scores for many years.

Wetland losses, diking and bank hardening, vegetation removal, increased impervious surfaces and regional changes in hydrology have altered the temporal and spatial patterns of groundwater inflows and in general reduced levels of groundwater input, although there is little quantitative information to assess the specific nature of these changes. These trends are likely to continue for the foreseeable future.

4.4.2.2. Alternative 3

Changes to hydrology may occur where the SDIC pump station capacity would be increased and may result in increased discharge at the outlet. The increased discharge may result in minor increases in turbidity at the outfall location, but this effect would be minor and turbidity levels would return to background levels within the mixing zone allowed under Oregon law.

During construction, ground disturbance would occur where the levees would be widened or raised, where a concrete pad would be enlarged to increase pump capacity, and during rehabilitation or replacement of mechanical structures. Ground-disturbing actions associated with construction and operation under this alternative may result in erosion and turbidity in the immediate locations of construction actions, affecting beneficial uses such as aesthetic quality and fish and wildlife habitat. The use of avoidance and minimization measures would ensure that water quality standards are not exceeded. The alternative would not result in increased water use or exacerbate climate change, and would decrease flood risk. Turbidity and erosion will be controlled during construction by AMMs specified in Table 4-1, making this impact less than significant.

Stormwater runoff from temporarily disturbed construction and staging areas could contribute sediment-laden runoff to water bodies and increase turbidity. All construction would occur in the dry, except where actions to widen the cross levee between PEN 2 and MCDD would result in fill of a ponded area located immediately west of the existing levee. Construction areas would be isolated from water bodies to the degree possible by sediment-containment fences. Construction actions near interior floodplain wetlands or channels would create turbidity in the immediate work area, but since the work would occur when there was little or no flow, turbidity would be unlikely to move out of the construction area, and downstream turbidity impacts would not be likely to occur. As a result, these impacts would be less than significant, and would be reduced further by implementation of avoidance and minimization measures identified in Table 4-1.

During construction, petroleum products and hazardous materials such as fuels, oils, and lubricants would be present onsite, primarily in vehicles and construction equipment. Use of these materials as well as uncured concrete increases the risk of accidental discharge into riparian areas or directly into water bodies, resulting in impaired water quality as well as injury or mortality of aquatic species. Leakage of hydraulic fluids, fuels, and solvents could occur during construction near aquatic areas. These impacts would be minimized by implementation of a Spill Prevention, Control, and Containment plan as well as use of standard construction impact minimization measures designed to contain hazardous materials and reduce the chances of spills or leaks. These measures are described in Table 4-1. Construction under this alternative is expected to have less than significant impacts on water resources in and around the study area.

Operations activities may result in long-term impacts to some designated beneficial uses, specifically aquatic life. Aquatic life such as invertebrates and waterfowl would likely be impacted in the long-term by loss of aquatic habitat from filling ponded areas within the diked areas to widen the levees in specific locations; however, the total area of filled aquatic resources will be less than 0.25 acres and no sensitive populations of invertebrates or waterfowl would be likely to be affected, resulting in an impact that would be less than significant.

4.4.2.3. Alternative 4

Impacts to water resources under this alternative would be similar to those described under Alternative 3. In addition, by increasing the capacity of the pumps at the pump stations, interior water levels may be drawn down faster than under existing conditions, and water will be discharged into receiving waters at a greater rate. Higher discharge rates may slightly increase turbidity somewhat in receiving waters, but it is likely that the pumps would operate at this higher capacity only during high flows, when receiving waters would already be turbid. This impact would be less than significant. Minor increases in impervious surfaces would occur if concrete pads at pump stations were expanded to add capacity or redundancy. New impervious surfaces would cover less than ½ acre, which would be a negligible component of the overall study area, therefore this impact would be negligible.

4.4.2.4. Alternative 5

Impacts to water resources under this alternative would be similar to those described under Alternative 4. The amount of new impervious surfaces would be increased by up to 16,800 sq. ft. relative to Alternative 4, due to construction of the floodwall in PEN1 and PEN2. New impervious surfaces would cover less than 1 acre, which would be a negligible component of the overall study area. Changes to stormwater runoff would be minimal and contained within existing infrastructure, so this impact would be negligible.

4.5. Physical Resources

This section describes topography, geology, unique physical land features, potential geologic hazards, and soils data, including erosion and liquefaction risk, for the study area.

4.5.1. Affected Environment

4.5.1.1. Topography

The study area lies within the floodplain of the Columbia River and topography is generally flat (City of Portland 2009, Table 4-5). Localized topography features constructed levees, railroad berms, and highway embankments, but there is very little variation in elevation within the levee-protected area. The southwestern edges of MCDD and SDIC have slightly more variation in topography, as this edge of the study area includes some small areas outside of the 100-year floodplain.

Table 4-5 Elevation Range for Each Levee District

District	**Elevation Range (m)** (NAVD88)
PEN 1	-4.9 – 18.5
PEN 2	-10.9 – 17.8
MCDD	-3.2 – 26.7
SDIC	3.1 – 26.7

4.5.1.2. Soils

Soils derived from alluvial deposits underlie the majority of the study area. Seventy-seven percent of study area soils are silt loam, sandy loam, silty clay loam, or loam (NRCS 2018); see Appendix G (Additional Affected Environment Data). Fifteen percent are loamy sand or sand. These sandy soils fall within MCDD (see Appendix G). Reflecting the flat topography of the study area, 89 percent of study area soils are classified as nearly level (slopes ≤ 2 percent, see Appendix G). These flat soil horizons help to minimize erosion at disturbed areas, such as the locations of pump stations or areas where levee or drainage maintenance has occurred. Pump discharge points may have localized erosion, particularly at sites that discharge below the normal water surface elevation.

In support of the 2012 *Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes*, the Oregon Department of Geology and Mineral Industries (DOGAMI) assessed the susceptibility of Oregon sediments to liquefaction. Liquefaction occurs when shallow, loose, saturated sediments temporarily lose strength during strong ground shaking events. In developed areas, liquefaction can significantly damage buildings and other structures (USGS 2019b). For all assessed areas, DOGAMI assigned a susceptibility value of 0 (none), 1 (very low), 2 (low), 3 (high), or 4 (very high) (DOGAMI 2013b). The susceptibility to liquefaction is very high in 89 percent of the study area and 100 percent of PEN 1 and PEN 2 (DOGAMI 2013a, DOGAMI 2013b); see Appendix G (Additional Affected Environment Data). The susceptibility to liquefaction is very high (4) in 89 percent of the study area and 100 percent of PEN 1 and PEN 2 (DOGAMI 2013a, DOGAMI 2013b); see Appendix G, Table G-4. The susceptibility to liquefaction is high (3) to very high (4) in most of MCDD and SDIC (89 and 93 percent, respectively), but portions of both districts (11 percent of MCDD and 8 percent of SDIC, respectively) have low (2) to no (0) susceptibility to liquefaction (DOGAMI 2013a, DOGAMI 2013b); see Appendix G.

4.5.1.3. Geology

Alluvial deposits, breccia formed from mudflow deposits, artificial fill, Missoula Flood deposits, and a small amount of sandstone underlie the study area (DOGAMI 2015); see Appendix G (Additional Affected Environment Data). At the west end of the study area, alluvium and artificial fill underlie the entirety of PEN 1 and PEN 2. Artificial fill underlies 11 percent of PEN 1 and 24 percent of PEN 2. Alluvial deposits underlie 82 percent of MCDD, and fine- and coarse-grained sediments deposited by the Missoula Floods underlie an additional 7 percent. Artificial fill underlies only 4 percent of MCDD, and breccia formed from Mt. Hood mudflows (0.5 percent) and Troutdale Formation sandstone (1.6 percent) underlie the remainder of MCDD. Geology within SDIC differs considerably from the rest of the study area; see Appendix H (Cultural Resources). Breccia formed from Mt. Hood mudflows underlies 74 percent of SDIC, and alluvium underlies only 16 percent. Troutdale Formation sandstone (4 percent), artificial fill (5 percent), and Missoula Flood deposits (1 percent) underlie the remainder of SDIC (DOGAMI 2015); see Appendix G (Additional Affected Environment Data).

There is one fault in the study area: Blue Lake Fault, which runs east-west through SDIC and the northeast corner of MCDD (DOGAMI 2015).

4.5.1.4. Landslide Risk

While landslides are one of the most significant erosional processes in western Oregon, the landslide risk in the relatively flat study area is low. According to a 2016 regional assessment by DOGAMI that rated landslide susceptibility throughout Oregon from low to very high, the susceptibility to landslides is low in 75 percent of the study area (DOGAMI 2016); see Appendix G (Additional Affected Environment Data). The susceptibility to landslides is moderate in 19.5 percent of the study area, and high in the remaining 4.5 percent, which consists of the slopes of levees and the railroad berm. The risk of slope instability ("landslides") related to levees is related to flood conditions and is accounted for in the future without project conditions. The

percentage of land area falling into each susceptibility class is relatively consistent throughout the four districts (see Appendix G). As of 2017, no debris flows, debris slides, rock falls, earth flows, earth slides, fill failures, flows, landslides, rockfalls, or slides had been observed in the study area (DOGAMI 2017).

4.5.1.5. Mineral Resources

The only mineral resource in the study area is aggregate (crushed stone) (DOGAMI 2009). There are two former Oregon Department of Transportation (ODOT) aggregate production areas in the study area, one in the southeast corner of MCDD near Fairview and one in SDIC near the Troutdale Airport. ODOT does not have an active permit for either site (DOGAMI 2019a). CalPortland operates the Blue Lake Aggregate Yard on NE Marine Drive north of Blue Lake Regional Park. It receives and distributes sand and gravel products (CalPortland 2019).

There are no permitted oil or gas wells in the study area (DOGAMI 2019b).

4.5.2. Environmental Consequences

Project construction would have temporary impacts resulting from increased soil erosion, soil compaction and mixing of soil horizons. These impacts would be avoided through use of avoidance and minimization measures that would reduce impacts.

Impacts associated with soils, topography, or geology could occur if an alternative resulted in any of the following:

- Increased risk from geologic hazards such as liquefaction, earthquakes, landslides
- Substantial erosion or sedimentation
- Fugitive dust generated during construction
- Interference with groundwater recharge.

4.5.2.1. Alternative 1 (No Action)

Under the Future Without-Project Condition, physical resources in the study area would not change substantially. Soils will continue to degrade naturally through erosion and as a result of human modifications in the study area. No substantial changes to geologic layers, landslide risk, or topography are anticipated to occur in the future. As the study area soils are highly prone to liquefaction, this condition could occur on a wide scale in the event of a strong local earthquake.

Currently, sediment contributions to the study area are minimal due to modification of the floodplain and reduced flooding events. Sediment transport processes on the mainstem Columbia River will continue to be interrupted as a result of upstream revetments and dams. Disconnection of upstream sediment from downstream reaches of the Columbia River result in a trend of allowing less coarse sediment to move through the Columbia River system. This results in greater deposition of fine sediments than coarse sediment.

Aquatic sediment in the Columbia River mainstem will continue to increase in fine materials.

4.5.2.2. Alternative 3

During construction, up to 320,000 cy of materials would be deposited at the site to widen the levees or to construct additional levees. Earthwork would result in a temporary increase in soil erosion and compaction. Soil disturbance would result from preparation of ground surfaces where the levees would be widened or raised, an action that would span the length of the western and southern PEN 1 levees, and the Peninsula Slough cross levee, and in PEN 2 along Marine Drive. Additional soils impacts would result from clearing and grubbing construction areas. Each of these elements would occur on dry land and could result in temporary increases in erosion at exposed sites. AMMs would ensure that erosion impacts associated with these actions would be less than significant.

During construction, fugitive dust could be generated, but would be controlled by watering exposed soils at least once daily and covering stockpiled soils. This impact would be less than significant.

The completed upgraded flood risk management features would be designed to comply with Federal requirements for seismic safety. However, the levees are not considered to be high risk factors in regard to seismic concerns, as the chances of them failing due to an earthquake during a high flow event are very minimal, therefore the risk to human life is relatively low.

All new or otherwise exposed levee side slopes would be revegetated immediately after construction, and the levee crests would be graveled. Minor erosion would occur until vegetation is established, but this effect would be short-term and is not expected to deliver substantial amounts of sediment to area water bodies.

The sources of soils that would be imported for construction have not been identified at the current level of design. It is assumed sand would be sourced from Columbia River dredged sand, and other soil material would come from commercially available sources. Any dredged or fill material would be obtained from a clean source, and would be evaluated to ensure that all soils brought to the site would be of suitable composition and free of hazardous materials and substantial amounts of weed seeds.

Soils excavated during construction would be reused to the degree possible. Any unsuitable soils would be disposed of at an area landfill, and contaminated soils would be disposed of at a facility that is licensed to accept such materials. Such facilities are found in Hillsboro, Oregon, and Arlington, Washington.

During operations, some suspended sediments found in the interior drainages are entrained in the pump flows. These sediments are deposited into the Columbia River or Columbia Slough where they are likely to disperse as part of flood flows.

4.5.2.3. Alternative 4

Impacts to physical resources under Alternative 4 would be similar to those occurring under Alternative 3, but the amount of imported material would increase to approximately 475,000 cy. Impacts will be less than significant due to implementation of AMMs described in Table 4-1.

4.5.2.4. Alternative 5

Impacts to physical resources under Alternative 5 would be similar to those occurring under Alternative 3, but the amount of imported material would increase to approximately 725,000 cy. Impacts will be less than significant due to implementation of AMMs described in Table 4-1.

4.6. Air Quality & Greenhouse Gases

This section describes air quality and climate change and discusses potential impacts the alternatives could have on air resources. The air quality area of analysis is administered by ODEQ. Greenhouse gases (GHGs) and climate change are described at a regional or global scale.

4.6.1. Affected Environment

4.6.1.1. Air Quality

Air quality is typically described in terms of the concentrations of various pollutants in the atmosphere. Ambient (outdoor) air quality standards define air pollution levels that are harmful to public health and the environment. Ambient air quality standards are generally set at the Federal and state levels, and monitoring and enforcement are sometimes delegated to local clean air agencies. ODEQ is responsible for protecting air quality and for enforcing Federal, state, and local ambient air quality standards in Oregon. ODEQ maintains monitoring networks that measure air pollution to ensure that communities meet Federal air quality standards and report hourly health levels to the public.

Under Sections 108 and 109 of the Federal Clean Air Act, the EPA establishes National Ambient Air Quality Standards (NAAQS) to protect public health and public welfare and to regulate emissions of hazardous air pollutants. The EPA has established health-based NAAQS for particulate matter (PM) less than 10 micrometers in diameter (PM_{10}), PM less than 2.5 micrometers in diameter ($PM_{2.5}$), ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide and lead (see Appendix G (Additional Affected Environment Data)).

The Oregon Clean Air Act State Implementation Plan, adopted under Oregon Administrative Rule (OAR) 340-200-0040 in response to the NAAQS (ODEQ 2018b), defines Air Quality Control Regions (AQCR) and Air Quality Maintenance Areas (AQMA) throughout the state. Portland is in the Portland Interstate AQCR. In previous years, air quality conditions in Portland resulted in its classification as non-attainment for ozone and carbon monoxide. As a result, though this area is now in attainment, it is classified as an AQMA. The study area is in the

Portland/Vancouver AQMA, and as such, is subject to specific air quality standards for ozone and carbon monoxide.

The Air Quality Index provides a daily account of air quality based on levels of particulate matter, ozone, and carbon monoxide (EPA 2016). Data from the nearest monitoring station, shown in Table 4-6, indicate that air quality in the study area is generally good, except on days when smoke from wildfires concentrates particulate matter in the air basin.

Table 4-6 shows the AQI for Portland for calendar year 2017, the latest for which data has been published (ODEQ 2018b).

Table 4-6 2017 Air Quality Index for Portland, Oregon

Air Quality Standard	Days Meeting Standard
Good	309
Moderate	41
Unhealthy for Sensitive Groups	9
Unhealthy	5
Very Unhealthy	1
Hazardous	0

4.6.1.2. Greenhouse Gases

GHGs are chemical compounds in the earth's atmosphere that absorb and trap long-wave thermal radiation emitted by the land and ocean and radiate it back to earth. GHGs include carbon dioxide, methane, and nitrous oxide. No ambient standards exist for these pollutants. For context, total U.S. anthropogenic (human-caused) GHG emissions were 6,576 million metric tons of carbon dioxide equivalent in 2009, and 40 percent of these were from the electric power sector (EIA 2015). Unlike criteria pollutants and air toxics, GHG concentrations have been increasing over time and are continuing to increase. Increasing concentrations of GHGs could result in increases in the earth's average temperature by up to 7.2 degrees Fahrenheit (°F) by the end of the 21st century (EPA 2015).

4.6.2. Environmental Consequences

Impacts associated with air quality could occur if an alternative resulted in any of the following:

- Obstruction of the implementation of an air quality plan
- Violation of any state or Federal air quality standard
- A cumulatively considerable net increase of a criteria pollutant for which the planning area is in non-attainment
- Exposure of sensitive receptors to substantial pollution concentrations
- Objectionable odors affecting a substantial number of people.

4.6.2.1. Alternative 1 (No Action)

Air quality regulations, including those for fuel formulations, help control emissions from heavy-duty diesel on-road and off-road vehicles. New gasoline reformulation rules should substantially reduce benzene emissions throughout the region. These standards, combined with a more efficient vehicle fleet, are expected to reduce vehicle emissions in the study area over the next 25 to 30 years. In 2017, ODEQ implemented a ban on open burning on days when the AQI is low, and will likely strengthen such regulations over time. These factors will help to maintain compliance with Federal and state clean air rules.

4.6.2.2. Alternative 3

Temporary impacts to air quality may occur from emissions from construction vehicles or from stationary sources during operations. Tailpipe emissions include criteria pollutants that are regulated by the EPA, which delegates some authority for regulating air quality to individual states.

Although emissions would be produced by vehicles during the period of project construction, these emissions are not likely to change the area's attainment status. AMMs specified in Table 4-1 would further reduce the potential for air quality impacts related to construction vehicle emissions.

Dust would be generated at construction sites, but would be controlled by regular watering with a water truck. Dust generation would be minimized at staging areas by using paved areas or covering the work surfaces with crushed rock and enforcing low speed limits on dirt access roads. Impacts from dust would be localized and less than significant.

The completed project would not lead to increased traffic or new stationary sources of emissions, therefore there would be no impacts to air quality from these sources during operations. Installation of more powerful pumps may result in slightly higher emissions at the power generating station that provides the electricity used by the pumps, but this impact would be intermittent and less than significant.

4.6.2.3. Alternative 4

Impacts to air quality under Alternative 4 would be similar to those occurring under Alternative 3, but would extend over 3 years rather than 2 years. However, emissions from construction under this alternative are not expected to change the area's attainment status, and there would be no new stationary sources of emissions.

4.6.2.4. Alternative 5

Impacts to air quality under Alternative 5 would be similar to those occurring under Alternative 4, but would extend over 3.5 years rather than 3 years. Daily air emissions from construction vehicles would increase as the number of daily truck trips would increase from approximately 50

(Alts. 3 and 4) to as many as 80 under Alternative 5. This increase is not expected to exceed thresholds in this air basin.

4.7. Noise

This section describes baseline conditions related to noise, potential impacts related to noise in the study area, and sensitive receptors. The analysis includes any area that could be affected by noise from construction or operations.

Noise is the intrusion of a new sound inconsistent with and above the background level of the existing soundscape. Sound is measured in decibels (dB) on a logarithmic scale. A change in sound level of 3 dB or less is barely perceptible by the human ear; a change of 10 dB is perceived as a doubling or halving of sound level (FHWA 2016). Decibel levels that are weighted to account for differences in human perception of sound at different frequencies are referred to as dBA (using the "A" weighting system).

4.7.1. Affected Environment

4.7.1.1. Noise Sources

Depending on the location, the study area soundscape is dominated by traffic and aircraft noise, industrial noise, and natural sounds such as small waves, wind through vegetation and wildlife such as birds. Development in and near the project site influences the soundscape. Portland International Raceway generates noise levels up to 95 dBA in the PEN 2 area when it is in use for automobile races. Other sources of noise in the study area include traffic on the rail line at the west end of the study area, river navigation, and residential activity (City of Portland 2008).

Railways

Train whistles have been documented as the most intrusive sound source in the residential neighborhoods of the study area (City of Portland 2008). Measured sound pressure levels from train whistles equating to inside sound levels over 75 dBA with windows closed were recorded in these neighborhoods (City of Portland 2008). Light rail in the region also contributes intermittently to noise levels, but this source results in much lower noise levels than freight trains.

Airports

Substantial noise levels are generated by aircraft use of Portland International Airport. Most of MCDD is within the 2035 55-dBA day-night average level noise contour (City of Portland 2011a). A smaller area surrounding the airport is within the 65-dBA day-night level (L_{dn}) noise contour and is subject to the regulations stated in the Portland International Airport Noise Impact Overlay Zone. The Overlay Zone reduces the impact of aircraft noise on development within the noise impact area surrounding the airport by limiting residential densities and requiring noise

insulation, noise disclosure, and noise easements. Impacts are further reduced by concentrating flight patterns over the Columbia River to minimize direct overflights of occupied areas.

Freeways and Freight Corridors

Traffic noise is audible along the I-205 corridor near the center of the MCDD area, in the area that separates PEN 1 and PEN 2 from I-5, and within SDIC and MCDD East from I-84. Sound levels associated with traffic along the North Columbia Boulevard freight corridor exceed Federal Highway Administration criteria of 67-dBA average sound level (Leq) for noise abatement and U.S. Department of Housing and Urban Development criteria of L_{dn} for site acceptability (City of Portland 2008).

4.7.1.2. Ambient Noise Levels

Noise level measurements that characterize the entire study area are not available, but general calculations of ambient noise levels can be made based on population density, as shown on Table 4-7 (FTA 2006). The population density in the study area is between 3,200 and 7,700 people per square mile (U.S. Census Bureau 2012). This density equates to a daytime background sound level between 50 and 55 dBA Leq, exclusive of traffic (FTA 2006).

Table 4-7 Estimating Existing Environmental Background Noise Levels

Population Density (people per square mile)	L_{eq} Daytime Noise Levels Exclusive of Traffic (dBA)
1-100	35
100-300	40
300-1,000	45
1,000-3,000	50
3,000-10,000	55
10,000-30,000	60
30,000 and up	65

Source: FTA 2006

Traffic on roads and highways increases the ambient sound level, particularly on freight routes and heavily used highways such as I-5 and I-205. For the purposes of this analysis, it is assumed that ambient noise levels in the study area are 65 dBA in the vicinity of the primary roadways, and 55 dBA in areas removed from the influence of primary transportation routes and airports.

4.7.2. Environmental Consequences

Impacts associated with the noise environment could occur if an alternative resulted in any of the following:

- Violation of applicable Federal, state, or local noise ordinances
- Incompatible land uses for areas with sensitive noise receptors near the planning area.

4.7.2.1. Alternative 1 (No Action)

The City of Portland's focus on infilling existing neighborhoods is likely to increase population density in most neighborhoods in the study area. Traffic volumes on the primary transportation routes that serve and traverse the study area are likely to increase commensurate with population increase and as various parts of the study area continue to add distribution centers and other facilities that will increase truck traffic.

These factors are likely to increase noise levels throughout the study area. The effects will likely be more dramatic in areas closest to transportation routes and railroads. Some improvements to overall sound levels may occur as new generations of quieter commercial aircraft are brought online at Portland International Airport.

4.7.2.2. Alternative 3

Constructing the project would require use of common heavy construction equipment and machinery. Noise associated with construction would have temporary, moderate impacts on residences and sensitive receptors near the construction sites.

A mathematical model based on the Federal Transit Administration and FHWA noise modeling and impact assessment methods was used to estimate noise levels associated with project construction (FHA 2006, FTA 2006). Table 4-8 presents the estimated noise levels associated with construction activities at the two applicable reference distances, 50 ft. and 100 ft. Noise is reported as dBA, with both the maximum sound level (Lmax) of each piece of construction equipment and the composite equivalent sound level (Leq) of all construction equipment reported. In order to provide an upper bound of impacts, the model assumes no equipment mufflers or other sound dampening or shielding effects.

Table 4-8 Estimated Construction Sound Levels Near Residences

Construction Equipment	Count At Peak	Usage Factor (%)	Noise Level at 50 ft., dBA Lmax	Composite Noise Level at 50 ft., dBA Leq	Noise Level at 100 ft., dBA Lmax	Composite Noise Level at 100 ft., dBA Leq
Air Compressor	1	30	80	88	74	82
Backhoe	1	70	80		74	
Bulldozer	1	20	85		79	
Dump Truck	2	30	84		78	
Excavator	1	30	85		79	
Forklift	1	20	85		79	
Front End Loader	1	40	80		74	
Fuel Truck	1	10	85		79	
Generator	1	40	82		76	
Water Pump	1	50	77		71	
Water Truck	1	30	82		76	

Source: FHWA 2006; FTA 2006; Tetra Tech staff analysis

Residences and other sensitive receptors within 100 ft. of the construction sites would experience noise impacts of up to 82 dBA during construction (Table 4-8). Sensitive receptors that may be affected by construction noise occurring within 100 feet include residential areas in the Bridgeton and East Columbia neighborhoods; golf courses, public parks, and sports facilities in PEN 1, PEN 2, and MCDD; and hotels along the I-5 corridor and Airport Way. These impacts would be temporary and would be less than significant with implementation of the avoidance and minimization measures described in Table 4-1. Construction in areas where sensitive receptors are present would only occur during normal working hours. In the event that construction actions occur outside of normal working hours, it would be restricted to industrial areas where there is no chance of affecting sensitive receptors.

Workers at the construction sites would experience increased noise levels. Workers would wear adequate hearing protection as appropriate and in accordance with the project health and safety plan and applicable occupational health and safety regulations, so impacts would be minimal.

Noise impacts during operations would be similar to existing conditions, and would result from use of machinery to maintain levees or to remove aquatic vegetation. Minor noise would result when operating pumps, but the pumps are electric and emit very little noise except in the immediate vicinity of the pump stations, where a low hum may be audible. There are no sensitive receptors in the immediate vicinity of the pump stations, and these impacts would be negligible and temporary.

Noise impacts could also occur during operations if the alternative led to a substantial increase in the population density of residential neighborhoods or led to land uses that would change noise levels. Although this alternative would provide a higher level of flood protection, it is assumed that population density will increase at similar rates with or without the project, therefore there would be no new noise impacts associated with population increase during operations. The proposed project would not result in changes to land uses, and no noise impacts are anticipated.

4.7.2.3. Alternative 4

Potential noise impacts under Alternative 4 would occur over 36 months, rather than 24 months under Alternative 3. Noise effects would be more widespread due to the need to raise the levees at Marine Drive and Airport Way. However, similar to Alternative 3, noise volumes would be similar to background volumes in surrounding areas and impacts would be less than significant. Construction timing would be the same as described for Alternative 3.

4.7.2.4. Alternative 5

Potential noise impacts under Alternative 5 would be similar to those occurring under Alternative 4, except that construction of the floodwalls along the Columbia River in PEN 1 and PEN 2 would increase the duration of noise in the Bridgeton neighborhood. Although the duration of noise impacts would be increased to 42 months, noise volumes would be similar to background volumes in surrounding areas and impacts would be less than significant. Construction timing would be the same as described for Alternative 3.

4.8. Utilities

This section describes public and private utilities in the study area, including water and wastewater services, communication facilities, electrical services, stormwater infrastructure, solid waste management, and natural gas distribution. The impact analysis assesses whether the alternatives would result in conditions that would exceed the capacity of these services or create the need for new utilities.

4.8.1. Affected Environment

Utilities in the study area are provided by cities, public and private service providers, and regional and state agencies. Oregon Department of Transportation (ODOT) and TriMet maintain internal infrastructure in the study area that serves each agency's own uses and does not provide service to the public. These internal utilities include power, stormwater, sanitary sewer, and water supply.

4.8.1.1. Stormwater

Stormwater is managed in the study area under guidance provided in the following plans:

- The City of Portland's *Stormwater Management Manual* (City of Portland 2014)
- The City of Fairview's *Stormwater Management Plan* (City of Fairview 2011)
- The City of Gresham's *Stormwater Management Manual* (City of Gresham 2018).
- The Port of Portland's *Integrated Stormwater Management Plan* (Port of Portland 2010); for Portland International Airport and Troutdale Airport.

Each of these plans describes best management practices for construction and development projects to reduce polluted stormwater runoff and accidental releases of possible contaminants. Each plan emphasizes reduction of impervious surfaces and use of bioswales and other sustainable methods to detain stormwater to the degree possible. All these plans detail collection and control methods required under their respective municipal separate storm sewer system permits.

4.8.1.2. Water Supply

Most water supply in the study area comes primarily from the City of Portland's Bull Run Watershed. Water is distributed to various parts of study area by multiple providers, which are consolidated under the public works department of each of the four cities in the study area. Water is supplied to Portland International Airport by the City of Portland.

The Columbia South Shore Well Field is the second-largest water source in the State of Oregon and serves as a backup water source for Bull Run deliveries during dry periods. It provides water to Portland, Gresham, and Fairview, each of whom have adopted ordinances to establish a wellhead protection program and have the authority to implement and enforce the requirements

contained in the *Columbia South Shore Well Field Wellhead Protection Area Reference Manual*, which provides management guidance for the wellfields (City of Portland 2010).

4.8.1.3. Sewer

Sewer service is provided by the four cities serving the study area. A network of force mains and trunk lines is found throughout the study area. The City of Portland's Columbia Boulevard Wastewater Treatment Plant provides the primary treatment of Portland's wastewater before it is discharged to the Columbia River (City of Portland 2019d). Wastewater from parts of the study area located in Fairview and Gresham is routed to the City of Gresham Wastewater Treatment Plant for processing prior to discharge to the Columbia River. Troutdale Public Works provides wastewater services of collection and treatment in the study area.

4.8.1.4. Electricity and Natural Gas

Electricity is provided to the area west of I-5, including PEN 1 and PEN 2, by Portland General Electric. East of I-5, electricity is provided by Pacific Power and Light. Both utilities maintain substations within the study area. Natural gas is provided to the entire study area by Northwest Natural. A large electrical distribution substation operated by Bonneville Power Administration is located on the northern edge of SDIC.

4.8.1.5. Solid Waste

Solid waste service is provided by numerous companies under contract with Metro. Metro coordinates solid waste pickup and hauling under guidance provided in its *2030 Regional Waste Plan* (Metro 2019a).

4.8.1.6. Communications

Cable and internet service are provided by Comcast, and telephone service is provided by Qwest (ODOT 2011). Communications towers are located throughout the study area, particularly within PDX and Troutdale Airport properties. Two Entercomm Communication towers are located near Big Four Corners on the south side of NE Marine Drive. Fiber optic communications cables owned by AT&T, Comcast, Qwest, Integra, and Time Warner pass through the project area (Kitchin 2008).

4.8.1.7. Clustered Utilities

Numerous utility lines are clustered at or near the I-5 bridge crossing to Washington, which is found between PEN 1 and PEN 2. These include a major water main, natural gas feed line, and telephone, television, data, and fiber optic lines carried on the I-5 crossing. Underwater communication and power lines are located under the bed of North Portland Harbor to feed services to Hayden Island (ODOT 2011).

4.8.2. Environmental Consequences

Impacts associated with utilities could occur if an alternative resulted in any of the following:

- A substantial increase in the consumption of resources
- Disruption in the use of utilities
- Generation of outputs that compromise the provision of adequate utilities services, including water, wastewater, solid waste, electricity and natural gas, to the surrounding area.

4.8.2.1. Alternative 1 (No Action)

Under Alternative 1, and as the study area continues to develop, additional infrastructure will be needed to handle stormwater, although Metro and its constituent municipalities are actively working to reduce impervious surfaces and manage storm runoff locally. Increased population in the study area will increase demand on infrastructure that is in place to manage wastewater, deliver potable water, and provide electricity and natural gas, possibly requiring upgrades and expansions of such infrastructure. Although existing landfills in the immediate Portland area are reaching capacity, suitable landfills with enough capacity for the next 100 years are available within 200 miles of Portland, and waste removal is likely to shift to those locations.

4.8.2.2. Alternative 3

Utilities are clustered at the I-5 bridge overpass, where the floodwall would be extended and raised. Some of these utility features are attached to the bottom of the bridge deck, and others are buried. During the project design phase, the designers will coordinate with utility providers to identify the locations of conveyance pipelines, communications cables, and other utility infrastructure at this location and all locations where ground-disturbing actions will occur. The design plans will show the locations of all utility infrastructure and specify measures to ensure that they are protected in place or relocated.

Preliminary estimates indicate that approximately 170,000 cy of unsuitable materials such as asphalt and concrete, as well as organic materials excavated during site preparation and construction, would be disposed of offsite. Although it is assumed that some of this material would be composted or recycled, landfills with suitable capacity for this amount of material are located within 200 miles of the study area, so this impact would be less than significant.

4.8.2.3. Alternative 4

Potential impacts to utilities under Alternative 4 would be increased compared to Alternative 3 due to the larger project footprint. The project designers will coordinate with utility providers to identify the locations of conveyance pipelines, communications cables, and other utility infrastructure at all locations where ground-disturbing actions will occur.

The amount of exported materials would be approximately 8,000 cy greater than under Alternative 3 due to clearing and grubbing near the Troutdale Outlet Mall, but the amount of exported materials for disposal will remain within the capacity of receiving landfills, so potential impacts associated with landfill capacity would be less than significant.

Alternative 4 would lead to slightly increased use of electricity to run the larger pumps. The increase in power demand is well within the capacity of existing power lines servicing the area and would not tax the capacity of the grid that serves the area. This alternative would not increase the use of water, sewer, or gas.

Increases in impervious surfaces or other features that could increase stormwater outputs would total approximately 0.5 acre as a result of constructing the floodwall, and would cause negligible impacts to stormwater capacity. The existing stormwater conveyance system has capacity to handle stormwater under current and proposed conditions, and no reconfiguration of the stormwater system would be needed.

4.8.2.4. Alternative 5

Potential impacts to utilities would be similar to those under Alternative 4, except that the installation of floodwalls along the north side of PEN 1 and PEN 2 would increase impervious surfaces by approximately 0.5 acre as a result of constructing the floodwall, potentially increasing stormwater runoff. Because this amount of impervious surface would be spread over such a long area and much of the runoff would drain directly into the Columbia River or existing storm drains, the increased amount of runoff going to stormwater facilities at any one point would be minimal and would be unlikely to impact stormwater management.

4.9. Biological Resources

This section describes fish and wildlife, vegetation, habitat types and quality, and sensitive biological resources found in and near the study area. The impact analysis describes potential effects on general biological resources and resources that are specifically protected under Federal regulations, including the Clean Water Act and the Endangered Species Act.

4.9.1. Affected Environment

The project is entirely within the Willamette Valley ecoregion, defined by the Oregon Conservation Strategy (OCS 2019). This ecoregion extends from the Coast Range to the Cascade Range and covers 5,308 square miles. Elevations range from 400 feet at the southern end to nearly sea-level along the Columbia River. The climate is characterized by mild, wet winters and warm, dry summers.

4.9.1.1. Habitats

Vegetation

Historically, the study area consisted of a variety of wetland, floodplain, riparian, and upland vegetation communities. An 1851 study reported the presence of northern mixed deciduous riparian forest, black cottonwood riparian forest, ash swamp, willow swamp, seasonally wet prairie, wet meadow, Douglas fir forest with mixed deciduous or mixed with Western hemlock, Western red cedar, and grand fir, Douglas fir and oak mixed forests, and upland and xeric prairies (City of Portland 2019e). Since that study, there has been an overall loss of 67 percent loss of native vegetation (City of Portland 2019e). Vegetation types in the study area today include riparian shrub or forest, mixed-canopy forest, non-forested open areas, and landscaped or urban areas (LRC 2017). Invasive or non-native plant species have also become established throughout the study area. Vegetation communities that are present in the project area today are described below.

Mixed-Canopy Forested Area. Forested uplands in the Columbia Slough Watershed are primarily mixed deciduous stands dominated by big leaf maple, black cottonwood, red alder, Oregon ash and willow species, with occasional Oregon white oak (City of Portland 2019e). These forests contain a diversity of native and non-native understory vegetation. Conifers are most often found in the local parks, though several revegetated areas along the Columbia Slough include western red cedar, Douglas fir, and grand fir saplings (City of Portland 2019e).

Non-Forested Open Areas. Open areas devoid of trees often occur where disturbance is greatest, including at dredge material disposal sites, along levees, in empty lots, and throughout Portland International Airport lands (City of Portland 2019e). There are no longer any areas of native meadow habitat in the study area. Open areas may contain sparse shrubs or herbaceous cover and the soils are usually fill and/or compacted. These areas are dominated by non-native plants, such as reed canarygrass and Himalayan blackberry. Despite the disturbance to these vegetation communities, they still serve as habitat for small mammals, coyotes and raptors, and, rarely, they have been known to support use by the streaked horned lark, a Federally listed species (see Section 4.9.1.3).

Landscaped and Urban Areas. Landscaped and urban areas are not considered natural vegetation communities. Large swaths of landscaping are present at the numerous golf courses in the study area, including a vast expanse of turf grasses and ornamental tree species. These communities may provide resting or foraging stops for birds or small mammals that are more tolerant of human presence. Urban areas may have small naturescapes, particularly in residential yards, pocket parks, or along roadsides where swales and trees have been planted.

Riparian Habitat. Riparian habitats occur along water bodies and are essential to healthy ecosystem function of rivers, streams, ponds, and wetlands. Overall, riparian forests have been substantially disturbed due to the region's extensive development. Much of the riparian area within the Columbia Slough Watershed is developed and has minimal riparian vegetation. Riparian forest habitat that is present is generally a narrow band dominated by black cottonwood,

Oregon ash, willow species, and red osier dogwood, with an understory of non-native Himalayan blackberry, common snowberry, and non-native reed canarygrass (City of Portland 2019e). A few small stands of Oregon white oak are also in the watershed. Overall, riparian zones in the study area are too narrow to adequately provide their essential ecosystem functions, including shade, cover, bank stabilization and sediment control, pollution control, stream flow moderation, organic matter input, a contiguous wildlife corridor, and large woody debris (City of Portland 2019e). Riparian habitats identified by the Oregon Conservation Strategy as a strategy habitat are present along the Columbia Slough and the Lower Sandy River.

Wetlands. Information regarding wetlands in the study area comes from the National Wetland Inventory (NWI) (USFWS 2019a) and from *Levee Ready Columbia* (LRC) (2017). The NWI reports 1,725 acres of wetlands within the project boundaries, including the wetland types shown in Table 4-9 and in Figure 4-2 through Figure 4-6.

Table 4-9 Wetland Acreage in Study Area According to the National Wetland Inventory

	PEN 1		PEN 2		MCDD		SDIC		Entire Study Area	
Wetland Types	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Freshwater Emergent	11.3	1.1 %	2.0	0.1 %	136.2	1.6 %	159.1	10.1 %	308.6	2.4 %
Freshwater Forested and Shrub	11.0	1.1 %	0.002	0.0001 %	264.5	3.1 %	19.7	1.2 %	295.2	2.3 %
Freshwater Pond	61.1	6.0 %	27.2	1.7 %	105.3	1.2 %	11.7	0.7 %	205.2	1.6 %
Lake	54.5	5.4 %	58.3	3.6 %	186.5	2.2 %	10.4	0.7 %	309.8	2.4 %
Riverine	33.1	3.3 %	87.5	5.4 %	284.4	3.3 %	200.9	12.7 %	605.9	4.7 %
Total	**171.0**	**16.9 %**	**175**	**10.3 %**	**976.8**	**11.3 %**	**401.8**	**25.4 %**	**1,724.6**	**13.4 %**

Note: Mapped by USFWS using USDA 1-m resolution aerial imagery from 2009. The target mapping unit for this scale of imagery is 0.5 acres. The target mapping unit is "an estimate of the size class of the smallest wetland that can be consistently mapped and classified at a particular scale of imagery" (FGDC 2009).

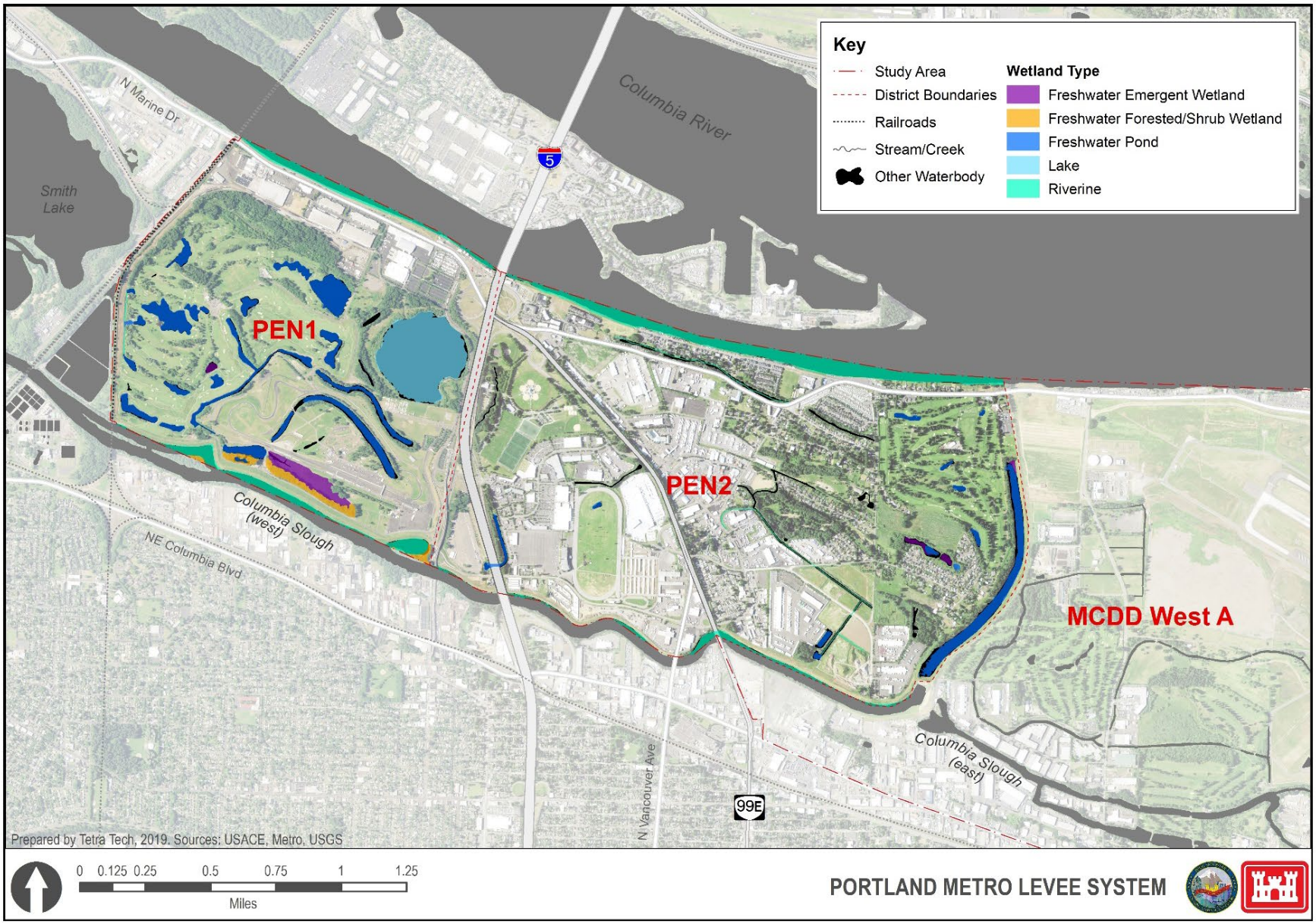

Figure 4-2 Wetlands in PEN 1 and PEN 2

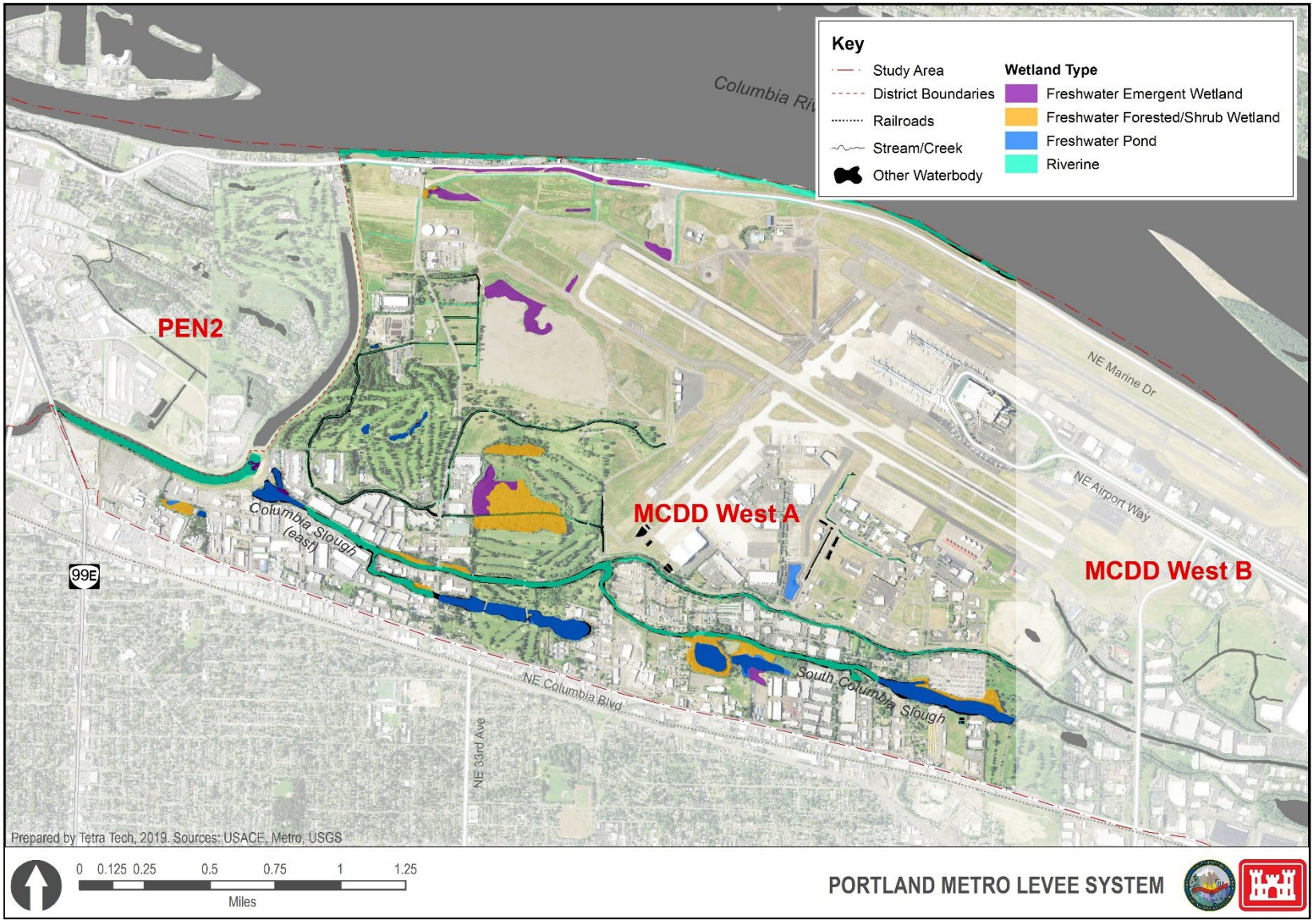

Figure 4-3 Wetlands in MCDD West A

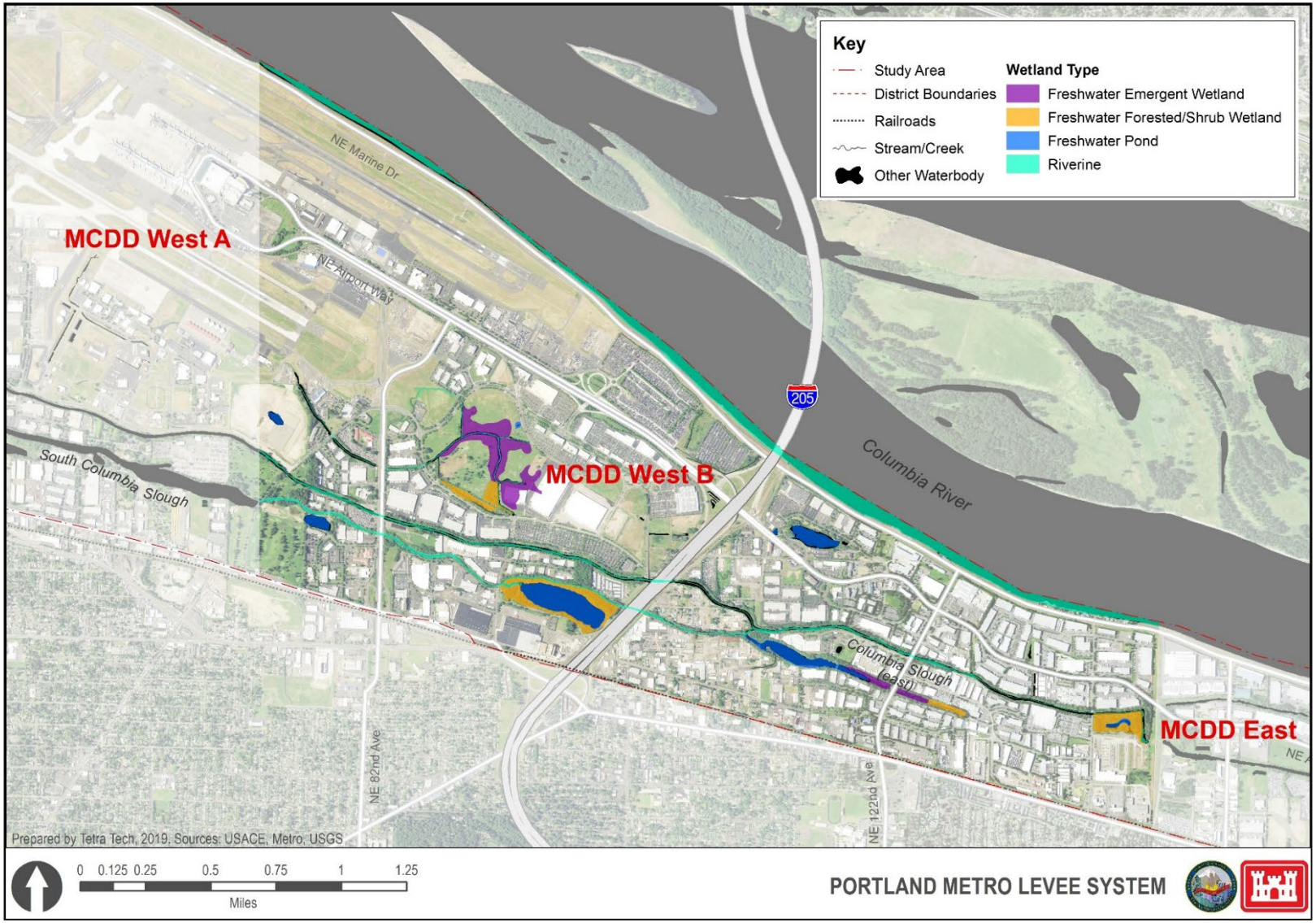

Figure 4-4 Wetlands in MCDD West B

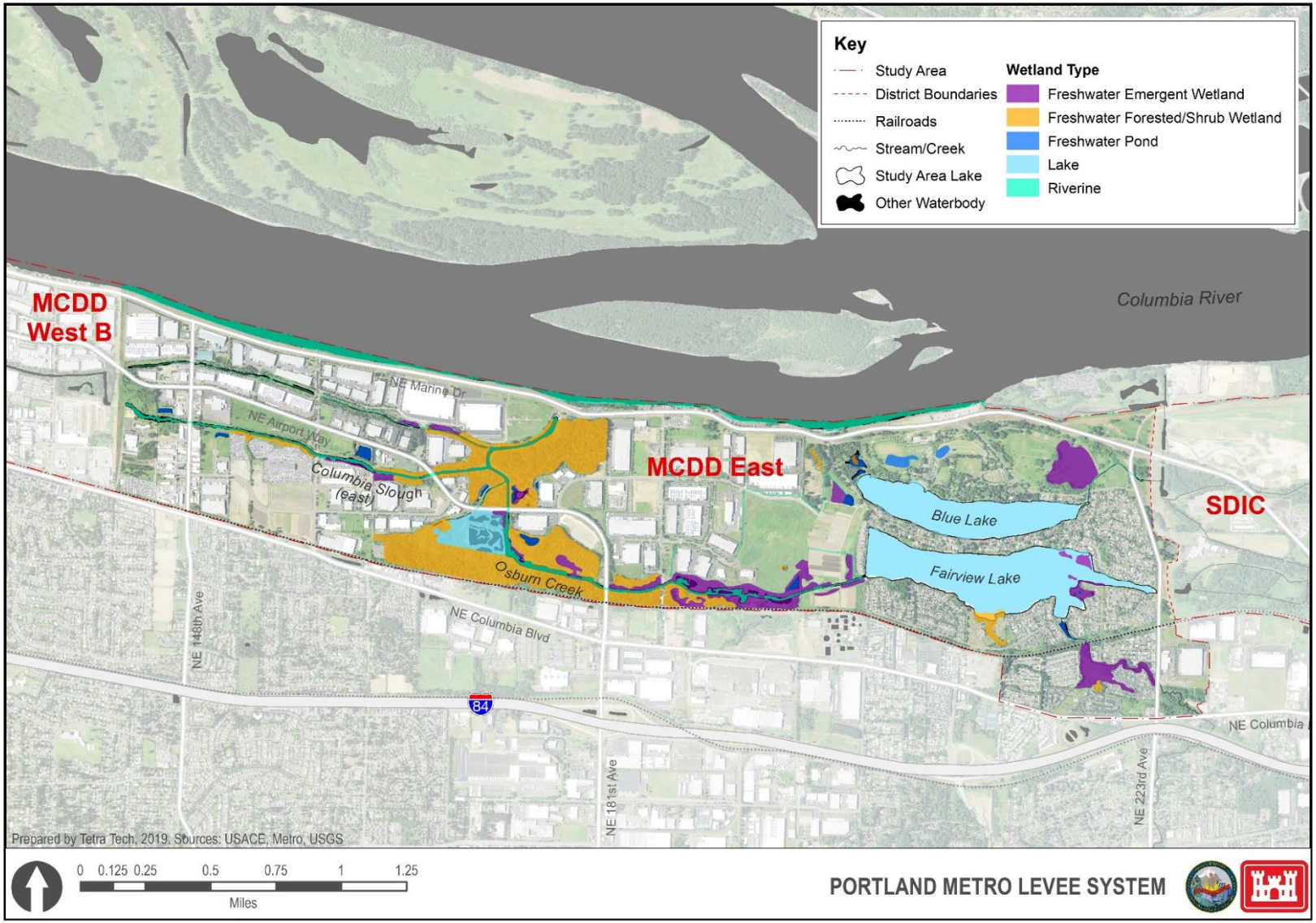

Figure 4-5 Wetlands in MCDD East

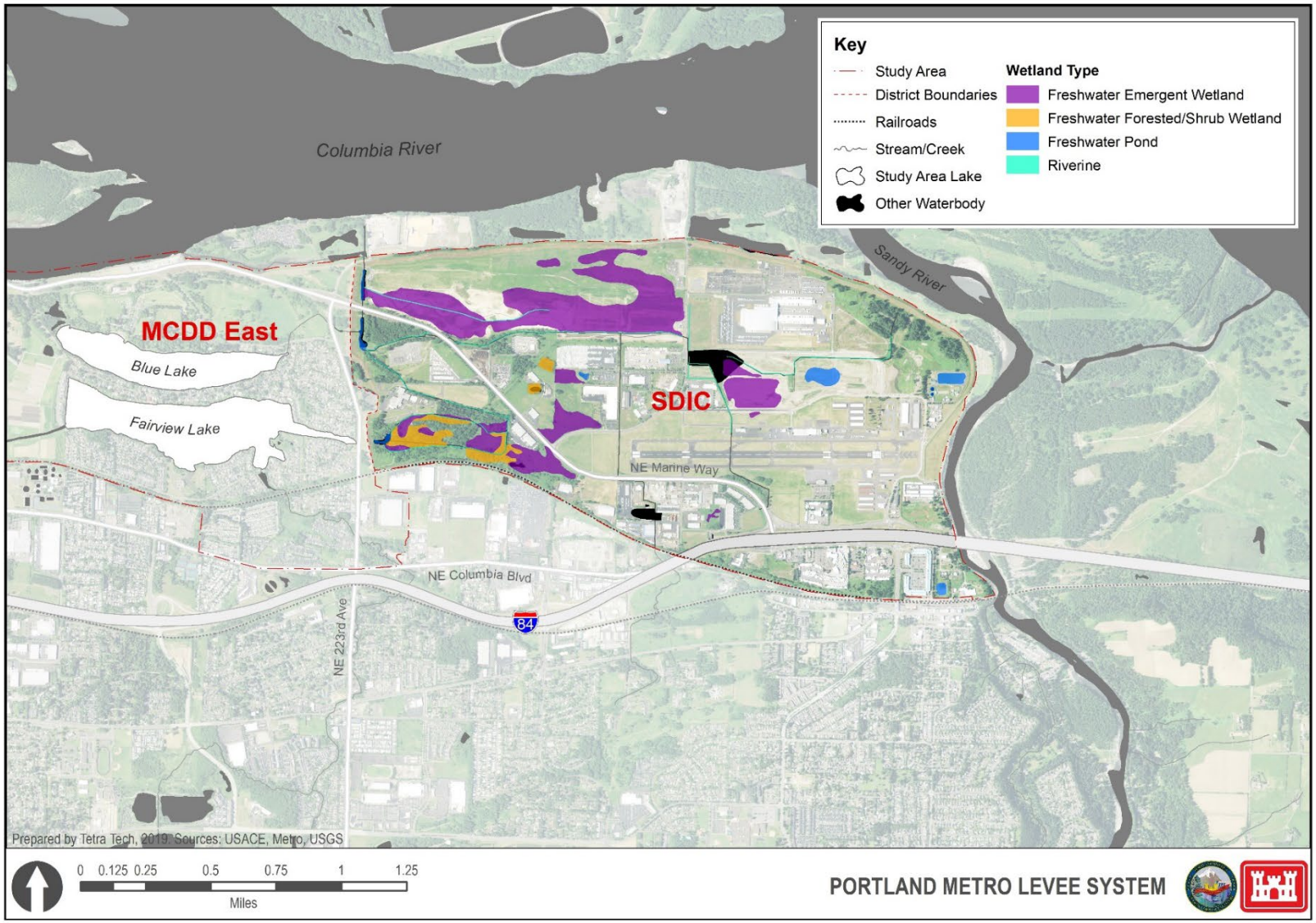

Figure 4-6 Wetlands in SDIC

The following category descriptions are taken from the NWI (USFWS 2019a):

- Freshwater wetlands have salinity of less than 0.5 parts per thousand and may host emergent, scrub-shrub or forest vegetation, or a combination of these:
    - Emergent plants are herbaceous, non-woody plants (annual or perennial).
    - Scrub-shrub vegetation dominated by woody trees and shrubs below 20 feet tall
    - Forested wetlands dominated by trees over 20 feet tall.
- A freshwater pond is an area of open water less than 20 acres consisting of freshwater that is no deeper than 8.2 feet.
- Lakes are also freshwater but are greater than 20 acres in surface area and remain above 8.2 feet in depth even at low water.
- Riverine wetlands refer to flowing water systems, including rivers, streams, creeks, or sloughs.

Riverine and Open Water

Major rivers in or adjacent to the study area include the Columbia and Sandy Rivers. Smaller creeks, sloughs, and canals are also present. Other waterways of note are the Columbia Slough and Fairview Creek (LRC 2017). Larger open water ponds and lakes in the study area include those associated with the Vanport Wetlands, Blue Lake, and Fairview Lake (LRC 2017).

4.9.1.2. Fish and Wildlife

Fish occur in all aquatic habitats in the study area and can include native and non-native species. A study of lower Columbia Slough in 2009 provides a list of fish that are likely to occur in waterways encompassed by the study area levees (Van Dyke et al. 2009). These are incorporated here by reference to LRC (2017). Other warm water game fish that occur in Blue Lake (ODFW 2016), include bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), largemouth bass (*Micropterus salmoides*), brown bullhead (*Ameiurus nebulosus*), and rainbow trout (*Onchorhynchus mykiss*) stocked by ODFW. Predominant Fairview Lake fish include common carp (*Cyprinus carpio*), and yellow bullhead catfish (*Ameiurus natalis*) (LRC 2017).

Breeding bird surveys conducted by the City of Portland Bureau of Environmental Services reported that numerous bird species are known to occur regularly, and the most prevalent in the study area are the song sparrow (*Melospiza melodia*), American robin (*Turdus migratorius*), and American goldfinch (*Spinus tristis*) (City of Portland 2017). A blue heron (*Ardea herodias*) rookery is located in PEN1 in the northwest corner adjacent to the Heron Lakes Golf Course. The number of nests in this colony is not known.

Common mammals in the study area are racoon (*Procyon lotor*), coyote (*Canis latrans*), opossum (*Didelphis virginiana*), deer (*Odocoileus hemionus*), red fox (*Vulpes vulpes*), mice (*Apodemus* spp), voles (*Microtus* spp), and rabbits (*Sylvilagus* spp) (LRC 2017). Aquatic mammals present include beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), and otter (*Lontra canadensis*).

The Columbia Slough provides habitat for three species of native freshwater mussels, including Oregon floater (*Anadonta oregonensis*), California floater (*A. californiensis*), and winged floater (*A. nuttalliana*).

4.9.1.3. Threatened and Endangered Species

The U.S. Fish and Wildlife Service's *Information for Planning and Consultation* shows nine threatened or endangered terrestrial species that may occur in the study area (Table 4-10, USFWS 2019b). Though there is critical habitat designated for several of these species, none occurs in the study area. The National Marine Fisheries Service (NMFS) lists 16 populations of anadromous fish species that may use the study area during their life history as threatened or endangered (

Table 4-11, NMFS 2019). The Lower Columbia Slough provides critical habitat for coho salmon. Coho are likely to be found within the study area, although confirmed observations of listed salmon have not been recorded for the study area. The mainstem Columbia River provides critical habitat for Chinook salmon, chum salmon, coho salmon, steelhead trout, sockeye salmon, bull trout, and eulachon. The Sandy River adjacent to the study area is also designated critical habitat for each of these species, except chum salmon.

Table 4-10 Species Protected Under the Endangered Species Act (USFWS)

Common Name ***Scientific Name***	**Listing Status**[1]	**Habitat Requirements**	**Potential**
Northern spotted owl[2] *Strix occidentalis caurina*	T	Late-seral or old-growth conifer, hardwood, or mixed forests	Unlikely
Streaked horned lark[2] *Eremophila alpestris strigata*	T	Large expanses of bare or sparsely vegetated grasslands, including fields, prairies, dunes, beaches	Confirmed
Yellow-billed cuckoo[2] *Coccyzus americanus*	T	Floodplain riparian habitat	Unlikely
Bull trout[2] *Salvelinus confluentus*	T	Colder waters found within the headwaters of tributaries	Possible
Bradshaw's lomatium *Lomatium bradshawii*	E	Seasonally saturated or flooded prairies, adjacent to creeks and small rivers	Unlikely
Kincaid's lupine[2] *Lupinus sulphureus ssp. kincaidii*	T	Native upland prairies and open oak woodlands	Unlikely
Nelson's checker-mallow *Sidalcea nelsoniana*	T	Wet prairies and stream margins, with open early seral vegetation	Unlikely
Water howellia *Howellia aquatilis*	T	Small vernal wetlands with consolidated bottoms	Unlikely
Willamette daisy[2] *Erigeron decumbens*	E	Early seral upland prairie or oak savanna habitat with low-growing grasses and forb	Unlikely

Common Name *Scientific Name*	Listing Status[1]	Habitat Requirements	Potential

Notes: [1]T = threatened, E = endangered. [2]Critical habitat designated but not in study area.

Table 4-11 Federally Listed Fish Species That Occur in the Study Area (NMFS)

Common Name, Scientific Name	Listing Status[1]	Population
Chinook salmon, *Oncorhynchus tshawytscha*	T	Lower Columbia River ESU
	E	Upper Columbia River Spring-Run ESU
	T	Upper Willamette River
	T	Snake River Fall-Run ESU
	T	Snake River Spring/Summer-Run ESU
Steelhead trout, *O. mykiss*	T	Lower Columbia River DPS
	T	Middle Columbia River DPS
	T	Upper Columbia River DPS
	T	Upper Willamette River
	T	Snake River DPS
Sockeye salmon, *O. nerka*	E	Snake River ESU
Coho salmon, *O. kisutch*	T	Lower Columbia River ESU
Chum salmon, *O. keta*	T	Columbia River ESU
Bull trout, *Salvelinus confluentus*	T	Columbia River DPS of Conterminous U.S.
Green sturgeon, *Acipenser medirostris*	T	Southern DPS
Pacific eulachon, *Thaleichthys pacificus*	T	Southern DPS

Notes: [1]T = threatened, E = endangered. Source: NMFS 2019

According to the Oregon Conservation Strategy, several listed fish species have been documented in the lower Columbia Slough, including steelhead trout and Coho, Chinook and chum salmon (OCS 2019). In addition, several Federal species of concern have been observed in the nearby vicinity of the project area, including the acorn woodpecker (*Melanerpes formicivorus*), northern red-legged frog (*Rana aurora*), olive-sided flycatcher (*Contopus cooperi*), Western pond turtle (*Actinemys marmorata*), purple martin (*Progne subis arboricola*), willow flycatcher (*Empidonax traillii*), and yellow-breasted chat (*Icteria virens auricollis*).

4.9.1.4. Migratory Bird Treaty Act Species

The U.S. Fish and Wildlife Service (USFWS) has identified 15 bird species protected under the Migratory Bird Treaty Act that may occur in the study area, shown in Table 4-12. The breeding period for each of these species are also shown, as this is their most sensitive life stage.

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Table 4-12 Federally Listed Species Protected Under the Migratory Bird Treaty Act

Common Name	Scientific Name	Breeding
Bald eagle*	*Haliaeetus leucocephalus*	Breeds Jan 1 to Sep 30
California thrasher	*Toxostoma redivivum*	Breeds Jan 1 to Jul 31
Clark's grebe	*Aechmophorus clarkia*	Breeds Jan 1 to Dec 31
Golden eagle	*Aquila chrysaetos*	Breeds Jan 1 to Aug 31
Great blue heron	*Ardea herodias fannini*	Breeds Mar 15 to Aug 15
Lesser yellowlegs	*Tringa flavipes*	Breeds elsewhere
Long-billed curlew	*Numenius americanus*	Breeds elsewhere
Marbled godwit	*Limosa fedoa*	Breeds elsewhere
Olive-sided flycatcher	*Contopus cooperi*	Breeds May 20 to Aug 31
Red-throated loon	*Gavia stellate*	Breeds elsewhere
Rufous hummingbird	*Selasphorus rufus*	Breeds Apr 15 to Jul 15
Semipalmated sandpiper	*Calidris pusilla*	Breeds elsewhere
Short-billed dowitcher	*Limnodromus griseus*	Breeds elsewhere
Western screech-owl	*Megascops kennicottii*	Breeds Mar 1 to Jun 30
Whimbrel	*Numenius phaeopus*	Breeds elsewhere

*Notes: *The bald eagle is also protected under the Bald and Golden Eagle Protection Act.*

4.9.1.5. State Protected Fish and Wildlife

In addition to the Federally protected species, several species of fish and wildlife that are present in the study area are protected at the state level. These include several birds, bats, amphibians, insects, and invertebrates. According to the recent LRC study, state-protected species that may occur in the project area include 21 bird species, six bat species, two turtles, one frog, four mussels, two snails, and one limpet. These are incorporated by reference of the LRC report (Table 7-16 in LRC 2017).

4.9.1.6. Invasive Fish and Wildlife

Invasive animal species in Oregon are determined by the OCS and listed by Oregon ecoregion (OCS 2018). The following are invasive fish and wildlife species that may be found within the Willamette Valley ecoregions that encompass the project area:

- American bullfrog, *Lithobates catesbeianus*
- Asian clam, *Corbicula fluminea*
- Brown rat, *Rattus norvegicus*
- Chinese mystery snail, *Cipangopaludina chinensis malleata*
- Common carp, *Cyprinus carpio*
- Common snapping turtle, *Chelydra serpentina*
- Eurasian collared dove, *Streptopelia decaocto*
- European starling, *Sturnus vulgaris*
- Fathead minnow, *Pimephales promelas*

- Golden shiner, *Notemigonus crysoleucas*
- Goldfish, *Carassius auratus*
- Grass carp, *Ctenopharyngodon idella*
- House sparrow, *Passer domesticus*
- Mute swan, *Cygnus olor*
- New Zealand mudsnail, *Potamopyrgus antipodarum*
- Nutria, *Myocastor coypus*
- Red-eared slider, *Trachemys scripta elegans*
- Rock pigeon, *Columba livia*
- Siberian prawn, *Exopalaemon modestus*
- Virginia opossum, *Didelphis virginiana*
- Western mosquitofish, *Gambusia affinis*

Aquatic invasive species are of particular concern, since they spread rapidly and can quickly alter the function of an ecosystem. The zebra mussel (*Dreissena polymorpha*) and quagga mussel (*D. bugensis*) are mollusks that spread by drifting and quickly colonize underwater infrastructure such as screens, trash racks, and water delivery systems, which has the potential to render facilities inoperable. The Columbia River Basin is the last U.S. river system free of these mussels (Oregon Live 2018).

4.9.2. Invasive Plant Species

The Oregon Department of Agriculture (ODA) WeedMapper identifies the following invasive species found in the study area. Priority target invasive species (ODA 2018) include tansy ragwort (*Senecio jacobaea*), giant hogweed (*Heracleum mantagazzianum*), field bindweed (*Convolvulus arvensis*), garlic mustard (*Alliaria petiolata*), and goatsrue (*Galega officinalis*).

Other common non-target invasive species include milk thistle (*Silybum marianum*), Armenian blackberry (*Rubus armeniacus*), Japanese knotweed (*Fallopia japonica*), diffuse knapweed (*Centaurea diffusa*), yellow toadflax (*Linaria vulgaris*), English ivy (*Hedera* spp.), purple loosestrife (*Lythrum salicaria*), spurge laurel (*Daphne laureola*), yellow flag iris (*Iris pseudocorus*), thistle species (*Cirsium* spp), poison hemlock (*Conium maculatum*), and scotch broom (*Cytisus scoparius*).

Aquatic invasive species (City of Portland 2019f) include Eurasian watermilfoil (*Myriophyllum spicatum*) at Blue Lake and in the Columbia Slough, and pond water-starwort (*Callitriche stagnalis*), curly pondweed (*Potamogeton crispus*), and parrotfeather (*Myriophyllum aquaticum*) all found in the Columbia Slough.

Aquatic species are of particular concern, since they spread rapidly and can quickly alter the function of an ecosystem. Eurasian watermilfoil is a propagative species, meaning that small fragments of the plant can spread quickly through the water, reroot and colonize new areas.

4.9.2.1. Invasive Species Management

Invasive animal and plant species are generally managed at the local level. There is no comprehensive invasive species management plan for the entire study area. Most agencies that

manage lands in the study area include invasive species management measures in their land management plans.

4.9.3. Environmental Consequences

Impacts associated with biological resources would occur if an alternative resulted in any of the following:

- Loss or degradation of plant or animal communities
- Destruction or alteration of habitat
- Interruption of normal breeding behavior
- Introduction of invasive species.

4.9.3.1. Alternative 1 (No Action)

Under the Future Without-Project Alternative, biological resources would decline incrementally due to factors related to urbanization, population growth, etc. The study area is a growing commercial, industrial, and residential area that is likely to experience ongoing development as the population of the Portland metro area increases. With this continued development, the small areas of remaining natural habitat will continue to shrink in size and biodiversity, become fragmented and disconnected, sustain increasing invasive plant and animal populations, and provide fewer ecosystem functions for the species that remain. Urban runoff that delivers nutrients to surrounding vegetation and enters surface water will continue to increase as development increases; resulting in further growth of non-native aquatic plants. Local, state, and Federal law will provide protection to sensitive species, though continued use of the commercial, industrial, and residential areas will cumulatively impact natural habitats. Federal and local interests would continue to work together to protect sensitive fish and wildlife and their habitats. Invasive species will continue to be managed by special interest groups through physical removal and chemical treatment in localized areas.

4.9.3.2. Alternative 3

Construction actions would result in temporary and permanent impacts to biological resources. Construction areas would be cleared and grubbed, and habitat within the increased levee footprints or new floodwall footprints would be permanently lost. Noise and human disturbances during construction would affect wildlife behaviors, including foraging and breeding.

Wetland and Riparian Impacts. Constructing the railroad embankment and widening the Columbia Slough levee in PEN 1 would result in the loss of approximately 0.08 acre of wetlands, based on comparison of construction footprints with existing NWI mapping. A wetland delineation will be performed as the recommended alternative is refined and prior to finalizing the feasibility study to determine jurisdictional wetland impacts.The Corps will offset unavoidable direct impacts resulting to jurisdictional wetland losses in a manner that complies with the CWA/404(b)(1) guidelines. Table 4-13 shows the potential losses of wetlands, by

measure. The total area of potentially-affected wetland was estimated by reviewing aerial imagery to evaluate conditions in areas of proposed levee widening. Trees would be removed to accommodate the expanded levee footprint, primarily along the railroad berm and the Peninsula Canal cross-levee. These areas have mixed species and size classes of trees. Trees that would be removed are typical of riparian and upland habitats in the Portland area, and include bigleaf maple, black cottonwood, Oregon ash, red alders, and various species of willow.

Table 4-13 Potentially Affected NWI Wetlands, Alternative 3

Measure	Amount of NWI Wetlands Lost (Acres)
5: Improve Levee Performance and Reliability	0.08

Protected Species. Alternative 3 may have minor temporary effects on critical habitat for ESA-listed species if turbidity increased as a result of construction. There would be no in-water work on the riverward side of the levees, and avoidance and minimization measures for erosion control would be implemented prior to any ground disturbing actions. Listed anadromous fish species are found in the adjacent Columbia River and in the lower Columbia Slough, and may experience minor noise impacts from heavy equipment operating in upland areas. This impact would be less than significant. Essential Fish Habitat, which is regulated under the Magnuson-Stevens Fishery Conservation Management Act, would not be affected by the project other than by minor and temporary increases in turbidity,

Streaked horned larks are not expected to be affected by this alternative, as known populations of this species are well removed from the construction area, and their nesting habitat would not be affected (Brown 2019).

Bald eagles are known to nest at up to 10 locations on Port of Portland lands (Atwell 2019). However, all known nesting locations are outside of the study area. Eagles may occur elsewhere in the study area, but nests outside of Port of Portland lands have not been documented. Eagles and their habitat will be protected as required under the BGEPA, including development of buffer zones around active nests or breeding populations during construction.

A blue heron rookery is located in PEN1 near the proposed parallel levee. The number of nests in this colony is not known. The rookery appears to be outside of the direct construction area, but nesting birds or fledglings may be disturbed by construction noise and human presence.

Species protected under the MBTA are found throughout the study area. MBTA species would be adversely affected by removal of trees, primarily along the railroad berm and the Peninsula Canal cross levee. In coordination with the USFWS, the Corps will develop measures as part of the Fish and Wildlife Coordination Act (FWCA) Report to reduce impacts to MBTA species to the degree possible.

MBTA species may also be affected by construction noise and disturbance. To the degree possible, construction plans will specify that construction in areas likely to support nests or sensitive life stages of MBTA species will be avoided during the breeding season to the degree possible. This impact would be incidental and less than significant.

Avoidance and minimization measures identified in Table 4-1would be implemented to reduce the potential for disturbance of sensitive species due to construction. Throughout the planning process, the Corps will continue to coordinate with USFWS and NMFS for compliance with the Fish and Wildlife Coordination Act, and will implement recommendations agreed to during preparation of the final coordination memorandum.

Invasive Species. Construction activities would clear large areas and import dredged or fill material, increasing the potential for weedy and non-native plants to become further established throughout the study area. Avoidance and minimization measures listed in Table 4-1 include cleaning construction equipment before bringing it to the study area, controlling dredged or fill material sourcing, recontouring areas after construction, and revegetating with native grassland, shrub, and tree species.

Since minimal in-water work is required for localized construction, it is not likely that existing non-native fish or other aquatic species would increase in number or that new populations would become established.

Installation of signage for flood evacuation routes or other flood risk information throughout the study area would result in temporary construction impacts. Wildlife may be disturbed when people or large machinery are in the installation areas, and vegetation may be cleared to allow for installation. Following installation, disturbed areas would be returned to their original contours and revegetated with non-invasive species. There would be no impacts to biological resources in the study area from non-structural measures or from installing signs.

Following construction, standard operation and maintenance procedures would be carried out under existing protocols, which are designed to prevent adverse effects. No substantial changes in the biological habitat in the area would result from operations. There would be no permanent loss of additional wetlands, vegetation, or other sensitive species habitat as a result of operations. Invasive species management will require regular manual or chemical treatment to ensure that restored areas are maintained. Treatment methods will be determined as appropriate by location and species.

4.9.3.3. Alternative 4

Under Alternative 4, types of impacts to biological resources would be similar to those described for Alternative 3, but impacts to wetlands and trees would be increased due to the larger levee footprint. Table 4-14 shows the amounts of NWI wetlands that would be affected under this alternative.

Table 4-14 Potentially Affected NWI Wetlands, Alternative 4

Measure	Amount of NWI Wetlands Lost (Acres)
5: Improve Levee Performance and Reliability	0.05
30: Build Additional Levee/Floodwall	0.20
Total	**0.25**

New levee roads would be constructed along levees and railroad embankments, which are already heavily developed and disturbed environments. These areas are designed to be clear of vegetation for operation purposes, and the development of levee roadways would not substantially change the existing condition.

Several localized construction measures are proposed under this alternative. Depending on the final configuration of the selected alternative, construction of additional pumps, debris control, and gates may require access to sites that are submerged throughout the year. Dewatering these sites, as well as clearing the surrounding area for access, would cause temporary increases in turbidity and may result in releases of pollutants related to fluids from construction equipment, such as lubricants or gasoline, or from disturbance of ground that contains such materials. With the proper dewatering methods and implementation of best management practices, increased turbidity in the Columbia Slough would be avoided or contained through placement of silt fencing.

The state-protected Western pond turtle may occur throughout the site. Prior to any dewatering or construction measures along wetland areas, biological surveys would be conducted for Western pond turtles and other sensitive species. Relocation of turtles or avoidance would be conducted following USFWS protocol. With adequate impact avoidance and minimization measures in place, there would be no significant adverse effects as a result of construction activities for the localized construction or non-structural measures included in Alternative 4.

4.9.3.4. Alternative 5

Under Alternative 5, impacts to wetlands and protected species would be similar to those occurring under Alternative 4. Table 4-15 shows the amount of wetland habitat that would be affected by this alternative.

Table 4-15 Potentially Affected NWI Wetlands, Alternative 5

Measure	Amount of NWI Wetlands Lost (Acres)
5: Improve Levee Performance and Reliability	0.05
30: Build Additional Levee/Floodwall	0.68
Total	**0.75**

Impacts avoidance and minimization measures would be implemented to ensure the preservation of sensitive habitats. Biological monitoring would be conducted prior to construction if needed, and sensitive species such as western pond turtles will be relocated if they are identified in or near the construction sites. Following construction, cleared areas would be revegetated or restored to their previous or better condition.

As with each of the other action alternatives, the implementation of flood risk education for residents and visitors would not have adverse effects on the biological resources in the study area.

4.10. Cultural Resources

This section describes cultural resources in the study area, which are locations of human activity, occupation, or use. They include expressions of human culture and history in the physical environment, such as precontact or historic archaeological sites, buildings, structures, objects, districts, or other places. Cultural resources can also include natural features, plants, and animals that are considered important to a culture, subculture, or community or that allow the group to continue traditional lifeways and spiritual practices. This section provides a summary of cultural resource identification efforts completed to date and addresses potential impacts on cultural resources under NEPA.

Historic properties, as defined by 36 CFR 800 (the implementing regulations of Section 106 of the National Historic Preservation Act [54 USC § 300101 et seq.]), are cultural resources that are eligible for inclusion in the National Register of Historic Places. Historic properties may be districts, sites, buildings, structures, artifacts, ruins, objects, works of art, natural features important in human history at the national, state, or local level or properties of traditional religious and cultural importance to an Indian tribe.

4.10.1. Affected Environment

4.10.1.1. Cultural Resources Setting

The study area includes the four drainage districts, which collectively occupy 12,750 acres on the Columbia River floodplain. This area also constitutes the Area of Potential Effect. The

floodplain has been a focus of both precontact and historic-period human settlement, which extends into the present.

Archaeological data indicate that precontact occupation of the floodplain extends back at least 4,000 years and is probably much older. Geological data demonstrate the presence of deposits of Mt. Mazama ash buried up to 60 feet below the surface (Gates 1994), which indicates the potential for deeply buried precontact archaeological resources. European American explorers and fur traders in the late 1700s and early 1800s reference native settlements in the area, and the floodplain was rapidly settled in the 1840s and 1850s by American immigrants.

Annual Columbia River flooding precluded agricultural use other than livestock grazing through the nineteenth century. The formation of drainage districts beginning in 1916 transformed the floodplain into more intensive agricultural production, which continued until the 1980s.

Beginning in the 1930s, other forms of development-including what is now Portland International Airport-increasingly characterized the area. The former City of Vanport was constructed beginning in 1942 and was Oregon's second largest city at the peak of shipyard activity during World War II. The community was destroyed in the major Columbia River flood of June 1948. Commercial and industrial development now dominate many areas, and agricultural use constitutes a relatively small area within the districts. Systematic research and surveys for archaeological resources in the area date back to the mid-1970s.Cultural Resources Identification Efforts

The State Historic Preservation Officer (SHPO) lists 53 archaeological resources in the study area, including 39 sites and 12 isolates (one isolate was recorded as a site and subsequently determined to not be a site by the SHPO as it consisted of fewer than 10 artifacts, although it retains a site number [35MU83]) (Table 4-16).

Table 4-16 Previous Cultural Resource Survey Areas by District

District	Total Acres	Acres Surveyed	Percentage Surveyed
SDIC	1,555	869	56
MCDD	8,587	3541	41
PEN 1	995	244	25
PEN 2	1,611	284	18
Total	**12,748**	**4,938**	**39***

*Notes: * Cumulative acreage surveyed in all four districts*

Of the 39 sites, 30 were recorded as precontact in age, seven are historic-period sites, and two are multicomponent sites. SHPO lists four precontact sites, four historic-period sites, and one multicomponent site as not eligible for listing on the National Register. Seven precontact sites and one multicomponent site have been determined eligible for the National Register. The remaining 22 sites are shown as unevaluated (see Appendix H (Cultural Resources)). SHPO does not keep records on sites that have been destroyed by construction, so some of these sites may no longer be extant. All but nine of the sites are located on MCDD lands.

The SHPO Historic Sites Database lists 56 historic resources in the study area (see Appendix H (Cultural Resources)). Of these, only four have been unquestionably determined eligible for or actually listed on the National Register of Historic Places. The majority of historic resources in this database are listed as eligible/contributing, but this designation is the SHPO's default for resources that lack sufficient information for determining eligibility (it is unclear why these resources are not listed as "undetermined").

The most important historic resource in the study area is the Columbia Slough Drainage Districts Historic District. This Historic District was determined to be eligible for the National Register of Historic Places in 2006 and confirmed by the SHPO in 2011. The contributing resources in the Historic District consist of the following:

- The levees and cross levees in all four drainage districts,
- Most of the sloughs and other drainages in all four districts, and
- The Schmeer Road Pumping Station in PEN 2.

The levees and cross levees are defined as extending from toe to toe. The character-defining features of the levees and cross levees are their alignments, slope ratios, heights, widths, construction (compacted earthen structure with clay core), and general absence of trees and buildings in the critical sections.

The drainages defined as contributing resources in the Historic District are the Columbia Slough, City Canal or Peninsula Drainage Canal, McBride's Slough, NE 182nd Drainage System, Salmon and Arata Creek Drainage System, Switzler Lake Drainage, Mud Slough, Bayou Slough, and Force Lake Drainage. The drainages are physically defined as bank top-to-bank top. Their character-defining features are their alignments.

For the Schmeer Road Pumping Station, the character-defining features are its rectangular, one-story massing and the horizontally articulated metal siding, cornice, and parapet. Other character-defining features of the pumping station are the intact original 10-light wood windows on the north elevation and the wood double-doors with three-light windows on the east elevation. These are the features that most clearly articulate the pumping station's historic character. The one-story, shed-roof attachment on the west elevation is not historic, nor are any of the adjacent facilities.

4.10.2. Environmental Consequences

Impacts associated with cultural resources could occur if an alternative resulted in any of the following:

- Obstruction to implementation of an historic property management plan;
- Violation of any state or Federal regulation protecting cultural resources; or
- Damage or disturbance to these resources.

4.10.2.1. Alternative 1 (No Action)

Under this alternative, state and Federal cultural resource protection regulations will continue to be implemented. Avoidance and minimization measures, including establishment of buffer areas, have been designed in consultation with SHPO, affected Tribes and property owners, to ensure that existing cultural resources are preserved to the extent possible. These laws are designed to help minimize impacts on archaeological and historic resources, identify important historic properties and ensure their protection into the future.

4.10.2.2. Alternative 3

Under Alternative 3, impacts to cultural resources could occur as a result of the following types of actions:

1. Ground-disturbing actions could disturb or destroy known or presently unknown archaeological resources.
2. Widening of an existing levee or construction of a new levee could disturb or destroy known or presently unknown archaeological resources.
3. Filling or removing drainages or segments of drainages that are contributing resources in the Historic District.

Widened Levees

This proposed widening of the railroad berm is a high probability area for precontact archaeological resources. It was historically a complex network of both major and minor sloughs, numerous small lakes and wetlands, as well as two larger lakes. The last included the lake that is now occupied by the Vanport Wetlands. The easternmost shoreline of Smith Lake and some of the sloughs and lakes have been incorporated into the Heron Lakes golf course.

The widened levee would cross the historical locations of slough channels and two historic lakebeds, including the remnant Smith Lake bed. Portions of these are extant as water hazards on the golf course. Six cultural resource surveys have been conducted within PEN 1: Connolly 1987, Musil et al. 1994, Musil et al. 1995, Chapman et al. 1998, Bland and Connolly 2006, Minor 2011. Only one archaeological resource was identified in PEN 1, but it must be emphasized that only six surveys have been conducted and subsurface probing was undertaken in only four limited areas. The presence of 35MU113 is evidence of precontact use or occupation of the area, which is not unexpected given the rich resources the floodplain would have offered and proximity to important water-transportation routes such as the Columbia River and Columbia Slough. There is a high density of precontact archaeological resources around Smith and Bybee Lakes to the west and along Columbia Slough downstream of PEN 1.

The widened levee therefore has a high probability for impacting precontact archaeological resources, especially where sheet pile cutoffs are proposed that would extend 40 feet deep. This designation would also apply to the proposed new floodwall that would extend from the northern end of the new levee to the existing floodwall along the south bank of North Portland Harbor.

Heron Lakes Golf Course is recommended as eligible for listing on the NRHP for its design and association with Robert Trent Jones, a famous golf course designer. Construction of the parallel levee would entail removal of many of the trees that define the western border of the golf course, which are an important element of the course's landscape and design. The parallel levee would therefore constitute an adverse effect to the golf course as a historic property. Those effects would vary, to some extent, by differences in the proposed width and character of the parallel levee among the three alternatives. Clearing and grubbing for the Alternative 3 levee would affect 10 acres of the golf course. The Corps will coordinate with the City of Portland Parks and Recreation Department on potential realignment of the affected fairways and replacement of the trees that would be removed during construction, making this impact less than significant.

PEN 1 Columbia Slough Levee Widening

The proposed alignment for widening this part of the levee was subject to extensive subsurface probing in 1995 and no evidence of any archaeological resources was encountered. This project element is considered to have a low probability for archaeological resources, and impacts would be less than significant.

Peninsula Canal Cross Levee

The levee would be widened, and a new toe drain installed. The Peninsula Canal consists of a channelized natural slough (McBride's Slough) and an artificial channel that originally extended to the Columbia River to provide sufficient flow after a dam and Pump Station 1 were constructed, disconnecting the eastern and western Columbia Slough drainages.

Two surveys have been conducted in this area: Minor et al. (1994) and Paraso and Taylor (2015). The only archaeological resources identified in either survey were two historic-period sites (35MU260 and 35MU261) dating to the mid-1900s. Both sites were determined to not be eligible for the NRHP.

The northern portion of the cross levee improvements is considered to have a low potential for archaeological resources as it parallels the artificial channel. The channelization of McBride's Slough may have disturbed or destroyed sites on the slough bank, but the area is still regarded as having a moderate to high potential for precontact archaeological resources.

Construction actions have a high potential to adversely impact cultural resources at this site. Consistent with 36 CFR 800, a qualified archeological monitor will be on-site in sensitive areas during ground disturbance. These areas will be identified through consultation with the SHPO and tribes. The degree of impacts would be offset by avoidance and minimization measures described in Table 4-1, as well as by ensuring that imported soils come from clean sources that have been evaluated for cultural resources, making them less than significant.

4.10.2.3. Alternative 4

Impacts under Alternative 4 would include the potential impacts identified for Alternative 3, as well as potential impacts identified in the following paragraphs.

Under Alternative 4, the potential to impact cultural resources would be greater than under Alternative 3 as this alternative would affect 2 additional acres of Heron Lakes Golf Course, increasing the potential for accidental discovery of previously unknown cultural resources and causing the loss of more of this NRHP-eligible resource. The additional actions described below would increase the potential to affect cultural resources, but with implementation of an incidental discovery plan and AMMs identified in Table 4-1, impacts would be less than significant.

Under Alternative 4, NE Airport Way would be raised where it crosses the MCDD cross levee between NE 138th and NE 148th. The alignment of Airport Way on the east side of the cross levee extends across a previously reported archaeological site, 35MU80. The site is a precontact site with evidence for processing plant resources. It was recorded in 1989 prior to construction of Airport Way (Fleming and Atwell 1989). Later fieldwork at the site failed to identify any archaeological materials on the surface or in subsurface probes (Minor et al. 1994:104, 113) and the site was recommended as not significant. However, SHPO officially lists this site as unevaluated.

Raising of the roadway is projected to involve approximately one acre of clearing and grubbing. Any clearing or grubbing outside the roadway prism on the east side of the cross levee would affect 35MU80 as currently defined. Removal of the existing pavement could also affect the site, which extends underneath Airport Way as the site was defined in 1989.

4.10.2.4. Alternative 5

Potential impacts to cultural resources under Alternative 5 would be greater in intensity to those occurring under Alternatives 3 and 4 due to the larger parallel levee footprint and construction of the floodwall along the PEN1 and PN2 levees. The parallel levee at the railroad berm would affect an additional 4 acres of the golf course relative to Alternative 4, increasing the potential for inadvertent discovery and loss of this NRHP-eligible resource. The additional actions described below would increase the potential to affect cultural resources relative to Alternatives 3 and 4, but with implementation of an incidental discovery plan and AMMs identified in Table 4-1, impacts would be less than significant.

Alternative 5 includes a new floodwall and flood gate along the south bank of the North Portland Harbor. The new floodwall would consist of sheet pile placed to a depth of 24 feet for 1,900 feet to the west, with the remainder to the east to 9 feet. Only one previous survey has been conducted in this portion of PEN 1, Connolly 1987. That survey consisted of a very limited examination of bank exposures due to extensive development. No archaeological resources were identified.

There are few data on which to define a probability for archaeological resources in the floodwall area. No precontact archaeological resources have been identified to date along North Portland Harbor on either the south bank or on Hayden Island. There have been very few cultural resource surveys along the south bank of the Columbia River from the I-205 Glen Jackson Bridge and the mouth of the Willamette River, and no archaeological sites recorded along this bank in this stretch of the river. Strong's (1967:26-27) list of precontact archaeological sites also shows no

sites along this stretch of the river other than one reportedly destroyed site opposite the lower end of Government Island. Historic maps (e.g., US Coast and Geodetic Survey 1888) show some scattered buildings and orchards on the south bank opposite Hayden Island, which indicates a potential for historic-period archaeological sites. Industrial development of the floodwall area beginning in the early 1900s would have impacted archaeological deposits associated with those historical occupations. It is unknown what may be extant.

The floodwall area is considered a moderate probability area for historic-period archaeological resources, therefore there is moderate potential for adverse impacts to cultural resources associated with construction of the floodwall.

PEN 2 Columbia Slough Levee

The Columbia Slough levee would be raised and widened. This project area is considered to have a moderate to high probability for archaeological resources. As with PEN 1, PEN 2 was historically a network of sloughs, lakes, and marshes, dominated by one large but now-filled lake, Switzler Lake. Almost all of these natural features have been filled and developed, with a few sloughs having been channelized to serve as drainage ditches and a few remnant sloughs in the northeastern portion of PEN 2.

Only one previous survey has been conducted in the immediate levee vicinity (Musil et al. 1994). That survey did not include any subsurface probes and no resources were identified. However, in 1984 a report was received by SHPO of a precontact site illegally excavated into the levee by an artifact collector. As this excavation had compromised the structural integrity of the levee at that location, fill was reportedly placed over the excavation. The excavation may have been prompted by a reference in Strong (1967:32) to a site at or near this location. This site (Strong's designation was "MU17," which is not an official site designation) was described as the "Woodlawn site": "once a very large village, it was entirely carried away for fill material for a dike." It is therefore possible the artifacts exposed in 1984 were in the levee fill rather than in the native bank under the levee.

Based on this information, the Columbia Slough levee in PEN 2 is considered a moderate to high probability area for precontact archaeological resources.

Columbia River Levee

A minor increase in levee height is proposed where the 40-Mile Loop Trail (aka Marine Drive Trail) crosses Marine Drive at the eastern end of the James Gleason Memorial Boat Ramp. Previous surveys in the vicinity (Ellis and Panzarino Paraso; Finley 2016; Musil et al. 1994; Panzarino Paraso and Ellis 2009) did not identify any archaeological resources. With the exception of the survey reported in Finley, these surveys included subsurface probes in the present project vicinity and did not yield any evidence of archaeological resources.

Although the previous surveys and minimal ground disturbance would indicate a low potential for archaeological resources, there is reason for some concern. As described in Appendix H (Cultural Resources), the historical record references small Native settlements along the

shoreline in this area in the 1850s. This area is also in the general vicinity of the Ne-er-cho-ki-oo village visited by the Lewis and Clark Expedition in 1805-1806. There is therefore a potential for artifacts associated with these settlements to be present in the levee fill. There is no record of historic-period use or occupation of this location until after World War II.

4.11. Hazardous, Toxic and Radioactive Waste

This section describes baseline conditions related to hazardous substances including hazardous materials and hazardous waste. It also discusses potential impacts related to use of, or exposure to, hazardous materials within the analysis area. This discussion includes any area that could be affected by releases of hazardous substances. The following summarizes information provided in Appendix F (Hazardous, Toxic, and Radioactive Waste (HTRW)).

4.11.1. Affected Environment

A preliminary HTRW Assessment has been performed for the purpose of identifying known or suspected HTRW issues within the proposed study area. The assessment is intended to reduce, but not eliminate, uncertainty regarding the existence of known or potential HTRW sites. The HTRW Assessment was initially prepared by conducting a thorough search of databases identifying properties with known or suspected environmental concerns within the study area (EDR 2019). Given the large areal extent of the study area boundaries, the scope of inquiry was limited to investigating HTRW potential within the project boundaries. Methodology was limited to a review of reasonably attainable state and Federal databases of known and suspected contaminated sites.

Over 5,500 records of sites were identified in the initial search (EDR 2019); see Appendix F (Hazardous, Toxic, and Radioactive Waste (HTRW)). The search was further narrowed to specifically target properties within the immediate vicinity of a proposed levee measure (increasing levee height, widening levee, build additional levee or floodwall). That targeted search narrowed the results to 32 sites. The database search results include properties that are known to manage hazardous materials or waste but does not necessarily mean that a release of hazardous substance or waste occurred.

Appendix F provides a summary of the database search results, and for each site, lists the 1) site identification, 2) location, 3) associated alternative and levee measure, 4) levee section, 5) environmental database containing records of the site, and 6) site ranking. Site maps are also provided in Appendix F, Section 5.

In addition to previous spills in the project area and onsite storage, the transport of hazardous materials is a regular occurrence. The PMLS is crisscrossed by numerous roads, highways, and railroads that carry hazardous materials on a daily basis. Fueling stations throughout the project area regularly receive petroleum products via truck delivery.

4.11.2. Environmental Consequences

Impacts related to hazardous substances could occur if an alternative resulted in any of the following:

- Substantial hazard to the public, construction workers, or the environment through the generation, use, storage, transport, or disposal of hazardous substances or waste
- Substantial hazard to the public, construction workers, or the environment through reasonably foreseeable accident conditions involving the release of hazardous substances into the environment.

4.11.2.1. Alternative 1 (No Action)

Hazardous materials will continue to be used for industrial purposes in the project area, and transported through the project area by vehicles and via railway. These materials will continue to be controlled through Federal, state, and local laws under the No Action Alternative. Existing hazardous materials spills will remain in place throughout the PMLS unless addressed by owners, state agencies or local groups.

4.11.2.2. Alternative 3

Seven sites of concern were found within the proposed footprint of Alternative 3, including two properties with a medium level of environmental concern, and five with a high level. They include the following shown in Appendix F (Hazardous, Toxic, and Radioactive Waste (HTRW)); Section 5: Site M (Map 7), Site AD (Map 8), Sites TC, EE, and EJ (Map 8), Site 67 (Map 2), and Site 4057 (Map 2). Measures proposed for Alternative 3 that could potentially intersect with these sites of concern include:

- Sites 4057 and 67 are located beneath the proposed railroad embankment floodwall.
- Site M is located beneath the proposed I-5 floodwall.
- Sites TC, EE, and EJ are near the proposed Columbia Slough and Cross Levees, but are not expected to be within the footprint of construction.

Prior to construction, each of these sites will be further evaluated and, if warranted, fully remediated. The non-Federal sponsor is responsible for providing all real estate required for the project; and all real estate provided for the project must be acceptable and free of substantial concentrations of hazardous materials. No construction will occur where known hazardous wastes may be released or exposed and cause a human health risk. In the event that undocumented hazardous wastes are discovered during construction, all further activity would cease until an assessment and any necessary remediation was complete.

During construction, petroleum products and hazardous materials such as fuels, oils, and lubricants would be present onsite, primarily in vehicles and construction equipment. Use of these materials as well as uncured concrete increases the risk of accidental discharge into riparian

areas or directly into water bodies, resulting in habitat degradation as well as injury or mortality of aquatic species.

To manage petroleum products and hazardous materials and respond to spills and releases, construction would employ avoidance measures. Workers would be trained so they were aware of petroleum products and hazardous materials onsite and would know how to properly handle and dispose of these materials. The construction contractor would be required to have a written hazardous materials remediation workplan and SPCC Plan to ensure that accidental discharge of hazardous materials and petroleum products would be contained quickly and remediated thoroughly. Workers would be trained on these procedures.

Any area where concrete would be poured to elevate the SDIC pump station or for other measures would be fully contained by use of straw bales, trenches, or other measures to ensure that uncured concrete did not enter water bodies.

With these measures in place, the potential impacts would be less than significant.

4.11.2.3. Alternative 4

Nine sites of concern were found within the proposed footprint of Alternative 4, including two properties with a medium level of environmental concern, and seven with a high level. They include the sites already listed above for Alternative 3 (Sites M, AD, TC, EE, and EJ). Additional sites include the following shown in Appendix F (Hazardous, Toxic, and Radioactive Waste (HTRW)); Section 5: DV, DN, and DX (Map 8), Site MW (Map 16), Site 3155 (Map 18), Site PI (Map 18), and Site 4331 (Map 25). In addition to the measures described above for Alternative 3, measures proposed for Alternative 4 that could potentially intersect with these sites of concern include:

- Sites DN and DX are near the Columbia Slough levee, but are not expected to be within the footprint of construction.
- Site DV is located beneath or adjacent to the Columbia Slough levee and may be within the project footprint.
- Site MW is located beneath the proposed Closure Structure/Airport Way Levee Raise.
- Sites 3155 and PI are located beneath the proposed Closure Structure/Marine Drive Levee Raise.
- Site 4331 is near the proposed levee at the outlet mall, but is located across Graham Road to the west and not expected to be within the footprint of construction.

Prior to construction, any sites found in the project footprint will be further evaluated and, if warranted, remediated. The non-Federal sponsor is responsible for providing real estate required for the project; and all real estate provided for the project must be free of substantial concentrations of HTRW and remediated as needed. No construction will occur where known hazardous wastes may be released or exposed and cause a human health risk. In the event that

undocumented hazardous wastes are discovered during construction, all further activity would cease until an assessment and any necessary remediation was complete.

Hazardous materials and concrete would be treated as described for Alternative 3. With these measures in place, impacts would be less than significant.

4.11.2.4. Alternative 5

Twenty-three sites of concern were found within the proposed footprint of Alternative 5, including two properties with a low level of environmental concern, four with medium level of concern, and 17 with a high level of concern. They include the sites already listed above for other Alternatives (Sites M, AD, TC, EE, EJ, 3155, PI, and 4331). Additional sites include the following shown in Appendix F (Hazardous, Toxic, and Radioactive Waste (HTRW)); Section 5: Sites E and H (Map 2), I (Map 7), X, Y, Z (Map 8), and AK (Map 9). Measures proposed for Alternative 5 include each of those noted for Alternatives 3 and 4. Additional structural and ground-disturbance work is proposed for the construction of floodwalls along the Columbia River in PEN 1 and PEN 2. The sites that could potentially intersect with these floodwalls include:

- Sites E, H, X, Y, Z, AD, and AK are located beneath the Columbia River floodwall.
- Site I is located adjacent to the floodwall and proximity to the construction footprint is unknown.

Hazardous materials and concrete would be treated as described for Alternative 3. With these measures in place, impacts would be less than significant.

4.12. Land Use, Planning and Zoning

This section describes land use in the study area and the possible impacts of the alternatives on land uses. The land use area of analysis is generally restricted to the study area and any easements that could be needed for the alternatives.

4.12.1. Affected Environment

4.12.1.1. Land Use

The study area includes approximately 13,000 acres along the south bank of the Columbia River. Seventy-nine percent of the study area lies within the City of Portland, but jurisdictions also include the Cities of Gresham, Fairview, and Troutdale, as well as Multnomah County. The study area is within the Portland metropolitan area's urban growth boundary, which is managed by Metro, the regional government for the Oregon portion of the Portland metropolitan area (Metro, 2019). Metro directly manages two facilities in the study area: the Portland Expo Center and Blue Lake Regional Park. The study area includes four drainage districts, each of which

manages the lands on which their respective levee systems are found. Land use in each district is described below.

Peninsula Drainage District #1

This drainage district protects an area of 955 acres and is unique in that 86 percent of the land is publicly owned. Primary property uses include the Portland Expo Center, Portland International Raceway, Heron Lakes Golf Course, Delta Park West, and the Port of Portland's Vanport Wetlands. There are no residential properties within the district, though multiple floating homes are present on the Columbia River adjacent to the project area. The PEN 1 levee system is bordered by I-5 to the east, embankments of the Union Pacific Railroad and BNSF Railway to the west, and the Columbia Slough to the south.

Peninsula Drainage District #2

This district is approximately 1,600 acres. Approximately 1,300 acres are improved, and 20 acres are sloughs and drainage canals. Land use in the district is divided among commercial, residential, industrial, recreation, and agriculture. Developments within the district include Columbia Edgewater Golf and Country Club, Delta Park Sports Complex, Portland Meadows Race Track, Bridges Middle School, numerous commercial and retail businesses, small industrial buildings, and a large number of residences including floating homes. Residential areas make up approximately 35 percent of the PEN 2 area. PEN 2 is bounded to the west by the I-5 embankment, to the east by the Peninsula Drainage Canal cross levee, to the north by the Bridgeton Road and North Marine Drive levee, and to the south by the Columbia Slough levee.

Multnomah County Drainage District #1

The Multnomah County Drainage District (MCDD) levee system protects 8,590 acres of residential, industrial, commercial, agricultural, and open space land. Many of the properties are of vital importance to the region, including the Portland International Airport, Air and Army National Guard Facilities, the South Shore Well Fields, Columbia River Correctional Institution, the Inverness Jail, and Blue Lake Park. This district lies within three jurisdictions: the City of Portland, the City of Fairview, and the City of Gresham.

Sandy Drainage Improvement Company

The SDIC levee system protects 1,556 acres of industrial, commercial, and undeveloped public and private properties within the cities of Fairview and Troutdale and unincorporated Multnomah County. It includes critical utility and transportation infrastructure, including a Williams Company natural gas pipeline, substations for the Bonneville Power Administration, Portland General Electric, and PacifiCorp, portions of NE Marine Drive, and the Port of Portland's Troutdale Regional Airport. The Port has also developed the Troutdale Reynolds Industrial Park in SDIC, which includes private industry and distribution centers, such as FedEx and Amazon.

Overall Study Area

Land uses in the study area are shown in Figure 4-7 through Figure 4-11. Land use acreages and percentages of the study area are shown in Table 4-17. The table is broken down by municipality and shows the mapped land uses within each.

Table 4-17 Acreages of Land Uses in the Study Area

City/ Planning Designation	Area of Planning Designation within Study Area (acres)
Portland	**10093.1**
Farm and Forest	26.3
Industrial Sanctuary	6881.2
Institutional Campus	10.7
Manufactured Dwelling Park	22.2
Mixed Employment	817.6
Mixed Use—Dispersed	45.0
Mixed Use—Neighborhood	120.2
Open Space	1969.0
Single-Dwelling—20,000	33.2
Single-Dwelling—10,000	167.8
Gresham	**366.8**
General Industrial	345.5
Low Density Residential—5	21.3
Fairview	**700.6**
Commercial	1.9
General Industrial	254.5
Low Density Residential	127.8
Medium Density Residential	83.9
Parks	213.8
Public	2.9
River Oriented	15.9
Multnomah Co.	**161.2**
Urban Low Density Residential—10,000	4.6
Urban Low Density Residential—7,000	43.1
Urban Low Density Residential—5,000	113.4
Troutdale	**1183.1**
Commercial	91.7
Industrial	976.3
Open Space	105.8
Urban Planning Area Industrial	9.3

Source: Metro 2019b

Based on this mapping, the study area land uses are as follows (Metro, 2019a):

- Industrial (55 percent)
- Open space or park (19 percent)
- Mixed use / Other (20 percent)
- Residential (5 percent)
- Commercial less than 1 percent.

4.12.1.2. Zoning

Zoning is the legal designation placed on the land that determines what types of land uses can be developed on specific pieces of property. Zoning regulations are determined by individual municipal jurisdictions, but zoning designations within Metro's service area must be consistent with the urban growth boundary. Zoning designations for the jurisdictions in the study area have been combined in Table 4-18, and are shown in Figure 4-12 through Figure 4-16.

Table 4-18 Primary Zoning in the Study Area

General Zoning Class	Area of Zoning Class within Study Area (acres)
Commercial	893.2
Future Urban Development	107.1
Industrial	8,237.9
Mixed Use Residential	131.0
Multi Family	85.0
Parks and Open Spaces	2,404.7
Single Family	639.5

Source: Metro 2019b

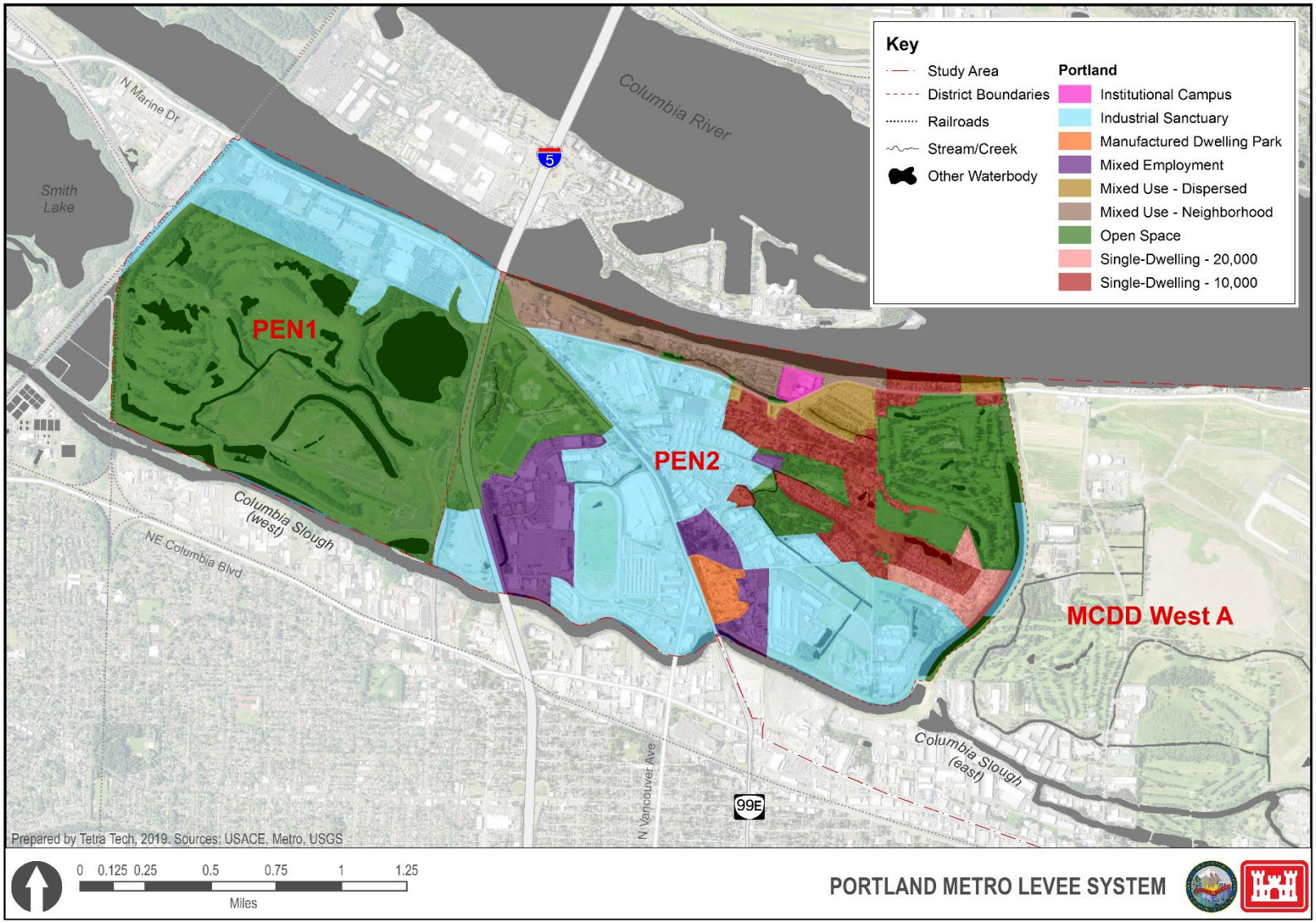

Figure 4-7 Land Use in PEN1 and PEN2

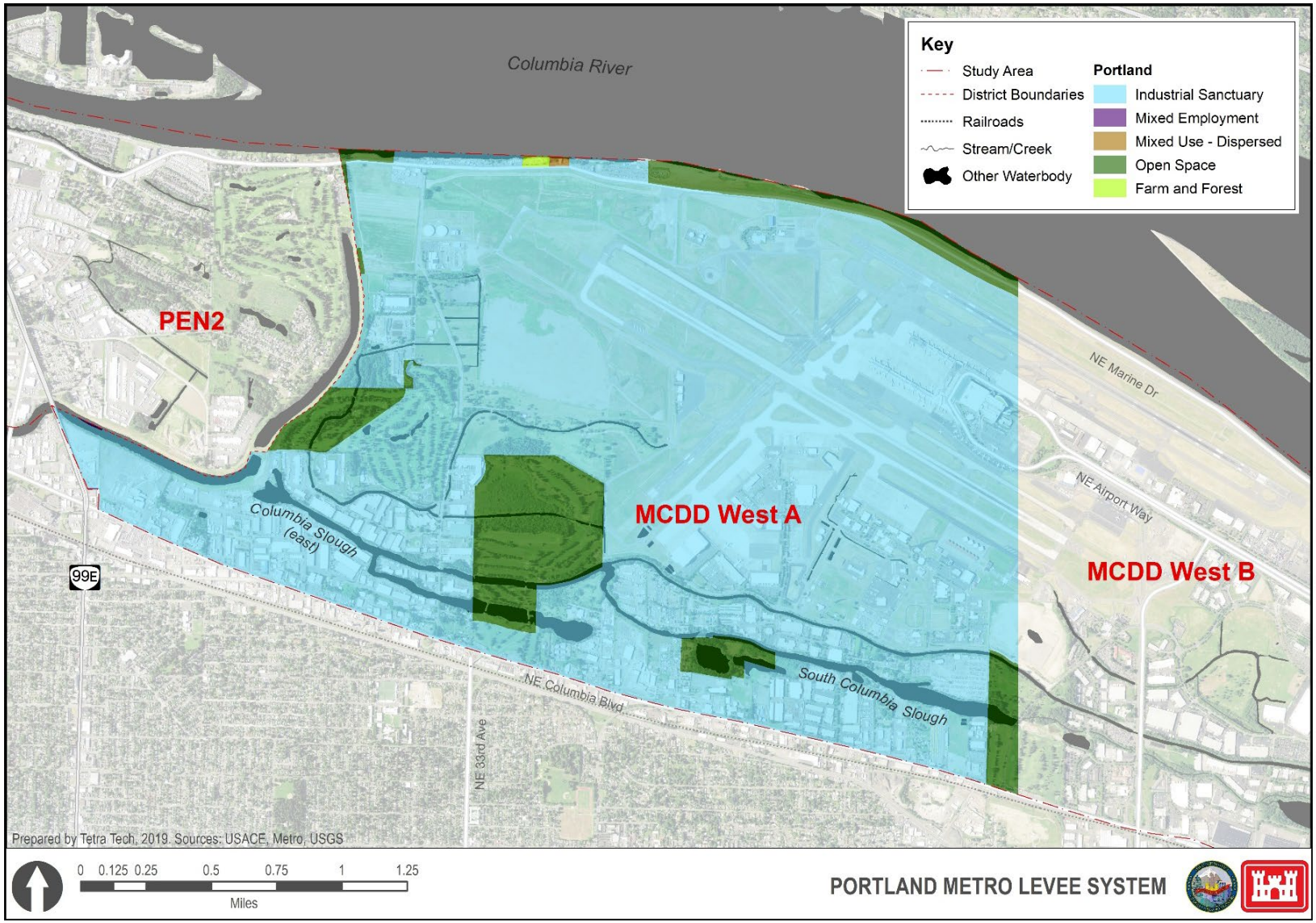

Figure 4-8 Land Use in MCDD West A

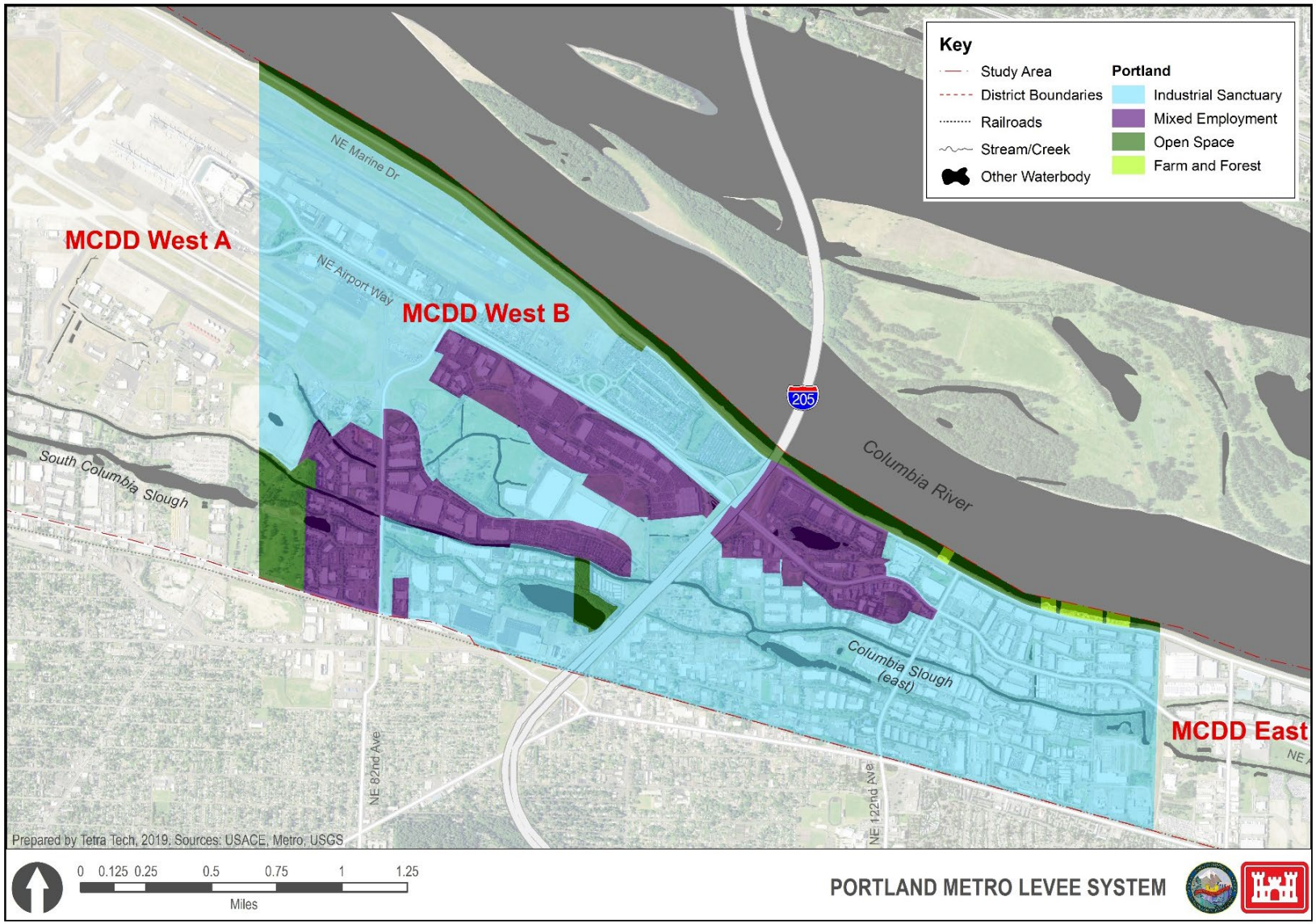

Figure 4-9 Land Use in MCDD West B

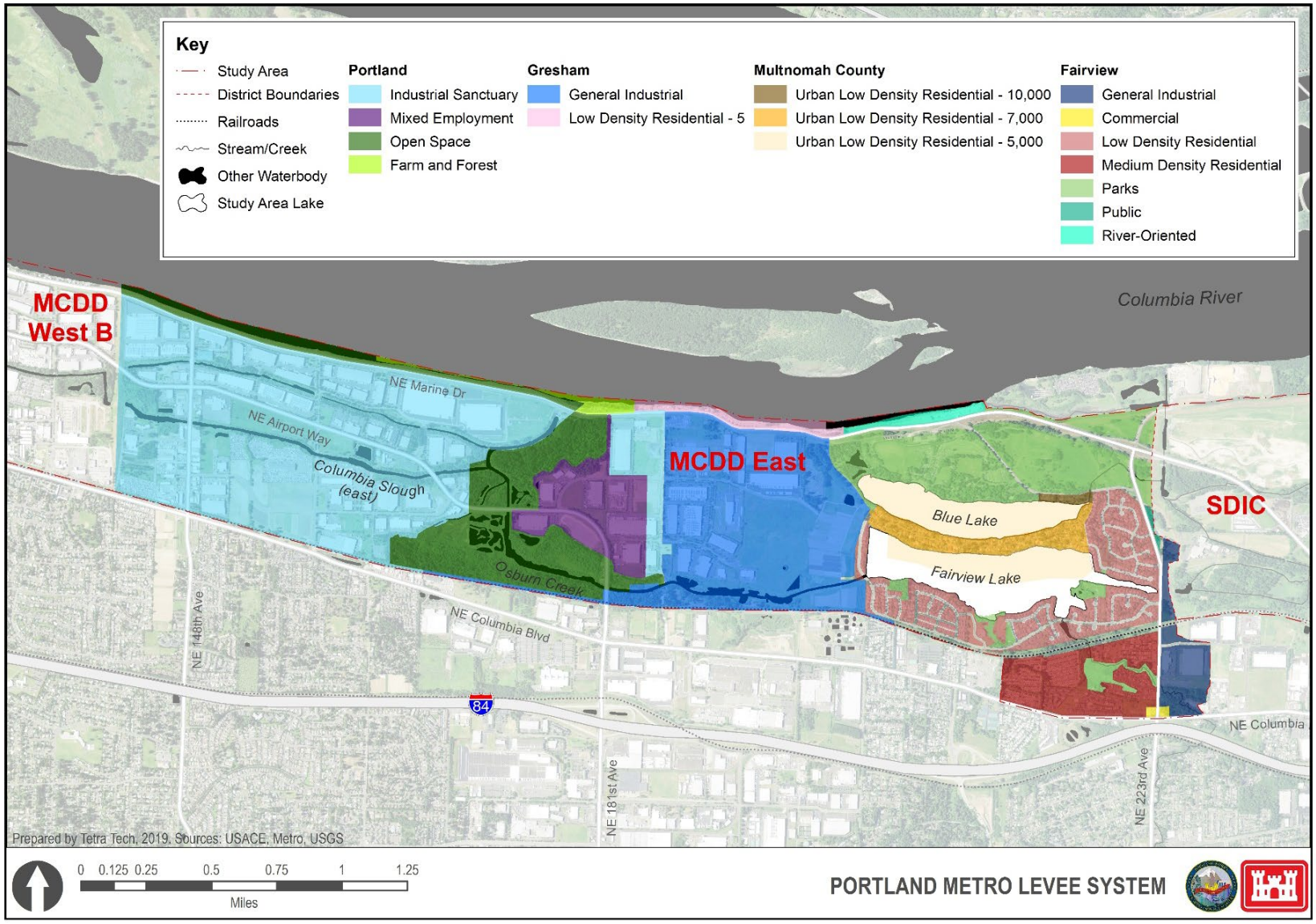

Figure 4-10 Land Use in MCDD East

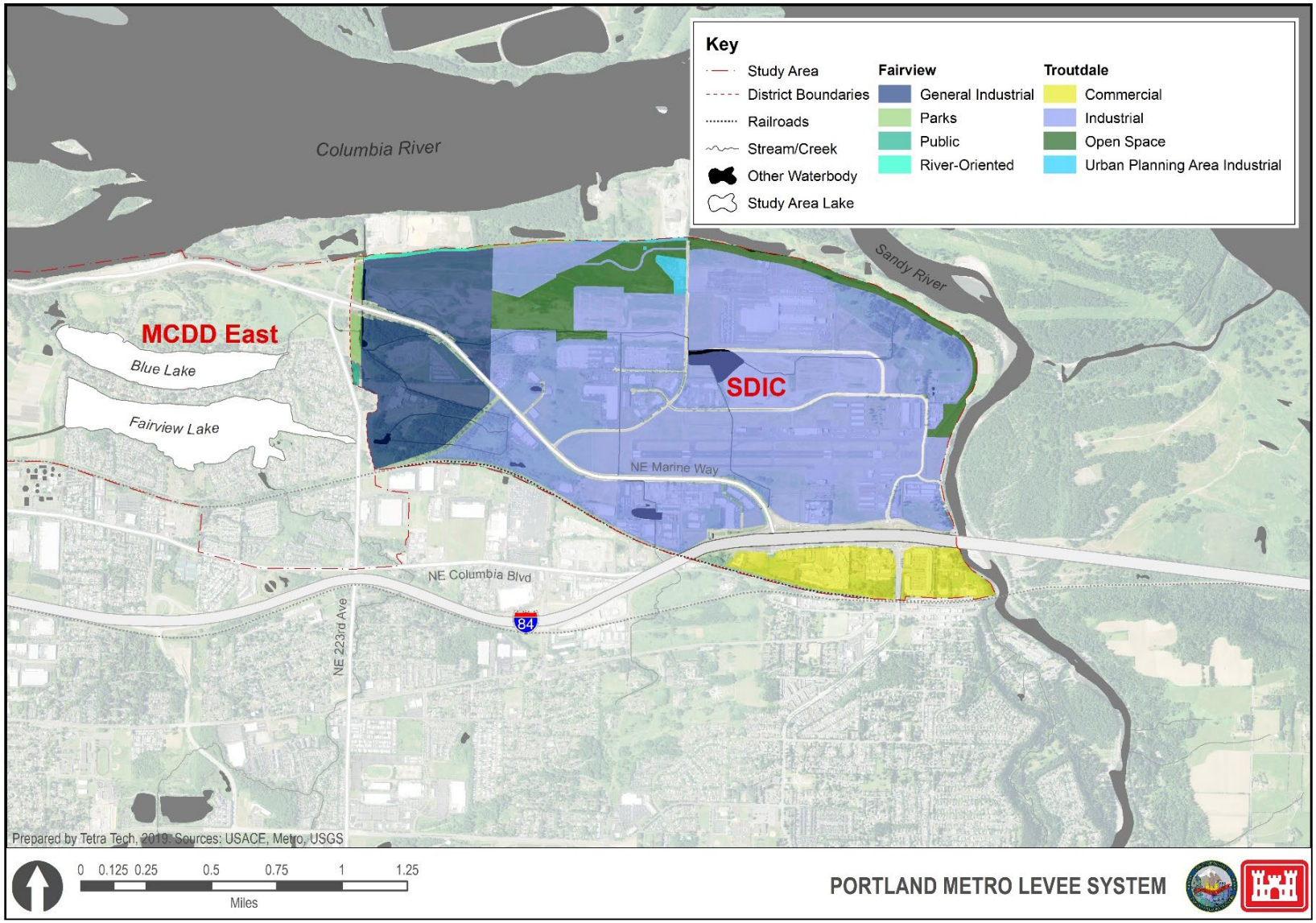

Figure 4-11 Land Use in SDIC

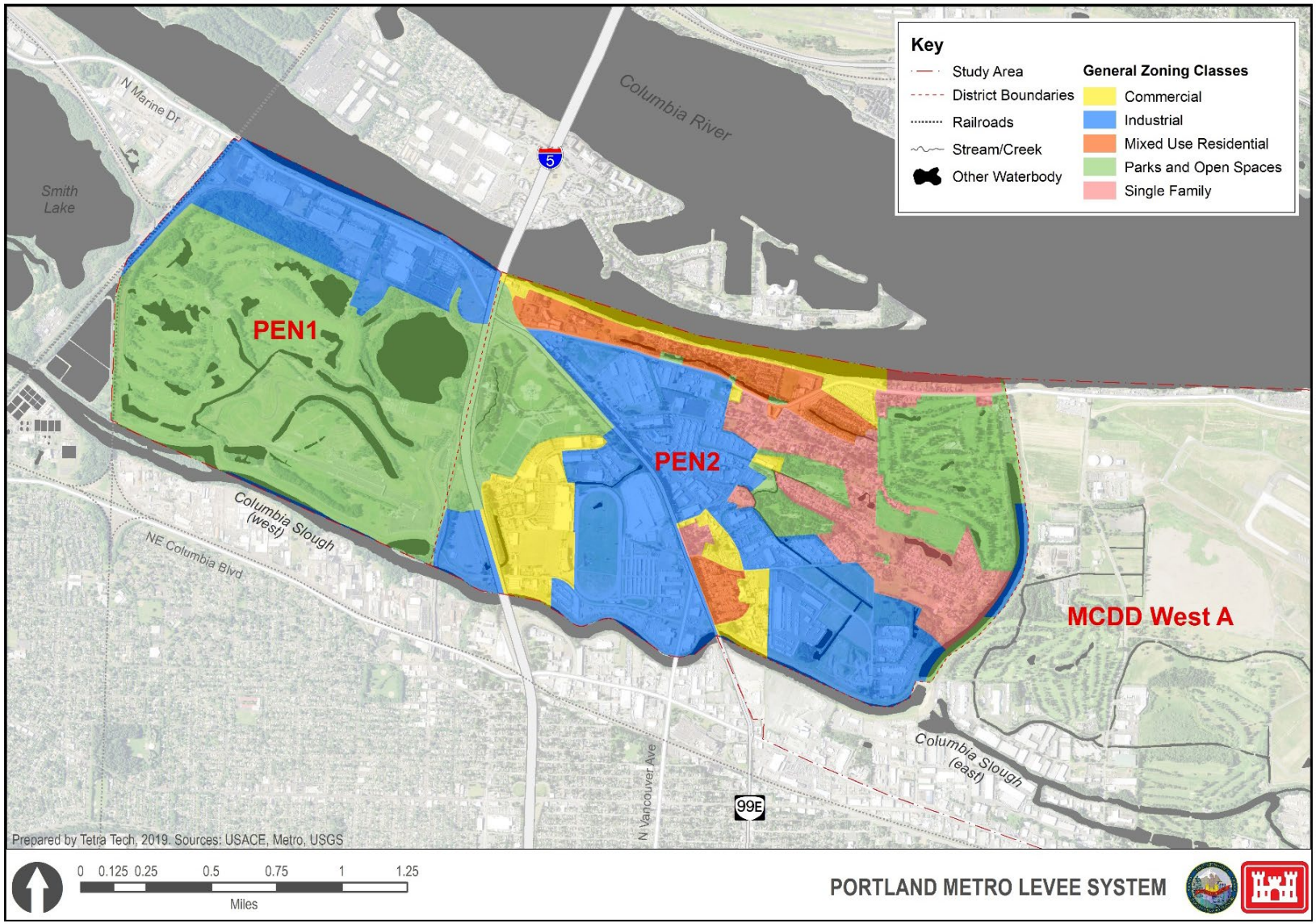

Figure 4-12 Zoning Classes in PEN 1 and PEN 2

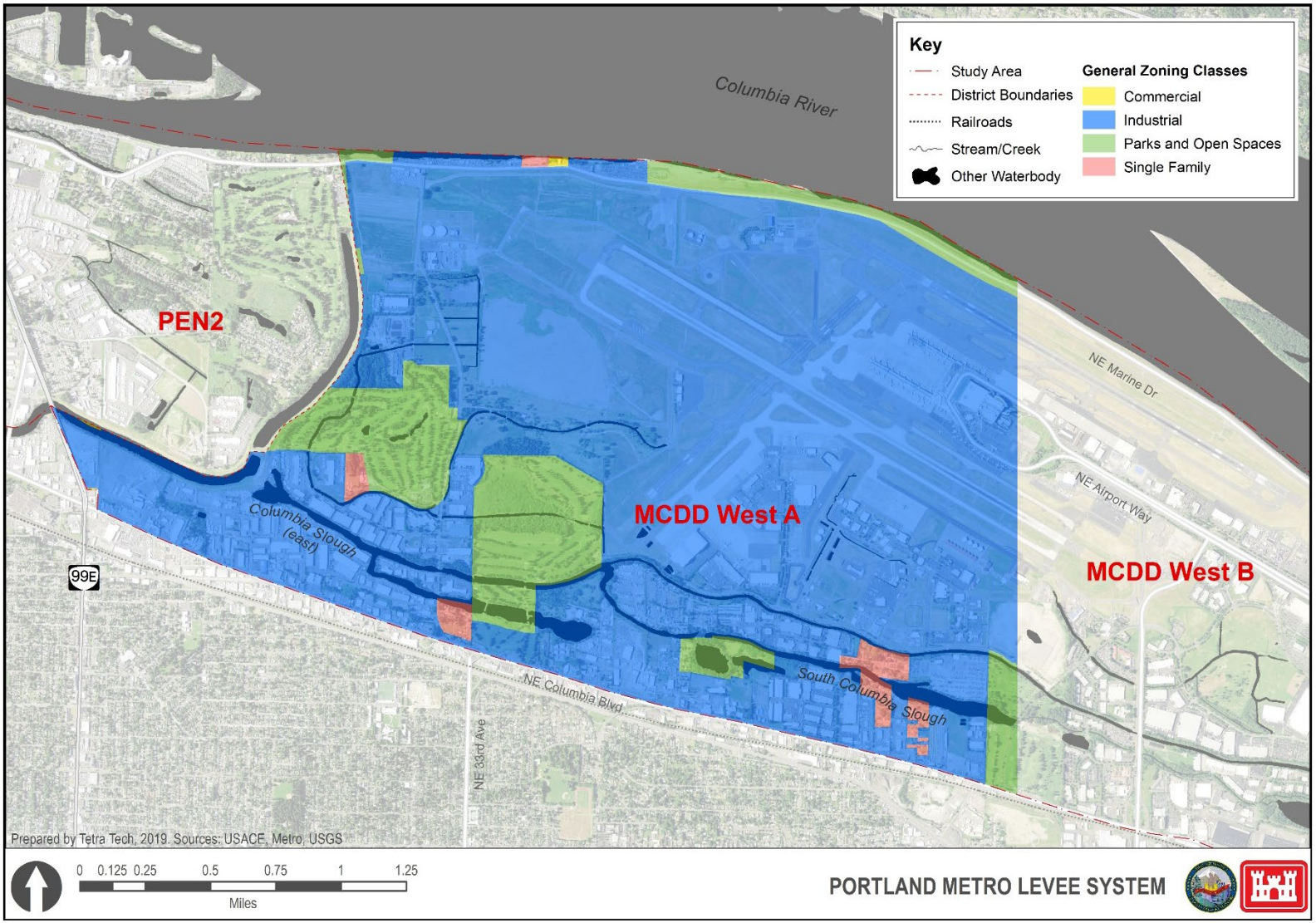

Figure 4-13 Zoning Classes in MCDD West A

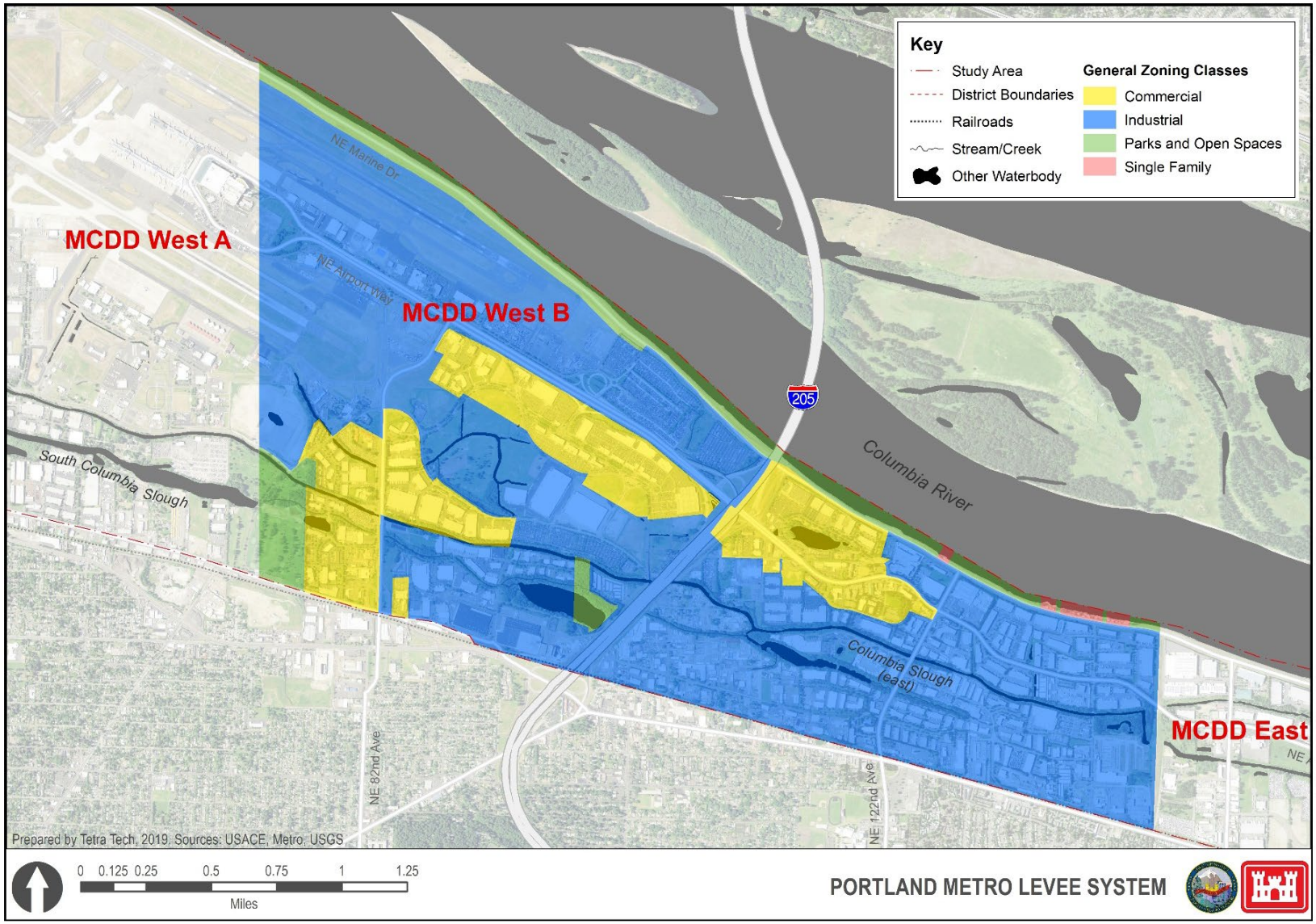

Figure 4-14 Zoning Classes in MCDD West B

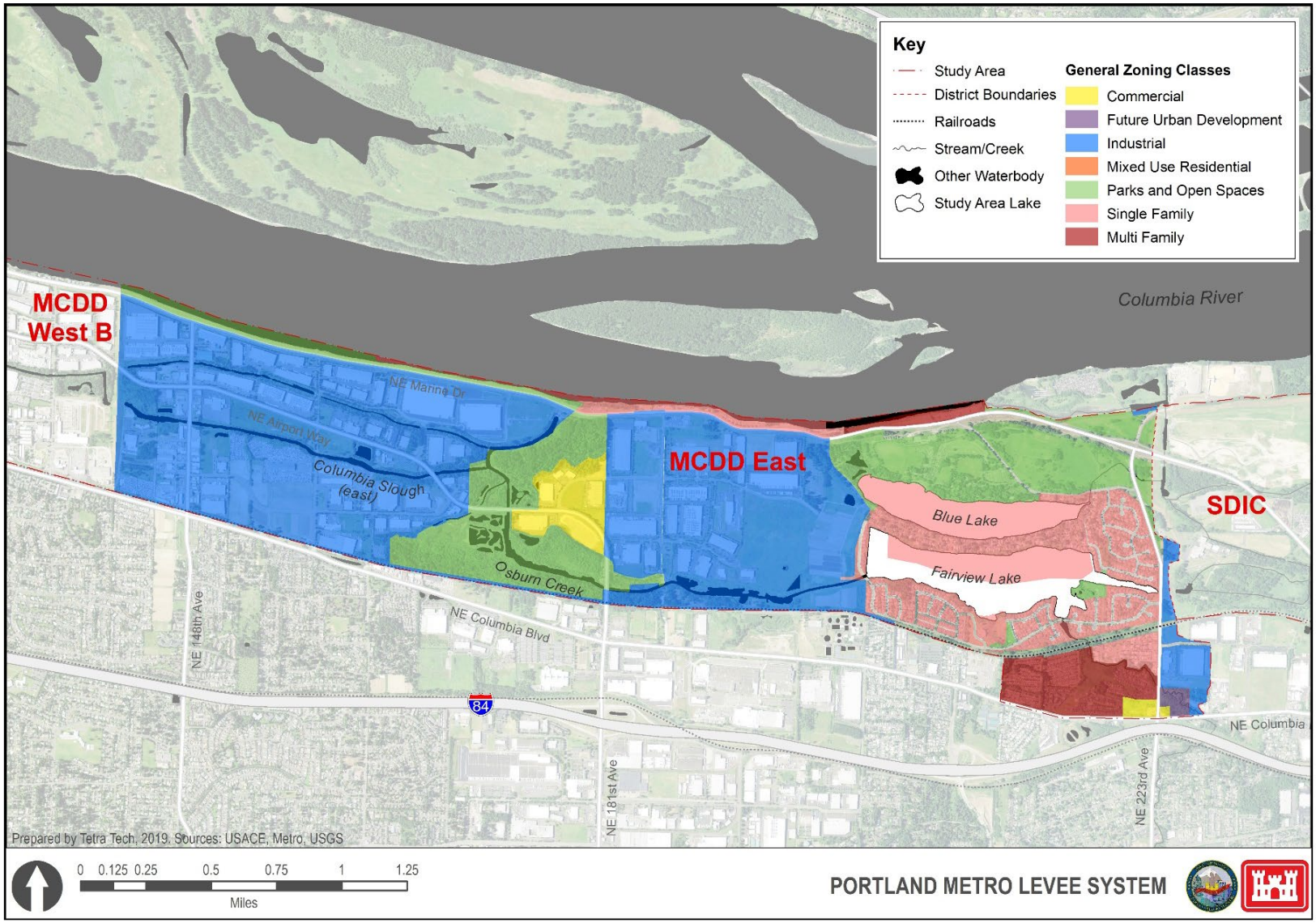

Figure 4-15 Zoning Classes in MCDD East

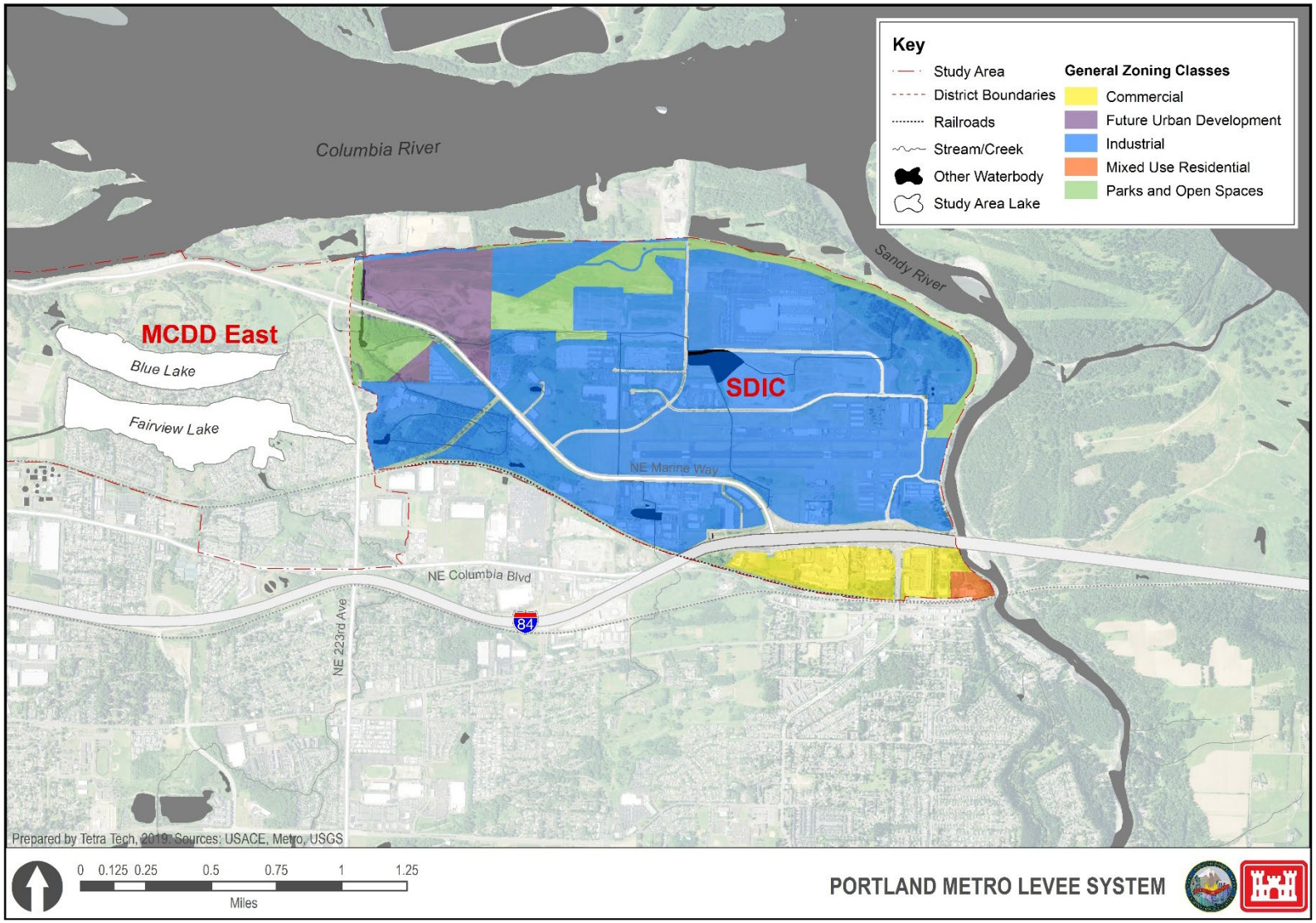

Figure 4-16 Zoning Classes in SDIC

4.12.2. Environmental Consequences

Impacts related to land use could occur if an alternative resulted in any of the following:

- A permanent inconsistency with established land uses
- The introduction of permanent features that would disrupt, divide, or isolate existing neighborhoods, communities, or land uses.

4.12.2.1. Alternative 1 (No Action)

Under the Future Without-Project Alternative, development could include the construction of a new I-5 bridge, expansion of Portland International Airport, redevelopment of Portland Meadows racetrack, and development of farmlands or municipal property. Some of this planned future development is already incorporated into master plans, including the *Airport Futures Plan* (City of Portland 2011a), *Metro 2040 Growth Concept* (Metro 1995), and Portland's *2035 Comprehensive Plan* (City of Portland 2018c). New development will include construction that is already planned to occur, and items identified in master plans. Zoning and building code requirements will persist, allowing current building standards to be applied to structures that will be built in the leveed area. Constraints of the urban growth boundary will increasingly result in a higher population density. Management plans applicable in the Metro Area may require modification of land use and zoning plans to accommodate a rapidly increasing population.

4.12.2.2. Alternative 3

In most parts of the study area, actions under Alternative 3 would be confined to the levee footprint, and would not affect land uses. However, the newly constructed widening of the railroad berm would occupy up to 10 acres of the western side of Heron Lakes Golf Course. The levee would encroach up to 60 feet into the golf course along a 5,000-ft. strip, requiring realignment of at least three fairways. Part of the area that would be affected is zoned for industrial uses, and the rest is zoned for parks and open space. The levee would be publicly-accessible so its presence would be consistent with the parks and open space zoning. The portion within the area zoned for industrial use is not currently used for that purpose, but the presence of the levee would be relatively consistent with this zoning designation.

A similar impact would occur at the western side of the Riverside Golf and Country Club due to the widening of the embankment along the east side of Peninsula Slough. This location is also zoned for industrial use and parks and open space. At this location, the widened levee would slightly encroach into two fairways located at the western edge of the golf course.

In both instances, changes to land uses would occur, but the overall land uses would remain the same. The golf courses would continue to operate, although under a slightly reduced capacity. The Corps will coordinate with the City of Portland Department of Parks and Recreation to determine compensatory measures for this impact, making it less than significant.

4.12.2.3. Alternative 4

Alternative 4 would impact parks and open spaces similarly to Alternative 3, although the amount of golf course fairways and greens lost at Heron Lakes Golf Course would increase to 12 acres.

4.12.2.4. Alternative 5

Alternative 5 would impact parks and open spaces similarly to Alternative 4, although the amount of golf course fairways and greens lost at Heron Lakes Golf Course would increase to 16 acres.

4.13. Socioeconomics

This section describes socioeconomic conditions in the study area. Typical socioeconomic indicators include population and demographics, housing, employment and income, taxes and government revenue, and environmental justice (Section 4.15). The socioeconomic resources relevant to the study area are described by considering their importance in maintaining safe, reliable conditions for the extensive industrial and residential areas that the levees protect from floodwaters.

4.13.1. Affected Environment

The U.S. Census Bureau provides socioeconomic data by geographic region. Census tracts (CT) are small and relatively permanent statistical subdivisions of a county that offer a localized review of population characteristics. A census block group is a statistical subdivision used by the U.S. Census Bureau. Census block groups typically contain between 600 and 3,000 people and 240 and 1,200 housing units (U.S. Census Bureau 2019).

The study area intersects with CT 72.02 Block Group 1, CT 73 Block Group 1, CT 102 Block Group 1, and CT 102 Block Group 3, all within Multnomah County. CT 102 Block Group 3 includes islands (Government, McGuire, and Lemon) in the Columbia River where there are no permanent populations (Figure 4-17). Similarly, the portions of the block groups extending beyond the study area boundaries were reviewed and were found to be either open space or to have a predominant commercial/industrial use. As such, it was judged that use of the block-group-level information was appropriate for characterization of socioeconomic characteristics associated with the permanent populations in the study area. Two additional census block groups (CT 103.03 Block Group 1 and CT 103.05 Block Group 1) intersect small portions of the study area. These tracts were removed from analysis of study area demographics because they would be biased heavily toward neighborhoods outside the study area. The portions of these tracts in the study area are commercial and do not contain permanent populations. Commercial assets in these tracts within the study area are accounted for in the flood risk analysis (see Appendix A (Hydrology and Hydraulics).

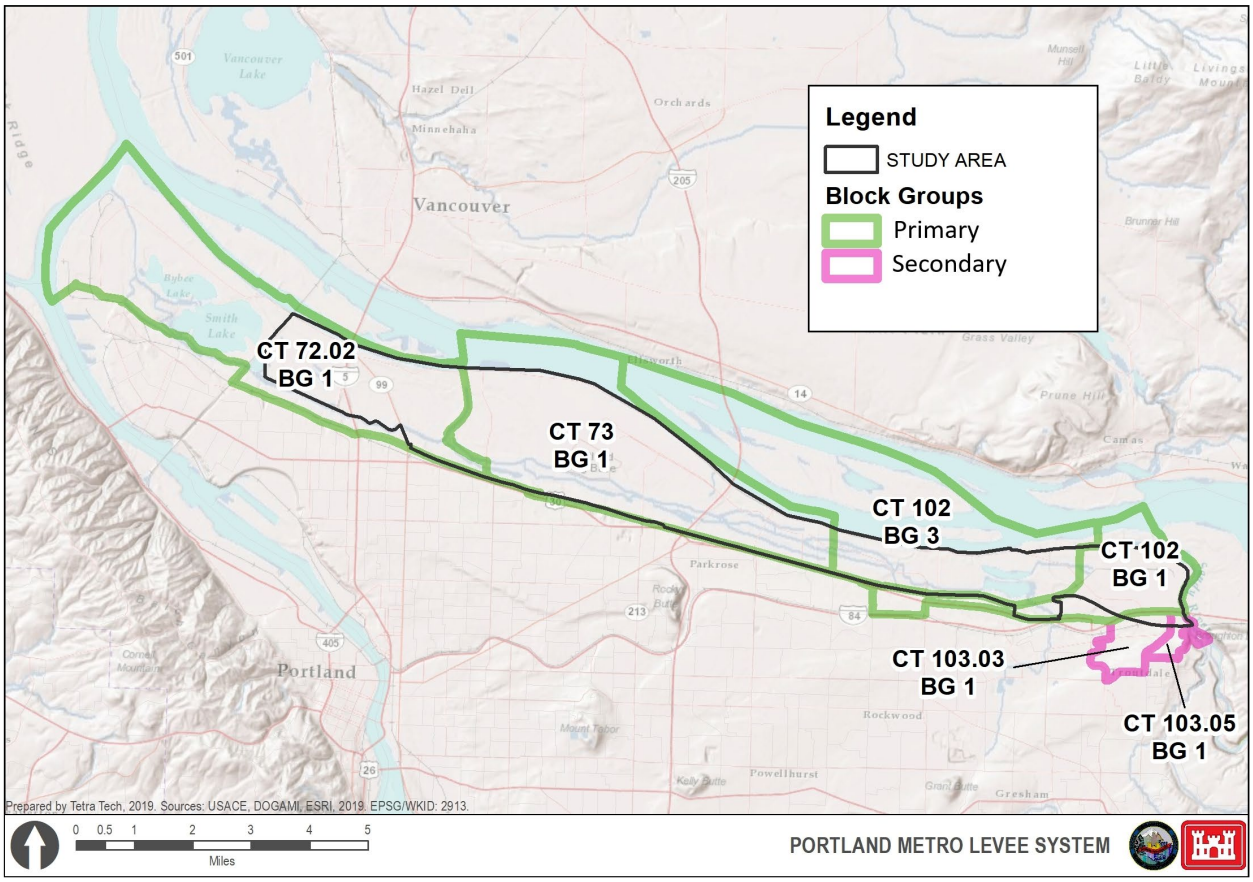

Figure 4-17 Census Tracts Overlapping the Study Area

4.13.1.1. Population, Demographics, and Housing

Data for population, demographics, and housing were taken from the American Fact Finder, which provides statistics prepared by the American Community Survey (USCB 2019). This analysis relies on the 2013-2017 5-Year Estimates dataset, which is the most recent estimates currently available at the block group level of detail. Information is presented at the block group level, and the combination of these four block groups is presented as the study area total. For comparison, data was compared to the Portland-Vancouver-Hillsboro Metropolitan Statistical Area (Metro Area), the state of Oregon, and the U.S. Detailed tables are provided in Appendix B (Economics) and are referenced in the discussion below. Note that while Census data provides the best available source of demographic information, the best available estimate of total resident population in the study area was determined to be the USACE National Structure Inventory, which estimates a population of 8,900 including incarcerated populations. The following discussion references the Census-derived population estimate of 8,720 for consistency in presentation of demographic data.

The residential population of the study area block groups is 8,720 people, including 3,810 women (43.7 percent) and 4,910 men (56.3 percent). Approximately 65 percent of the population

is between 20 and 64 years of age, followed by those over 65 years old (18 percent); see Appendix B (Economics).

Data for population, demographics, and housing were taken from the American Fact Finder, which provides statistics prepared by the American Community Survey (USCB 2019). The overall population in Multnomah County grew by over 27 percent between 1990 and 2000, then grew by 10.6 percent between 2010 and 2017 (USCB 2019). CT 72.02 experienced a 37 percent rise from 2010 to 2017, though CT 73 decreased by 44 percent in the same time frame (UCSB 2019). Overall, the population increased from 10,099 people in 2010 to 11,230 in 2017 within the study area CTs.

Identification of minority populations in the study area includes population of Hispanic or Latino ethnicity, and populations of races black or African American alone, American Indian or Alaska Native alone, Asian alone, Native Hawaiian and Other Pacific Islander alone, another race, or two or more races together. Overall, the study area consists of 40 minority populations, higher than the Metro area and the state at 26 and 23 percent, respectively (see Appendix B).

The study area has 3,021 occupied housing units, comprised mostly of owner occupied units (75 percent) (see Appendix B). Nearly 50 percent of homes are single-family homes, 27.5 percent are attached or apartment dwellings, and 23 percent are mobile homes. There are seven mobile home (RV) parks in the study area according to Google mapping. One senior care facility is located at NE Win Sivers Drive. Along the south shore of the Columbia River, there are over 700 floating homes or other structures.

Additional populations in the study area include a homeless camp and two prisons. Dignity Village is an intentionally developed community for homeless men and women, where 43 basic dwelling structures provide shelter to approximately 60 residents (Dignity Village 2019). In addition, incarcerated populations in the study area include up to 595 inmates at the Columbia River Correctional Institution and up to 1,074 inmates at Multnomah County Inverness Jail (Appleby and Bauer 2018).

4.13.1.2. Employment and Income

The proportion of the total study area population in the civilian labor force between 2013 and 2017 was 51.4 percent (Census 2019). The civilian labor force includes a total of 4,479 people, of whom 95.8 percent are employed and 4.2 percent are unemployed (Census 2019). This overall value for the study area is lower than the computed regional, state, and national rates of 6.2-6.6 percent unemployment, though CT 102 BG 1 has a rate higher rate, at 11.3 percent; see Appendix B (Economics). Top industries for employed residents of the study area are educational services, health care and social assistance industry; professional, scientific, and management, and administrative and waste management services; and retail trade (see Appendix B). Median household income in the study area ranges from $44,453 to $62,250 (see Appendix B).

4.13.2. Environmental Consequences

Socioeconomic impacts could occur if an alternative resulted in any of the following:

- Substantial population growth in the area surrounding the proposed project
- A substantial shift in population trends
- An adverse effect on regional spending and earning patterns
- Introduction of an overwhelming demand for public services or utilities
- Impact on a sector of the economy, productivity, competition, prices, or jobs
- A substantial long-term decrease in local employment due to direct loss of jobs or an effect on the local economy that results in an indirect long-term loss of jobs.

4.13.2.1. Alternative 1 (No Action)

Under the Future Without-Project Alternative, the population in the study area is expected to grow at a rate similar to Portland as a whole as infill and redevelopment for higher density continues within the urban growth boundary. Incomes will not likely change as a result of the expansion of commercial operations in the area, since few residents of the study area also work in the study area. Age, sex, and race composition are unlikely to change substantially from current conditions, and any changes would likely be consistent with changes for the greater Metro Area.

According to a recent study, without the implementation of flood risk reduction measures, more than half of residents in the study area would be displaced by flooding. At least half of the residential buildings, Dignity Village, and incarcerated populations in the study area would be exposed to flooding (Appleby and Bauer 2018).

4.13.2.2. Alternative 3

During the construction period, seasonal employment within the construction industry would increase in the study area. However, construction employees would be expected to already live in the area, or commute into the study area, and no need for new permanent housing would be expected. The need for retail and food service trades may increase incrementally as a result of additional construction workers in the study area, but overall, there would be no substantial changes in the socioeconomic status of the study area.

Following construction, Alternative 3's emphasis on measures intended to maximize life, public health and safety combined with the reduction in flood risk would provide a long-term benefit to the residents and businesses in the study area. More than half of the structures and residents in the study area would benefit from increased flood risk management. Despite improved safety, the levee modifications are not anticipated to result in substantially increased growth within the study area, since much of the area is fully built out and subject to growth guidelines provided by city and local master plans. There would be no substantial increase or change in operation and maintenance activities in the study area.

4.13.2.3. Alternative 4

Construction effects to the study area resulting from Alternative 4 would be similar to those described for Alternative 3. However, the temporary boost to the economy resulting from this large construction project would be extended to three years.

Alternative 4 prioritizes measures for maximizing resiliency and reliability in the system to address uncertain future conditions. The installation of several measures under this alternative could result in substantial benefits to the preservation of homes, businesses, and life in the study area. Flood warning systems in residential areas, educational measures, and a signed evacuation route would ensure preparation and protection of residents and employees in the event of flood.

4.13.2.4. Alternative 5

Construction effects to the study area resulting from Alternative 5 would be similar to those described for Alternative 3. However, the temporary boost to the economy resulting from this large construction project would be extended to 3.5 years.

In comparison to Alternatives 3 and 4, this alternative provides the greatest net benefits in terms of flood risk management. Although this alternative does not include as many non-structural safety and education measures, it does include flood risk education for local residents and businesses, and therefore does provide beneficial impacts to the study area population.

4.14. Environmental Justice Communities

This section defines environmental justice communities and identifies any such communities in the study area. The analysis of potential impacts determines whether the alternatives would result in disproportionate impacts on such communities.

4.14.1. Affected Environment

The EPA defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (EPA 2019). Environmental justice communities are defined as neighborhoods where residents are predominantly minority or low-income.

4.14.1.1. Minority Populations

The occurrence of minority populations was evaluated based upon ethnicity and race data at the block group level in the study area, compared to regional, state, and national level statistics. As presented in Appendix B (Economics), the study area has a similar proportion of minority population as the nation, but a substantially higher proportion than the Metro Area as a whole, or the state of Oregon as a whole (by 14-17 percent). This higher proportion of minority populations is driven by the populations living in CT 72.01 BG 1 and CT 73 BG 1, which both

have approximately 50 percent minority populations, while CT 102 BG 1 and CT 103 BG 3 have 20-25 percent minority populations. This information is consistent with data presented in EPA's EJScreen mapper (EPA 2019). Based on this analysis, project impacts which disproportionately affected CT 72.01 BG 1 or CT 73 BG 1 (generally corresponding to the PEN and MCDD reaches) may result in disproportionate effects to minority populations.

4.14.1.2. Low-Income Populations

Low-income populations are defined as communities living beneath the poverty level. The American Community Survey reports that 0 percent to 14.4 percent of families in the study area have incomes below the poverty level, with an overall rate for the study area of 3.5 percent (see Appendix B (Economics)). For individuals, the poverty rate ranges from 2.5 percent to 27.3 percent among the study area block groups, with an overall rate of 9 percent, which is lower the regional, state, and national rates. Within the study area, the percent of individuals and families living below the poverty level is highest in CT 73 BG 1, and is the only block group with poverty levels exceeding the Metro area, state, or national levels. This corresponds generally to the MCDD West reach, which has the smallest proportion of total population. Part of the low-income population is comprised of houseless individuals and families, who may reside in Dignity Village or overnight throughout the study area. Based on this analysis, project impacts which disproportionately affected CT 73 BG1 (generally corresponding to the MCDD reaches) may result in disproportionate effects to low-income populations.

4.14.2. Environmental Consequences

Impacts associated with environmental justice could occur if an alternative resulted in disproportionately high human health or environmental effects on programs, policies, and activities for minority or low-income populations.

4.14.2.1. Alternative 1 (No Action)

Under the Future Without-Project Alternative, conditions are not likely to change substantially for low-income or minority populations. No influx of minority populations is anticipated in the future and no increase in low-income populations is expected. Without the implementation of flood risk reduction measures, existing low-income populations would be at risk of environmental damage, with at least half of all residents in the study area being displaced in the event of a flood (Appleby and Bauer 2018). In PEN 2, nearly all residents would be displaced due to exposure to flood water, and approximately 75 percent would have homes damaged by flooding. In MCDD, 50 to 60 percent of homes would be exposed to and damaged by flooding. Emergency routes in each district may become impassable during a levee breach and major flood, which could disproportionately affect historically low-mobility populations such as low-income and elderly populations.

4.14.2.2. Alternative 3

Overall, the construction of levee modification measures would impact the local population of the study area through changes in traffic patterns and the increase in number of construction employees in the area. However, these changed conditions are not anticipated to alter the minority composition or income levels in the study area, and are not expected to disproportionately affect minority or low-income populations. Regardless of final configuration of this alternative, CTs 72.01 and 73 would not sustain a disproportionate amount of the construction impacts. Following construction, there would be a substantial increase in protection to minority and low-income populations that occur in the study area.

4.14.2.3. Alternative 4

Impacts are expected to be similar to Alternative 3. The greater level of risk reduction provided by this alternative would not result in any additional or disproportionate adverse effects on study area populations but would result in a further increase in protection for EJ populations.

4.14.2.4. Alternative 5

Impacts are expected to be similar to Alternative 3. The greater level of risk reduction provided by this alternative would not result in any additional or disproportionate adverse effects on study area populations but would result in a further increase in protection for EJ populations.

4.15. Aesthetics/Visual Resources

This section describes visual resources in the study area, which consist of natural and human-made features that give a particular environment its aesthetic qualities. To determine whether alternatives would appear compatible with existing features or would contrast noticeably within the setting, the landscape character needs to be evaluated.

Views are considered sensitive when they have high scenic quality and are experienced by relatively large numbers of people (i.e., views from publicly accessible areas). Scenic quality is a measure of the overall impression or appeal of an area created by the physical features of the landscape, such as natural features (landforms, vegetation, water, color, adjacent scenery, and scarcity) and human made features (roads, buildings, railroads, other built elements, and agricultural patterns).

4.15.1. Affected Environment

The visual landscape in the study area is influenced by a variety of land uses, ranging from industrial and commercial to recreational and private uses. The vast majority of the study area is developed, and remaining land covers include water, vegetation, and agricultural use (LRC 2017).

Developed areas include heavy to light industrial and commercial areas. The Portland International Airport makes up the largest overall land use at 3,000 acres and is a combination of airport terminal and auxiliary support buildings, tarmac, runways, and open mowed grasslands (FAA 2019). Troutdale Airport covers 284 acres, having one runway (Port of Portland 2019a). Business parks, shopping centers, and Portland Meadows raceway dominate the commercial areas and consist of expansive buildings and parking lots. Small pockets of agricultural lands, country clubs, golf courses, sports complexes, and natural areas provide the only natural or semi-natural aesthetics to the area. Vegetation throughout the study area is highly disturbed and fragmented, even along waterways such as the Columbia River, Sandy River and Columbia River Slough. Native and non-native trees and shrubs are used for landscaping at golf courses and retail areas.

Levees along the Columbia River provide elevated views of the area, sweeping from local shorelines upstream across forested mid-channel islands, and on a clear day, reaching the peaks of the Cascade Mountains. Other areas of natural beauty include recreational areas such as local pocket parks, shoreline access, lakes, ponds, and rivers. Public access areas of high aesthetic value include Chinook Landing Marine Park, Blue Lake Regional Park, and the forest-wetland complex at the confluence of the Sandy River with the Columbia River.

4.15.2. Environmental Consequences

An alternative would impact visual/aesthetic resources if it would result in any of the following:

- Substantial effects on a scenic vista
- Substantial damage to scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within view of a state scenic highway
- Substantial degradation of existing visual character or quality of a site and its surroundings
- Creation of a new source of substantial light or glare that would affect day or nighttime views in the area.

4.15.2.1. Alternative 1 (No Action)

Under the Future Without-Project Alternative, visual resources would continue to be protected by local ordinances and interested community groups. As development continues with the increasing Portland-Vancouver metro population, the visual character of the area may diminish from a loss of natural areas. Buildout of residential, commercial, or industrial areas will encroach on the already severely diminished natural habitats, resulting in increasing impervious surfaces, buildings, power lines, and other accoutrements of development. Small improvements may result from coordination between community groups and public utilities to undertake localized restoration projects along the Columbia River, Columbia Slough, or other tributaries and open water habitats.

4.15.2.2. Alternative 3

Under this alternative, the aesthetic environment would be affected during the construction period, notably in areas that were cleared of vegetation, where heavy machinery was in use, or where staging areas were developed. Levee modifications would be engineered to minimize impacts to scenic vistas such as over the Columbia River or Mt. Hood, historic buildings, or other scenic resources would be impacted. Construction would generally occur daylight hours, but some nighttime light sources may be introduced for work occurring early in the morning or late in the afternoon. Following construction, temporarily cleared sites would be contoured, revegetated and restored to their original aesthetic condition. This impact would be temporary and less than significant.

Permanent changes to the visual landscape would be noticeable where new levees and floodwalls are constructed, or where existing levees are expanded. Overall, these changes would be minor with no substantial change in overall visual character.

New residential evacuation signage would be designed to match or complement existing roadway signage. Implementation of new signage would not result in noticeable changes to the visual landscape.

4.15.2.3. Alternative 4

Impacts under this alternative would be similar to those occurring under Alternative 3. The construction of new flood fight maintenance roads would be included under this alternative where levees already exist. The construction of roadways at these levees would be visually comparable to the existing condition, since each of these areas are already utilized for operations of levees and railroads.

Each of these new features would not be substantially different in character than the existing levees and other flood control and drainage district structures that are already in place. Overall, changes to the visual character of the study area would be minor or would be similar in character to existing conditions.

Once installed, new gates, pumps, and debris racks would be minor and may provide an improvement over previously degraded machinery. New residential signage would be designed to match or complement existing roadway signage. New residential evacuation signage would be designed to match or complement existing roadway signage. No significant adverse effects are expected to result from local and non-structural measures.

4.15.2.4. Alternative 5

The levee modification measures in this alternative are comparable to those in Alternative 4, with similar impacts as described above.

Under this alternative, the floodwall on the northern levee would be lengthened to run the entire length of PEN 1 and PEN 2. Although the floodwall would be designed to be visually congruent

with it' surroundings, it may impair views of the river and surrounding landscape in the area. In most areas, the floodwall would be low enough to allow a view over the top of it, but the view would be impaired at locations where the wall may be up to seven feet tall. Because this effect would only occur along about 200 feet of the wall, this impact would be less than significant.

4.16. Recreation

This section describes recreation in the study area, including city parks, Columbia River recreation facilities, golf courses, yacht and country clubs, and natural areas.

4.16.1. Affected Environment

The study area is home to numerous and varied recreational opportunities. In the west end of the study area are the Portland International Raceway, Delta Park-Owens Sports Complex, and Portland Meadows. At the east end of the study area lie Blue Lake Regional Park and the Sandy River. Throughout the length of the study area there are golf courses, city parks, sports complexes, and natural areas. Along the Columbia River are numerous water recreation facilities, including marinas, boat launches, and beaches. A popular bike and pedestrian access trail is found along most of the levees.

4.16.1.1. City Parks

Major parks in the study area include the following:

- The City of Portland Parks and Recreation Department owns and operates the Portland International Raceway adjacent to the neighborhood of Kenton and west of I-5, within the PEN 1 district (PIR 2019a). It offers a 1.97-mile track, a motocross track, parking, and other facilities within a 268-acre area that is visited by an estimated 350,000 people each year (PIR 2019b). The Portland International Raceway Dogpark and Portland Model Rocket Park are also part of the complex.
- The Delta Park-Owens Sports Complex is located in PEN 2 between Highway 99E and I-5. It is home to seven softball fields, nine soccer fields, and a concession building (PRD 2019).
- Portland Meadows is a horse racing and off-track betting facility located in PEN 2 between Highway 99E and I-5. Although owners have announced the closure of Portland Meadows in June 2019, it may remain home to ongoing events until redevelopment begins (Portland Monthly 2019).
- The Portland Parks and Recreation Department owns and operates the Columbia Children's Arboretum, a 28-acre area located in PEN 2 between NE 6th Drive and NE Gertz Road. The area is a complex of pastoral lands with picnic benches, an orchard, riparian forests, and wetlands (PRD 2004).

- Blue Lake Regional Park is in the east end of the study area and managed by Metro within the MCDD. It offers a variety of recreational opportunities, including boating, fishing, swimming, trails, natural and cultural interpretation, playgrounds, sports facilities, picnicking, and disc golf (Metro 2019c).
- Whitaker Ponds Nature Park is a 24.7-acre park located in the MCDD east of NE 47th Avenue and south of NE Buffalo Street. The area is a complex of two ponds and wetlands, bordered by black cottonwood forest. Facilities include a 0.5-mile walking trail, covered gazebo, observation docks, canoe launch, and picnicking areas.
- Pocket parks in the study area include Pelfrey Park, Hockaday City Park, and Lakeshore Park, all within the SDIC. These parks typically offer a grassed area, play structures, sports facilities, and picnic tables.

4.16.1.2. Columbia River Recreation Facilities

Recreation facilities associated with the Columbia River in the study area include the following:

- M. James Gleason Memorial Boat Ramp is on the south shore of the Columbia River north of Portland International Airport within the MCDD. It offers a public boat launch, disabled-accessible docks, restroom facilities, picnic and viewing areas, and a seasonal river patrol station. The facility is owned and operated by Metro (2019).
- Broughton Beach Park is adjacent to the Gleason Boat Ramp to the east and also owned and operated by Metro and within the MCDD. Facilities include parking and restrooms. Activities include swimming, picnicking, walking, and enjoying nature (Metro 2019d).
- Chinook Landing Marine Park, one of Oregon's largest public boating facilities, is located north of Blue Lake Regional Park, just north of the study area. Owned and operated by Metro, the site has six boat launch lanes, picnic and viewing areas, restroom facilities, an archery range with six targets, and a seasonal river patrol station (Metro 2019d). Although it is not within the MCDD, it is immediately adjacent to the study area, and is accessed via Marine Drive.
- Marine Drive Trail is a paved, 17.6-mile trail that starts west of PEN 1 at Kelley Point Park and ends at Portland-Troutdale Airport. The trail follows Marine Drive and offers bicycling, inline skating, walking, and wheelchair access.

4.16.1.3. Golf Courses, Yacht and Country Clubs

Golf courses and yacht and country clubs in the study area include the following:

- Heron Lakes Golf Club is a public, municipal facility owned by the City of Portland and operated by PPD. It is located in PEN 1 and provides two 18-hole courses, including Great Blue and Greenback courses. Practice facilities are also available. The golf course is a Certified Audubon Cooperative Sanctuary (PRD 2019).

- Broadmoor Golf Course is a public 18-hole course covering 220 acres in the MCDD and available for tee times year-round. It is located southwest of Portland International Airport, along NE Columbia Boulevard.
- Colwood Golf Center is a par-3, 9-hole course owned and operated by the Portland Parks and Recreation department in the MCDD at the intersection of NE Columbia Boulevard and NE Alderwood Road. Parking and banquet facilities are provided.
- There are two private golf clubs in PEN 2 (Columbia Edgewater Country Club and Riverside Golf and Country Club) and one private yacht club in the MCDD (Rose City Yacht Club).

4.16.1.4. Natural Areas

In addition to the formal recreational facilities described above, the study area is home to a variety of natural areas that attract visitors interested in bird watching, wildlife viewing, nature walks, and natural area rejuvenation:

- The study area extends to NE Marine Drive, which forms the levees for PEN 1, PEN 2, and the MCDD. North and immediately adjacent to the levees is the shoreline of the Columbia River, which provides a nearly continuous natural area for wildlife watching, bike riding along the Marine Drive bike path, and access to public beaches that provide no formal recreation facilities.
- Vanport Wetlands is a 90.5-acre wildlife habitat site located in PEN 1 between I-5 and the Portland Expo Center. More than 160 species of birds and other wildlife and over 80 species of native plants are recorded in the area (Topinka 2019).
- Big Four Corners is a natural area in the MCDD that stretches from Marine Drive in the north to the Union Pacific Railroad in the south, generally between NE 162nd and 185th Drives. It is a complex of emergent wetlands, willow scrub, and cottonwood riparian forests surrounding the Columbia Slough. It is possible to paddle the surface waters through this area, launching from NE Airport Way and NE 166th Avenue.
- The Columbia Slough Water Trail offers 19 miles of accessible waterway trail between Fairview Lake and Kelley Point Park, and is open to human-powered watercraft (Columbia Slough 2019).
- Throughout the study area are other pockets of wetlands, forest, and ponds that may have official or unofficial trails through the sites. Examples include the West Sundial Wetlands, forests and meadows along the Columbia Slough, Johnson Lake, and the Sandy River shoreline.

4.16.2. Environmental Consequences

An alternative would impact recreational resources if it permanently reduced the acreage or quality of recreation available, or permanently prevented access to recreational areas.

4.16.2.1. Alternative 1 (No Action)

The natural and developed recreational facilities throughout the study area would continue to be preserved and improved by the operations of city, municipal, and local organizations that have management responsibility. Potential flood risks to these areas would remain, and action plans would need regular updating to ensure that facilities are adequately protected from flooding, or to replace the capacity of these facilities at other locations in the event of prolonged flooding. Natural areas would continue to be preserved, restored, and enhanced under local and city management.

4.16.2.2. Alternative 3

Under Alternative 3, the proposed widening of the railroad berm would occupy up to 10 acres of the western side of Heron Lakes Golf Course. The widening would encroach up to 60 feet into the golf course along a 5,000-ft. strip (6.89 acres), requiring realignment of three fairways and temporary closures of part or all of the affected fairways during construction. Widening of the embankment along the east side of Peninsula Slough would result in minor loss of the edges of two fairways at the Riverside Golf and Country Club, located at the western edge of MCDD.

Construction of levee modifications would be designed and phased to allow continual access to recreation areas and facilities, and access would be enhanced during operations by construction of a pedestrian and bicycle path along the PEN 1 Columbia Slough levee. However, modifications to the Marine Drive levee would require intermittent and temporary restrictions in access to the pedestrian and bicycle path that runs along Marine Drive. These closures would be posted prior to construction and provide exact closure dates, locations, and alternate routes. These impacts would be temporary and less than significant.

4.16.2.3. Alternative 4

Impacts from the primary construction measures under Alternative 4 would be similar to those occurring under Alternative 3, but the amount of affected area at Heron Lakes Golf Course would increase to 12 acres and would provide increased flood risk protection. Installation of local measures, such as new gates, pumps, debris racks, and signage would not interfere with recreational activities. Recreation access to the Columbia Slough would remain the same. There would be no adverse effects from operation of the measures included under this alternative.

4.16.2.4. Alternative 5

Impacts under this alternative would be similar to those for Alternative 4, but the amount of fairways lost at Heron Lakes Golf Course would increase to 16 acres.

4.17. Public Services / Health and Safety

This section describes public services related to health and safety, which include law enforcement, fire protection, paramedics, and emergency care hospitals. The impact analysis

assesses whether the alternatives would result in conditions that would exceed the capacity of these services or create the need for new utilities.

4.17.1. Affected Environment

Responsibility for public health and safety in the study area is divided among the MCDD and the municipalities that each drainage is within, collectively referred to as the CCDDJCA. MCDD is divided between the Cities of Portland, Fairview, and Gresham. PEN 1 and PEN 2 are entirely within the City of Portland. The SDIC lies within the jurisdiction of the cities of Fairview and Troutdale. MCDD works with the following emergency partner agencies to ensure a coordinated approach during emergency events:

- Multnomah County emergency management
- Portland Bureau of Emergency Management
- U.S. Army Corps of Engineers emergency management
- Port of Portland emergency management
- Landowners and non-profit and community organizations

Flood Response

The Districts are the first responders in an emergency flood event. The *Flood Emergency Action Plan* establishes protocols and responsibilities for MCDD as the first responder in the event of a Columbia River or Columbia Slough high water threat or flood emergency (MCDD 2016). During these events, the District implements plans to keep levees and facilities functioning to protect life, property, and the environment.

The organization of an evacuation plan and the provision of personal services is coordinated by local cities during a flood event. The City of Portland evacuation plan is specific to PEN 1, PEN 2, and MCDD (PBEM 2017). The Cities of Gresham, Fairview, and Troutdale include evacuation protocols in their basic emergency operations plans.

During an evacuation, or for any other public health and safety needs, each local city provides law enforcement services, fire and emergency response, search and rescue teams, and medical care facilities.

Law Enforcement

The following law enforcement facilities are within or near to the study area and provide service to the study area:

- The City of Portland Police Bureau's North Precinct is located south of the study area (443 NE Emerson Drive., Portland, OR 97211) provides law enforcement for most of the study area, including all project lands west of NE 185th Drive between the cities of Portland and Gresham. Bureau districts 540, 610, 641, 642, 651, and 652 have jurisdiction over the study area.

- The Gresham Police Department (1333 NW Eastman Parkway, Gresham, OR 97030) and Gresham River Patrol Columbia River Office (4325 NE Marine Drive, Portland, OR 97211) provide land and water police service 24 hours a day. The police department headquarters are located south of the study area, while the river patrol is located within the study area.
- Multnomah County Sheriff (234 SW Kendall Court, Troutdale, OR 97060) provides law enforcement throughout the unincorporated portions of Multnomah County surrounding the cities of Portland and Gresham and within the Troutdale and Fairview areas. The office is located outside of the study area.
- The Port of Portland has a police department at Portland International Airport (7000 Northeast Airport Way #3109, Portland, OR 97218). This department, together with the Port of Portland Fire Department, provides health and safety services on airport property or for aircraft emergencies in the area. The two departments can deploy law enforcement, fire engines, emergency ambulances and water rescue teams. Both of these departments are located within the study area.

Fire Response, Fire Engine and Paramedics

The following fire and paramedic facilities are within or serve the study area:

- City of Portland Fire and Rescue, 55 SW Ash Street, Portland, OR 87204
- Station 02, Parkrose, 4800 NE 122nd Avenue, Portland, OR 97220
- Station 17, Hayden Island, 848 North Tomahawk Drive, Portland, OR 97217
- Station 08, Kenton, 7134 North Maryland Avenue, Portland, OR 97217
- Station 14, Vernon, 1905 NE Killingsworth Street, Portland, OR 97211
- Station 12, Sumner, 8645 NE Sandy Boulevard, Portland, OR 97220
- City of Gresham Fire and Emergency Services Station 74, 1520 NE 192nd Avenue, Portland, OR 97230
- Port of Portland Fire Department, 5250 NE Marine Drive, Portland, OR 97218, provides fire and emergency care response for fires and other emergencies at Portland International Airport

24-Hour Emergency Care Hospitals

The following medical facilities serve the study area, but are not within the study area:

- Legacy Emmanuel Health Center, 2801 North Gantenbein Avenue, Portland, OR 97227
- Providence Portland Medical Center, 4805 NE Glisan Street, Portland, OR 97213
- Adventist Health Portland, 10123 SE Market Street, Portland, OR 97216

4.17.2. Environmental Consequences

Impacts associated with public services could occur if an alternative resulted in any of the following:

- The need for new or physically altered governmental facilities in order to maintain acceptable service ratios, response times or other performance objectives for any public services (i.e., fire, police, schools, libraries)
- Increased police or fire department response times, or impaired implementation of an adopted emergency response plan or emergency evacuation plan

4.17.2.1. Alternative 1 (No Action)

Under this alternative, public health and safety would continue to be protected by the agencies and organizations described above. Drainage districts, fire stations, police, and public health departments will endeavor to ensure the safety and health of all citizens that work, play, or live in the study area. As the population of the Portland metro area grows, the need for public health and safety officers and organizations will increase in the area. However, without construction of this project, levee safety will continue to be addressed in a piecemeal fashion, without comprehensive, site-wide safety improvements. Furthermore, climate change research indicates that sea levels will rise and high flow events will increase in magnitude, increasing the risk that the existing levees are not adequate to provide a high level of public safety in the study area. As the population of the study area increases, the population at risk will increase at a commensurate rate. In the event of a 100-year flood combined with a levee breach, analysis indicates that 65-75 percent of buildings across most of the drainage districts would be exposed to flooding; in PEN 2 as many as 95 percent of buildings would be exposed to flood damage (Appleby and Bauer 2018). The same analysis notes that the combined number of buildings that could be exposed to flooding in PEN 2 and MCDD West may total over 1,000.

4.17.2.2. Alternative 3

Alternative 3 is intended to protect the study area from the damages that could result if the existing levees breached during a 100-year flood. Completion of this alternative would provide substantial flood risk reduction to the residents and businesses in the study area, as well as increased flood fight capacity for first responders, thereby improving public health and safety substantially.

Implementation of the levee modification measures would require a carefully designed traffic management plan. This plan would determine construction phasing, daily schedules, alternate routes, and a coordinated public health and safety plan. The plan would require that construction efforts avoid or minimize the potential for reduced public safety and worker safety, which could require additional emergency response to the study area. The plan would also provide measures for ensuring that emergency response times to all parts of the study area are maintained through open and regular communication between construction teams, law enforcement, fire stations, medical facilities, and ambulance providers. The traffic flow and circulation plan would reduce

the potential for impacts to public health and safety during the construction process. This impact would be temporary and less than significant.

The project designs will include measures to ensure access to parks, schools, hospitals, libraries, and other public services during the construction period. Access to some non-essential public services may be delayed due to traffic delays and temporary lane closures at access routes to these facilities. This impact would be temporary and less than significant.

Providing education and signage to the residents of the study area would increase the awareness of flood risks, safety measures, and evacuation routes, which would be a beneficial impact.

Operation of the completed project may induce growth in parts of the study area that are not already built out. Such growth would increase the need for law enforcement, emergency response, or other public services. Growth would occur as a result of increased protection for homes and businesses, providing an economic boost to the study area and offsetting the added expenses associated with public services. There would be no adverse effects as a result of levee modifications and this would instead provide a beneficial impact to public health and safety and public services.

4.17.2.3. Alternative 4

Impacts to public health and safety and public services would be similar to those occurring under Alternative 3. Improving redundancy and resiliency of the existing system, through installation of new pumps, gates, and debris removal racks will further ensure drainage control and flood risk reduction. Creating new levees to raise the elevations of Marine Drive and Airport Way would preserve access to areas within the newly protected areas during a flood event.

4.17.2.4. Alternative 5

Alternative 5 is designed to provide the same level of protection to the study area as the other action alternatives and would provide similar beneficial impacts.

4.18. Transportation and Traffic

This section discusses traffic, transportation facilities, and rights of way in the study area, and identifies potential impacts that could occur from implementing the alternatives.

4.18.1. Affected Environment

4.18.1.1. Surface Traffic

Highways and Roads

Access to the study area is provided by numerous highways, arterial roads, connector streets, and trails (Figure 4-18). Two interstate highways, I-5 and I-205 provide the primary access to the

study area. I-84 also connects to the study area near Troutdale. Major surface streets serving the study area from west to east include NE Marine Drive, NE Columbia Boulevard, NE Sandy Boulevard, and NE Airport Way. Major roadways running north to south include NE Martin Luther King Jr. Boulevard (State Highway 99E), North Vancouver Avenue, NE 33rd Drive, NE 82nd Avenue, NE 122nd Avenue, NE 148th Avenue, and NE 223rd Avenue.

Traffic counts in the study area are automatically collected at stations along I-5, I-205, and I-84. Average daily traffic (ADT) counts are provided by month, calculated as the number of individual vehicles passing the station each day, averaged over 30 days (Table 4-19, ODOT 2018). Several primary arterials in the study area report annual ADT (AADT) traffic counts, calculated as number of individual cars passing the station each year, divided by 365 (Table 4-20, ODOT 2019a).

Table 4-19 Average Daily Traffic Counts at Stations in the Study Area in 2017

Station	**26-001**[1]	**26-004**[2]	**26-024**[3]	**26-028**[4]
January	17,978	108,802	127,931	79,704
February	24,860	127,319	149,337	99,415
March	31,355	132,992	155,462	107,290
April	34,517	134,224	160,228	111,209
May	39,289	133,998	162,772	113,295
June	42,934	139,402	168,548	118,808
July	48,489	138,427	167,447	121,048
August	45,812	139,712	166,996	119,086
September	38,983	135,100	162,120	100,904
October	33,595	134,734	158,803	110,097
November	29,992	132,461	154,036	104,025
December	26,009	130,111	150,775	99,461

Notes:
[1] *I-84; MP 17.71; Columbia River Highway No. 2*
[2] *I-5; MP 307.97; Pacific Highway No. 1; 0.41 mile south of Oregon-Washington State Line*
[3] *I-205; MP 25.50; East Portland Freeway No. 64; 1.06 miles south of Oregon-Washington State Line*
[4] *I-84; MP 11.45; Columbia River Highway No. 2; 1.59 miles west of NE 181st Avenue Interchange*

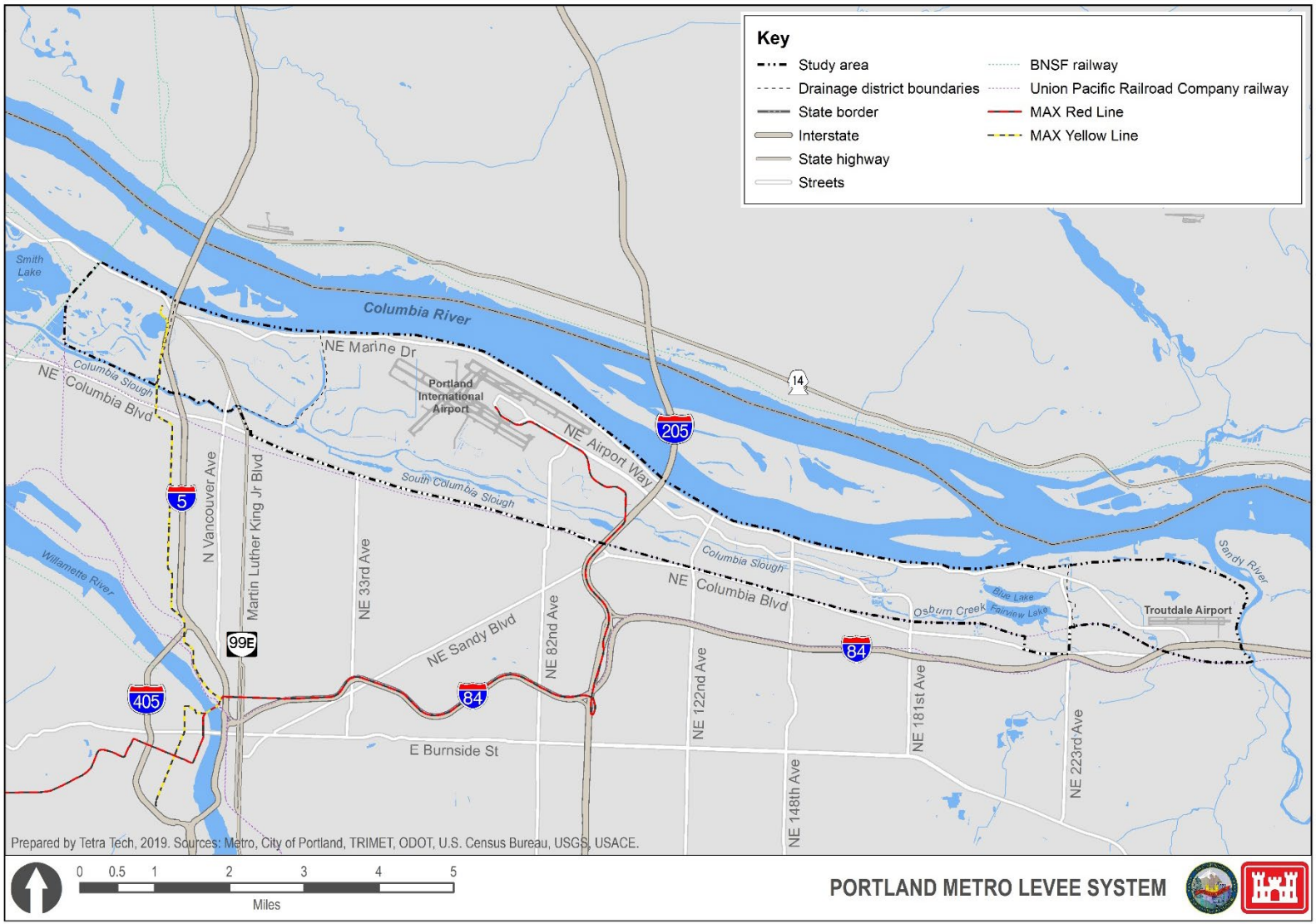

Figure 4-18 Transportation Features in the Study Area

Table 4-20 Range of AADT at Selected Locations in the Study Area

Location	AADT Range
Marine Drive east of NE 13th Avenue	10,000-15,000
Marine Drive east of NE 185th Drive	10,000-15,000
Highway 99E between NE Gertz Road and North Vancouver Avenue	10,000-15,000
NE Columbia Boulevard between NE 17th and NE 21st Avenues	15,000-20,000
NE 33rd Drive at the Columbia Slough bridge	5,000-10,000
NE Airport Way between Portland International Airport and NE 122nd Avenue	20,000-30,000
NE Airport Way east of NE 122nd Avenue	15,000-20,000
NE Sandy Boulevard from I-205 to east project boundary	10,000-15,000

Notes: AADT = Average Annual Daily Traffic

Bicycling throughout the study area is available along dedicated multi-use paved paths and on shared roadways (PBOT 2019). Dedicated bike paths run adjacent to I-5, I-205, I-84, NE Marine Drive, portions of Airport Way, and Alderwood Road. Painted bike lanes are present on NE Martin Luther King Jr. Boulevard, Marine Drive, NE 33rd Drive, Alderwood, Cascades, Mt. St. Helens, Airport Way, and Sandy Boulevard.

Public Transit

Public transportation services in the study area include TriMet buses and MAX Light Rail (TriMet 2019). Seven bus routes pass through the study area:

- Route 6—Martin Luther King Jr. Boulevard
- Route 21—Sandy Boulevard/223rd
- Route 70—12th/NE 33rd Avenue
- Route 74—162nd Avenue
- Route 75—Cesar Chavez/Lombard
- Route 87—Airport Way/181st
- Route 272—Portland International Airport night bus.

The MAX Light Rail Red and Yellow Lines pass through the study area. The Red Line connects Portland International Airport with Portland City Center and Beaverton, passing through the study area along I-205, NE Cascades Parkway, and Airport Way. The Yellow Line enters the study area along North Interstate Avenue as it crosses North Columbia Boulevard, running just west of I-5 and ending at the Portland Expo Center stop between North Expo Road and Marine Drive. The Delta Park/Vanport Max Station is at North Interstate Avenue and North Victory Boulevard.

4.18.1.2. Air Traffic

Portland International Airport

The Portland International Airport is a joint civilian and military airport and the largest in Oregon, covering 3,000 acres of land. It is owned and operated by the Port of Portland and provided flights to nearly 20 million passengers in 2018 (Port of Portland 2019b). The airport is encompassed by the study area and is entirely within Portland's city limits, approximately 12 miles from downtown Portland. It serves 90 percent of passenger air travel and more than 95 percent of air cargo for the state (Loy 2001). Of the 205,038 commercial flights flown in 2018, 96 percent were domestic, and 4 percent were international (Port of Portland 2019b). The passenger terminal is accessed from the east by NE Airport Way. Roads feeding into NE Airport Way include I-205 and NE 82nd Avenue.

Troutdale Airport

The Troutdale Airport is owned and operated by the Port of Portland and is located in east Multnomah County, approximately 8 miles east of Portland International Airport. It is a popular airport for fixed-wing flight training, scenic tours, and recreational flying (Port of Portland 2019b). The airport has a single runway of 5,400 feet, an FAA-contract air traffic control tower and 15 businesses operating on site. Access to Troutdale Airport is from NW Frontage Road, via NE Marine Drive.

Air National Guard

The 142nd Fighter Wing of the Oregon Air National Guard, part of the U.S. Air Force, is based on the south side of Portland International Airport and north of NE Cornfoot Road. This fighter wing operates the F-15 Eagle and provides continuous air defense and air sovereignty capabilities in support of homeland defense (OANG 2017). The unit is allocated 3,500 annual flight hours that result in 2,335 annual sorties by 30 assigned pilots.

4.18.1.3. Rail Traffic

The Portland/Vancouver area is a critical link in the rail transportation network for the region. The BNSF and Union Pacific Railroad companies, both Class I Railroads, as well as Amtrak Trains, all pass through the study area. On an average day, 39 trains cross the North Portland and Peninsula Junction railroad stops that are located along I-5 at the west end of the study area, including both freight and passenger trains (ODOT 2015).

The Union Pacific Railroad passes through or adjacent to the study area with stops at Troutdale, Fir, Kenton, Peninsula Junction, and North Portland Junction. It runs along the project boundary at North Portland Road and the west edge of Heron Lakes Golf Course and PEN 1. It then passes outside the study area as it runs several blocks to the south of NE Columbia Boulevard. It passes back into the study area in SDIC and generally forms the southern border of the study area from there to the east end.

Other freight and passenger trains use the railroad trestle downstream of the I-5 bridge along the western boundary of the study area, including BNSF and Amtrak. BNSF operates freight trains that pass through the North Portland and Peninsula Junctions, moving north to south through the study area. BNSF does not operate a rail line that passes east to west through the study area.

Amtrak passenger trains stop at Union Station and travel along rail lines passing through the study area (Amtrak 2019). The *Coast Starlight* carries passengers from Los Angeles to Seattle; the *Cascades* runs from Vancouver, BC to Eugene, and the *Empire Builder* travel from Portland to Chicago via Vancouver, WA (Amtrak 2019). Ridership of all passengers through Portland was estimated at 565,940 passengers for the 2018 FY (Amtrak 2018).

4.18.2. Environmental Consequences

Impacts associated with transportation would occur if an alternative resulted in any of the following:

- Conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system
- Inadequate or obstructed emergency access.

4.18.2.1. Alternative 1 (No Action)

The transportation network in the study area is expected to expand to accommodate a growing population under the guidance of relevant transportation plans, including the Portland 2035 Transportation System Plan (City of Portland Bureau of Transportation 2018). In particular, highways and public transportation will continue to need expansion and upgrades. The I-5 bridge over the Columbia River, which is the main connecting bridge between Oregon and Washington, is over-capacity and there is broad consensus that it needs to be replaced, possibly with the inclusion of a light rail line connecting Vancouver to Portland. Although the project was previously studied and never completed, a project office was included in Washington's 2019-2021 Governor's Budget for the purpose of replacing the I-5 bridge. Under the No Action alternative, the transportation network within the study area would be significantly compromised if a flood even occurred causing inundation within the system. Impacts to transportation is described in more detail in the economics appendix (Appendix B).

4.18.2.2. Alternative 3

Construction of the levee modification measures, parallel levee, and floodwall would require temporary alterations to traffic flow and circulation. Impacts would include traffic delays due to temporary lane closures, truck ingress and egress, detours, and use of metered traffic lights. Long term benefits to transportation are expected to occur as a result of decreasing the chances of flood risk in the system.

Impacts to traffic would also occur as a result of increased truck traffic to deliver construction materials and equipment, and to remove materials for disposal. Under this alternative, up to

330,000 cy of materials would need to be imported to, or exported from, the project area, requiring at least 23,600 truck trips over the 24-month construction period. Assuming these truck trips would be spread evenly across the construction period, an average of 47 truck trips would be required on a daily basis. Although the source of dredged or fill material has not been identified, it is assumed that trucks would use Marine Drive, Airport Way, Columbia Boulevard, and other surface streets to access the construction sites. Trucks entering or exiting these roadways would slow traffic and potentially cause traffic hazards. Considering traffic volumes on the primary access roads shown in Table 4.20, if all trucks took the same access road, this number of trucks would increase traffic on that road by less than one percent on an average day, which is unlikely to result in substantial changes to traffic flow. Additionally, it is likely that trucks will use various access roads on any given day, which would reduce the intensity of this effect. Traffic may be impeded at particular intersections or on particular stretches of the primary arterials where work is occurring, meaning that impacts will be temporary and localized.

In order to ensure regular operation of roads, railroads, and public transit, and to minimize interruptions in services, a construction traffic management plan would be developed and approved by the appropriate local or state agency. This plan would identify construction phasing, daily schedules, access routes, alternate routes, lane closures, detour routes, and a coordinated public health and safety plan. Any changes to the typical traffic patterns would be posted prior to construction. Lane closures and detour routes would be minimized as much as possible, and would be clearly managed with flaggers. Upon implementation of the traffic management plan, impacts to traffic are expected to be less than significant.

Local construction or non-structural measures are not large enough to require road closures and if heavy machinery is needed, it can be placed off-road and flagged. There would be no adverse effects from construction or operation of these measures. Instead, the placement of evacuation signage, increased availability of educational materials, and automation of public emergency notification systems, which will be designed to streamline traffic during an emergency, will provide beneficial impacts to residents and businesses. Additionally, reduced flood risk will result in fewer traffic interruptions due to flooding.

4.18.2.3. Alternative 4

Under this alternative, up to 470,000 cy of materials would need to be imported to the project area, requiring at least 33,600 truck trips over the 36-month construction period. Assuming these truck trips would be spread evenly across the construction period, an average of 47 truck trips would be required on a daily basis, similar to Alternative 3. Considering traffic volumes on the primary access roads shown in Table 4-20, if all trucks took the same access road, this number of trucks would increase traffic on that road by less than one percent on an average day, which is unlikely to result in substantial changes to traffic flow. Additionally, it is likely that trucks will use various access roads on any given day, which would reduce the intensity of this effect. With implementation of a traffic management plan as described under Alternative 3, this impact would be less than significant.

Under this alternative, traffic would be affected at Marine Drive and Airport Way due to the need to raise the roadways. This potential impact would be addressed in the traffic management plan, and although traffic may slow or be diverted at these locations during the construction period, impacts would be reduced by measures included in the traffic management plan. This impact would be less than significant.

Operation of the completed project would not require any changes in traffic flow patterns. No roads would be permanently closed or re-routed. There would be no adverse effects to traffic as a result of project operation. There would be long-term benefits as a result of reducing flood risk and the expected damages that would occur to the transportations system resulting from flooding.

4.18.2.4. Alternative 5

Under this alternative, up to 724,000 cy of materials would need to be imported to the project area, requiring at least 50,700 truck trips over the 42-month construction period. Assuming these truck trips would be spread evenly across the construction period, an average of 81 truck trips would be required on a daily basis. If all trucks took the same access road on a given day, the increase to traffic on that road would be less than 1.6 percent. Additionally, it is likely that trucks will use various access roads on any given day, which would reduce the intensity of this effect. With implementation of a traffic management plan as described under Alternative 3, this impact would be less than significant. As with the other action alternatives, a traffic management plan would ensure that effects to traffic were less than significant. All other avoidance and minimization and impacts under this alternative are expected to be the same as for Alternative 4, and would be less than significant.

The presence of the floodwall in PEN1 and PEN2 would reduce access to parking along N. Bridgeton Drive. Vehicles would need to park parallel to each other, and up to 74 of the 220 available parking spaces would be lost. Loss of parking spaces along N. Bridgeton Drive would result in increased use of parking along streets in the residential area south of N. Bridgeton Dr. and may increase the amount of time needed for residents of the area who rely on on-street parking to find a space at peak times. There would be long-term benefits as a result of reducing flood risk and the expected damages that would occur to the transportations system resulting from flooding.

4.19. Cumulative Impacts

Cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

This section provides a review of actions that have taken place in the past, actions that are currently underway, and projects that are scheduled to be undertaken in the reasonably

foreseeable future. The geographic scope of the cumulative impacts analysis includes the study area and areas within the immediate vicinity where effects may combine to magnify the level of impact. In general, projects found to be applicable to this section include those that have a footprint within the PMLS or that influence environmental conditions within the PMLS. However, for some resource areas it is appropriate to expand the description of cumulative impacts to a larger region. For example, air quality has been affected by regional impacts over the last hundred years, while water resources are affected by changes to hydrology of the Columbia River that have occurred many miles upstream.

4.19.1. Past Actions

Cumulative effects are dependent on the timeframe in which they occur. For the built environment, the timeframe of most relevance is the period since the levees were constructed in 1917. For natural resources, broad changes within the study area began with European migration in the 1800s. Past actions are shown in Table 4-21.

Table 4-21 Past Actions

Time Period	Type of Action	Contribution to Cumulative Impacts
1846	**Ferry service initiated from Vancouver to Portland**	Spurred development of roadways, bridges, and railroad lines in the study area
1840-Present	**Settlement for agriculture and industry**	Initiated conversion of natural habitats to agricultural and industrial land cover types, which continues in the study area to the present day
1890s	**Construction of trolley lines in Portland**	Encouraged urbanization and development of neighborhoods in north Portland
1910-present	**Railroad construction including a rail bridge over the Columbia River at what is now the western edge of PEN 1**	Allowed increased freight transport to Port of Portland and encouraged development of import and export industries and services
1917	**Columbia River Interstate Bridge opened**	Allowed easier transportation between northern OR and southern WA, as well as through the broader Pacific Northwest.
1917	**MCDD formed**	To meet the need for increasing flood protection, the MCDD was formed and began to build levees in the study area (City of Portland 2005).
1930s-1970s	**Dam construction**	Numerous dams were built on Columbia River to provide navigation and energy to a growing population. Combined with overfishing, the dams significantly reduced salmon populations that pass through or utilize the study area during part of their life history

Time Period	Type of Action	Contribution to Cumulative Impacts
1940s	**World War II**	Mobilized resources for ship building in the lower Willamette and Columbia Rivers, bringing wartime employment and creating a housing shortage
1948	**Vanport Flood**	Displaced 20,000 public housing residents in what is now PEN 1 and PEN 2

Early European-American settlement in the study area began in the 1800s, as fur trappers and other pioneers established outposts along the Columbia River. A ferry service was initiated between Vancouver and Portland in 1846 (The Columbian 2008). From the ferry terminal, located in what is now PEN1, railroads were constructed, a network of roadways was built, and bridges were extended across the river. Each of these actions altered the landscape and encouraged a greater influx of settlers to the area.

Dams changed the hydrology of the Columbia River, altering the timing of flows and reducing flooding, which affected the connectivity of the river to the floodplains within the study area. Flood control measures allowed the growing metropolitan-area population to develop the shoreline of the study area, further exacerbating changes to the riparian and floodplain environments.

Increasing commerce led to the development of shipping ports and airports in the study area. Trains, light rail and vehicles along the I-5 and I-205 bridges transport freight and passengers on the ground. Residential development increased along with these changes. A recent study that encompasses the study area found that natural forests, open water, tidal, and wetland communities in the area diminished by 67 percent on average between 1870 and 2011 (LRC 2017). In contrast, agricultural land and development increased by 891 percent and 12,492 percent, respectively, over the same period (LRC 2017).

The levee system and tide gates divide the Columbia Slough into the Lower, Middle, and Upper Slough. Historically, the Columbia Slough received waters from the Columbia River and lakes in the area, then flowed westward and joined the Willamette River. The Middle and Upper Sloughs are now managed with numerous piped surface waters, dikes, levees, and a system of pumps developed by CCDD. The original inlet to the Upper Slough from the Columbia River is blocked and receives water only from the Fairview Creek and Lake system (LCA 2017).

With the addition of levees, culverts, and dikes, the slough now acts more as an estuarine channel, with tidally influenced waters moving into the Lower Slough, while the Middle and Upper Slough are often ponded slack or slow-moving waters. Today, the Columbia Slough Watershed is more than 50 percent built-out and is highly fragmented by development (NMFS 2005). Industrial and agricultural uses of the area have resulted in water and sediment quality issues, with several 303(d) water quality impairments listed for the Columbia Slough. In 2011, the City of Portland completed the Combined Sewer Overflow Control project, providing a 99 percent reduction in combined sewer overflows to the Columbia Slough. This project

reconfigured downspouts, sumps, stream diversions, and sewers to remove millions of gallons of stormwater from combined sewers.

4.19.2. Present and Future Actions

The study area encompasses a large area of industrialized, retail, and residential land uses. For this reason, there are numerous projects that have been undertaken in the area. The sections below describe projects that have recently been completed or are currently underway. The projects listed below have a footprint within the PMLS, or would require staging, traffic pattern changes, or other physical use of the PMLS that would affect the people who live and work in the PMLS. Present actions are presented in Table 4-22.

A search of local municipality, state, and Federal websites identified projects proposed to be constructed in the foreseeable future, as described in Table 4-23.

Table 4-22 Present Actions

Time Period	Type of Action	Contribution to Cumulative Impacts
Ongoing – Late 2019	**Repaving of I-205**	Nighttime closures of the Airport Way southbound on-ramp and northbound off-ramp. Construction is to be completed in late 2019. Also at I-205, construction is underway at the North Victory Boulevard and Marine Drive junctions, including repaving highway and entrance ramps. Impacts include increased traffic backups and slower commute times (ODOT 2019b).
2005 – Ongoing	**Habitat restoration**	City of Portland and watershed groups have implemented projects such as the Lower Columbia Slough Refugia Engineered Log Jams, Ramsey Refugia Restoration, and Columbia Slough Confluence Project to increase fish habitat value and promote improved water quality in Columbia Slough.

Table 4-23 Reasonably Foreseeable Future Actions

Time Period	Type of Action	Contribution to Cumulative Impacts
2025 Completion	**PDXNext**	Five major construction projects are anticipated to be completed at PDX, requiring a $2 billion investment and having a target completion date of 2025. Projects include energy-efficiency upgrades, construction of a south airfield regulator building, runway LED upgrade, and expansion of parking lots.
2019-2022	**Portland Meadows Redevelopment**	A permit was filed in March 2019 to begin the initial phase of redeveloping Portland Meadows and possibly dividing the land into one building per lot.
2020	**I-5 Trunnion Replacement**	A cracked trunnion is to be replaced on the northbound I-5 bridge in 2020. The project is anticipated to cost between $5 million and $10 million and will require a complete northbound bridge closure for two weeks (State of Oregon 2019).

4.19.3. Cumulative Impacts Analysis

Cumulative impacts resulting from the construction of the TSP include the beneficial and adverse effects of the project combined with past, present, and reasonably foreseeable future projects. Cumulative impacts resulting from the TSP have been summarized below by resource area. Overall, the TSP is intended to reduce flood risk to a population of over 48,000 people who live and work in the area protected by the PMLS.

Water Resources and Climate Change

The identified past, present, and future reasonably foreseeable actions, when combined with the effects of the TSP, could temporarily increase turbidity in the Columbia River and Columbia Slough. The TSP would result in up to 0.5 acre of new impervious surfaces, which, in combination with new development projects, would result in permanent increases in runoff into the watershed. All such actions are required to comply with local, state, and Federal water quality regulations for surface water quality and stormwater control, which limit impacts to such waters during construction and operations. Compliance with these regulations would limit adverse cumulative impacts, and no significant impacts on water quality are expected from the combined effects of the TSP and the past, present, and future actions.

In combination with likely changes to patterns in which water is released from dams on the Columbia River, the TSP would provide a beneficial cumulative impact to flood risk management and planning for climate change. The TSP is designed to account for anticipated changes to hydrologic patterns resulting from climate change, which, in combination with similar planning for releases from upstream dams, will allow water management agencies to better plan for flood risk management.

Physical Resources

The TSP would result in minor changes to topography where levees would be raised or widened. The potential for erosion of disturbed soils will increase during construction of the TSP and any other present and reasonably foreseeable future action, but by stabilizing soils at the end of construction of these projects, cumulative impacts to physical resources would be less than significant.

Air Quality and Greenhouse Gases

The identified past, present and future reasonably foreseeable actions, when combined with the effects of the TSP, could incrementally increase emissions within the air basin in which the project area is found. These impacts would be limited to the construction period, and there would be no new stationary sources of emissions resulting from the TSP. The air basin in which the proposed action and past, present, and foreseeable actions have or would occur is in attainment and the cumulative impacts of these projects would be limited by their respective compliance with all EPA and state air quality standards. No significant cumulative direct or indirect air

quality impacts would result from the combination of anticipated effects of the proposed action and past, present, and reasonably foreseeable future actions.

Noise

Numerous Federal, state and local laws and ordinances are designed to reduce impacts of noise in the project area. The proposed use of heavy machinery for construction will be regulated by these laws. Although construction will contribute to an overall cumulative increase in noise throughout the project area during the construction period, the increase will be temporary and consistent with Corps' standards for managing noise. Any future project in the area would also need to assess and minimize construction noise levels that could impact nearby residents. Although construction noise is anticipated to be relatively high in the neighborhoods along Marine Drive in PEN 1 and PEN 2 during construction of the proposed action, most of the past, present and reasonably foreseeable future actions are not located in this vicinity or have different construction schedules that would ensure that they don't overlap. Therefore, cumulative noise impacts from the TSP, in combination with past, present and reasonably foreseeable actions, would be less than significant.

Utilities

Minor increases in vertical impervious surfaces due to construction of a floodwall along Marine Drive and larger pads at specific pump stations would increase stormwater inputs to various storm drains. However, storm drains in the area have ample capacity due to completion of the Big Pipe project, and this increase will constitute a less than significant contribution to cumulative impacts.

The TSP will result in offsite disposal of up to 8,000 cy of excavated soils and building materials including asphalt and concrete. In combination with past, present, and reasonably foreseeable future actions, and depending on the amount of materials to be disposed of, these materials may slightly reduce the capacity of the specific landfills that accept this material. This impact is expected to be cumulatively less than significant, since there are numerous landfills with high capacity within 200 miles of the project area.

Biological Resources

The geographic area for biological resources includes the area in which construction would result in water quality and noise impacts or permanent loss of habitat. This area generally includes Columbia Slough and its associated riparian zones, the southern half of the Columbia River along the study area, and the levee-protected area. This geographic area has been highly altered by settlement and conversion to agricultural and industrial uses. The TSP, in combination with reasonably foreseeable future actions, will further reduce the habitat available to wildlife in the geographic area. However, most areas that will be modified are already extensively developed and managed and provide minimal habitat value. Where levees are to be widened or raised, floodwalls installed, or systems to be modified, the existing habitat is generally of poor or no value. The exceptions include where widening the railroad embankment and levees in MCDD will result in permanent removal of trees and wetlands. The total loss is less than one acre of

wetlands, and the Corps will replace the functions and values of lost jurisdictional wetlands in compliance with CWA requirements. Although these losses will contribute to a temporary cumulative effect in combination with ongoing trends of increasing development and habitat conversion, long term cumulative impacts will be less than significant since all projects would proceed only after development of environmental protection measures that have met with agency approval. By complying with these plans and regulatory requirements, cumulative impacts to biological resources would be less than significant.

Cultural Resources

Implementation of a cultural resources protection plan will ensure that all known cultural resources will be avoided to the extent possible, but at least one resource eligible for inclusion on the NRHP would be affected by the TSP. In compliance with Federal regulations for protection of cultural and archaeological resources, excavation in areas where cultural resources may occur would not proceed until an incidental discovery plan had been developed and approved by the SHPO. All known cultural resources will be evaluated and protected during construction, therefore there will be no significant cumulative impacts to cultural resources.

HTRW

The PMLS protected area has been the ongoing site of transport, use, and disposal of hazardous wastes since it was first settled. As a requirement of the TSP, all sites of concern that will intersect with project construction are to be remediated prior to the start of project construction, and it is the local sponsor's responsibility to ensure that lands necessary for the project are free from contaminants over state and Federal limits. Combined with similar actions at other present and reasonably foreseeable actions, there will be a beneficial cumulative effect to the amount and distribution of hazardous materials in the area because the risk for hazardous materials to be introduced to the system from a significant flood event will be reduced.

Land Use

Cumulative impacts to land use occur when a combination of actions result in permanent alterations of established land uses or divisions of existing communities. Although minor changes to land uses at golf courses in the project area would occur, these actions would not change the fundamental and long-established uses of these lands. Although the redevelopment of Portland Meadows is likely to affect similar land uses in the project area, redevelopment of this facility is not dependent upon completion of the project, and the cumulative impact would be less than significant.

Socioeconomics and Environmental Justice

The TSP and other present and reasonably foreseeable actions are intended to enhance the economic vitality of the study area. This includes provision of National Economic Development benefits, lower risks to safety, and increased flood risk protection of the study area. The TSP, in combination with present and reasonably foreseeable future actions, will contribute to a beneficial cumulative impact to socioeconomic resources. Temporary adverse cumulative

impacts to air quality, noise, water quality, and biological resources resulting from the TSP and present and reasonably foreseeable future actions would be minimal, and would not affect low income or minority populations disproportionately.

Aesthetics and Visual Resources

Due to the already highly altered visual condition of the PMLS protected area, the alterations to the area will not result in a significant cumulative change in visual character. Greenways and open spaces will not be permanently affected. Areas with levee widening will result in an expansion of elevated land, but will not change in general visual character. There will be no cumulative effects.

Recreation

Temporary loss of access to recreational access may occur during construction. A permanent loss of part of several fairways at project area golf courses will occur, but this impact is less than significant since it would affect only a small part of the available area and the courses would be redesigned to minimize these effects. Other present and reasonably foreseeable future projects are not projected to reduce recreational opportunities, and this cumulative impact would be less than significant.

Public Services, Health and Safety

Temporary changes in emergency access will occur during construction of the project, and cumulative impacts to emergency access may occur if multiple actions occur at once. However, coordination between the project and local public services will minimize interruption in health and safety services. There will be an overall cumulative improvement in public health and safety once the PMLS has been modified to improve flood risk management.

Transportation

During construction, traffic on Marine Drive and Airport Way may be delayed to allow for construction of the floodwall and to raise the levee and overpasses in several locations. This impact, in combination with other present and reasonably foreseeable future actions, is likely to be less than significant due to implementation of a traffic management plan that will account for all projects that could affect traffic in the construction areas. Following completion of construction, there will be no changes in traffic flow or circulation. There would be long-term benefits as a result of reducing flood risk and the expected damages that would occur to the transportations system resulting from flooding.

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5. Tentatively Selected Plan

The Tentatively Selected Plan is Alternative 5, it reasonably maximizes net economic benefits consistent with protecting the environment and best meets the objectives for the project. Alternative 5 is described below.

5.1. Plan Components

This alternative seeks to address inconsistencies within the levee system to provide more uniform flood risk throughout the study area. This alternative focuses on both the internal and external sources of flooding. It includes a levee raise and other improvements to the levees in PEN 1 and PEN 2 to address both fragility and overtopping risks. A new floodwall would be added along the Columbia River segments of the PEN 1 and PEN 2 levees, including under the I-5 bridge. The alternative includes a new levee parallel to the existing railroad embankment on the west edge of PEN 1. The alternative increases levee heights at locations with low spots in MCDD and SDIC. Pump station measures are included to ensure more consistent performance between the interior drainage systems. Improvements include capacity increases at three pump stations, better debris control at three locations, and elevating/replacing the Sandy pump station. Measures in this alternative include both structural and non-structural measures described in Table 5-1 and displayed in figures within Chapter 3. More detailed figures were included in Chapter 3, Appendix D (Civil Design).

Since increasing levee heights (Measure 7) within PEN 1 and PEN 2 are included in this alternative three measures (5, 7, and 30) are essentially combined. The alternative proposes a floodwall along the entire Columbia River mainstem therefore measure 30 and 7 are combined within that reach. On the other segments of levee, they will both be raised (Measure 7) and improvements to performance and reliability addressed (Measure 5).

Table 5-1 Alternative 5 Measures and Description

No.	Measures	Description
5	**Improve Levee Performance and Reliability**	Widen the PEN 1 Columbia Slough levee and add seepage controls (toe drains). In MCDD West, seepage controls (toe drains) at the Peninsula Slough cross levee are included. In SDIC, widening of the cross levee to Sundial Avenue is included.
6	**Flood Warning in Residential/ PAR areas**	Revise and update flood hazard and evacuation plans for Portland, Port of Portland, and Multnomah County NHMP to include flood risk information resulting from this feasibility study. Develop expanded communication and evacuation plans.
7	**Increase Levee Heights**	Increase levee heights up to three feet for PEN 1 and PEN 2 levees along Columbia mainstem and Columbia Slough. In MCDD West, includes filling in isolated low spots in the Peninsula Slough cross levee and Station 511+00 of the Columbia River levee (near Broughton Beach Park). Includes raising low spots near the Troutdale outlet mall and the Columbia River segment of SDIC.
10	**Add Pump Capacity**	Add capacity at pump stations where the need has been identified. (PEN 2 13th Avenue Intake, MCDD Pump Station 2 pumps and discharge lines).
14	**Improve Flood Fight**	Develop 4-season maintenance road on Peninsula Canal cross levee between MCDD and PEN 2, railroad parallel levee.
20	**Add Redundancy to Pump Stations**	Includes elevation and replacement of SDIC Sandy Pump Station, and installation of redundant power sources within the system of pump stations.
22	**Debris Removal (trash in water and trees/limbs)**	Trash Rakes replaced at MCDD-AirTrans, MCDD Pump Station 4, and MCDD Broadmoor.
30	**Build Additional Levees/ Floodwalls**	Construct a parallel levee at the PEN 1 railroad embankment. Install floodwalls along Marine Drive in PEN 1 and PEN 2.
36	**Education**	Develop flood risk education materials for the population at risk and visitors within the study area. Materials will be based up on flood risk information developed related to the levees and coordinated with USGS to incorporate seismic aspects, as well as emergency responders and educators to meet a broad audience.
37	**Signage for Evacuation**	Install flood hazard and evacuation route signage throughout the study area including designated evacuation routes.
41	**Safe Zones**	Develop designated safe zones at high points within the PMLS for those that cannot evacuate from the flood-plain. Would be implemented in conjunction with Measure 6.

5.1.1. Real Estate Requirements

The Portland Metro Levee Project footprint will impact approximately 108 acres (135 parcels; 48 owners) both owned by private and public entities. Significant areas of concern include:

- 15 Single Family Resident Parcels located north of Marine Drive in Pen 2 are constructed on the original levee centerline. If the Pen 2 levee is raised in its current alignment, this may require a full taking. If the alignment is modified, easements will be required.
- There are three Railroads that could be affected on the west end of Pen 1: Union Pacific Railroad (UPRR), Burlington-Northern Santa Fe (BNSF), and the Peninsula Terminal Company. Adding material to the existing seepage berm would require cooperation from all three railroads. If a parallel levee is constructed to the existing railroad embankment, BNSF and UPRR would be outside the levee system, but an agreement would be required with the Peninsula Terminal Company to cross their embankment. Some form of railroad access will be required to support the project.
- Proposed improvements near the railroad embankment will encroach onto the Heron Lakes Golf Course. This will require reconfiguration of some holes of the golf course. Potential public utility/facility relocations and Business relocation assistance (P.L. 91-646).

The Corps is required to acquire the minimum interest in the real property necessary to support the project. The Non-Federal Sponsor has condemnation authority if required. There is anticipation that non-standard estates may be required. If required, public utilities/facilities will be relocated and Business relocation assistance (P.L. 91-646) will be available.

Real estate estimated costs were derived using a rough order of magnitude, utilizing property values from the county assessor. An encumbrance factor was applied for the easements required. Single Family residences that may require a full taking were assigned full market value. The dollar figures reported are for planning purposes only and not to be mistaken as an appraisal on the parcels. Fair Market Valuations for each individual parcel will need to be formally appraised during feasibility design.

5.2. Cost Estimate and Economic Costs and Benefits

The cost estimate for the TSP (Alternative 5) is shown in Table 5-2 below. This cost estimate was prepared using MCACES, and is of a higher level of detail than the parametric cost estimates used to compare alternatives. This table includes construction costs, Preconstruction Engineering and Design (PED), Construction Management (CM) which includes Engineering During Construction (EDC) and Supervision and Administration (S&A) during construction, and LERRDs. A risk-based contingency has been applied to each of these cost categories and is summed in Table 5-2. Based upon the MCACES estimate, total Estimated Cost is $123,407,000 (FY 2020 price level). Escalated to the expected Program Year of 2021, Project First Cost is $130,710,000 (FY 2021 price level). The Project First Cost serves as the basis for providing the cost of the project for which authorization is sought.

Table 5-2 MCACES Total Project Cost Summary Table (FY 2021 Price Levels)

Item	Cost
Construction Costs	$62,083
Preconstruction Engineering/Design (PED)	$7,567
Construction Management (EDC, S&A)	$6,306
Contingency	$34,653
Real Estate (LERRDs)	$20,100
Total Project First Cost	**$130,710**

Table 5-3 provides the benefit-cost analysis for the TSP. Since the economic benefits are in FY2020 price levels, the FY 2020 estimated project cost is used to calculate net benefits and the benefit-cost ratio. Economic costs include the calculation of interest during construction and are presented at FY2020 price level, annualized over the 50-year period of analysis using the FY20 Federal discount rate of 2.75 percent.

Table 5-3 Equivalent Annual Benefits and Costs (FY 2020 Price Level, 50-year Period of Analysis, 2.75% Discount Rate)

Estimated Project Cost	**$123,407**
Interest During Construction [1]	$5,902
Total Investment Cost	**$129,309**
Annualized Investment Cost [2]	$4,790
Annual O&M[3]	$34
Total Annualized Investment Cost	**$4,824**
Annual Benefits	$13,777
Annual Net Benefits	**$8,953**
Benefit-Cost Ratio	**2.86**

Notes: Cost figures shown at FY2020 Price Level. All figures are in $1,000s.
1) Interest During Construction assumes equal annual outlays for construction period 42 months.
2) Total Investment Cost is annualized using the FY2020 Federal Discount Rate of 2.75% and 50-year period of analysis.
3) O&M costs account for the difference between with-project and without-project routine work that is expected to occur each year over the life cycle of the project.

Using the Federal Standard Discount Rate of 7% that is commonly used for budgetary prioritization purposes, interest during construction and annualized investment cost are recalculated at $15.4 million and $10.1 million respectively, resulting in a benefit-cost ratio of 1.36.

5.3. Cost Sharing

Cost sharing for construction would be consistent with the requirements of Section 103 of WRDA 1986, as amended. Table 5-4 shows the cost apportionment for the Federal and non-Federal shares of total project cost. The sponsor is responsible for providing all lands, easements, rights of way, and disposal sites and performing all relocations (together referred to as lands, easements, rights of way, relocations, and disposal sites, or LERRD) required for the project. Items included in the LERRD total include the land to construct the project and the relocation of

facilities/utilities. Costs for any Hazardous, Toxic, and Radioactive Waste (HTRW) response/remediation is a non-Federal sponsor responsibility and is not a project cost. Table 5-4 shows the estimate two different ways: the project first cost and the total project cost (fully funded cost). The project first cost is used for congressional authorization, and is escalated to the expected fiscal year the final feasibility study is submitted (FY2021). The fully funded total project cost is escalated to the estimated midpoint of construction (FY2024). Total project cost is the cost estimate used in project partnership agreements. The total project cost provides the non-federal sponsor an estimate for use in financial planning, as it provides information regarding the overall non-federal cost sharing obligation.

Table 5-4 Project Apportionment of the NED Plan (Cost in $1000s and FY2021 Price Level)

	Non-Federal Sponsor Contribution (Project First Cost)	Federal Contribution (Project First Cost)	Non-Federal Sponsor Contribution (Fully Funded Cost)	Federal Contribution (Fully Funded Cost)
Total Project Cost	**$130,710**		**$142,000**	
LERRD	$22,165		$22,976	
Lands and Damages	$20,100		$20,703	
Relocations	$2,065		$2,273	
Cash				
Minimum 5%	$6,536		$7,100	
Additional Cash Required	$17,048		$19,624	
Total	**$45,749**	**$84,962**	**$49,700**	**$92,300**
Cost Share	35%	65%	35%	65%

5.4. Design and Implementation

The current design is based on preliminary planning-level designs and common engineering practices in enough level of detail to evaluate and compare alternatives similarly. The features include necessary components to implement the primary features of each alternative. See Appendix D (Civil Design) for detailed discussion of designed features.

At the current level of design, it is assumed that construction would be awarded under one contract. A tentative project schedule has been developed which assumes Feasibility ends and PED beginning in October 2020, followed by Construction beginning in Spring 2022 and concluding in Fall 2025. The sponsor is responsible for O&M of the system after construction. O&M activities will remain similar to current practices, but the addition of project features such as toe drains and floodwalls will require additional O&M.

5.5. Minimization Measures for Adverse Environmental Effects

Although no significant impacts were identified during the environmental review process, the Corps has developed measures to offset environmental impacts resulting from the proposed action wherever possible. Measures to minimize the extent and intensity of impacts to natural, socioeconomic, and cultural resources are identified in Table 4-1.

5.6. Residual, Transformed, and Transferred Risks

If implemented, the TSP would improve levee performance and resilience, but flood risk would still remain after construction. Although floodplain users and occupants may desire total protection from flooding, this is an unachievable goal. Residual risks of flooding will remain after completion of any flood risk management project. It is important to emphasize and communicate the level of flood risk that remains after project implementation such that floodplain occupants are aware of the nature of the flood threats and are able to make informed decisions about acceptable levels of risk.

Transformed risk is a risk that emerges or increases as a result of mitigating another risk. In this system, all alternatives would have minimal effect on transformed risk. None of the alternatives would substantially transform the type of flooding likely to occur in the study area because the study area is already within the protected area of an existing levee system.

Transferred risk relocates risk from one area to another. Within the study area, the alternatives have negligible effect on transferred risk, as no alternative would increase the risk of flooding at any location within the study area. Effects on areas outside the study area are negligible for Alternatives 3 and 4, which would result in no increased height at the Vancouver Gage for the 500-year event and 0.01 feet for the 1000-year event, based upon modeling induced flooding along the Columbia River (see Appendix A (Hydrology and Hydraulics)). For Alternative 5, the project would also result in no increase for the 500-year event, but would result in 0.08 feet of increased stage at Vancouver Gage for the 1000-year event. While a minor increase, modeling estimates this is associated with an increase in inundated are of 660 acres between River Mile 23 and 145 for the 1000-year event. This total area is composed of many small areas along the river, and the effects are minor. Alternative 5 would have no effect on FEMA levee certification of nearby levee systems, since the 1% and 0.2% AEP events are unaffected.

Per EM-1110-2-1619, Section 3-5, Paragraph b, “The economic consequences of capacity exceedance are quantified in terms of residual event and expected annual damage. Residual expected annual damage is computed with the results of economic benefit computations; it is the with-project condition EAD.” Appendix A (Hydrology & Hydraulics) provides estimates of the with-project assurance metric, which provides the probability the levee system will perform for an event of a given magnitude. For example, after construction of the TSP, there is still an 18 percent chance that PEN 1 or PEN 2 levees would not contain a 0.2 percent annual exceedance probability (500-year) flood event. If this event were to occur, and the levee were to fail, this would result in approximately $147M and $585M in damages to the PEN 1 and PEN 2 areas,

respectively. These are specific event damage figures as opposed to expected annual damages that are probabilistically weighted (annualized) across many events for purposes of calculating the benefit-cost ratio. The table below provides estimated damages for the 0.2 percent event that show residual risks remain under the TSP Alternative 5.

Table 5-5 Residual Risk Summary (with-project)

Leveed Area	0.2% AEP (500-year) Flood Event		
	Assurance (Future Without-Project)	**Assurance (Alternative 5)**	**Damages ($1,000's)**
PEN 1	27%	82%	$147,200
PEN 2	47%	82%	$584,600
MCDD West	59%	87%	$2,938,700
MCDD East	89%	90%	$1,185,100
SDIC	79%	93%	$233,803

5.7. Incremental Analysis

Alternatives in this study were formulated to meet objectives for the entire levee system. While alternatives were formulated as a complete bundle for the system, an incremental economic analysis breaks down the measures in smaller groupings to evaluate whether measures are economically justified. According to the Principles and Guidelines (U.S. Water Resources Council 1983), an effort should be made to "include only increments that provide net NED benefits after accounting for appropriate mitigation costs. Increments that do not provide net NED benefits may be included, except in the NED plan if they are cost effective measures for addressing specific concerns." This section analyzes the TSP to determine if measure increments within the TSP are economically justified.

The Corps developed three distinct types of improvements proposed in the TSP. These improvements can be evaluated independently from each other:

1. Non-structural measures
2. Pump station measures
3. Levee measures

The non-structural measures were not analyzed incrementally. They have no impact on the economic benefits, instead providing benefits to life loss in the system. They are fairly low cost measures that help boost preparedness and flood risk awareness in the PMLS.

The pump station measures have an effect on interior drainage, which is nearly independent of the levee analysis. The pump station measures were evaluated together as a single increment. These measures were low costs and benefits relative to the levee measures.

The levee measures generate the highest costs and benefits, levee measures were broken down into smaller increments. Breaking the levee measures into smaller, discrete increments is challenging, since the PMLS acts as a system. Since some of the measures have dependencies on

each other, groupings of measures were included as increments rather than evaluating every individual measure. Groups of measures included those that improve the performance of the system and would be constructed as a single unit. It is not appropriate to evaluate some measures independently. For example, if there are multiple low spots in a levee that are at a similar elevation, filling only one low spot would not be a reasonable increment, since it is only a partial solution that would have very limited benefit and would be difficult to quantify as a standalone measure. Measures that were considered together as an increment include levee widening and increases in levee height. These were combined because the effect of a levee raise and improvements for fragility is greater than the sum of the individual measure benefits. In many instances, neither a levee raise alone nor fragility improvements alone are economically justifiable, but the combination of both of them working together is economically justifiable.

Two approaches were taken for the incremental analysis: a sequential approach, and a last-added approach. The first approach to incremental analysis adds increments sequentially from the future without-project condition until the complete alternative is reached. The TSP has a strategy of addressing inconsistencies within the PMLS to provide a more uniform AEP across the system. Increments are selected consistent with this alternative strategy, using groups of sited measures that generate significantly improved AEP. The increments are ordered based on the highest probability of flooding in the future without-project condition (worst-first using probability of inundation to determine the order). The increments are:

1. **PEN 1 and PEN 2 performance improvements and levee raise (Measure 5/7/30)**: This includes PEN 1 new levee parallel to railroad embankment and Columbia Slough seepage/stability improvements. Levee raise to approximately 40 feet NAVD88. Both PEN 1 and PEN 2 are evaluated simultaneously since they are hydraulically connected via the cross-levee at I-5 at elevation 35 feet NAVD88.
2. **MCDD-W cross-levee performance improvements and levee raise (Measure 5/7):** This increment includes **s**eepage/stability improvements at Peninsula Canal cross-levee in conjunction with re-grading the top of levee. Small levee raise at a low spot at MCDD-West near the Gleason boat ramp on the Columbia River that would overtop before the cross-levee.
3. **SDIC performance improvements and levee raise (Measure 5/7).** The levee raise proposed in SDIC is in the same area as the seepage/stability improvements. Only raising one area is not effective due to another low spot, so the small levee raise at the southern end is also included in this increment.

Incremental analysis results for this method are given in Table 5-6, showing that each sequentially-added increment provides a positive net benefit. The sum of the increment benefits adds up to the total alternative benefit. The distribution of real estate costs to the increments is approximate. A percentage of the total LERRD costs for the alternative was distributed to each increment based on the amount of LERRD area required. OMRR&R costs were distributed to increments based on the quantities of new features to be maintained.

Table 5-6 Incremental Analysis of TSP (sequentially-added increments)

Flood Risk Reduction Increment (All figures shown in $1,000's)	Increment Annual Damages Reduced (Benefits)	Increment Annual Cost	Increment Annual Net Benefits	Increment Benefit-Cost Ratio
Interior Drainage Only	$1,905	$409	$1,496	4.7
PEN 1 Levee Performance Improvements and PEN 1 and PEN 2 Levee Raise	$9,579	$4,777	$4,802	2.0
PEN 2/MCDD West Cross Levee improvements and MCDD West Levee Raise	$1,955	$688	$1,267	2.8
SDIC Performance Improvements and Levee Raise	$470	$248	$222	1.9

This analysis shows that all increments are above unity and incrementally justified. The SDIC increment was the lowest increment at 1.9. The assumptions used for the cost estimate were fairly conservative, assuming that the entire reach from the 223rd Avenue cross-levee to Sundial Road requires performance improvements. It is possible that a more targeted design effort would reduce the amount of improvements required, further reducing costs. Note that these cost estimates have a 50% contingency, and were used to compare alternatives. MCACES cost estimates are different than these estimates, and have a higher level of detail. Based on the abbreviated risk analysis, the contingency for the MCACES cost estimate of the TSP is around 45%. The total cost of the MCACES estimate is lower than the alternative-level estimates, so the net benefits of the PEN 1/PEN 2 increment is expected to improve when transitioning to the MCACES estimate.

The second way to perform the incremental analysis is to evaluate each increment on a last-added basis. This approach shows how the net benefits of the TSP would change if an increment was removed. In this approach, the sum of the increment benefits does not add up to the total alternative, since the same benefits can be counted when evaluating different increments. The SDIC incremental measures were already analyzed as a last-added increment in the sequential analysis, so no further analysis was done for that increment. The interior drainage measures are almost completely independent from the levee measures, so there is minimal difference whether they are evaluated as a first-added or last-added measure and were not evaluated further. The MCDD measures would show a positive net economic benefit as a last-added increment, since the previous sequential analysis showed a high benefit-cost ratio, and the SDIC measures have only a limited connection to the MCDD-West areas. Therefore, the PEN 1 and PEN 2 measures are the only increment that was analyzed as a last-added increment.

As previously shown, the PEN1 and PEN2 measures are economically justifiable if they are viewed as a first-added increment. If evaluated as a last-added increment, the net benefits are lower, but the increment is still above unity, as shown in Table 5-7. As the TSP moves to a more detailed level of design, cost estimates will be refined, which may reduce costs. For instance,

floodwalls are used for much of the levee raise in PEN 1 and PEN 2, but a more economical option may be building up the levee embankment where possible. Optimization of the amount of levee raise would adjust costs and benefits. Significant reductions in cost are also possible if cooperation with the railroad is achieved. The TSP currently includes a parallel levee to the railroad embankment off the railroad property line, effectively assuming no cooperation is possible. If cooperation were achieved and agreement was reached to add on to the existing seepage berm, costs could be approximately half of the parallel levee approach. Table 5-7 shows how the incremental net benefits would change if this cost savings were realized.

Table 5-7 Incremental Analysis with PEN 1/PEN 2 measures as last-added increment

Flood Risk Reduction Increment (All Figures shown in $1,000's)	**Increment Damages Reduced (Benefits)**	**Increment Annual Cost**	**Increment Annual Net Benefits**	**Increment Benefit-Cost Ratio**
Last-added increment analysis: PEN 1 Levee Performance Improvements and PEN 1 and PEN 2 Levee Raise	$4,941	$4,777	$164	1.03
Potential Reduced Cost: Add to railroad embankment instead of parallel levee		-$230		
Last-added increment analysis if cost-savings achieved via cooperation with railroad	$4,941	$4,547	$394	1.09

While the increments contained within Alternative 5 all justify based on NED benefits, there are additional non-monetary benefits in the form of life safety for this project and in particular associated with the last added increment of Alternative 5 using the second methodology. The PEN 1 and PEN 2 measures were formulated to meet the objectives of the study. These measures increase the resilience of the system to future high water events, and they provide measurable benefits to life safety. The majority of the residential population resides in PEN 2, and the proposed PEN 1/PEN 2 increment of measures in the TSP help address life safety concerns with these populations. The PEN 1/PEN 2 increment of the TSP is the most effective of any measure at reducing life loss risk.

Life safety risk is a function of both probability of the event and the consequences of a levee breach. In the TSP, non-structural measures are implemented that increase preparedness and evacuation effectiveness. However, these non-structural measures only have a small effect on the life loss consequences. Other measures to reduce consequences were explored, but were considered impractical (e.g. relocation, buyouts, elevating structures). Since non-structural measures only had a limited effect on consequences, the other option to reduce life safety risks is to address the probability of a breach. The failure mode that poses the highest life safety risk is overtopping at PEN 2. Failure prior to overtopping at PEN 1 also poses a significant life safety risk to the PMLS. The proposed improvements to PEN 1 and PEN 2 significantly reduce life

safety risk from these failure modes. The breach prior to overtopping risk at PEN 1 is greatly reduced, and the improvements to PEN 2 also provide a very significant reduction in life risk (almost a tenfold reduction in probability). The PEN 1/PEN 2 increment provides these significant life safety benefits, without this increment, the most critical life safety risks to the project would not be addressed.

While the PEN 1/PEN 2 increment is currently economically justified, the potential exists that costs will escalate during design, resulting in higher costs than benefits for this increment. If the net economic benefits of this increment become negative in the future, the current TSP would no longer be the NED plan. In this case, to retain the current TSP as the selected plan, a policy exemption letter would be required justifying the selection of this alternative on grounds other than economic justification alone.

Exhibit G-1 (3.c) of the Planning Guidance Notebook states that "Where two cost-effective plans produce no significantly different levels of net benefits, the less costly plan is to be the NED plan, even though the level of outputs may be less." For the PMLS, the TSP has significantly higher levels of economic net benefits than the other alternatives. The PEN 1/PEN 2 increment provides $164,000 in annual economic net benefit, as well as resilience and life safety net benefits. While this increment is relatively costly, it provides a much higher level of output than a plan that would remove this increment from the TSP.

6. Compliance with Environmental Statutes

Federal laws and executive orders that pertain to this EA have been summarized, along with compliance actions for each law, below in Table 6-1.

6.1. Environmental Operating Principles

The Corps has reaffirmed its commitment to the environment by formalizing a set of "Environmental Operating Principles" applicable to all of its decision-making programs. These principles foster unity of purpose on environmental issues, reflect a new tone and direction for dialog on environmental matters, and ensure that employees consider conservation, environmental preservation, and restoration in all Corps activities. The principles are described in Engineer Circular 1105-2-4040 "Planning Civil Work Projects under the Environmental Operating Principles," 1 May 2003.

This study addresses the Corps' Environmental Operating Principles as described below:

1. Foster sustainability as a way of life throughout the organization.
    - Environmental sustainability, when applied to a water resource project, must be designed to balance three major elements: environmental health, economic prosperity, and social well-being.
    - The proposed project will contribute to future economic prosperity by creating jobs during construction and reducing flood risks for the community.

2. Proactively consider environmental consequences of all Corps activities and act accordingly.
    - The Corps has proactively considered environmental consequences of the proposed project. Potential consequences to environmental resources have been analyzed for the alternatives. Measures to avoid and reduce impacts on resources have been developed and will be implemented.

3. Create mutually supporting economic and environmentally sustainable solutions.
    - The project will provide significant national and regional economic development benefits. Construction of the project is anticipated to support additional jobs and provide income for workers.
    - The proposed project reduces risk of flooding while balancing environmental impacts against levels of residual risk.

4. Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps which may impact human and natural environments.
    - The values of environmental sustainability are incorporated into the Nation's laws and mandates to governmental and private actors. The statute that provides a basis for evaluation of environmental impacts is NEPA. The planning framework found in the

Water Resources Council's P&G provides a guide for seeking sustainable solutions in civil works projects.

- The proposed project incorporates a coordinated approach to the need for flood risk management while complying with environmental laws such as NEPA, the Clean Water Act, the Clean Air Act, the Fish and Wildlife Coordination Act, and the Endangered Species Act, among others. All applicable requirements will be met.

5. Consider the environment in employing a risk management and systems approach throughout life cycles of projects and programs.

- The environment was considered in employing a risk management and systems approach.
- The Corps will continue to communicate impacts and residual risk to stakeholders and the public throughout the life cycle of the proposed project.

6. Leverage scientific, economic, and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.

- The Corps must effectively utilize sources of expertise among other professional organizations, and other Federal, state, and local entities to address problems of regional and national significance. The Corps has utilized the scientific expertise within the agency, and the expertise of resource agencies.

7. Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

- The Corps and the non-Federal sponsor have sought the views of individuals and groups on the best way to improve the flood risk management system. The Corps will continue to provide information to keep the public informed on the study. The Corps will continue to actively listen and respond to and incorporate public concerns.

6.2. Executive Order 11988, Floodplain Management

Executive Order (EO) 11988, Floodplain Management, signed 24 May 1977 requires Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of natural flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "*each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities*."

To comply with EO 11988, projects are formulated and recommended that, to the extent possible, avoid, minimize and/or mitigate adverse effects associated with use of the floodplain, and avoid inducing incompatible development in the floodplain unless there is no practicable alternative. Under the Order, the Corps is required to provide leadership and take action to:

a. Avoid development in the base flood plain unless it is the only practicable alternative;
b. Reduce the hazard and risk associated with floods;
c. Minimize the impact of floods on human safety, health and welfare; and

d. Restore and preserve the natural and beneficial values of the base floodplain.

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, 10 Feb 1978 (43 FR 6030), as referenced in the Engineer Regulation (ER) 1165-2-26, 30 Mar 1984, require an eight-step process that agencies should carry out as part of their decision-making process on projects that have potential impacts to or within the base floodplain. The eight steps reflect the decision-making process required in Section 2(a) of the Order. The evaluation and decision making process described below are consistent with the EO.

1. Determine if the proposed action would be in the base (1 percent ACE or 1/100-year) floodplain.

The proposed action (project) is located within the defined base floodplain. The location of the existing levee system is within the base floodplain.

2. If the proposed action would be in the base floodplain, identify and evaluate practicable alternatives to the action or to locating the action in the base floodplain.

The floodplains for the study area are already established by the existing flood risk management projects. As described in ER 1165-2-26, it is the policy of the Corps to formulate projects which, to the extent possible, avoid or minimize adverse impacts associated with use of the base floodplain and avoid inducing development in the base floodplain unless there is no practicable alternative. Practicable alternatives are those capable of being done within existing constraints. The decision on whether a practicable alternative exists is based on weighing the advantages and disadvantages of floodplain sites and non-floodplain sites. The test of practicability applies to both the proposed action and to any induced development likely to be caused by the action. Practicable structural and nonstructural measures and alternatives were identified and evaluated. Locations for the action alternatives were limited by the need to reduce damages and life, safety, and health risks caused by flooding of the existing levee system. There are no practicable alternatives to undertaking an action inside or outside the floodplain which address the identified flood risk management problems and meet the objectives. No development is likely to be induced by the action alternatives within the base floodplain.

3. If the action must be in the floodplain, advise the general public in the affected area and obtain their views and comments.

The Corps has conducted three public open houses and three meetings with regulatory agencies to describe the project and ensure that its location is fully disclosed. Details of these meetings are provided in Appendix I (Public Involvement). The Corps will hold additional public meetings after release of the Draft IFR/EA.

4. Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial floodplain values. Where actions proposed to be located outside the base floodplain will affect the base floodplain, impacts resulting from these actions should also be identified.

Beneficial and adverse impacts resulting from the proposed action are identified in Chapters 3 and 4. No adverse impacts to the floodplain or losses of natural and beneficial floodplain values are anticipated from the proposed action, as a flood risk management system is already in place.

5. If the action is likely to induce development in the base floodplain, determine if a practicable non-floodplain alternative for the development exists.

There are no direct or indirect impacts to the floodplain that are likely to induce development in the floodplain or outside it. The proposed action does not include construction of any new, permanent housing or commercial activities, and is not expected to induce any new residential or commercial growth beyond that already planned.

6. As part of the planning process under the P&G, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial floodplain values. This should include reevaluation of the "no action" alternative.

During the environmental analysis of the proposed action, wherever there were potential adverse impacts by the proposed action, appropriate Best Management Practices or other environmental commitments are identified. The proposed action would not induce development in the floodplain. The proposed action is site specific and would not aggravate current hazards of the floodplain and would not disrupt the natural and beneficial floodplain values.

7. If the final determination is made that no practicable alternative exists to locating the action in the floodplain, advise the general public in the affected area of the findings.

During the course of the planning process, the Corps will further evaluate and determine if a practicable alternative exists to locating the proposed action in a floodplain. If the final determination is that there is no practicable alternative, the Corps will advise the public within the area of this determination.

8. Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order 11988.

The Corps has tentatively determined that Alternative 5 best fulfills the planning objectives and is consistent with the requirements of EO 11988. The Corps will continue this evaluation throughout the rest of the planning process.

Table 6-1 Compliance with Applicable Environmental and Cultural Resources Regulations

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Abandoned Shipwreck Act of 1987, 43 U.S.C. §§ 2101, *et seq*.	Assures title to abandoned shipwrecks to the respective States for management.	There are no known shipwrecks in the study area. Any abandoned shipwrecks discovered in the study area will be managed through application of this act.	Prior to completion of final IFR/EA
American Indian Religious Freedom Act of 1978, 42 U.S.C. § 1996	Requires Federal agencies to ensure that religious rights of Native Americans are accommodated during project planning, construction, and operation.	Should the Corps be notified of any Tribal concerns regarding access to locations of religious or spiritual importance in the PMLS study area, it will consult with Tribal representatives to address these concerns. Compliance determination to be made after completion of NEPA impact assessment, public involvement process, SHPO and Tribal consultations and final construction implementation.	During project planning

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Antiquities Act of 1906, 16 U.S.C. §§ 431-433	The first Congressional act to protect archaeological resources on Federal lands, it has largely been superseded by the Archaeological Resources Protection Act. Some Federal agencies will issue Antiquities Act permits rather than ARPA permits for activities on Federal lands managed by that agency.	No lands administered by agencies that issue Antiquities Act permits are known within the PMLS project area. Should such lands be identified in the future, the appropriate agency would address Antiquities Act requirements.	During project planning
Archaeological Resources Protection Act of 1979, 16 U.S.C. §§ 470aa-470mm	Secures the protection of archaeological resources and sites which are on public lands and Indian lands.	No public or Indian lands are known within the PMLS project area. Should such lands be identified in the future the appropriate agency would address ARPA requirements.	Prior to completion of final IFR/EA
Bald and Golden Eagle Protection Act of 1940, 16 U.S.C. § 668 et seq.	Prohibits the take, possession, or disturbance of any bald or golden eagle.	Coordination with the USFWS throughout the planning process will ensure protection of bald and golden eagles during construction.	Prior to completion of final IFR/EA

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. §§ 9601–9675, and the Resource Conservation Recovery Act (RCRA), 42 U.S.C. §§ 6901–6992k.	Establishes regulations for hazardous waste management.	The EA will provide a review of CERCLA sites and evaluate hazards in the project area.	During Feasibility and on-going prior to construction as applicable
Clean Air Act, as amended, 42 U.S.C. § 7401–7671q	Requires Federal agencies to control and abate air pollution.	Coordination with ODEQ will ensure that air quality is maintained during construction process.	Prior to completion of final IFR/EA
Clean Water Act, as amended, 33 U.S.C. 1251–1387 § 401Requires Federal agencies to comply with state water quality standards. The Corps will obtain a Water Quality Certification from Oregon DEQ during the project implementation phase. Prior to construction Clean Water Act, as amended, 33 U.S.C. 1251–1387, § 402	A Section 402 permit is needed for projects that may discharge stormwater to surface waters.	The Corps will acquire a permit under the NPDES program prior to project implementation. Project may require a Section 1200-Z permit from Oregon DEQ.	Coordination is on-going during Feasibility, permits will be obtained prior to construction

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Clean Water Act, as amended, 33 U.S.C. 1251–1387 § 404	Requires Federal agencies to protect waters of the United States. Regulates the discharge of dredged or fill material into waters (and excavation) unless it can be demonstrated there are no reasonable alternatives.	Corps has prepared a Section 404(b)(1) evaluation to demonstrate the project's compliance with this law.	Coordination is on-going during Feasibility and finalized prior to construction
Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of the NEPA, 40 C.F.R. §§ 1500–1508	Council on Environmental Quality (CEQ) regulations provide Federal agencies with the direction and procedures for compliance with NEPA, ensuring that agencies responsible for preparing NEPA documentation do so consistently and thoroughly.	This Feasibility Study is integrated with an EA, which has been prepared to identify environmental impacts and make a determination of the need for preparation of an Environmental Impact Statement (EIS) or a Finding of No Significant Impact (FONSI). The EA has been prepared in accordance with Corps of Engineers ER 200-2-2 Procedures for Implementing NEPA.	Prior to completion of final IFR/EA

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Endangered Species Act as amended (16 U.S.C. §§ 1531–1544)	Requires Federal agencies to protect listed species and consult with USFWS and/or NOAA Fisheries regarding the TSP.	ESA consultation is ongoing in conjunction with the feasibility study. A BiOP will be required from NMFS.	Prior to completion of final IFR/EA
Farmland Protection Policy Act (7 U.S.C. §§ 4201, *et seq*.)	Avoids or minimizes the unnecessary and irreversible conversion of farmland to nonagricultural uses by Federal projects.	The Corps will coordinate with NRCS to protect existing farmlands from conversion or encroachment if farmland is affected.	Prior to completion of final IFR/EA
Fish and Wildlife Coordination Act (16 U.S.C. §661 et seq.)	Requires Federal agencies to consult with the USFWS on any activity that could affect fish or wildlife.	Coordination with the USFWS is ongoing concurrently with the feasibility study and will result in effect determinations for fish and wildlife species.	Prior to completion of final IFR/EA
Magnuson-Stevens Fishery Conservation and Management Act—Fishery Conservation Amendments of 1996, (16 U.S.C. §§ 1801–1883)—Essential Fish Habitat (EFH)	Governs marine fisheries management, protects and enhances fisheries populations, including anadromous fish migrating through the project area.	Consultation with NMFS will ensure the protection of commercial fisheries throughout the Columbia River, Sandy River, and their tributaries passing through the project area.	Prior to completion of final IFR/EA

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Migratory Bird Treaty Act (16 U.S.C. §§ 703-712)	Prohibits the take, possession or disturbance of any migratory bird, nests, or eggs without a Federal permit.	Permits to take MBTA species will be sought during implementation, if necessary.	Prior to project implementation
National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. §§ 4321–4347)	Requires Federal agencies to consider the environmental effects of their actions and to seek to minimize negative impacts.	This integrated FS/EA has been prepared to identify environmental impacts and make a determination of the need for preparation of an Environmental Impact Statement (EIS).	Prior to completion of final IFR/EA
National Historic Preservation Act (54 USC 300101 et seq.): Protection of Historic Properties	Requires Federal agencies to identify and protect cultural and historic resources.	The Corps is coordinating with Tribal representatives and the OR SHPO. The Corps will continue this coordination to meet requirements of Section 106 of the NHPA prior to implementing any measures that may affect cultural resources. The compliance process will continue until conclusion of the NHPA consultation process.	Prior to completion of final IFR/EA

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Native American Graves Protection and Repatriation Act (NAGPRA) 25 U.S.C. 3001 et seq.	Protects Native American and Native Hawaiian cultural items.	Should any Federal or tribal trust lands be identified in the future and any Native American remains or associated cultural items are discovered, the appropriate agency or Tribe would address the NAGPRA requirements.	During project implementation
Resource Conservation and Recovery Act of 1976, 42 U.S.C. § 6901-6987	Gives EPA the authority to control hazardous waste from the "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from USTs storing petroleum and other hazardous substances.	The Corps has performed database searches to identify any USTs or other potential sources of contamination. The Corps maintains a Spill Prevention, Control, and Countermeasure Plan for all of their facilities and projects.	During the NEPA process and during project implementation
Rivers and Harbors Act of 1899 (33 U.S.C. § 403)	The creation of any obstruction to the navigation of any waters of the United States is prohibited without congressional approval.	A Section 10 review will occur prior to conclusion of the feasibility study.	Prior to completion of final IFR/EA

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Executive Order 11988, Floodplain Management, 24 May 1977	Executive Order (EO) 11988 (May 24, 1977) requires a Federal agency, when taking an action, to avoid short and long term adverse effects associated with the occupancy and the modification of a floodplain. The agency must avoid direct and indirect support of floodplain development whenever floodplain siting is involved. In addition, the agency must minimize potential harm to or in the floodplain and explain why the action is proposed. Additional floodplain management guidelines for EO 11988 were also provided in 1978 by the Water Resources Council. Corps implementation guidance in Engineering Regulation (ER) 1165-2-26 (March 30, 1984).	See section 6.2	Prior to completion of final IFR/EA

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Executive Order 11593, Protection and Enhancement of the Cultural Environment	Requires Federal agencies to preserve, restore, and maintain the historic and cultural environment of the U.S.	Corps' policies ensure that all proposed actions are performed only after appropriate inventory, management, and protection of cultural resources has occurred. Compliance determination to be made after NEPA impact assessment and Section 106 consultation is complete.	Prior to completion of final IFR/EA
Executive Order 11514, Protection and Enhancement of Environmental Quality	Assigns responsibility to Federal agencies to protect and enhance the quality of the Nation's environment.	The action alternatives have been designed to minimize potential environmental impacts, and includes measures to offset the intensity of impacts, as shown in Section 4.1 of this report.	Prior to completion of final IFR/EA
Executive Order 11990, Protection of Wetlands	Requires Federal agencies to protect wetland habitats.	If jurisdictional wetlands are identified in the project footprint, the Corps will offset unavoidable wetland losses in a manner that complies with this EO.	Prior to project implementation

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	Requires Federal agencies to consider and minimize potential impacts on low- income or minority communities.	Section 4.14.2 of this report documents environmental justice concerns and finds that there would be no disproportionate impact to low income or minority communities.	Prior to completion of final IFR/EA
Executive Order 13007, Indian Sacred Sites	Directs Federal agencies to provide access and ceremonial use of sacred sites on Federal lands and avoid affecting their physical integrity.	No Federally owned lands are known in the PMLS area. Should such lands be identified in the future, the Corps and the relevant Federal agency will consult with appropriate Tribes to determine if any sacred sites are located on those lands.	During project implementation
Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks	Under this Executive Order, Federal agencies shall make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children; and shall ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.	Preparation of the EA includes evaluation of environmental health and safety risks, and measures necessary to protect all people, including children, from those risks. There are no measures that would disproportionately affect children or any other group.	Prior to completion of final IFR/EA

Relevant Law/Regulation	Requirements	Compliance Status	Timeframe of Compliance
Executive Order 13175, Consultation and Coordination with Indian Tribal Governments	Directs Federal agencies to recognize Indian sovereignty in government-to-government relationships and to consult with Tribes in adopting regulatory policies that have Tribal implications.	The Corps is consulting with Tribal representatives to identify and address Tribal concerns in the PMLS study area.	Prior to completion of final IFR/EA
Executive Order 13751, Safeguarding the Nation from the Impacts of Invasive Species	Requires Federal agencies to take reasonable measures to prevent the spread and introduction of invasive species as a result of their management or construction actions.	Preparation of the IFR/EA will document environmental conditions and effects and informs the determination of compliance with EO 13751 within the report in Section 4.9.3.	Prior to completion of final IFR/EA
Executive Order 13287, "Preserve America"	Enhances practices that protect the cultural heritage of the U.S.	The Corps recognizes the importance of historic properties within the PMLS study area and will work with State and National agencies to determine if any proposed actions would affect those properties." Preparation of the IFR/EA will document environmental conditions and effects and inform the determination of compliance with EO 13287 Section 4.11 of the report.	Prior to completion of final IFR/EA

7. Summary of Public Involvement, Review Process and Consultation

7.1. Public Involvement Process

The Corps has implemented a public involvement program to promote public awareness of the integrated feasibility study and NEPA process, to demonstrate that the plan is acceptable to state and local entities and the public and is compatible with existing laws, regulations, and public policies, to educate the public on the issues associated with the alternatives, and to encourage the public to become involved in the planning and environmental impacts assessment process. The objectives of the Corps' public involvement program include:

- Fulfill the NEPA requirements for public involvement
- Maintain community involvement in the study process by providing the public with project updates
- Help to formulate and evaluate alternatives for the planning process
- Provide opportunities for the public to provide input
- Use a variety of media including a website, handouts, slide presentations, and news media releases to provide information to the public, and
- Demonstrate to the public how their input is incorporated during the study process.

7.2. Public Scoping Process

The Corps is not required to hold a formal public scoping process, since it is not anticipated that the project will rise to the level of significance for requiring preparation of an EIS. The Corps elected to hold public and agency meetings prior to the preparation of the IFR/EA to gather public input related to the proposed action. These meetings are described in Appendix I (Public Involvement).

7.3. Draft IFR/EA Public Review

The draft IFR/EA will be released for public review after publication of a Notice of Availability (NOA). The NOA will initiate a public review period, during which the IFR/EA will be made available to the public via the Portland District's website or upon request. Typically, the review period for an IFR/EA is 30 days, but Portland District has extended the review period from January 6 to February 14, 2020. Two public meetings will be held mid-way through the comment period on the draft IFR/EA. The purpose of the meetings are to allow for direct interaction between the public and the project development team, to inform the public of the findings of the Report, provide the status of the feasibility study, and inform the public on how they can provide comments. Corps and MCDD staff will also be available to answer questions. The first meeting will occur at the City of Fairview offices (1300 NE Village Street, Fairview,

OR 97204) on Thursday, January 16 at 6:00 p.m. The second meeting will occur at the Portland Expo Center (2060 N Marine Drive, Portland, OR 97217) on Thursday, January 23 at 6:00 p.m.

7.4. Additional Coordination and Consultation

The Corps is actively coordinating with resource agencies and Tribes as part of the planning process. This coordination is described in greater detail in Appendix I (Public Involvement).

MCDD has established coordination with low-income and houseless communities in the project area to ensure that they are aware of the project and are informed of opportunities for public involvement. This coordination will continue throughout the planning process.

8. Draft Recommendation

I recommend that the Portland Metro Levee System, flood risk management project, be modified as generally described in this report as the recommended plan and with such modifications as may be advisable within statutory discretion be approved and remaining construction implementation completed. Implementation of these features will reduce the flood risks in the system from levee seepage and piping, levee landside slope instability, levee overtopping, and pump failures.

The Total Project First Cost for the recommended plan is $130,710,000 (FY2021 price level). Total average annual costs for the recommended plan is $ 4.79M (Federal discount rate of 2.75%, 50 year period of analysis). The recommended plan is the NED plan. The recommended plan also significantly reduces the risk of life loss.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the States, and interested Federal agencies will be advised of any modifications and will be afforded an opportunity to comment further.

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COLONEL AARON L. DORF
PORTLAND DISTRICT

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CERTIFICATION OF LEGAL REVIEW

The *Portland Metro Levee System Feasibility Study Draft Integrated Feasibility Report and Environmental Assessment*, dated January 2020, has been reviewed by the Office of Counsel, Portland District, and is approved as legally sufficient.

Andrew Ainsworth
Assistant District Counsel

January 2, 2020
Date