City of Tacoma, Washington

ONE TACOMA

A Comprehensive Plan for a Vibrant, Connected, and Sustainable City

Best Available Science Review DRAFT | JANUARY 2025

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Acronyms and Abbreviations

BAS	Best Available Science
BMP	Best Management Practices
CAO	Critical Areas Ordinance
CARA	Critical Aquifer Recharge Area
Commerce	Washington State Department of Commerce
the Corps	U.S. Army Corps of Engineers
CMZ	Channel Migration Zone
DNR	Washington State Department of Natural Resources
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESA	Environmental Science Associates
FEMA	Federal Emergency Management Agency
FFA	Frequently Flooded Area
FIRM	Flood Insurance Rate Map
FWHCA	Fish and Wildlife Habitat Conservation Area
GIS	Geographic Information System
GMA	Growth Management Act
LID	Low Impact Development
OHWM	Ordinary High Water Mark
NOAA	National Oceanic and Atmospheric Administration
NFIP	National Flood Insurance Program
NMFS	National Marine Fisheries Service
RMZ	Riparian Management Zone
RCW	Revised Code of Washington
TMC	Tacoma Municipal Code
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

1 INTRODUCTION

This review of the best available science (BAS) for critical areas was compiled as part of Tacoma's Periodic Update of their Comprehensive Plan under the Growth Management Act (GMA). The GMA requires that all cities and counties designate critical areas and protect their functions and values, using BAS in accordance with the GMA laws and regulations in the Revised Code of Washington (RCW) Chapter 36.70A and Washington Administrative Code (WAC) Chapters 365-195 and 365-196.

1.1 Document Organization

The content in this document is structured based on the following five regulated critical areas in Washington State, defined in RCW 36.70A.030 and WAC 365-190-030:

- Wetlands
- Areas with a critical recharging effect on aquifers used for potable water (i.e., critical aquifer recharge areas)
- Frequently flooded areas
- Geologically hazardous areas
- Fish and wildlife habitat conservation areas

Within each section functions, values, and standards and recommendations for critical area protection are discussed. For a summary of existing condition summaries with respect to each critical area type in the City of Tacoma, refer to the Environment and Watershed Health Element of the One Tacoma Comprehensive Plan.

1.2 Purpose

This document sets the framework for updates to policies and regulations to "protect the functions and values" of regulated critical areas, including giving special consideration to conservation or protection measures to preserve or enhance anadromous fisheries[1] (RCW 36.70A.172, WAC 365-195-900), using the best available science. Special consideration is also given to the anticipated effects of climate change on regulated critical areas, consistent with 2023 legislation, Washington State House Bill 1181. This BAS review serves as the basis for a "gap analysis" to identify where updates to current critical area regulations in Tacoma could be prioritized.

[1] "Anadromous" refers to fish or fish species that spend portions of their life cycle in both fresh and salt waters, entering fresh water from the ocean to spawn. "Fisheries" are generally an area where fish are caught.

Protection of critical area functions and values within the context of the GMA means "preservation of the functions and values of the natural environment, or to safeguard the public from hazards to health and safety" (WAC 365-196-830), establishing two ways in which critical areas are considered within this document. While all the regulated critical areas may provide a basic level of beneficial ecosystem functions, critical aquifer recharge areas, geologically hazardous areas and frequently flooded areas are also protected for public health and safety (Commerce 2023).

This report characterizes the functions, values, and/or hazards associated with each regulated critical area. It discusses the predicted effects of climate change and outlines protection strategies for each critical area. This information is provided so that decision-makers can incorporate climate resilience and the BAS to protect critical area functions and values into their policies and regulations.

1.3 BAS Reference Materials and Limitations

BAS means the current and best available information that follows a valid scientific process as specified in WAC 365-195-900 through WAC 365-195-925. Characteristics of a valid scientific process include peer review, standardized methods, logical conclusions and reasonable inferences, quantitative analysis, proper context, and references. Common sources of scientific information include research, monitoring, inventory, modeling, assessment, and synthesis (WAC 365-195-905). BAS literature reviews are a synthesis of the current scientific body of knowledge, and only resources that meet these requirements are included as reference materials for this BAS.

Other Washington State agencies provide comprehensive BAS reviews for specific critical areas including but not limited to the following documents:

- Wetlands in Washington State Volume 1: A Synthesis of the Science (Sheldon, et al. 2005)
- Wetlands Guidance for Critical Areas Ordinance Updates, Western and Eastern Washington (Ecology 2022)
- Wetland Mitigation in Washington State, Part 1: Agency Policies and Guidance (Ecology, the Corps, and EPA 2021)
- Critical Aquifer Recharge Areas Guidance (Ecology 2021)
- Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications (Quinn, Wilhere and Krueger 2020)
- Riparian Ecosystems, Volume 2: Management Recommendations (Rentz, et al. 2020)

This report provides a high-level summary of key topics from these documents and cited BAS resources.

Ecological systems are highly complex, and the scientific body of knowledge is constantly evolving with the advancement of new research and technology. Despite these advancements, there are limits to the current state of science and certain topics may not be fully understood. Where there is scientific disagreement in the literature about a particular subject, this review presents a range of potential ideas or findings. In accordance with WAC 365-195-920, decision-makers may opt for a precautionary, or no-risk approach, when scientific information is incomplete.

1.4 Functions and Values

One key component of this document is the characterization of critical area functions and values. The concepts of critical area “functions” and “values” are linked but warrant distinction. “Ecosystem functions” and “ecosystem values” are defined according to WAC 365-196-210(14) and (15), respectively, as follows:

"Ecosystem functions" are the products, physical and biological conditions, and environmental qualities of an ecosystem that result from interactions among ecosystem processes and ecosystem structures. Ecosystem functions include, but are not limited to, sequestered carbon, attenuated peak streamflows, aquifer water level, reduced pollutant concentrations in surface and ground waters, cool summer in-stream water temperatures, and fish and wildlife habitats.

"Ecosystem values" are the cultural, social, economic, and ecological benefits attributed to ecosystem functions.

Functions are beneficial services provided by certain qualities and processes within an ecosystem, while values are determined by how a service or ecosystem is recognized by people. Values can change while functions remain constant because factors that affect values are different than those that affect functions. Values may vary by groups of people, over time, and with landscape context, depending on the perceived importance and/or scarcity of beneficial services being provided by a critical area (Sheldon, et al. 2005).

Understanding ecosystem values is complex because values are dynamic. Not surprisingly, the scientific literature focuses on ecosystem functions. Although, emerging science is often a response to changing values. For example, within this document, anadromous fisheries (hereafter, broadened simply to “anadromous fish”) and climate change are considered for their potential to alter the value of critical area functions in Tacoma, as required by the state laws and regulations previously noted. Common values of vegetated critical areas in Tacoma include the economic benefits of natural surface water control and pollution abatement; aesthetic appeal; and the social and cultural benefits of improved community health, connection, and well-being.

This BAS review is not intended to provide definitive answers for policy and regulatory decisions needed to protect the functions and values of critical areas. The decision-making process must incorporate the cultural/social/economic/ecological values placed on the beneficial services provided by ecological functions into policies and regulations; and those values cannot be comprehensively addressed within the context of this BAS review.

Climate Change

This section outlines predicted climate change effects in Washington State that have the potential to alter critical area functions and values. These primary mechanisms are referenced throughout the document. The risk of climate change effects on each critical area type is discussed by section. The following climate change effects have been observed or are projected in the Puget Sound region:

Increasing air temperatures and more extreme heat

- Long-term warming, a lengthening of the frost-free season, and more frequent nighttime heat waves have been observed (Mauger, Casola, et al. 2015).
- Models predict more “hot days” each year (Ecology 2024).
- Global warming of about 1°C has already occurred. Warming may exceed 1.5°C (2.7°F) by 2030 (Snover, et al. 2019).

Seasonal changes to precipitation patterns

- Increases in both the frequency and intensity of heavy rainfall events have been documented in western Washington (Mauger, Casola, et al. 2015).
- Summer precipitation is expected to decrease (Mauger, Casola, et al. 2015) and droughts will be more common (Ecology 2024).
- An observed and projected decrease in snowpack is anticipated to result in reduced stream flows later in the year (Ecology 2024).
- Increasingly larger and more frequent floods are predicted with less snow and heavier, more frequent precipitation events (Ecology 2024).
- A likely reduction in groundwater availability is anticipated due to changes in precipitation patterns and intensity and timing of snowmelt combined with increased summer demand from people and ecosystems (Ecology 2024).

Rising sea levels and changing Puget Sound conditions

- Sea levels have risen across Washington’s coastline and are expected to continue to rise at an accelerated pace (Ecology 2024).
- Projected future sea level rise estimates include:
- An increase of 1.5-2.5 feet for all coastal areas of the state by 2100 (Ecology 2024).
- An increase of 0.6 to 1.2 feet in Tacoma by 2050 (Roop, et al. 2020).
- With higher sea levels, coastal flooding and damage from storm surges are predicted to increase (Mauger, Casola, et al. 2015).
- Washington’s coastal water temperatures have increased by 1.2°F since 1900 and warming is expected to continue (Ecology 2024).
- The acidity of the Puget Sound is increasing (i.e., pH values are decreasing) due to the absorption of carbon dioxide from the atmosphere into Puget Sound waters (Ecology 2024, Mauger, Casola, et al. 2015).

Increasing risk of wildfire and smoke

- Hotter, dryer summers and snowpack loss are projected to result in conditions that increase the likelihood of wildfires west of the Cascades (Mauger, Casola, et al. 2015); although the greatest wildfire risk increases occur outside of the Puget Sound region (Ecology 2024).
- While overall risk from wildfires in Tacoma may not be as extreme as in other parts of the state, smoke from wildfires elsewhere often moves into the Puget Sound basin. Projections for future changes in frequency or intensity of wildfire smoke are not available (Ecology 2024). The impact of wildfire smoke on natural systems is not fully understood (Voisin, et al. 2023).

Changing environmental conditions for flora, fauna and pathogens

- Climate change effects are anticipated to alter the timing of biological events, species' geographic distributions, productivity, and resilience of terrestrial ecosystems (Mauger, Casola, et al. 2015).
- The prevalence and location of certain pests and pathogens will likely shift. Responses are likely to be species- and host-specific (Mauger, Casola, et al. 2015).
- Introduced, adaptable species may experience greater opportunity to become established and spread after disturbance while locally evolved flora and fauna may experience stress from environmental changes that exceed historic ranges/thresholds. Plant and animal adaptability and resilience to climate change is variable by species.

Climate change considerations for City of Tacoma are further cover in the Tacoma Critical Areas and Climate Change: Best Available Science and Practices report by ESA, June 2023.

2 WETLANDS

2.1 Definition

Washington State defines wetlands in WAC 365-190-030(24) as follows:

“Wetland” or “wetlands” means areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. However, wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate conversion of wetlands, if permitted by the county or city.

The Tacoma definition of a wetland is very similar to the Washington State definition (TMC 13.01.110.W).

2.2 Functions and Values

Wetlands are highly productive ecosystems that provide functions through physical, chemical and biological processes. The literature has previously established that wetlands provide numerous ecological functions with associated cultural and social values and economic benefits. Wetland functions vary for a given wetland based on multiple factors, including wetland landform or hydrogeomorphic class, landscape setting, vegetation structure, hydroperiods, and presence or absence of priority habitats and species. The primary ecological functions of wetlands in Washington can be grouped into the following categories (Hruby and Yahnke, Washington State Wetland Rating System for Western Washington 2014 Update Version 2.0 2023):

- Improving water quality
  - Intercepting and detaining surface water runoff
  - Filtering sediment and pollutants
  - Uptake of nutrients including phosphorous and nitrogen
- Maintaining the water regime in a watershed (*i.e.*, hydrologic functions)
  - Desynchronizing surface water flows and reducing flooding
  - Recharging groundwater/aquifers
  - Maintaining base stream flows in the dry season

- Providing wildlife habitat
  - Seasonal/permanent inundation or saturation
  - Varying complexity of vegetative structure and diversity
  - Nesting and foraging habitat and migration corridors
  - Microclimate, refuge from heat

In Tacoma, many remaining wetlands also function to detain and clean stormwater runoff from adjacent developed areas.

Special Consideration for Anadromous Fisheries

Wetlands provide important functions that also benefit anadromous fisheries in the vicinity of Tacoma. Wetlands improve water quality for downstream water resources where anadromous fish live. They attenuate flood flows during wet periods and supply water to streams during drought. Wetlands located immediately adjacent to salmon bearing waters have the potential to provide direct habitat benefits. In general, wetlands have high value when considered within the context of anadromous fisheries.

Climate Change Effects

Climate change is predicted to significantly impact wetland ecosystems by altering hydrology, reducing biodiversity, disrupting carbon storage, modifying floral and faunal community composition, and increasing rates of disease (Aukema, et al. 2017, Burkett and Kusler 2000). Anticipated hydrologic changes that impact wetlands include sea level rise and associated shifts in salinity (Burkett and Kusler 2000), increased ponding during wet seasons, and decreased water levels during dry seasons (Halabisky 2017, Mauger, Casola, et al. 2015). Changes to wetland hydrology could result in loss of wetland area and shifts in plant communities. Changes to seasonal wetland hydrologic cycles can reduce the ability of wetland soil bacteria and plants to retain, process, and sequester pollutants (EPA 2015). Although wetlands are dynamic by nature, their ability to adapt to change is limited. Wetlands that are most vulnerable or likely to experience the greatest changes from the effects of global warming are those in coastal areas and those where surface water and stormwater are main sources of hydrology.

Wetlands provide functions that assist in the mediation of climate change impacts. Wetlands are important carbon sinks (Ecology 2022). Wetlands help offset climate change through carbon storage by limiting the decomposition of organic carbon and sequestering greenhouse gas emissions (Gallagher, Zhang and Chuan 2022). Wetlands and wetland buffers, like riparian corridors, support a shaded and cool microclimate that provides refuge for wildlife from higher temperatures as well as wildlife corridors at a local or landscape scale (ASWM 2015). Wetlands attenuate flood waters, which are anticipated to increase in frequency and intensity with climate change.

While climate change is predicted to impact wetland systems, wetlands will also play a role in mitigating the extent and anticipated effects of climate change. The potential outcome of climate change impacts on wetlands is two-pronged: loss of wetland area may result in release of stored carbon; and loss of wetland area or impacts to wetland conditions may reduce or impair the functions that wetlands can provide. These “positive feedback” mechanisms can incrementally intensify climate change by releasing stored carbon into the atmosphere and magnify its adverse impacts on communities by reducing wetland areas and impairing their functions. Consequently, the value of wetland functions can be perceived as very high when considered in the context of climate change.

2.3 Key Protection Strategies

Identification, Delineation, and Classification

The first step in protecting critical areas is knowing where they are located. While online local, state, or federal databases are useful planning tools, wetlands must be identified and delineated by a qualified professional. The nationwide standard for wetland delineations is the U.S. Army Corps of Engineers (Corps) Wetlands Delineation Manual (Environmental Laboratory 1987). In Tacoma, the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region Version 2.0 (Regional Supplement) also applies.

The Washington State Department of Ecology (Ecology) has developed a state-wide wetland rating system that has been periodically updated using the BAS—one version for eastern Washington and one version for western Washington. The Washington State Wetland Rating System for Western Washington (Hruby and Yahnke, Washington State Wetland Rating System for Western Washington 2014 Update Version 2.0 2023) applies in Tacoma and is the regional standard. This rating system is a rapid assessment tool that evaluates wetland functions in the categories of water quality, hydrology, and habitat, among a framework of three dimensions including site potential, landscape potential, and societal value (Hruby and Yahnke 2023). Using this system, wetlands are classified into one of four categories. This wetland classification system was designed to help agencies make decisions about protecting and managing wetlands. The rating system is also used to establish appropriate buffer distances from wetland categories based on the preservation of functions and values.

Current Protection Standards

This section summarizes current key protection standards for wetlands from published state guidance documents.

Wetland Guidance for Critical Areas Ordinance (CAO) Updates

Ecology has published Wetland Guidance for CAO Updates (Ecology 2022) that contains information for local jurisdictions working on designating and protecting wetlands under the GMA. This publication is informed by BAS documents and uses science as the basis for different approaches to protecting wetland functions.

Buffers and Habitat Connectivity

Wetland buffers are the primary mechanism for protecting wetlands in Washington. Buffers provide similar ecological functions as wetlands, primarily related to water quality improvement and wildlife habitat functions (Sheldon, et al. 2005). Buffers are effective in reducing impacts from adjacent land uses on wetlands, although effectiveness can vary based on a buffer's physical characteristics of buffers (e.g., slope, soils, vegetation, and width) (Sheldon, et al. 2005) (Hruby 2013).

The literature supports maintaining connectivity between wetlands to support viable populations of wetland-dependent species, including birds and amphibians. Current research indicates that buffers alone will not prevent many wildlife population declines, a broader approach is needed. Wetland buffer widths also correlate with plant biodiversity, including sensitive plants. The literature consistently documents greater habitat functions with greater buffer widths (Hruby 2013).

There are three alternatives for establishing wetland buffers presented in the current Ecology guidance for CAO updates (Ecology 2022). See Appendix A of this report, for a detailed summary. These options assume that wetland buffer areas are well vegetated with native species. Furthermore, the buffer options presented in this guidance document are based on a moderate-risk approach to protecting wetland functions (Ecology 2022).

Mitigation Sequencing

Mitigation sequencing is the structured process of avoiding, minimizing, and mitigating all impacts to a particular resource. It can be applied to many critical area types and their associated buffers or setbacks and is implemented to prevent the net loss of critical area functions and values. This process is included in the Wetland Guidance for CAO Updates (Ecology 2022). It includes the following, to be applied in this order (WAC 197-11-768):

- Avoiding the impact altogether by not taking a certain action or parts of an action;
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;

- Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and/or
- Monitoring the impact and taking appropriate corrective measures.

COMPENSATORY MITIGATION

When wetland impacts are unavoidable, mitigation is required to ensure no net loss of wetland functions. The interagency guidance document, *Wetland Mitigation in Washington State, Part 1—Agency Policies and Guidance* (Ecology, the Corps, and EPA 2021), is considered BAS for wetland mitigation, and it is incorporated into the *Wetland Guidance for CAO Updates* publication (Ecology 2022). As described in that document, a number of factors should be considered when developing a compensatory mitigation plan including but not limited to programmatic vs permittee-responsible mitigation approaches, concurrent vs advanced mitigation timing, mitigation method (e.g., restoration, creation, enhancement), mitigation site location, and mitigation site area. Other considerations like compensation site buffer widths, invasive species, beavers, and climate change are also covered in this comprehensive guidance document (Ecology, the Corps, and EPA 2021).

There is risk associated with compensatory mitigation, which is why mitigation sequencing and using the strategies discussed in Wetland Mitigation in Washington State, Part 1 (Ecology, the Corps, and EPA 2021) are important. Studies in 2002 and 2008 found that most wetland mitigation does not fully replace impacted functions and falls short of the goal of no net loss (Johnson, et al. 2002, ESA and Ross & Associates Environmental Consulting, Ltd 2008). In a status and trends report, continued loss of wetland area in coastal U.S. regions was documented from 2004 to 2009 (Dahl and Stedman 2013). Actions Ecology recommends to improve mitigation success rates include requiring mitigation sequencing, developing and implementing a variety of compensatory mitigation tools, thorough review of mitigation plans, and monitoring to ensure establishment (Ecology 2008, Ecology, the Corps, and EPA 2021) (Ecology, the Corps, and EPA 2021). Furthermore, in Compensating for Wetland Losses Under the Clean Water Act (National Research Council 2001), the following factors are identified as reducing the risk of mitigation failure: detailed functional assessment, high success standards, detailed mitigation plans, larger bonds with up-to-date market values, high replacement ratios, and greater expertise.

MONITORING AND MAINTENANCE

Compensatory mitigation sites typically require performance standard monitoring for a 3- to 10-year period, to ensure that they provide the functions which were planned. Most local governments in the Puget Sound region require a minimum of 5 years of maintenance and monitoring. There are few studies of long-term compliance with performance standards, and one assessment found a reduction in site compliance 8 to 20 years following installation (Van den Bosch and Matthews 2017).

Additional Protection Options

This section considers additional ways in which wetlands may be protected, beyond the protection standards already incorporated into reference guidance documents, noted in the previous section.

Current wetland protection standards (Ecology 2022) utilize a moderate-risk approach to wetland protection, meaning there is a moderate risk that wetland functions would be impacted when these standards (primarily buffers) are applied. The BAS review indicates that wetlands are highly valuable for anadromous fish and climate resilience, and vulnerable to climate change. As noted by Environmental Science Associates (ESA) in their report (ESA 2023):

Despite expected impacts to wetlands due to climate change […], an interview with Ecology staff revealed [that there are] no implemented planning efforts related to adapting buffer or other regulations in anticipation of drought impacts on wetlands. In Tacoma, it is more likely that forested buffers around wetlands will be affected by drought and extreme heat events.

The City may consider the following options for additional wetland protections:

- Increase the minimum standard for City projects from a goal of no net loss of ecological functions to a net gain of ecological functions.
- Update the City's wetland inventory database and identify vulnerable wetland types that may warrant increased protections (e.g., bogs, tidal wetlands, freshwater wetlands supported by surface water):
  - "Conduct additional studies to reduce the uncertainty around the vulnerability of wetlands in the City, including detailed spatial mapping. Collect GIS spatial data and identify the hydroperiod or hydrogeomorphic typology of Tacoma's freshwater wetlands in the City" (City of Tacoma 2016).
  - "Study the sedimentation/marsh aggradation of specific tidal wetlands" (City of Tacoma 2016).
- Incorporate climate resiliency into mitigation sequencing.
  - Consider the loss of wetland functions in the landscape within the context of climate change during mitigation sequencing.
  - Incorporate climate change impacts into mitigation and restoration planning.
    - "Greater resilience can be built into habitat restoration projects by planning for transition zones, allowing for greater seasonality in hydrologic performance and targets, and considering higher peak flows for restored wetland and stream systems. It will also be important to establish stronger, more resilient landscapes in open spaces by increasing plant diversity, extending establishment periods, and adding more habitat type" (City of Tacoma 2016).
    - Encourage use of climate resilient plants in mitigation or restoration sites and limit use of species vulnerable to climate change stresses and pests.
    - Allow assisted migration for seed selection of native plants from locations that are better adapted to future climate conditions.

- Increase compensatory mitigation area monitoring requirements to more than 5 years as warranted by mitigation site location, project goals, and objectives.
- Require applicants to document compliance with all applicable local, state and federal permit requirements.

3 CRITICAL AQUIFER RECHARGE AREAS

3.1 Definition

Critical aquifer recharge areas (CARAs) are defined in WAC 365-190-030(3) as follows:

Critical aquifer recharge areas are areas with a critical recharging effect on aquifers used for potable water, including areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water, or is susceptible to reduced recharge.

In Tacoma, "aquifer critical recharging areas" are (TMC 13.01.110.A):

Areas that, due to the presence of certain soils, geology, and surface water act to recharge groundwater by percolation.

CARAs contrast with other critical areas, like wetlands, in several key ways that are helpful to consider in this section:

- CARAs are defined by conditions underground which makes identifying their location and extent more challenging than other critical areas like wetlands, which are defined by conditions on the surface of the soil.
- CARAs may include both developed and undeveloped lands, while wetlands are always undeveloped.
- CARAs are critical areas based on their susceptibility to changes in water quality and quantity because clean drinking water is such an important product of the hydrologic processes in these areas. In contrast, wetlands are critical areas because of the many beneficial functions and services they provide.

3.2 Functions and Values

The goal of establishing CARAs is to protect the quantity and quality of a community's drinking water. Clean drinking water in aquifers is the product of beneficial ecosystem services in a watershed.

The primary function of CARAs is to recharge, or supply, aquifers with groundwater through percolation. Water for aquifer recharge can come from rainfall, snowmelt, lakes, rivers, streams or wetlands. Aquifer discharge occurs when water leaves an aquifer and is discharged to surface water (e.g., seeps, springs, wetlands, streams, lakes, estuaries, and shorelines) or extracted by wells or other means. The amount of water available for aquifer recharge is influenced by groundwater sources, aquifer storage capacity, aquifer discharge, and changes from land use and human activities. Land use and development typically alter the dynamics of aquifer recharge within a basin by altering vegetative cover, removing, and destroying native soil structure, modifying surface drainage patterns, and adding impervious and nearly impervious surfaces, such as roads and other compacted soils.

While aquifer recharge areas function to replenish groundwater supplies, they can also serve as a conduit for the introduction of contaminants to groundwater and aquifers. Vulnerability of contamination to public water supply is primarily influenced by two factors, the history of contamination loading and hydrogeologic susceptibility of the aquifer (DOH 2017). To be considered vulnerable, an aquifer would need to be both susceptible and have significant contamination loading.

Contamination loading refers to the quantity and types of pollutants present in an area, including exposure concentration, frequency, and chemical composition. Aquifer susceptibility refers to how easily water and pollutants can move from the surface through the ground to reach the underlying aquifer. There are many factors which influence susceptibility including the following (Ecology 2021, Eberts, Thomas and Jaguicki 2013):

Characteristics of the vadose zone including depth to water table and travel time. Travel time is influenced by hydrogeological factors including material composition and preferential flow paths

- Permeability
- Infiltration rate
- Chemical retardation
- Adsorption
- Hydraulic conductivity
- Hydrologic and pressure gradients
- Groundwater flow direction
- Groundwater flow rate

Special Consideration for Anadromous Fish

As stated previously, groundwater can be supported by aquatic resources like streams and wetlands (i.e., recharge sources). Streams and wetlands can also be locations of groundwater discharge. Since groundwater can be an important component of stream flow, CARAs are important for maintaining the groundwater supply for streams, especially during dry periods. The role CARAs play in maintaining stream flows directly benefits salmon and other anadromous species. Similarly, preventing groundwater contamination is important for fish and wildlife because they also rely on clean water.

Climate Change Effects

While more research is needed to understand past and future changes in groundwater within the context of climate change (Ecology 2024), groundwater is believed to be more resilient to the effects of climate change relative to surface water resources (City of Tacoma 2016). The

Tacoma Climate Change Resilience Study concludes that projected overall annual precipitation volumes are likely to continue to adequately recharge local aquifers (City of Tacoma 2016).

Aquifers could be impacted by climate change in the following ways:

- Since surface water features like lakes, streams, and wetlands are also potential sources of groundwater recharge, hydrology impacts to these features from climate change may in turn impact groundwater availability.
- As noted in ESA's study for Tacoma (ESA 2023), "snowpack and snowmelt play an important role in groundwater recharge in Pierce County. Reductions in snowpack and more rapid melting of snow may decrease groundwater recharge and cause increased variability in groundwater supplies in the county (Pitz 2016)."
- Wildfires may introduce more particulates and contaminants into the environment, which settle on surface water and infiltrate into groundwater (Burton, et al. 2016, Mansilha, et al. 2020).
- Increased winter flooding increases the likelihood of overwhelming existing stormwater treatment facilities and flooding roads, thereby transporting contaminants into surface water, including local streams and wetlands that can infiltrate and contaminate aquifers (Mauger and Won, Expanding the ensemble of precipitation projections for King County. Report prepared for the King County Department of Natural Resources 2019).
- Rising sea levels increase the potential for saltwater intrusion into coastal aquifers (Mauger, Casola, et al. 2015).
- Demand for aquifers may increase during the hotter, dryer summers as community groundwater consumption levels change in response to precipitation levels and temperatures.

3.3 Key Protection Strategies

Identification, Delineation, and Classification

Like with any critical area, identifying and delineating CARAs is necessary for protecting functions and values, including public health and safety. "The quality and quantity of groundwater in an aquifer is inextricably linked to its recharge area" (Commerce 2023). However, identifying and delineating CARAs can be challenging because of the underground nature of this critical area. Current CARA guidance (Ecology 2021) provides a number of resources that may be used in identifying the location and extent of CARAs. The City of Tacoma is currently working with HDR on a groundwater analysis.

Characterizing CARAs based on susceptibility allows decision makers to protect drinking water resources in priority areas. Ecology recommends the following to classify CARAs (Ecology 2021):

- *Analyze the susceptibility of the natural setting where groundwater occurs.*
- *Inventory existing potential sources of groundwater contamination.*

- *Classify the relative vulnerability of groundwater to contamination events.*
- *Designate areas that are most at risk to contamination events.*

Current Protection Standards

Current Ecology CARA guidance protection recommendations include (2021):

- *Protect by minimizing activities and conditions that pose contamination risks.*
- *Ensure that contamination prevention plans and best management practices (BMPs) implemented and followed. Review BMPs for infiltration designs with water quality treatment. Stormwater control usually affects the vadose zone and seasonal water tables with low risk to deeper water supply aquifers. Some exceptions are those glacial outwash plains with extensive deposits of coarse gravels near the surface.*
- *Manage groundwater withdrawals and recharge impacts to maintain availability for drinking water sources and maintain stream base flow from groundwater to support in-stream flows, especially for salmon-bearing streams.*

Additional Protection Options

- Incorporate the findings and recommendations of the groundwater analysis currently being performed by HDR, previously noted.
- Manage stormwater to maintain groundwater recharge in CARAs. Utilize a 20-year planning horizon to manage supply and demand given climate trends and projections (Asinas, Raymond and Mehta 2022). Long-term planning can be increased beyond 20 years to improve resiliency.
- Design stormwater systems to better mimic natural systems and mitigate some of the functions lost elsewhere in the landscape due to changes in surface and groundwater inputs. For example, the use of roadside bioswales may be expanded. Stormwater treatment capacity may be increased as needed to protect water quality and manage water quantity. Adaptive management of stormwater system as needed to achieve intended functions (ESA 2023). Actions should be consistent with Tacoma's current municipal stormwater NPDES permit and the City's stormwater manual.
- Planning and implementing flood mitigation strategies can reduce the likelihood of contaminated runoff events.
- Preserve open space and concentrate urban development away from the most susceptible CARAs.
- If necessary, strengthen regulatory protection of CARAs. For example, the City may review the CARA mapping, determine the areas of highest risk to drinking water, and prioritize protection of those areas. The City can reduce the risk of groundwater contamination by prohibiting land uses that are high-risk within high-priority areas. Public outreach education on best management practices (BMPs) for spills and leaks can also be improved.
- Maintain updated CARA maps and classifications.

- Review regulatory requirements for reclaimed water use and temporary dewatering during construction to ensure adequate protections are in place. This may involve additional site-specific analysis or City-specific studies, such as the in-process groundwater analysis.
- Continue to modify public outreach efforts to educate residents about best practices in CARAs and promote water conservation and water use efficiency programs.
- Promote and incentivize low-impact development, specifically infiltration of clean runoff to support aquifer recharge.
- Balance growth and development with the preservation and restoration of open spaces and native vegetation tracts.
- Planning for increased flooding can reduce the likelihood of contaminated runoff events (ESA 2023)
- Continue to modify public outreach efforts to educate residents about best practices in CARAs and promote water conservation and water use efficiency programs (ESA 2023)

4 FREQUENTLY FLOODED AREAS

4.1 Definition

Frequently flooded areas (FFAs) are defined in WAC 365-190-030(8) as follows:

Frequently flooded areas are lands in the flood plain subject to at least a one percent or greater chance of flooding in any given year, or within areas subject to flooding due to high groundwater. These areas include, but are not limited to, streams, rivers, lakes, coastal areas, wetlands, and areas where high groundwater forms ponds on the ground surface.

In Tacoma, “flood hazard areas” are defined as follows (TMC 13.01.110.F):

Lands in a floodplain including areas adjacent to lakes, streams, oceans or other bodies of water lying outside the ordinary bank of the water body and which are periodically inundated by flood flow with a one percent or greater expectancy of flooding in any given year.

4.2 Functions, Values, and Hazard Characterization

Floods are events that can result in the destruction of property and loss of life but are also part of a natural ecological process that sustains river systems. Floods typically occur following large storm events but may also result from a release of impounded water, such as from a dam or levee failure, or beaver activity. FFAs are dynamic and ecologically productive environments that provide habitat for fish and wildlife and are an important component of watershed processes including:

- Flood water storage and conveyance,
- Nutrient and sediment deposition, and
- Mobilization of large woody debris.

Floodplains have been directly impacted by agriculture, residential development, and urbanization for centuries because the geographic locations tend to be well-suited for development during periods between floods. Floodplains have also been indirectly impacted by similar watershed-scale land use changes. Increased impervious surfaces and deforestation increase flooding magnitude and frequency (Booth, Hartley and Jackson 2002). Increased flooding magnitude and frequency create greater risk for people and infrastructure within a floodplain. Historically, approaches to mitigate floodplain risks have worsened downstream flood impacts and impacted fish and wildlife habitat (e.g., channel straightening and armoring, construction of dikes and levees, and floodplain fill). Continuing to manage risks from flooding to people and infrastructure in an urban city like Tacoma is important for public health and safety.

Special Consideration for Anadromous Fish

FFAs commonly occur along salmon bearing streams and marine shorelines, where the protection of natural systems and processes like flooding directly benefit fish and wildlife habitat, including habitat for anadromous fish.

Extreme floods impose both positive and negative effects on stream health, and therefore on anadromous fish habitat. Potential flood impacts include physical trauma and stress to aquatic organisms, displacement or stranding, erosion and sedimentation, loss of vegetation, pollution, disruptions to food webs and spawning, and disrupted migration. As a result, extreme floods have been documented to reduce fish densities (Milner, et al. 2013). However, some studies show that fish assemblages are resilient to the effects of floods at a basin scale and recover quickly (George, et al. 2015). Positive effects of flooding on anadromous fish include the creation of new habitats in the form of side channels and pools, mobilization of large woody debris, and nutrient redistribution (Peters, et al. 2015).

Climate Change Effects

Climate change in the Pacific Northwest is anticipated to result in wetter autumns and winters and drier summers (Mote and Salathe 2010). Climate change models predict that the frequency of atmospheric rivers, which contribute to intense deluges in rainwater and other extreme weather events, will become more frequent and severe (Mauger and Kennard 2017, Salathe, et al. 2014). Greater flood risks are predicted as a result of the increased precipitation paired with the increased frequency and intensity of extreme weather events (Ecology 2021). The resulting increase in floodwater elevation and expansion of floods to new areas is a risk to property and public safety.

Flood magnitude and frequency are predicted to increase in Pierce County, leading to greater risk and impacts to public safety, infrastructure, and riverine ecosystems (Pierce County 2023). High risks are associated with the increased potential for the Puyallup River to overtop levees near Tacoma, which could result in severe impacts to people and infrastructure (including Interstate 5). Frequency and duration of inundation along marine shorelines is also expected to increase. The adaptive capacity and resilience of flood areas associated with the Puyallup River and marine shorelines is low due to substantial development that surrounds these areas (City of Tacoma 2016).

4.3 Key Protection Strategies

Identification, Delineation, and Classification

The Federal Emergency Management Agency (FEMA) maintains and updates flood maps, called Flood Insurance Rate Maps (FIRM). FEMA flood maps include any place considered to have a high risk of flooding, which is a one percent chance of flooding each year, or higher. FEMA maps are based on past flood events and do not include sea level rise or other climate impacts (Commerce 2023).

Current Protection Standards

The National Flood Insurance Program (NFIP), administered by FEMA, publishes basic building standards that can be implemented to protect both floodplain ecological functions and buildings, infrastructure, and people from flood risk. These standards are generally the minimum required, and local jurisdictions may choose to implement higher standards to further reduce risk (Commerce 2023).

In addition to managing flood risks through critical area protection standards, the City of Tacoma manages risk through the Stormwater Asset Management Program and under the Stormwater Municipal National Pollutant Discharge Elimination System (NPDES) Permit. Furthermore, the City's Stormwater Management Manual (City of Tacoma 2021) (and as revised) contains minimum requirements and technical standards for stormwater management, which aim to minimize flooding and protect water quality associated with development proposals.

Additional Protection Options

Commerce's Critical Areas Handbook (2023) presents the following as an optional strategy to help local governments plan for flood risk:

Ecology's RiskMAP ("risk mapping assessment and planning") program provides additional maps that can help local governments plan for flood risk in their communities. It integrates several regulatory and nonregulatory products for hazard mitigation planning, including FEMA's National Flood Hazard Layer, 1000-year floodplain maps, depth grids (expected depth of flooding from a 100-year event), earthquake layers, landslide inventories, and building footprints for residential and critical facilities buildings. It also includes project data for RiskMAP assessment projects in certain counties. Maps of the 1000-year floodplain are included; floods of this magnitude are becoming more common with climate change and wildfires, and more communities are starting to plan for 500-year and 1000-year floods (instead of just 100-year floods). Communities may also see areas with urban flooding due to inadequate storm drainage, or issues with groundwater flooding or high sediment loads in certain streams causing them to meander into new areas. One of the most popular non regulatory products developed through RiskMAP is map of the base flood elevation plus one, two and three feet. Base flood elevation is how high FEMA statistically predicts the water to rise in a 100-year flood event. This helps local communities understand the inundation in low lying areas. The map also shows information about buildings from local assessor's offices, like occupancy, use, value, and materials. It has a GIS model that was developed by FEMA to estimate damage to structures from a 100-year flood or an earthquake.

A number of recommendations and adaptation strategies were included in Tacoma's Climate Change Resilience Study (2016):

- Conduct various local studies to better understand future flood risks and sea level rise on City infrastructure.
- Learn more about the geologic and geomorphic characteristics of streams to help determine susceptibility to increases in peak flow.
- Consider ways to adapt wastewater and surface water systems to reduce flood exposure and flood sensitivity.
- Reestablish historical drainage pathways to reduce flood risk, potentially by acquiring high flood-risk properties.
- Identify where "managed retreat" of armoring or infrastructure could occur in response to predicted sea level rise.

The City could also consider utilizing the FEMA Climate Resiliency approach to support flood hazard management and mitigation planning and follow grant funding opportunities (Mauger and Kennard 2017, FEMA 2022).

Lastly, the Pierce County 2023 Comprehensive Flood Hazard Management Plan (Pierce County 2023), Tacoma's Municipal Stormwater NPDES Permit and the Urban Watershed Protection Plan (City of Tacoma 2024) include stormwater management actions that are aimed to prevent flooding and improve climate resiliency among other purposes.

5 GEOLOGICALLY HAZARDOUS AREAS

5.1 Definitions

Washington State defines geologically hazardous areas in WAC 365-190-030(9) as follows:

"Geologically hazardous areas" are areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to siting commercial, residential, or industrial development consistent with public health or safety concerns.

Similarly, Tacoma's definition includes (TMC 13.01.110.G):

Areas that may not be suited to development consistent with public health, safety or environmental standards, because of their susceptibility to erosion, sliding, earthquake, or other geological events as designated by WAC 365-190-080(4). Types of geologically hazardous areas include: erosion, landslide, seismic, mine, and volcanic hazards.

Per TMC 13.11.710, the following are designated as geologically hazardous areas in Tacoma:

- Erosion hazard
- Landslide hazard
- Seismic hazard and tsunami hazard
- Mine hazard
- Volcanic hazard

Erosion Hazard Areas

According to WAC 365-190-030(5), erosion hazard areas "are those areas containing soils which, according to the United States Department of Agriculture Natural Resources Conservation Service Soil Survey Program, may experience significant erosion. Erosion hazard areas also include coastal erosion-prone areas and channel migration zones."

In Tacoma, erosion hazard areas are defined as "areas which contain soils classified by the United States Department of Agriculture Soil Conservation Service that may experience severe to very severe erosion hazards" (TMC 13.01.110.E).

Landslide Hazard Areas

According to WAC 365-190-030(10), landslide hazard areas "are areas at risk of mass movement due to a combination of geologic, topographic, and hydrologic factors."

In Tacoma, landslide hazard areas are defined as “areas potentially subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include areas susceptible because of any combination of bedrock, soil, slope aspect, structure, hydrology, or other features” (TMC 13.01.110.L).

Seismic Hazard Areas and Tsunami Hazard Areas

According to WAC 365-190-030(18), seismic hazard areas “are areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction, debris flows, lahars, or tsunamis.”

In Tacoma, seismic hazard areas are defined as “areas subject to severe risk damage as a result of seismic induced settlement, shaking, lateral spreading, surface faulting, slope failure or soil liquefaction. These conditions occur in areas underlain by soils low cohesion or density usually in association with a shallow groundwater table. Seismic hazard areas shall be defined by the Washington Department of Ecology Coastal Zone Atlas (Seismic Hazard Map prepared by GeoEngineers) as: Class U (Unstable), Class UOS (Unstable old slides), Class URS (Unstable recent slides, Class I (intermediate) and Class M (Modified) as shown in the Seismic Hazard Map” (TMC 13.01.110.S).

In Tacoma, tsunami hazard areas are defined as “coastal areas and large lake shoreline areas susceptible to flooding and inundation as the result of excessive wave action derived from seismic or other geologic events. Currently, no specific boundaries have been established in the City of Tacoma limits for this type of hazard area” (TMC 13.01.110.T).

Mine Hazard Areas

According to WAC 365-190-030(12), mine hazard areas “are those areas directly underlain by, adjacent to, or affected by mine workings such as adits, tunnels, drifts, or air shafts.”

In Tacoma, mine hazard areas are defined as “those areas underlain by or affected by mine workings such as adits, gangways, tunnels, drifts, or airshafts, and those areas of sink holes, gas releases, or subsidence due to mine workshops. Underground mines do not presently exist within the City of Tacoma” (TMC 13.01.110.M).

Volcanic Hazard Areas

According to WAC 365-190-030(21), volcanic hazard areas “shall include areas subject to pyroclastic flows, lava flows, and inundation by debris flows, lahars, mudflows, or related flooding resulting from volcanic activity.”

In Tacoma, the following definition for volcanic hazard areas appears incomplete: "Areas subject to pyroclastic flows, [sic]" (TMC 13.01.110.V).

5.2 Hazard Characterization

Geologically hazardous areas in urban settings that are vegetated have the potential to provide the basic ecological functions associated with any vegetated area (for example, wildlife habitat, water interception and absorption, and water infiltration). However, these features are regulated as critical areas primarily to protect public health and safety.

Erosion and landslides are natural processes that move sediment, rocks, and large woody debris downslope, often to streams and other waterbodies. The movement of these materials is affected by several factors including:

- Slope grade and topography
- Sediment composition and geology
- Vegetation composition, structure, and cover
- Hydrology
- Development activities and land use changes

Seismic hazard areas are a function of the geological setting. Tacoma is located in an area of high seismic activity, as are all areas of western Washington. Therefore, nearly all areas in Tacoma have some level of risk associated with ground shaking caused by an earthquake. While seismic events cannot be predicted, the areas with the greatest risk to public health and safety occur where risks from secondary earthquake effects are also high. Secondary effects include: liquefaction; landslides and mudflows; dam or levee failure; fires; or flooding from tsunamis (Pierce County 2020).

Tacoma is located within approximately 60 miles of Mount Rainier, one of five major volcanos in Washington State. Volcanic events cannot be predicted, but areas of high volcanic hazard in Tacoma occur along the Puyallup River Valley. The Puyallup River originates on Mount Rainier, making it susceptible to lahars (volcanic mudflows).

Special Consideration for Anadromous Fish

Natural rates of material movement downslope through erosion and landslides, and the frequency of those events in undisturbed conditions, do not significantly impact streams and fish habitat (Knight 2009). However, activities such as clearing vegetation and the creation of new impervious surfaces can introduce sediments and pollutants to natural waterways (Booth 1991), which impact anadromous fish. The introduction of periodic pulses or chronic turbidity and suspended solids associated with erosion has been demonstrated to harm certain types of aquatic life, particularly salmonids (Bash, Berman and Bolton 2001).

Marine bluffs naturally function to provide beach material nourishment which is important for salmon habitat in the nearshore environment (Knight 2009).

Climate Change Effects

Climate change is not currently predicted to affect the frequency or severity of earthquakes or volcanic eruptions. However, erosion and landslide hazard areas are anticipated to be influenced by climate change. Climate change models project warmer, drier summers, and increased precipitation in other seasons (Dalton, Mote and Snover 2013). Extreme precipitation events modeled by the UW Climate Impacts Group are expected to increase in intensity and frequency (Mauger and Won 2019). Increased magnitude and frequency of rain events can lead to over-saturated soils and contribute to slope instability in hazard areas. Consequentially, geologic hazard risks are anticipated to increase because rainfall intensity and duration are known indicators of landslide events (DNR 2020).

Additionally, the severity and frequency of wildfire is expected to increase, heightening susceptibility to erosion and landslide hazards (Mauger, Casola, et al. 2015). The risk of flash floods and debris flows increases following wildfires due to changing hydrologic characteristics in landscapes with bare soils and lacking vegetation (DNR n.d.).

Changing climate is also anticipated to affect vegetation community composition and native plant mortality due to shifts in plant hardiness zones and species ranges (Lenoir and Svenning 2014). Existing species assemblages, canopy types, and root systems may be disrupted and displaced by invasive species. Opportunistic invasive plants often have shallow root systems and short lifespans that are less effective at anchoring soils than native counterparts. Himalayan blackberry, for example, is a widespread invasive plant likely to displace lost plants and has shallow root system and can cause soil erosion by preventing the establishment of native plant species (Gaire, et al. 2015). High levels of plant diversity also generally improve soil stability by combining multiple depths and forms of root architecture (Ghestem, et al. 2014).

ESA also notes the following effects (2023):

- Drier conditions and soils are likely to increase landslide risk by widening gaps in rocks and soils (Mauger, Casola, et al. 2015).
- Increased [volume and velocity of] streamflow may cause more aggressive channelization of waterways and increase bank instability (Mauger, Casola, et al. 2015).
- Coastal bluffs and areas that are subject to tidal influence [including king tides and storm events] will likely experience greater rates of erosion with sea level rise (Mauger, Casola, et al. 2015, Huppert, Moore and Dyson 2009).

5.3 Key Protection Strategies

Identification, Delineation, and Classification

The Washington Geologic Information Portal is the first resource that local governments should consult for identifying and designating geologically hazardous areas (Commerce 2023).

Current Protection Standards

Protection measures for geologic hazard areas focus on protecting people and property. This may occur through emergency response and early warning system and risk management through planning and development considerations. Risks are commonly minimized by limiting occupancy and development in geologically hazardous areas. This risk of development in geologic hazard areas is typically evaluated with classification systems to inform site development restrictions and requirements. A common method to manage risk is the use of buffers around geologic hazard areas to restrict development in hazard areas. For development in erosion hazard or landslide hazard area, design and construction standards are necessary to prevent the development from reducing slope stability and ensuring that development is resilient to potential hazards. Any such development in the hazard area or its buffer should be evaluated on a site-specific basis by a licensed geotechnical engineer or engineering geologist to ensure hazard mitigation is adequate. Site study methods should adhere to best professional standards and include subsurface exploration and testing of soils at an appropriate frequency across the site, as necessary.

Additional protection strategies were identified by the SR-530 Landslide Commission following the Oso mudslide that occurred in March 2014. Recommendations from the commission include integrating and funding Washington's emergency management system, supporting a statewide landslide hazard and risk mapping program, establishing a geologic hazards resilience institute, conducting landslide investigations, and advancing public awareness of geologic hazards. Integrating Washington's emergency management system would bring together, "the Governor's office, the [state] Legislature, tribes, county and municipal government, first responders, transportation agencies, non-government support agencies, the private sector, and members of the public" (The SR 530 Landslide Commission 2014). To improve landslide hazard and risk mapping, collaboration among agencies and landowners is recommended along with risk prioritization, utilization of lidar mapping and GIS database tools.

Per the SR-530 Landslide Commission's 2014 findings, updates to critical area regulations are recommended to better identify and regulate land uses in geologic hazard areas. This may include requiring geologic risk assessments as part of subdivision permit application reviews, slope-density regulations, conservation easements, and grading ordinances. Slope-density calculation is a method for determining the number of allowable development units of subdivisions with geological hazards. Usually the steeper the slope, the fewer the number of units permitted.

Seismic hazards can be managed by applying earthquake-resistant building standards to at-risk areas. The Washington State Building Code (WAC 51-50) offers guidance from the 2018 International Existing Building Code with amendments specific to the state, including several directly related to seismic standards.

Additional Protection Options

- Encourage or require climate-informed design for development and infrastructure in or near geologic hazard areas (DNR 2020). Infrastructure management may include review to address landslide and erosion hazards to roads and infrastructure (ESA 2023).
- Require appropriate surface and ground water management practices for development near coastal bluffs (ESA 2023).
- Encourage utilization of soft shore protection strategies (ESA 2023).
- Encourage retreat and increased setbacks for bluff top development (ESA 2023).
- Identify and prioritize geologic hazards within the City, then update mapping as needed using current practices such as LiDAR and GIS database tools (ESA 2023).
- Keep in communication with the governor's office to ensure Tacoma is included in statewide collaborative efforts to manage geologic hazard areas (ESA 2023).
- Manage vegetation for climate resilience and slope stability.

Some specific recommendations from the Tacoma Climate Change Resilience Study (City of Tacoma 2016) include:

- *Evaluate development surrounding steep slopes to ensure that development practices do not either (1) put people or property at risk of harm, or (2) disconnect a vital sediment source from the nearshore. Extend development restrictions and/or setbacks in these areas to provide additional protection from future climate-related risks.*
- *Adjust and/or amend the Critical Areas Ordinance and drainage code under development regulations to build resilience to increased landslides and flooding. Current regulations and ordinances were developed under a current landslide and flood risk scenario. These requirements should be updated to reflect future changes in risk due to climate change.*

6 FISH AND WILDLIFE HABITAT CONSERVATION AREAS

6.1 Definition

Washington State defines fish and wildlife habitat conservation areas (FWHCAs) in WAC 365-190-030(6) as follows:

(a) "Fish and wildlife habitat conservation areas" are areas that serve a critical role in sustaining needed habitats and species for the functional integrity of the ecosystem, and which, if altered, may reduce the likelihood that the species will persist over the long term. These areas may include, but are not limited to, rare or vulnerable ecological systems, communities, and habitat or habitat elements including seasonal ranges, breeding habitat, winter range, and movement corridors; and areas with high relative population density or species richness. Counties and cities may also designate locally important habitats and species.

(b) "Habitats of local importance" designated as fish and wildlife habitat conservation areas include those areas found to be locally important by counties and cities.

(c) "Fish and wildlife habitat conservation areas" does not include such artificial features or constructs as irrigation delivery systems, irrigation infrastructure, irrigation canals, or drainage ditches that lie within the boundaries of, and are maintained by, a port district or an irrigation district or company.

The following FWHCAs must be considered for classification and designation (WAC 365-190-130):

(a) Areas where endangered, threatened, and sensitive species have a primary association;

(b) Habitats and species of local importance, as determined locally;

(c) Commercial and recreational shellfish areas;

(d) Kelp and eelgrass beds; herring, smelt, and other forage fish spawning areas;

(e) Naturally occurring ponds under 20 acres and their submerged aquatic beds that provide fish or wildlife habitat;

(f) Waters of the state;

(g) Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity; and

(h) State natural area preserves, natural resource conservation areas, and state wildlife areas.

In Tacoma, FWHCAs are “areas identified as being of critical importance to the maintenance of fish and wildlife species. FWHCA Marine Habitat Buffers are vegetated setbacks from the shoreline measured from the Ordinary High Water Mark” (TMC 13.01.110.F).

Existing Tacoma FWHCAs types generally include the types listed previously under WAC 365-190-130, although streams are considered a stand-alone critical area, under TMC 13.11.400. The City currently incorporates Priority Habitats and Species (PHS), as designated by Washington Department of Fish and Wildlife (WDFW), in their FWHCA classification system. PHS could be added as a type of FWHCA under this section. City staff have recognized Oregon white oak (Quercus garryana) areas and Biodiversity Areas and Corridors as the most common terrestrial Priority Habitat types present within the city.

6.2 Functions and Values

FWHCA functions include the biological, chemical, and physical processes that affect wildlife. Since wildlife may include all species, from the largest megafauna to microorganisms, these functions encompass a complex web of interacting ecological processes. At the highest level, FWHCAs provide wildlife with suitable habitat. They also provide communities with sources of food and materials for consumptive and productive uses and are valued for a range of cultural, social, and economic benefits. A few commonly recognized functions and processes that influence the habitat condition within FWHCAs are listed below. These are briefly summarized and not comprehensive.

- Vegetation composition and structure
- Hydrologic functions: flood water storage, surface and groundwater exchanges
- Shade and microclimate
- Dynamic processes and conditions, including large woody debris recruitment to streams, riparian detrital nutrient inputs, salmon spawning, and wetland/floodplain connectivity
- Water quality functions
- Habitat corridors and connections
- Habitats and species of local importance: significant oak stands, marine and saltwater habitats, etc.

Special Consideration for Anadromous Fish

One key purpose of designating FWHCAs as critical areas is to protect important habitat necessary for threatened and endangered species including salmon. FWHCAs, specifically those including streams and riparian areas, are critical for functioning salmon habitat and special consideration for anadromous fish is incorporated into the designation of this critical area type.

Climate Change Effects

Climate change is predicted to result in significant and irreversible impacts to fish and wildlife, and their habitats. Modeled changes include habitat loss and modification through temperature changes, sea level rise, ocean acidification, extreme weather events, changes in precipitation, biological invasions, food web disruptions, and disease (Nagelkerken, et al. 2023). The range of effects on fish and wildlife depend on species specific interactions and may include range shifts, phenological shifts, changes to morphology and behavior, biodiversity loss, and extinction (Sattar, et al. 2021). The cumulative impacts of these factors to wildlife are anticipated to result in loss of biodiversity and increases to extinction rates (Sattar, et al. 2021).

The stresses of climate change, primarily warmer and drier summers, stress native plants and are likely to cause a reduction in riparian vegetation. This potentially triggers a cascading effect. A decrease in riparian vegetation would decrease shading, increase stream temperature, decrease detrital inputs, reduce available habitat structure, and reduce stream bank stability. Changes in seasonal hydrologic cycles may increase frequency and magnitude of flashy stormwater runoff events and floods, mobilize greater volumes of sediments and pollutants into streams, and reduce groundwater recharge that supports base stream flows in summer.

Hot dry summers are projected to reduce stream flow volumes and increase instream temperatures. This stressor is compounded by extreme precipitation events, flooding, and erosion. All these stressors reduce instream habitat quality and stress salmonid populations. Global warming poses a threat to freshwater fish habitat (Crozier, Zabel and Hamlet 2008).

6.3 Key Protection Strategies

Identification, Delineation, and Classification

Numerous online resources are available that can be used to aid in determining likely presence or absence of the various types of FWHCAs. Several important online mapping tools are listed below; however, this list is not exhaustive. Not all FWHCAs are mapped, and anything identified online should be verified in the field by a qualified biologist.

- National Oceanic and Atmospheric Administration (NOAA) Fisheries Maps
- U.S. Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPaC) online tool
- WDFW Priority Habitats and Species Database (PHS on the Web)
- Washington State Department of Natural Resources (DNR) Natural Heritage Program Data Explorer

Waters of the State

Waters of the state include lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, wetlands and all other surface waters and watercourses (RWC 90.48.020, WAC 173-201A-020). The ordinary high water mark (OHWM) is typically used to determine the edge of surface waters for jurisdictional purposes. However, for tidal waters, the Corps uses the high tide line to determine jurisdiction, while Ecology uses the OHWM if present or the line of mean higher high tide if the OHWM cannot be found. The definition of OHWM is slightly different between the Corps and Ecology, but the meaning is essentially the same. The OHWM should be determined in the field by a qualified biologist using one of the following manuals:

- *National Ordinary High Water Mark Field Delineation Manual for Rivers and Streams* (David, et al. 2025)
- *Determining the Ordinary High Water Mark for Shoreline Management Act Compliance in Washington State* (Anderson, et al. 2016)

Aquatic areas are classified so that they can be managed and regulated based on their characteristics, fish use, and functions using the state's water typing system (WAC 222-16-030), summarized in Table 1. Characteristics common to water typing systems are flow volume, fish use and accessibility, seasonality, and the presence of salmonids.

The current riparian management zone guidance from WDFW does not use a water typing system but instead treats all streams equally and differentiates protection based on soil type and associated dominant tree species (Rentz et al. 2020). This is discussed further in Section 6.3.2.1.

Table 1: Water type classifications

Type	Description
Type S = Shoreline	Streams and waterbodies that are designated "shorelines of the state" as defined in chapter 90.58.030 RCW.
Type F = Fish	Streams and waterbodies that are known to be used by fish, or meet the physical criteria to be potentially used by fish. Fish streams may or may not have flowing water all year; they may be perennial or seasonal.
Type Np = Non-Fish	Streams that have flow year-round and may have spatially intermittent dry reaches downstream of perennial flow. Type Np streams do not meet the physical criteria of a Type F stream. This also includes streams that have been proven not to contain fish using methods described in Forest Practices Board Manual Section 13.
Type Ns = Non-Fish Seasonal	Streams that do not have surface flow during at least some portion of the year, and do not meet the physical criteria of a Type F stream.

Priority Species and Habitats

WDFW manages the PHS List (WDFW 2008), which includes species and habitats that are not covered under other state and federal protection mechanisms. WDFW regularly updates the

PHS List and provides accompanying management recommendations for PHS included in the list. In Tacoma, Oregon white oak priority habitat and biodiversity areas and corridors are some of the more common priority habitat types encountered. WDFW's management recommendations for these priority habitats are currently provided in the following documents:

Management recommendations for Washington's priority habitats: Best management practices for mitigation impacts to Oregon white oak priority habitat (Nolan and Azerrad 2024)

Landscape Planning for Washington's Wildlife: Managing for Biodiversity in Developing Areas (A Priority Habitat and Species Document) (WDFW 2009)

Current Protection Standards

WDFW Riparian Management Zones for Rivers and Streams

In 2020, the WDFW developed BAS guidance for the protection of riparian areas (Rentz, et al. 2020). The guidance emphasizes a shift in terminology and framework from the concept of "stream buffers" to "riparian management zones" (RMZs). A RMZ is defined as "…a scientifically based description of the area adjacent to rivers and streams that has the potential to provide full function based on the SPTH [site potential tree height] conceptual framework." Further, a RMZ is recommended to be regulated as a fish and wildlife habitat conservation area itself to protect its fundamental value, rather than as a buffer for rivers and streams (Rentz, et al. 2020). Stream buffers currently established in many local critical area ordinances are intended to protect streams but may or may not provide full riparian function. To achieve full riparian function, the guidance recommends that RMZs be considered a delineable, regulatory critical area and that the guidance be applied to all streams and rivers, regardless of size and type.

WDFW's current recommendations for establishing RMZ widths are based primarily on a site potential tree height framework. The site potential tree height is defined as "…the average maximum height of the tallest dominant trees (200 years or more) for a given site class." Exceptions may occur where the site potential tree height is less than 100 feet, in which case the agency recommends assigning an RMZ width of 100 feet at a minimum to provide adequate biofiltration and infiltration of runoff for water quality protection from most pollutants, but also in consideration of other habitat-related factors including shade and wood recruitment. A 100-foot-wide riparian buffer is estimated to achieve 95% pollution removal and approximately 85% surface nitrogen (Rentz, et al. 2020). WDFW recommends measuring RMZ widths from the outer edge of the Channel Migration Zone (CMZ), where present, or from the OHWM where a CMZ is not present (Rentz, et al. 2020).

To apply their recommendations, WDFW has developed a web-based mapping tool for use in determining site potential tree height based on the 200-year site index. Modeled site potential tree heights range from 75-231 feet. Where site potential tree height is 100 feet or more, the agency recommends RMZ establishment within one site potential tree height (Rentz, et al. 2020). Acknowledging that establishing functional RMZs using the recommended methods may not be practical in many developed areas, WDFW recommends effective watershed management, preservation, and protection, resulting in nearly full restoration of riparian ecosystem habitat functions as is feasible within existing constraints. Examples of watershed-scale approaches include considering stormwater management adjacent to pollution generating impervious surface areas and prioritizing replacement of impassable culverts on fish-bearing streams. For more detail, reference Riparian Ecosystems, Volume 2: Management Recommendations (Rentz, et al. 2020).

Alternative Protection Options for Rivers, Streams, and Riparian Areas

BAS-based literature points to a range of recommended management measures and buffer considerations to help maintain habitat functions for fish and wildlife. Effective methods to reduce impacts from urbanization and manage associated runoff can include the following:

- Limiting development densities and impervious surface coverage;
- Limiting vegetation clearing and retaining forest cover;
- Concentrating impact activities, particularly roads and pollutant sources, away from watercourses;
- Limiting the total area of roads and requiring joint use of new access roads;
- Protecting vegetation and limiting development on or near hydrologic source areas;
- Maintaining densely vegetated riparian buffers with native trees, shrubs, and groundcover species;
- Low impact development (LID);
- Municipal stormwater treatment equivalent or greater than NPDES Permit requirements;
- Public education.

If fixed-width buffers are implemented, buffers should be sufficiently wide to ensure that riparian buffers are effective under a range of variable conditions. Effective buffer widths vary based on a variety of site conditions, landscape position, and specific function being reviewed. .

Riparian studies often do not account for the contribution of engineering and public works projects, such as surface-water detention facilities, which can supplement natural riparian function in urban settings. To achieve improved water quality in the City's streams, small lakes, and ponds, riparian buffer areas should be utilized effectively to provide both biofiltration of stormwater runoff and protection from adjacent land uses. Both goals can be achieved by providing dense, well-rooted vegetated buffer areas. The City's stormwater management manual utilizes BAS and includes best management practices for vegetation (City of Tacoma 2021).

FEMA Floodplain Habitat Assessments for Listed Species

In 2008, the National Marine Fisheries Service (NMFS) issued a Biological Opinion under Section 7 of the Endangered Species Act, which found that the implementation of the National Flood Insurance Program (NFIP) in the Puget Sound region jeopardized the continued existence of federally threatened salmonids and resident killer whales. As a result, NMFS established Reasonable and Prudent Alternatives to ensure that development within the Special Flood Hazard Area (100-year floodplain), floodway, CMZ, and riparian buffer zone do not adversely affect water quality, flood volumes, flood velocities, spawning substrate, or floodplain refugia for listed salmonids. Because the NFIP is implemented by the Federal Emergency Management Agency (FEMA) through participation by local jurisdictions that adopt and enforce floodplain management ordinances, FEMA has delegated responsibility to the local jurisdictions to ensure that development does not adversely affect listed species. Projects within FEMA-designated floodplains are required to prepare habitat assessments to ascertain their potential effects on federally listed endangered species. In particular, floodplain storage volumes may not be decreased nor base flood level elevations increased.

Management Recommendations for Regulated Species and Habitats

State and federal species-specific management recommendations are available for endangered, threatened, and sensitive species, and for WDFW Priority Species and Habitats. These management recommendations (as revised) are considered effective BAS-based strategies to protect FWHCAs. The amount of information available in the management recommendations for each regulated species is variable, with some highly researched and others lacking in information and management guidelines. WDFW's management recommendations cover various habitats including riparian ecosystems, which are present throughout Tacoma (see previous discussion under Section 6.3.2.1). Oregon white oak priority habitat and Biodiversity Areas and Corridors are other important terrestrial habitats in Tacoma for which WDFW has developed and published associated management recommendations (Nolan and Azerrad 2024, WDFW 2009).

Additional Protection Options

The following actions or policies have been developed for other local jurisdictions in coordination with the University of Washington Climate Impacts Group and are potential strategies that Tacoma could use to reduce negative climate change impacts on FWHCAs (The Watershed Company 2022):

- Promote retention of trees and forests and maintain tree replacement and reforestation requirements.
- Encourage and incentivize enhancement and restoration of native forest patches throughout the City, particularly where connectivity to one or more FWHCAs is identified. Both voluntary and required restoration planting should be paired with monitoring and maintenance that allows for dry-season irrigation and adaptive management.
- Consider assisted migration for seed selection of native plants from locations that are better adapted to future climate conditions.

- A broader native plant species palette in regulated FWHCAs could be allowed to increase resilience of plant communities considering climate stressors as new scientific recommendations on native plant tolerances are published.
- Continue to manage stormwater infrastructure to avoid and minimize discharges of increased and/or untreated runoff to streams and thereby offset the anticipated increase in intensive rainfall events, which includes promoting the use of LIDs as a tool to effectively manage stormwater for minimal downstream impacts.
- Update and maintain regulations for habitats and species of local importance. This may include adding mapping resources to help identify the locations of potential habitats and species requiring protection and management.
- Prioritize and protect streams and riparian corridors to reduce the stresses of climate change on native fish species and anadromous fish, such as chinook salmon.
- Identify and protect cold water refugia in waterbodies.
- Conduct vulnerability assessments and climate action plans. This may include identifying areas and actions that yield the greatest ecological benefits, so the City can prioritize actions.
- Conduct additional studies to reduce uncertainty around the vulnerability of specific natural systems in the city, including through detailed spatial mapping. Research the geologic and geomorphic characteristics of streams in Tacoma and their susceptibility to increases in peak flow resulting from climate change (City of Tacoma 2016).

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