

TECHNICAL APPENDIX ◦ SEPTEMBER 2021

Eel River Valley Basin Surface Water Beneficial Use Assessment



P R E P A R E D F O R

GHD

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Cover photos clockwise from upper left: Van Duzen River near Carlotta (2020); Eel River downstream of the mouth of the Van Duzen River (2020); Van Duzen River alcove near Alton (2014); south abutment of Fernbridge (2017). All photographs taken by Stillwater Sciences.

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1 INTRODUCTION

This Technical Appendix for the Eel River Valley Groundwater Sustainability Plan (GSP) addresses the baseline conditions for surface water beneficial uses in the Eel River Valley Basin (ERVB) (Basin 1-010). The Sustainable Groundwater Management Act (SGMA) requires Groundwater Sustainability Agencies (GSAs) to consider the interests of all beneficial uses and users of groundwater, including surface water users if there is a hydrologic connection between surface and groundwater bodies (Water Code 10723.2). Furthermore, sustainable management criteria developed by the Humboldt County Groundwater Sustainability Agency (Humboldt County GSA) should avoid significant and unreasonable effects on beneficial uses of groundwater and interconnected surface water in the ERVB. Beneficial uses of surface water are listed in the Water Quality Control Plan (Basin Plan) for the North Coast Region (North Coast Regional Water Quality Control Board [NCRWQCB] 2018).

The information contained within this technical memorandum—when used in combination with the mapped groundwater dependent ecosystems (GDEs) (Stillwater Sciences 2021a), surface and groundwater hydrology, and hydraulic modeling—can be used to inform the development of sustainable management criteria for the ERVB. Because this memorandum and the groundwater model were developed concurrently, they will be synthesized in the final GSP, where the sustainable management criteria will be presented.

1.1 Groundwater Basin Setting

The ERVB is a coastal basin in western Humboldt County, located at the downstream end of the Eel River watershed and extending from the Pacific Ocean upstream through the lower reaches of the Eel and Van Duzen river valleys (Figure 1). The valley floor comprises the majority of the basin's 72,957-acre surface area and ranges in elevation from 0 to 30 feet above sea level (ft asl). The foothills that mark the basin's inland perimeter reach elevations of up to 300 ft asl.

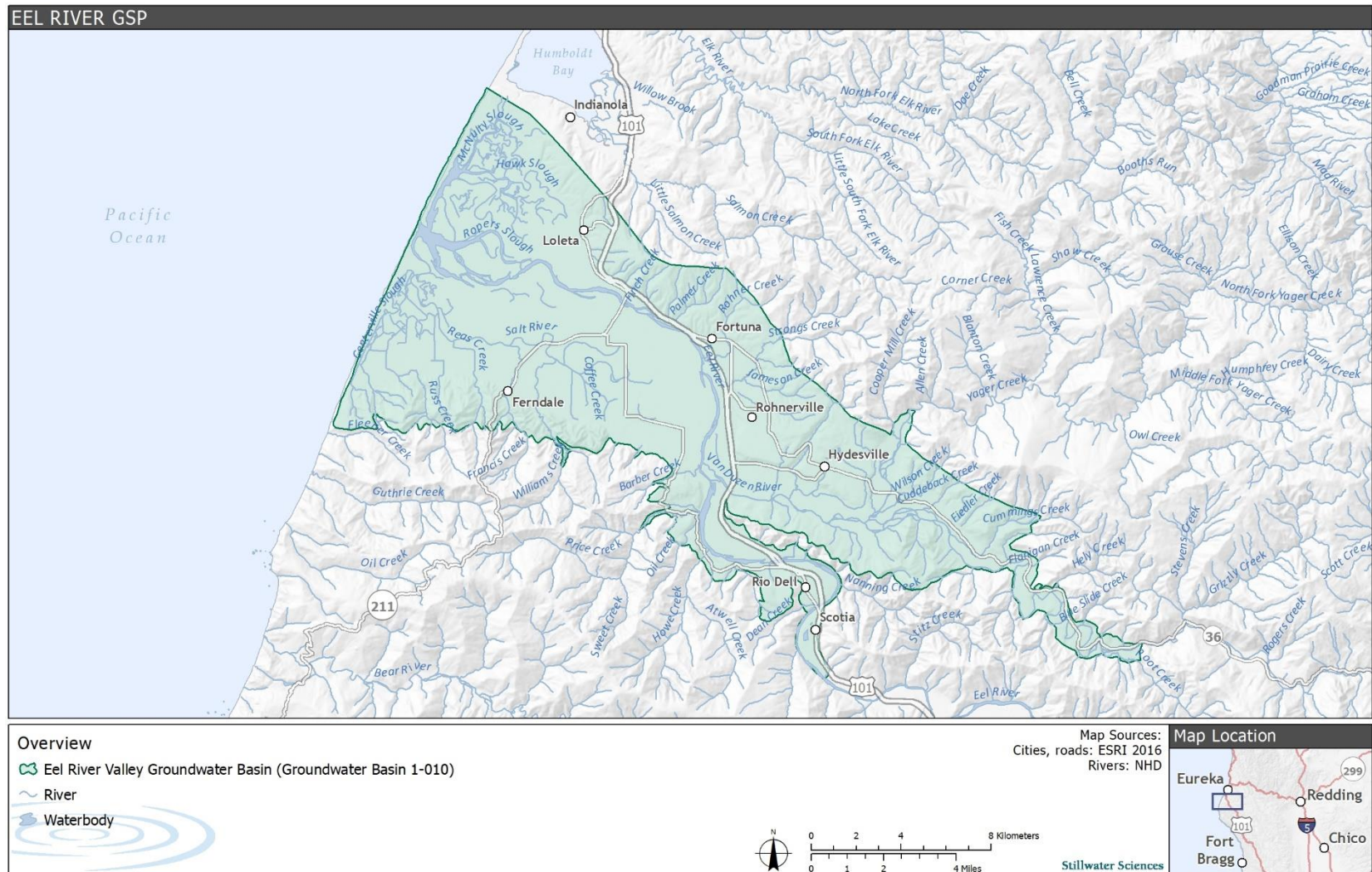


Figure 1. Eel River Valley Basin.

1.2 Hydrology

The Eel River is the third largest watershed in California, draining 3,684 square miles (California Department of Fish & Wildlife [CDFW] 2014). The mainstem Eel River is approximately 197 miles long, with headwaters in Mendocino County, 10 miles north of Lake Pillsbury. Upstream of the basin, the river is dammed at the Scott and Cape Horn dams, forming Lake Pillsbury and Van Arsdale Reservoir, respectively. Between 2010 and 2019, average annual discharge in the Lower Eel River near Scotia (U.S. Geological Survey [USGS] gage 11477000) ranged between 1,619 and 12,150 cubic feet per second (cfs); monthly average discharge ranged between 32 cfs (August 2014) and 54,201 cfs (February 2017) (USGS 2019). The Van Duzen River drains into the Eel River about 14 miles upstream of the Pacific Ocean. Other major tributaries include Yager Creek, which joins the Van Duzen below the Town of Carlotta.

The Eel River experiences very high levels of sedimentation (CDFW 2014). Sedimentation has significantly impacted the Salt River, a remnant channel of the Eel River; many of the Salt River's low-gradient tributaries have filled with sediment and do not convey significant surface flow. As of 2019, restoration efforts by the Humboldt County Resource Conservation District (HCRCD) have opened portions of the Salt River to tidal inundation and partial freshwater inputs (HCRCD 2021).

The primary aquifers in the basin are the Carlotta formation in the Upper Wildcat group and the sequence of overlying unconsolidated alluvial deposits. Groundwater in the Carlotta formation is typically confined or semi-confined by silt and clay interbeds. The Carlotta formation is typically over 1,500 ft thick and may be up to 4,000 ft thick locally, but the maximum productive depth is not well defined. Wells tapping the Carlotta formation are between 200 and 400 ft deep; artesian conditions occur in wells near the foothills (GHD 2021a). The alluvial aquifer is up to 200 ft thick and unconfined, with high conductivity. Most wells in the alluvial aquifer are about 70 ft deep. Hydrologic connectivity between the alluvial aquifer and the Carlotta formation is not well understood, but there is likely some connection between the two in the central part of the basin (GHD 2021a). The extent of interconnected surface water is currently being mapped using a combination of historical field observations and a groundwater hydrology model also in development.

The alluvial aquifer is the primary water source for most agricultural wells (GHD 2021a). Irrigation is the primary groundwater use sector. In 2016, the Humboldt County Resource Conservation District (HCRCD) estimated that annual groundwater extraction from the basin for irrigation ranges from 10,265 acre-ft to 16,680 acre-ft. This estimate is currently being updated (Humboldt County et al, 2021). Average annual extraction for municipal, cannabis cultivation, and other uses is approximately 1,733 acre-ft, 98 acre-ft, and 414 acre-ft, respectively (GHD 2021b).

Groundwater in the basin flows east to west, down the Eel and Van Duzen river valleys to the coast. Groundwater discharge occurs at springs and seeps in the upland areas and by subsurface flow to the tidal estuary (GHD 2021b). Since the completion of a 1975 USGS study, there has been no evidence to suggest that the location of freshwater-seawater transition zone is migrating landward, except for modest salinity increases near the Salt River and Loleta (SHN 2021). Most of the alluvial aquifer located north of the Eel River, adjacent to the tidally influenced reach of the river, is naturally degraded by seawater (USGS 1978). South of Eel River, elevated chloride concentrations (>100 mg/L) were detected in the alluvium along the coast where ground elevation was less than 10 ft asl. Chloride concentration increased with depth at a given distance from the

coast. Substantial recharge to the groundwater system from the Eel River upstream of the tidally influenced reach sustains a seaward hydraulic gradient that moderates seawater intrusion in the area (USGS 1978). During the dry season, tidal cycles produce fluctuations in surface water levels of as much as 1.5 ft, causing localized transitions between gaining and losing stream conditions (SHN 2019).

Surface water systems are strongly connected to the shallow alluvial aquifer (SHN 2019). Preliminary groundwater model river discharge results provided by GHD show gaining conditions on the Van Duzen River upstream of Yager Creek. Downstream of Yager Creek, losing conditions are more prevalent. For example, the Van Duzen goes dry most years in the vicinity of Highway 101, a losing reach. Continuous coupled groundwater and surface water monitoring initiated by Humboldt County in 2016 indicates that subsurface contributions from the Van Duzen strongly influence surface-groundwater connections on the east bank of the Eel River downstream of the Van Duzen confluence (SHN 2019). Due to the steep groundwater gradient toward the Eel River from the east, gaining stream conditions are thought to occur year-round in this reach, consistent with preliminary model results. Monitoring on the west bank of the Eel River between the Van Duzen River confluence and Fortuna shows losing conditions near the confluence, particularly during the dry season, transitioning to gaining conditions downstream that typically occur during the wet season (SHN 2019). Preliminary model results indicate that a slight gaining reach occurs downstream at Fortuna due to subsurface contributions from Strongs Creek and Rohner Creek. Gaining conditions also occur at Fernbridge and along much of the Salt River. Model results show slight losing conditions on some tributaries of the Van Duzen River (Fox Creek) and Salt River (Williams, Francis, and Reas creeks).

The shallow aquifer is hydraulically connected with the ocean along approximately 10 miles of coastline. In the Eel River, tidal influence extends upstream of Fernbridge, approximately 12 miles inland from the river mouth (SHN 2021).

2 BASIN PLAN AND BENEFICIAL USES OF WATER

The Basin Plan for the North Coast Region (NCRWQCB 2018) defines beneficial uses as “the waters of the state that may be protected against water quality degradation,” which “include, but are not necessarily limited to, domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves.” The ERVB is contained within the Lower Eel River and Van Duzen River hydrologic areas (HA) delineated by the NCRWQCB (2018). Because the shallow aquifer and surface water are interconnected in parts of the ERVB (SHN 2019), surface water beneficial uses could be impacted by groundwater management. The extent and degree to which groundwater management may affect surface water flows will be explored once the groundwater model is finalized. This will therefore be addressed in the final GSP.

The Basin Plan (NCRWQCB 2018) designates multiple beneficial uses for surface and groundwater within the ERVB. The HA share many of the same beneficial uses (Table 1), which include:

- MUN (Municipal and Domestic Supply) – Uses of water for community, military, or individual water supply systems, including, but not limited to, drinking water supply
- AGR (Agricultural Supply) – Uses of water for farming, horticulture, or ranching, including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing

- IND (Industrial Service Supply) – Uses of water for industrial activities that do not depend primarily on water quality, including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization
- GWR (Groundwater Recharge) – Uses of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers
- FRSH (Freshwater Replenishment) – Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity)
- NAV (Navigation) – Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels
- REC-1 (Water Contact Recreation) – Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible, including, but not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, whitewater activities, fishing, or use of natural hot springs
- REC-2 (Non-Contact Water Recreation) – Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible, including, but not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities
- COMM (Commercial and Sport Fishing) – Uses of water for commercial and recreational (sport) collection of fish, shellfish, or other aquatic organisms, including, but not limited to, uses involving organisms intended for human consumption or bait purposes
- COLD (Cold Freshwater Habitat) – Uses of water that support cold water ecosystems, such as preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates
- WILD (Wildlife Habitat) – Uses of water that support terrestrial ecosystems, including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources
- RARE (Rare, Threatened, or Endangered Species) – Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under State or federal law as rare, threatened, or endangered
- MIGR (Migration of Aquatic Organisms) – Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish
- SPWN (Spawning, Reproduction, and/or Early Development) – Uses of water that support high-quality aquatic habitats suitable for reproduction and early development of fish
- CUL (Native American Culture) – Uses of water that support the cultural and/or traditional rights of indigenous people, such as subsistence fishing and shellfish gathering, basket weaving and jewelry material collection, navigation to traditional ceremonial locations, and ceremonial uses

Additional beneficial uses for the Lower Eel River HA comprise:

- SHELL (Shellfish Harvesting) – Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes
- EST (Estuarine Habitat) – Uses of water that support estuarine ecosystems, including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds)

Potential beneficial uses in the Lower Eel River HA include:

- PRO (Industrial Process Supply) – Uses of water for industrial activities that depend primarily on water quality
- POW (Hydropower Generation) – Uses of water for hydropower generation
- MAR (Marine Habitat) – Uses of water that support marine ecosystems, including, but not limited to, preservation or enhancement of marine habitats and vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds)
- AQUA (Aquaculture) – Uses of water for aquaculture or mariculture operations, including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes

Additional beneficial uses for the Van Duzen River HA include:

- WARM (Warm Freshwater Habitat) – Uses of water that support warm water ecosystems, such as preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates

Additional potential beneficial uses for the Van Duzen River HA comprise PRO, POW, and AQUA.

Beneficial uses the NCRWQCB (2018) did not designate in the ERVB include:

- ASBS (Preservation of Areas of Special Biological Significance [ASBS]) – Includes marine life refuges, ecological reserves, and designated ASBS, such as areas where kelp propagation and maintenance are features of the marine environment, requiring special protection
- SAL (Inland Saline Water Habitat) – Uses of water that support inland saline water ecosystems, such as preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates
- FLD (Flood Peak Attenuation/Flood Water Storage) – Uses of riparian wetlands in flood plain areas and other wetlands that receive natural surface drainage and buffer its passage to receiving waters
- WET (Wetland Habitat) – Uses of water that support natural and man-made wetland ecosystems, including, but not limited to, preservation or enhancement of unique wetland functions, vegetation, fish, shellfish, invertebrates, insects, and wildlife habitat
- WQE (Water Quality Enhancement) – Uses of waters, including wetlands and other waterbodies, that support natural enhancement or improvement of water quality in or downstream of a waterbody, such as erosion control, filtration and purification of naturally occurring water pollutants, streambank stabilization, maintenance of channel integrity, and siltation control

Table 1. Beneficial uses in the Eel River Valley Basin (NCRWQCB 2018)

Hydrologic area	MUN	AGR	IND	GWR	FRSH	NAV		REC 1	REC 2	COMM	COLD	WILD	RARE	MIGR	SPWN	CUL	SHELL	EST	PRO	POW	MAR	AQUA	WAR M
Lower Eel	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	P	P	P	P	
Van Duzen	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X			P	X		P	X

X = Designated beneficial use
P = Potential beneficial use

3 ASSESSMENT

No studies of minimum instream flow requirements within the ERVB were found for any of the beneficial uses identified above or discussed below. However, there has been an ongoing long-term (2005–2020) instream habitat monitoring program within the ERVB conducted by the local instream gravel miners in compliance with their local, state, and federal permits. This monitoring program collected data within the lower Eel River (mouth of Van Duzen River to Fernbridge; approximately 6.7 river miles) and at selected sites in the Van Duzen River downstream of Carlotta (approximately 3.9 river miles). Data collected include pool, riffle, and flatwater ratios; preferred holding, spawning, and rearing habitats for adult and juvenile salmonid; and pool and riffle depths (Stillwater Sciences 2020b). Summary results from the monitoring program are reported below in Section 3.2.

3.1 Groundwater Dependent Ecosystem Units

SGMA defines GDEs as “ecological communities of species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface” (23 CCR § 351(m)). As described in The Nature Conservancy’s guidance for GDE analysis (Rohde et al. 2018), a GDE’s dependence on groundwater refers to reliance of GDE species and/or ecological communities on groundwater for all or a portion of their water needs. Stillwater Sciences (2021a) identified four GDE Units within the ERVB based on hydrologic characteristics within the basin (Table 2, Figure 2). These are:

- Intertidal Zone and Tributaries: Intertidal reach downstream of Fernbridge
- Middle Eel River: Fernbridge to Eel/Van Duzen rivers’ confluence
- Upper Eel River: Eel/Van Duzen rivers’ confluence to Scotia
- Van Duzen River and Tributaries: Lower Van Duzen River

Table 2. GDE unit acreages in the ERVB

GDE unit	Area (acres)
Intertidal Zone and Tributaries	5,981
Middle Eel River	3,809
Upper Eel River	1,136
Van Duzen River and Tributaries	2,878
Total	13,804

¹ Totals may not appear to sum exactly due to rounding error.

These GDE units provide a spatial framework for the beneficial uses discussion below.

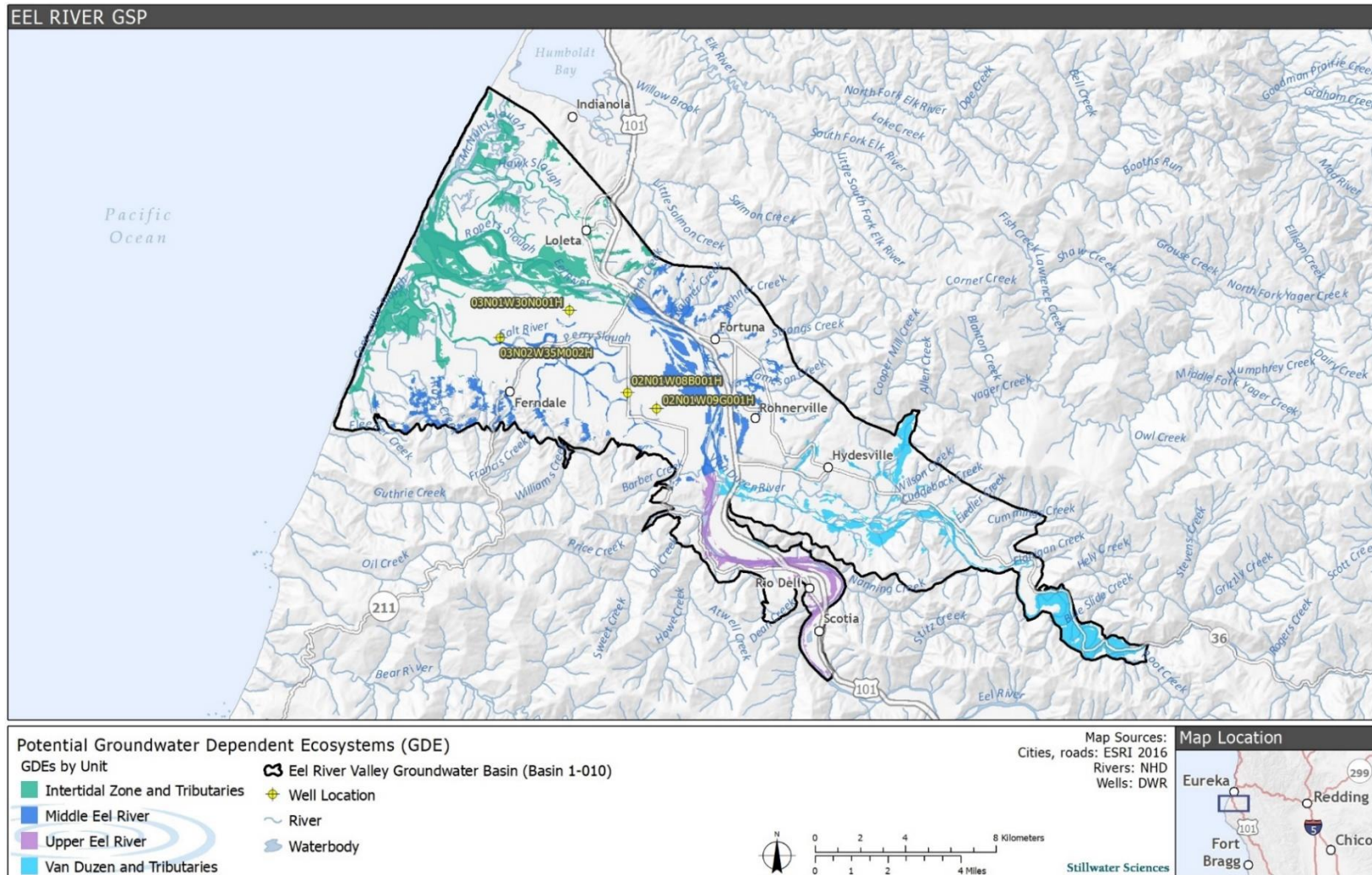


Figure 2. GDE units in the ERVB

3.2 Beneficial Uses Conditions

The Basin Plan (NCRWQCB 2018) identifies the surface waters of the ERVB as having a variety of beneficial uses pertaining to fish, wildlife, and GDEs. Beneficial uses within the ERVB linked to GDEs include COLD, WILD, RARE, MIGR, SPWN, and EST. Each of these contain biological attributes, some unique and others common, which illustrate the linkages between beneficial uses (Table 3).

Table 3. Attributes supported by beneficial uses in the ERVB

Beneficial uses	Attributes supported by beneficial uses									
	Aquatic habitat	Vegetation	Fish	Wildlife	Migration	Terrestrial habitat	Food sources	Water sources	Shellfish	Estuarine habitat
COLD	x	x	x	x						
MIGR	x		x		x					
RARE	x	x	x	x		x				x
WILD		x		x		x	x	x		
SPWN	x		x							
EST		x	x	x					x	x

The ERVB also supports beneficial uses REC-1 and REC-2. The recreational attributes supported by REC-1 include swimming, wading, skin and scuba diving, and fishing. The recreational attributes supported by REC-2 include picnicking, sunbathing, hiking, boating, hunting, sightseeing, and aesthetic enjoyment.

3.2.1 COLD

The Cold Freshwater Habitat (COLD) beneficial uses support cold water ecosystems for the preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. The GDE units within the ERVB are cold water systems and support habitat for a variety of cold-water-dependent species, including, but not limited to, Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), steelhead (*Oncorhynchus mykiss*), longfin smelt (*Spirinchus thaleichthys*), green sturgeon (*Acipenser medirostris*), and Pacific lamprey (*Entosphenus tridentatus*), which are described below in the RARE section. Several other fish and wildlife species also occupy the groundwater basin and will be described in other beneficial uses sections below.

COLD beneficial uses are a function of available habitat, including the extent of pools, riffles, and flatwater within a given reach. This section therefore summarizes available habitat to assess whether there are any temporal trends in habitat distribution and to help ascertain whether current groundwater and interconnected surface water management could be affecting habitat availability.

3.2.1.1 Pool, riffle, and flatwaters

The relative proportions of pool, riffle, and flatwater habitat in the lower Eel River Valley between the mouth of the Van Duzen River and Fernbridge have varied between 2005 and 2020 in response to winter flow patterns, changes in thalweg locations, sediment depositional patterns, and presence or absence of significant secondary channels. In general, the pool and flatwater

percentages have been inversely proportional while the riffles have varied by about five percent (Figure 3).

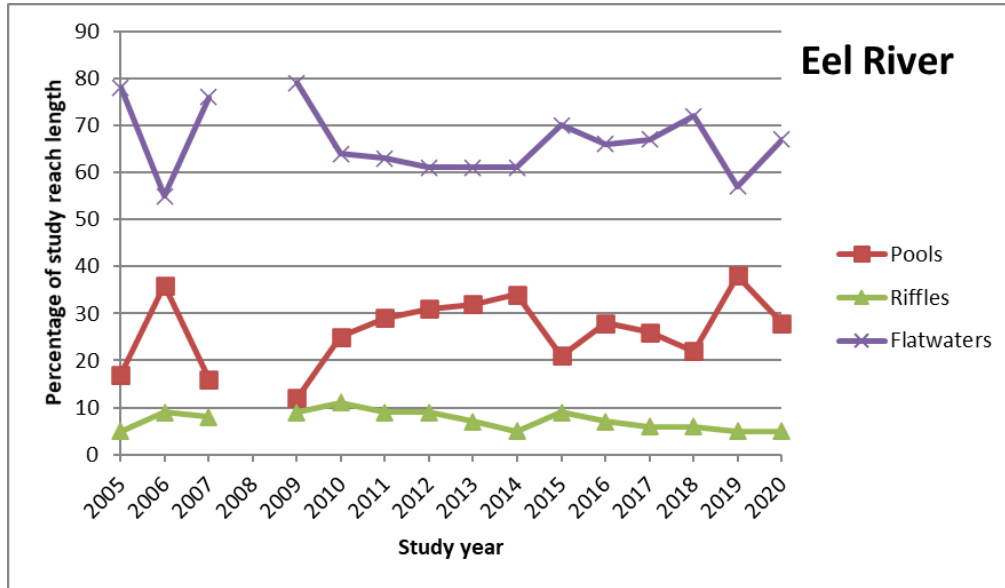


Figure 3. Pool, riffle, and flatwater percentages in the Middle Eel River GDE Unit 2005-2020 (Stillwater Sciences 2021b)

Similarly, in the Middle Eel River GDE Unit, the pool and flatwater percentages in the Van Duzen River and Tributaries GDE Unit have been generally inversely proportional while the riffles have varied by about 10 percent (Figure 4). However, some locations in the Van Duzen River go dry or have extremely low flows during the summer period, which also affect the pool, riffle, and flatwater percentages. The jump in the pool percentage during 2013 may have been due in part to the inclusion of an additional area (County of Humboldt’s PALCO Bar), which contains a higher percentage of pools than the more downstream alluvial flats area between Carlotta and the mouth of the Van Duzen River.

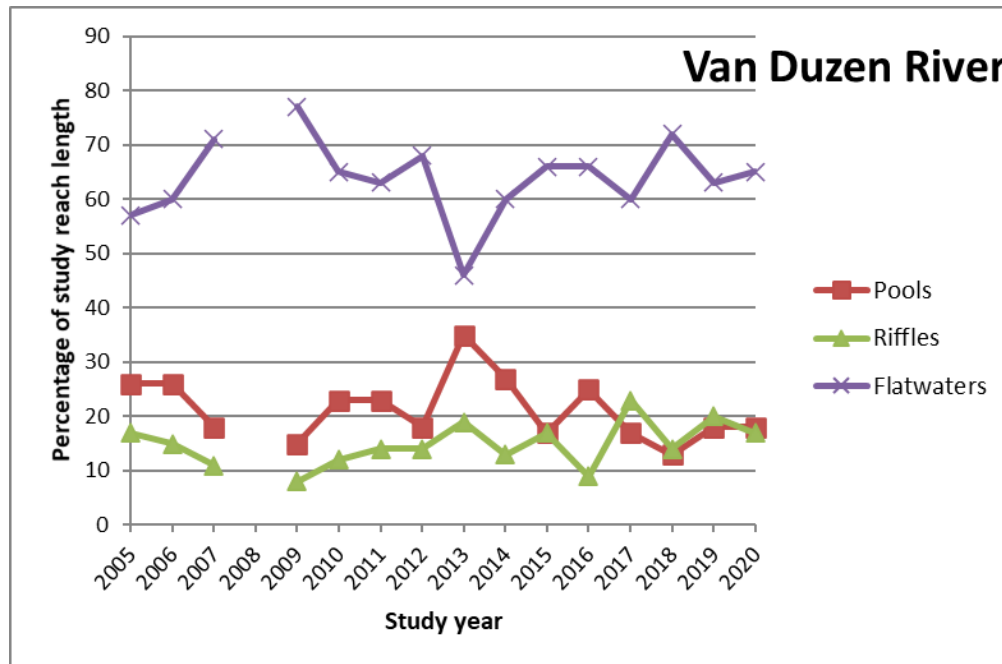


Figure 4. Pool, riffle, and flatwater percentages in the Van Duzen River and Tributaries GDE Unit 2005-2020 (Stillwater Sciences 2021b)

3.2.1.2 Instream habitat area

The preferred instream habitat areas for salmonid spawning, steelhead (age 2+) rearing, alcoves, juvenile coho salmon rearing, and adult holding in the Middle Eel River GDE Unit, from the mouth of the Van Duzen River to Fernbridge, and the Van Duzen River and Tributaries GDE Unit, from the confluence of the Eel River to Carlotta, have been mapped on a near-annual basis from 2005–2020 (Stillwater Sciences 2021b). Preferred holding habitat for adult Chinook salmon generally consists of pools with water velocities ranging from 0.5–1.5 ft per second (fps) and depths greater than 3 ft. In both reaches, spawning habitat typically occurs in pool tailouts, riffles, or runs where the water is 0.75–2.5 ft deep, flowing at 1–3 fps, over a small gravel to small cobble substrate. Juvenile coho salmon generally utilize the margins of pool and flatwater habitat units with relatively slow (0.5–1.5 fps) water velocities that contain overhanging and submerged vegetation and cool water seeps. Coho salmon have also been observed in alcoves containing cool water during the late summer and early fall. Age 2+ steelhead prefer to reside in run habitats where the water velocity is between 0.75 and 1.5 fps near the bottom, in depths of 1–3 ft, and have a cobble/small boulder substrate. Age 2+ steelhead also prefer head-of-pool habitats below the entry point of riffles. Alcoves are off-channel habitats located on the downstream end of gravel bars and may provide velocity refuge for juvenile salmonids during high flows, as well as potential thermal refuge during the summer season.

Due to the nearly annual changes to natural river thalweg, monitoring reach lengths during these years have varied considerably, which required normalizing the instream habitat metrics to square ft of habitat per linear ft of stream length. Adult holding habitat for all three salmonids is the most common habitat mapped within the Middle Eel River GDE Unit monitoring reach (Figure 5). Juvenile coho salmon habitat is non-existent due to the lack of pools formed by woody debris and warm water temperatures. Spawning habitat for all three salmonids is relatively scarce due to the relatively small substrate size and significant bedload transport. Alcoves are also relatively rare in

the Middle Eel GDE Unit, particularly since 2013. The presence of alcoves is a function of gravel scour that occurs during high flow events in secondary channels located along the back side of gravel bars. The upstream ends of alcoves are generally at higher elevations than the downstream areas that may stay watered the entire year.

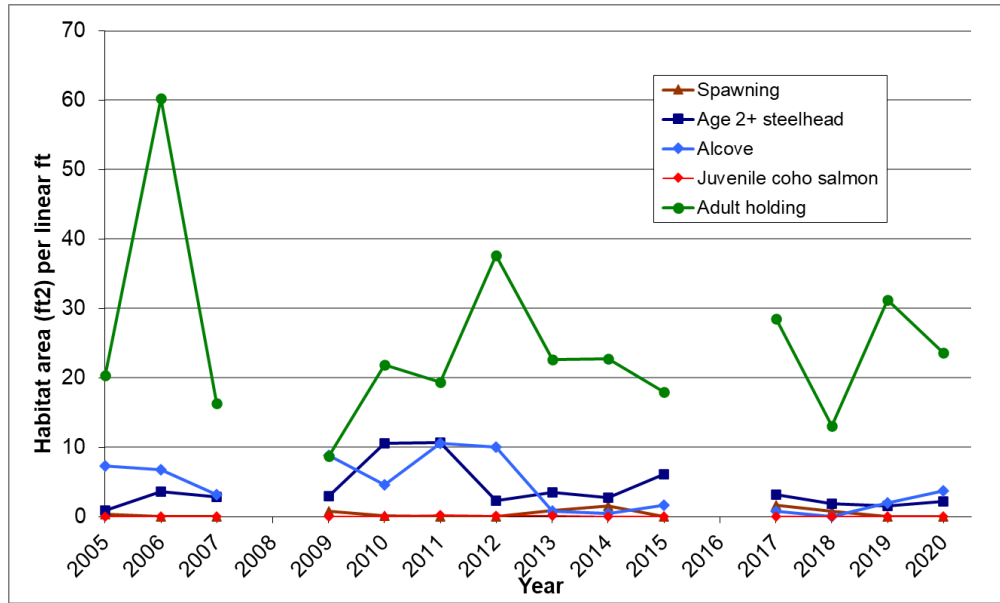


Figure 5. Preferred instream habitat area for Chinook salmon holding and spawning, age 2+ steelhead rearing, alcoves, and juvenile coho salmon rearing from 2005 to 2020 in the Middle Eel River GDE Unit (Stillwater Sciences 2021b)

The preferred instream habitat areas for salmonid spawning, age 2+ steelhead rearing, alcoves, juvenile coho salmon rearing, and adult holding in the Van Duzen River monitoring reaches have also varied considerably on an annual basis (Figure 6). In general, water years with high sustained winter flows have resulted in increases in pools and associated holding and age 2+ steelhead habitat. These high flows have also mobilized and sorted instream sediment deposits, which rejuvenated spawning gravel. Juvenile coho salmon habitat has been limited by a relative lack of woody debris and high water temperatures. Because the width of the Van Duzen River is so much narrower than the Eel River, the habitat areas are smaller per unit length of channel.

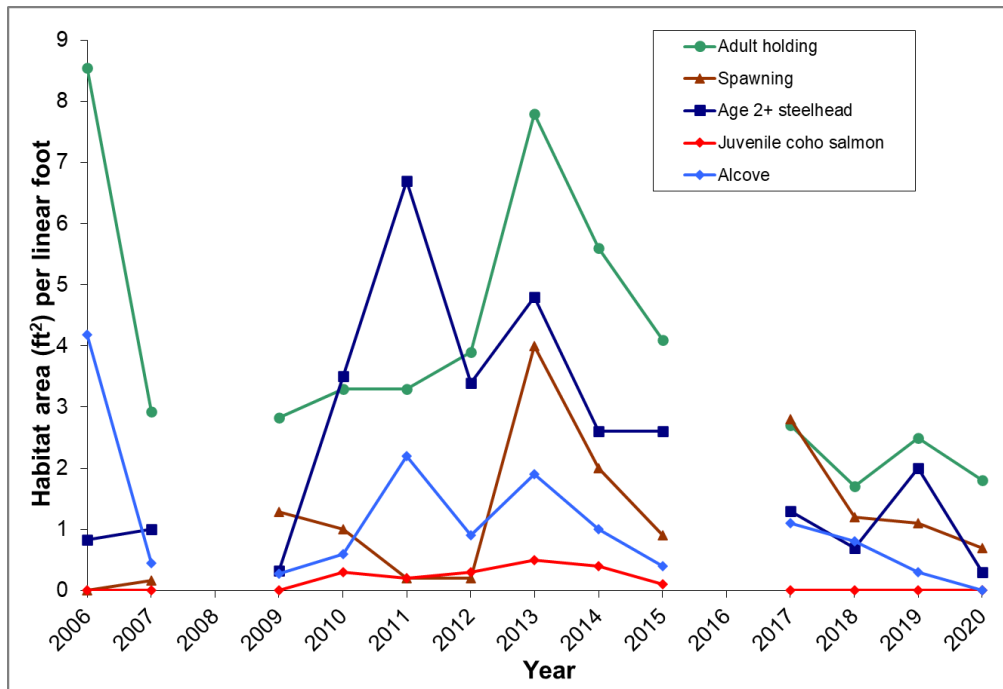


Figure 6. Preferred instream habitat area for salmonid spawning, age 2+ steelhead rearing, alcoves, juvenile coho salmon rearing, and adult holding 2006–2020 in the Van Duzen River and Tributaries GDE Unit (Stillwater Sciences 2021b)

Tributaries to the Middle Eel, Upper Eel, and Van Duzen River and Tributaries GDE units within the ERVB contain cold water habitat and support anadromous fish and other aquatic biota. CDFW and its predecessor, California Department of Fish and Game (CDFG), periodically conducted instream habitat inventories within the watercourses that are tributary to the GDE units using the Flosi et al. (1998) protocol. Instream habitat data collected as part of this protocol included, but was not limited to, flow (cfs), pool, riffle, flatwater lengths, and water temperatures. Selected instream habitat data are presented below for several tributaries that flow into the GDE units (Table 4). Although the CDFW/CDFG-inventoried streams flow into the GDE units, most of their lengths extend into the steeper areas outside GDE boundaries. These steeper reaches are not likely to be affected by floodplain groundwater management due to generally being within forested landscapes and due to the lack of wells.

Table 4. Tributary instream habitat data collected by CDFW during instream habitat inventories within the GDE units

Watercourse	GDE unit	Survey dates	Habitat attributes				
			Flow (cfs)	Pool %	Riffle %	Flatwater %	Temperature Celsius (°C)
Francis Creek	Intertidal	June 2–20, 2003	1.1	47	34	19	12–16
Barber Creek ¹	Middle Eel	July 22–28, 2008	-	47	38	7	12–13
Howe Creek	Upper Eel	August 13–18, 1998	0.5	6	66	28	14–19
Howe Creek	Upper Eel	June 21–29, 2017	4.8	17	48	35	12–18
Price Creek	Upper Eel	September 15, October 18–20 and 25–26, and November 2–3, 1999	-	12	57	30	7–15
Price Creek	Upper Eel	June 20–July 17, 2017	2	16	23	60	13–18
Oil Creek	Upper Eel	June 25–29, 2002	-	42	28	31	13–16
Monument Creek	Upper Eel	July 6–7, 2010	1.9	33	47	20	12–14
Hely Creek ²	Van Duzen River	June 5–19, 2006	2.1	23	37	37	12–14
Hely Creek	Van Duzen River	September 25–October 4, 2017	1.4	22	28	37	10–13

¹ Additional Level II Habitat: 1% culvert, 1% dry

² Additional Level II Habitat: 3% dry

3.2.1.3 Water temperatures

Sufficiently cool water temperatures is a habitat requirement for salmonids. Water temperatures above 20 °C stress Chinook salmon and steelhead; those above 25°C can be lethal. Coho salmon have lower water temperature tolerances and tend not to be present in waters with maximum temperatures exceeding 18°C unless there are cool water refuges available. Water temperatures tend to be higher in the summer when air temperatures are highest, and lowest during the winter due to lower air temperatures and greater inflows. Water temperatures in wide mainstem river reaches tend to be warmer than smaller tributary streams during the summer due to sunlight heating the substrate, lack of shade canopy, and relatively high air temperatures. Water temperatures are typically lower in tributaries outside of the ERVB where more confined channels and increased vegetative shading are present. Groundwater management may affect stream temperatures in reaches with interconnected surface water by increasing the relative flux of cooler groundwater to warm streams, but the degree to which this occurs in the ERVB has not been investigated.

Water temperature monitoring was conducted in 1998 within the Eel River from the mouth of the Van Duzen River to Fernbridge (Table 5). Monitoring was also conducted at three locations in the Van Duzen River between Carlotta and Highway 101. The data analysis included calculating the average daily and average maximum water temperatures for the warmest week. The data showed that water temperatures within the lower Eel and Van Duzen rivers exceed stressful levels (>18–20°C) for anadromous salmonids, as well as that water temperatures cooled slightly the closer the river was to the coast and zone of marine influence.

Table 5. Mainstem Eel and Van Duzen rivers’ water temperatures for the warmest week of the summer, 1998 (Halligan 1998, unpub. data)

Location	Lat/long (deg min sec)	GDE Unit	Average daily (°C)	Average maximum (°C)
Eel/VD river confluence	40°32’17”N, 124°09’15”W	Middle Eel	22.2	24.1
Hauck/Hansen	40°32’52”N, 124°09’13”W	Middle Eel	21.3	23.1
Drake	40°36’10”N, 124°10’30”W	Middle Eel	21.7	22.8
Worswick	40°36’20”N, 124°11’20”W	Middle Eel	21.3	22.3
Bess	40°31’30”N, 124°03’10”W	Van Duzen River	20.8	24.1
Noble	40°31’25”N, 124°05’40”W	Van Duzen River	20.7	23.7
Leland	40°32’07”N, 124°08’20”W	Van Duzen River	20.4	23.1
Fernbridge	40°36’57”N, 124°12’05”W	Intertidal	21.4	22.7

As part of their Habitat Conservation Plan monitoring program, Humboldt Redwood Company (HRC) has been collecting water temperature data in selected tributary watercourses to the Upper Eel River and Van Duzen River GDE units. HRC analyzes their data and reports the temperature information as a maximum weekly average temperature (MWAT; Table 6). Water temperatures for the watercourses below do not exceed the 16.8°C threshold for coho salmon.

Table 6. 2019 Maximum weekly average water temperatures at selected site within tributaries that flow into the Upper Eel River and Van Duzen River GDE units (HRC 2020)

ATM site/number	GDE unit	Year	MWAT (°C)
Monument 106	Upper Eel	2019	16.1
Atwell/242	Upper Eel	2019	16.7
Hely/112	Van Duzen River	2019	15.2
Cummings/108	Van Duzen River	2019	15.7

The Eel River Recovery Project (ERRP) conducted water temperature monitoring in 2012 and 2013 on the lower Eel River to check for suitability for holding adult Chinook salmon (ERRP 2013, 2014). Water temperatures in the lower Eel River were coolest at Fernbridge and warmed progressively upstream, with a substantial jump between the 12th Street pool (Fortuna) and Howe Creek, upstream of the Van Duzen River. The floating weekly water temperatures of the lower Eel River reaches accessible to Chinook salmon remained above stressful until the first week of September in 2012 (Figure 7). However, in 2013, the river was significantly warmer (3–5°F), but an early rain reduced water temperatures to more suitable ranges by the second week of September (ERRP 2014). Figure 7 also shows that water temperatures decreased in a downstream direction as the river entered the zone of coastal influence.

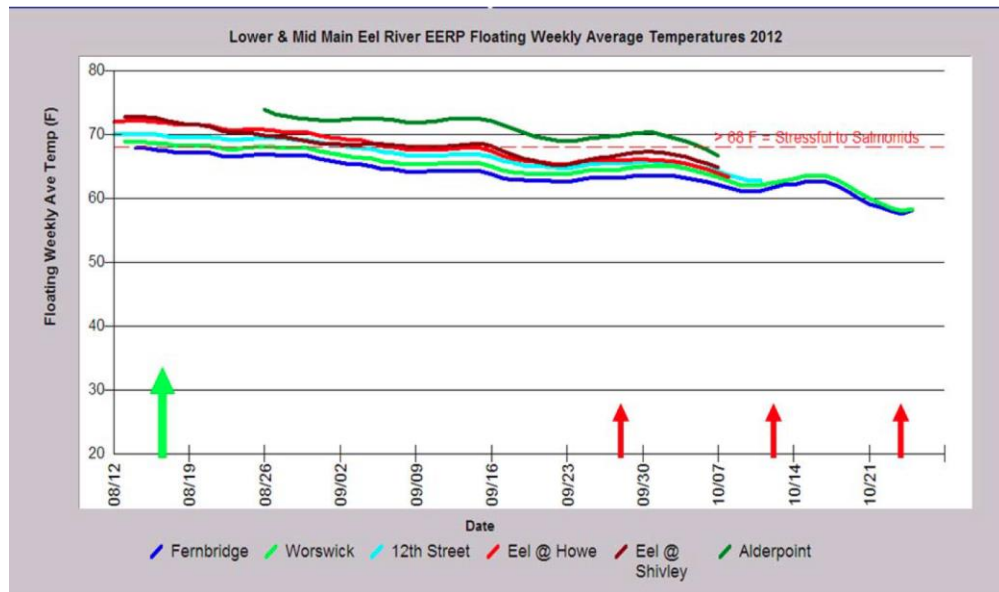


Figure 7. Lower Eel River water temperatures at several locations in the Middle Eel and Upper Eel GDE units, and in locations farther upstream (Shivley and Alderpoint), indicating stressful conditions for adult Chinook salmon at the time of first entry (green arrow) until mid-September; red arrows indicate underwater survey dates by the ERRP (ERRP 2013); salmonids experience stress at temperatures greater than 68°F (20°C)

Water temperatures in the Eel River Estuary vary depending on the season, location, channel depth, heights of tides, and river discharge. Seasonal water temperatures in the Intertidal GDE Unit can range from ambient sea water (~50–55°F) to ambient river water (~38–75°F) (Puckett 1977 and Cannata 1994–95 field notes, as cited in CDFG 2010). During the winter, the coldest water is usually found on the surface when river flows exposed to cold air flow into the estuary. Conversely in summer as river flows decline, the coldest water is delivered by ocean tides. Tides push a wedge of cold seawater up the main estuarine channel that mixes with the warmer fresh or brackish water of the middle and upper estuary zones (CDFG 2010).

In summary, water temperatures within the Middle Eel, Upper Eel, and Van Duzen River GDE units are generally too warm during the summer to support adult salmonids. Nearly all juvenile Chinook salmon would have migrated to the estuary and ocean prior to the onset of warmer water temperatures. In addition, water temperatures are too warm to support juvenile coho salmon and are stressful for juvenile steelhead. Water temperatures in the Intertidal Zone and Tributaries GDE Unit are moderated by the influences of the marine climate and tidal flux.

3.2.2 WILD

The wildlife habitat beneficial uses of water support (preserve and enhance) terrestrial ecosystems and habitat for vegetation, wildlife (e.g., mammals, birds, reptiles, and amphibians), or wildlife water and food sources. Several special-status wildlife species that are dependent on the GDEs in the ERVB (see Section 3.2.3, below).

3.2.3 RARE

The ERVB supports several threatened, endangered, and species of special concern (Figure 8), including fish, avian, amphibian, and reptile species. These species are briefly described below. The following species summaries are adapted from the format contained in the Critical Species LookBook (Rohde et al. 2019).

3.2.3.1 Fish

The following special-status fish species are present in the ERVB on a seasonal or permanent basis.

California Coast ESU Chinook salmon (*Oncorhynchus tshawytscha*)

Status: Federally threatened

Reliance on groundwater: Direct. Chinook salmon are reliant on groundwater-fed rivers to provide adequate water quality, temperature, and volume for upstream migration (in the fall before rainfall elevates river flows), as well as for spawning and freshwater residency.

Habitat: Chinook salmon in the Eel River spend a relatively short time in freshwater as juveniles before heading to estuaries or marine environments for the bulk of this phase of their lives. Adult Chinook spawn in larger rivers and streams, where they require sufficient flows for migration and largely sediment-free gravel for spawning. Juveniles need areas of refuge from high water velocities during the wet season (e.g., in floodplains, backwaters). Water quality, including temperature and dissolved oxygen, is important for juveniles living in estuaries.

Presence in the ERVB: Chinook salmon in the Eel River are primarily fall-run, although a small number of spring-run fish do spawn and rear in the Middle Fork Eel River. They can be found in the Eel River Valley during the fall adult upstream migration, early juvenile rearing, and spring downstream smolt migration periods. Fall-run juvenile Chinook salmon generally do not rear in freshwater during the summer and fall. Spring-run juveniles will rear for a year prior to migrating downstream to the estuary and the ocean.

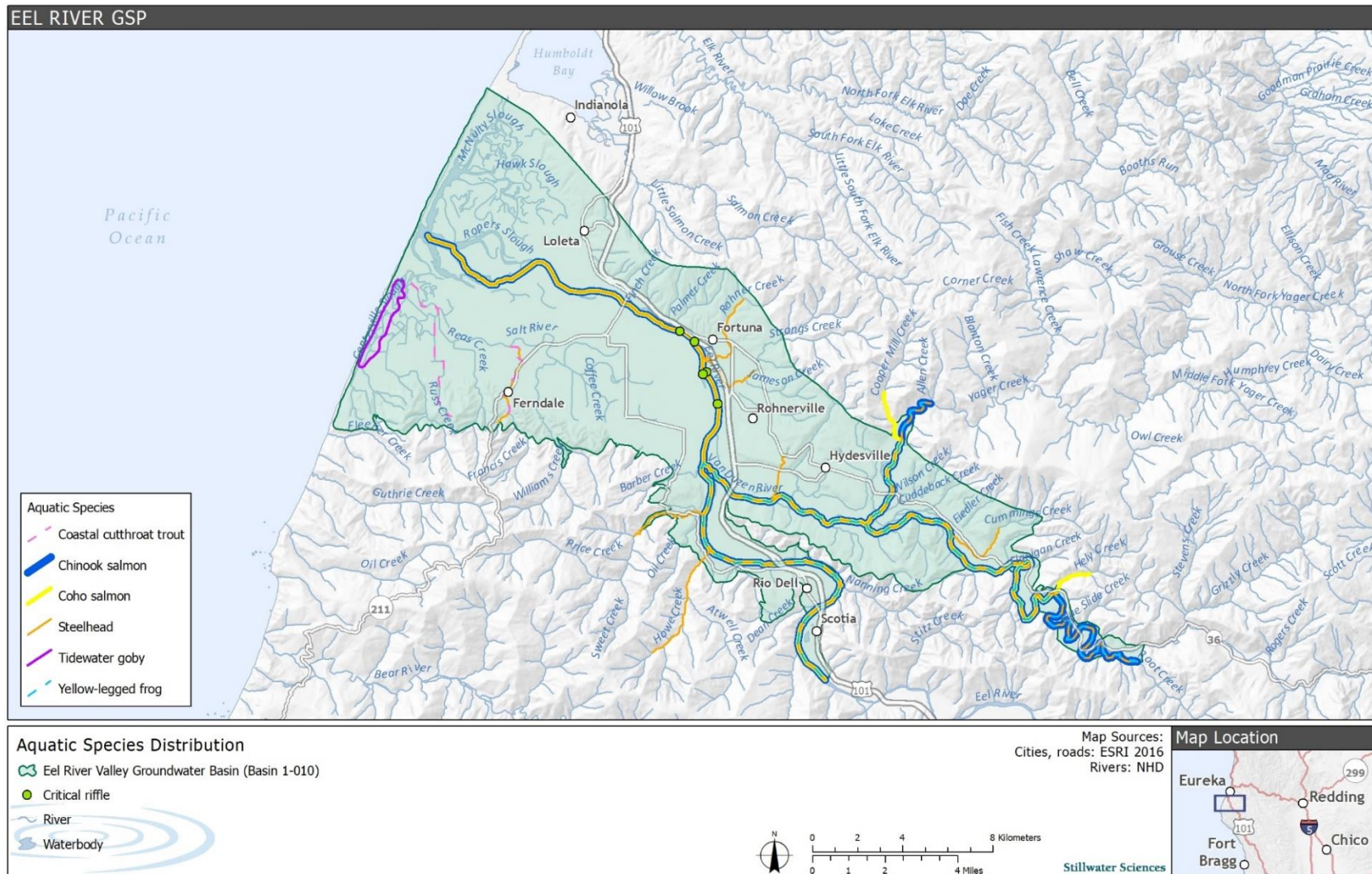


Figure 8. Aquatic species distribution in the ERVB; green circles indicate the general locations of critical riffles observed from 2006 to 2020 (Stillwater Sciences 2021b)

Southern Oregon Northern California Coast ESU Coho salmon (*Oncorhynchus kisutch*)

Status: Federally threatened; State threatened

Reliance on groundwater: Direct. Coho salmon are reliant on groundwater-fed rivers to provide adequate water quality, temperature, and volume for upstream migration (in the fall before rainfall elevates river flows), as well as for spawning and freshwater residency. Juvenile salmonids generally require cold, clear, well-oxygenated water and adequate streamflow volume during their time in freshwater. Adult salmon similarly require adequate water quality and volume during their upstream migration. Juveniles can rear in mainstem rivers but are dependent on locations that contain cold water tributary inflow, bank seeps, or subsurface flow upwelling. Backwater alcoves with stratified water temperatures also provide habitat during the warm summer months.

Habitat: Juveniles spend one year in freshwater prior to migrating to the estuary and ocean during the spring. Juveniles require deep pools with cool water temperatures, slow water velocities, and abundant instream cover during their rearing phase. Juveniles are associated with native riparian vegetation that provides instream cover and food resources from insect drop. Adults return to freshwater to spawn in the mid-fall to early winter of their third year. They primarily spawn in tributaries to rivers but would spawn in larger rivers during drought years when tributary flows are low.

Presence in the ERVB: The mainstem Eel (upstream of Fernbridge) and Van Duzen rivers are used for migration only due to high summer water temperatures and general lack of habitat. Juveniles have been found in Yager, Price, Williams, Francis, and Howe creeks.

Northern California Coast steelhead (*Oncorhynchus mykiss*)

Status: Federally threatened

Reliance on groundwater: Direct. Steelhead are reliant on rivers and streams that are likely supported by groundwater. Juvenile steelhead generally require cold, clear, well oxygenated water and adequate streamflow volume while residing in freshwater. Adult steelhead also require adequate water quality and instream flows during their upstream and downstream migration, which can be limited by streamflow depletion. However, adult steelhead typically conduct upstream migrations in the winter and spring when streamflow are usually adequate. Cold groundwater inputs can provide local areas of water temperature refugia in which rearing juvenile steelhead are less susceptible to stress or mortality that can otherwise result from elevated water temperatures during warm, dry months when stream flows are typically lowest.

Habitat: While steelhead are generally more adaptable to habitat extremes than either coho or Chinook salmon, they nevertheless require cold water and complex instream habitat during their freshwater juvenile residency, which generally lasts at least one year, including at least one dry season. Juveniles outmigrate during the spring and early summer. A smaller outmigration occurs in the late fall after water temperatures cool. Estuaries can provide important rearing habitat for steelhead, with opportunities for rapid growth prior to entering the marine environment. For upstream migration to spawning grounds, all adult salmonids require sufficient flow and suitably cool water temperature, followed by streambeds with clean gravel, free of excessive fine sediment deposition, in which to spawn. Some adult steelhead will survive to spawn a second or third time; thus, adequate stream flows are required for post-spawn adult steelhead to migrate downstream during spring.

Presence in the ERVB: Present in the mainstem Eel and Van Duzen rivers and tributaries. Small numbers of juvenile steelhead have been observed rearing in the lower Eel and Van Duzen rivers in alcoves and heads of pools (immediately downstream of riffles) during the summer and fall months (D. Halligan, Stillwater Sciences, pers. comm. 2021).

Coastal cutthroat trout (*Oncorhynchus clarkii clarkii*)

Status: State species of concern

Reliance on groundwater: Direct. Coastal cutthroat trout are reliant on groundwater-fed rivers, creeks, and sloughs to provide adequate water quality, temperature, and volume for upstream migration. Juvenile salmonids generally require cold, clear, well-oxygenated water and adequate streamflow volume during their time in fresh water.

Habitat: Prefer cool, clean water with ample cover and deep pools for holding in summer. They prefer small, low gradient coastal streams and estuarine habitats, including lagoons. This species' range overlaps with steelhead, but they tend to occupy smaller streams and can be found upstream of barriers to anadromous salmonids. Spawning occurs in December to February, but could extend further into the year. Juveniles rear in upstream reaches of streams for one year before moving downstream to the estuary. These fish may move back and forth from estuarine to freshwater environments.

Presence in the Eel River Valley groundwater basin: Present in the Intertidal GDE Unit within the Salt River drainage. Found in Barber Creek (Middle Eel GDE Unit) in 1992 by CDFG. The Van Duzen River is the southern-most range of this species.

Longfin smelt (*Spirinchus thaleichthys*)

Status: State threatened

Reliance on groundwater: Direct. These fish rely directly on groundwater discharge that supports estuarine wetlands and sloughs used by the species for spawning, feeding, and rearing. Longfin smelt have a low tolerance for warm waters.

Habitat: The smelt depend on a diverse range of habitats, such as offshore areas, coastal lagoons, bays, estuaries, sloughs, and freshwater rivers and streams. Longfin smelt are euryhaline, meaning they can tolerate a variety of salinity in their habitats, from completely freshwater to marine, though spawning occurs preferentially in freshwater and areas of low salinity.

Presence in the ERVB: Longfin smelt are known to be present downstream of Fernbridge in the Salt River area. The last recorded sighting upstream of Fernbridge was near the mouth of the Van Duzen River in 1956 when several individuals were collected in a beach seine by the USFWS.

Green sturgeon (*Acipenser medirostris*)

Status: Southern DPS – federally threatened; Northern DPS – federal species of concern; State species of special concern

Reliance on groundwater: Direct. This species relies on surface water flows that may be supported by groundwater.

Habitat: This anadromous species spends most of its life at sea but returns to freshwater to spawn. Young fish may remain in freshwater for up to two years. Adults spawn in fast, deep water during the first half of the year. Post-spawn adults then move back down the river during the fall and re-enter the ocean.

Presence in the ERVB: Green sturgeon are known to inhabit the lower Eel River and have been frequently observed upstream of Fernbridge in the 12th Street pool adjacent to Riverwalk during fall salmon surveys. Sturgeon have also been observed holding in the intertidal area downstream of Fernbridge. Finally, Northern DPS sturgeon are presumed to spawn in the mainstem Upper Eel River, based on observations at Fort Seward, approximately 80 miles upstream of the ERVB. Spawning does not occur in the ERVB. The Southern DPS green sturgeon likely enter the Eel River Estuary but are known to spawn only in the Sacramento River.

Tidewater goby (*Eucyclogobius newberryi*)

Status: Federal endangered

Reliance on groundwater: Direct. Tidewater gobies rely on surface waters in coastal areas that are likely to be supported by groundwater discharge.

Habitat: These fish live in lagoons and estuaries with submerged and emergent aquatic vegetation that can provide protection from predators and flooding. They also occupy locations

characterized by muted tidal flow in areas subject to tides, and can be found in backwater marshes and freshwater tributaries to estuarine environments. Food sources comprise macroinvertebrates (e.g., amphipods, aquatic insects).

Presence in the ERVB: Gobies are present in the sloughs of the Eel River Delta and the Salt River restoration area. They are not present upstream of Fernbridge.

Pacific lamprey (*Entosphenus tridentatus*)

Status: California species of special concern

Reliance on groundwater: Direct. This species relies on surface water flows that may be supported by groundwater.

Habitat: Spawning typically takes place from March through July depending on water temperature and local conditions, such as seasonal flow regimes. Spawning occurs both in the mainstem of medium-sized rivers and smaller tributaries and generally takes place in pool and run tailouts and low gradient riffles. Both males and females build nests (redds), which are approximately 1.25 square ft and constructed in gravel and cobble substrate. After about 30 days, the eyeless larvae (ammocoetes) emerge from the gravel and begin drifting downstream. Eventually they settle out of the water column and burrow into fine silt and sand substrate in low-velocity, depositional areas such as pools, alcoves, and side channels where they may spend between four and 10 years prior to migrating to the ocean, where they reside for approximately 18–40 months before returning to freshwater.

Presence in the ERVB: The ERVB is primarily used by adult lamprey as an upstream migration corridor. However, lamprey ammocoetes may be found within the basin rearing in backwater areas containing organic silty deposits or in the fine substrate between cobbles in the mainstem river.

3.2.3.2 Birds

Bank swallow (*Riparia riparia*)

Status: Federal species of concern; State threatened

Reliance on groundwater: Indirect. This species relies on surface water that may be supported by groundwater. Bank swallows' diet consists of aquatic and terrestrial insects caught over nearby water bodies and associated floodplain grasslands. On the Sacramento River, bank swallow reproductive success appears to be positively associated with the previous winter's streamflow, and nesting burrows are more common in actively meandering reaches. This suggests that higher flows in winter (prior to the initiation of nesting) improve nesting habitat and foraging conditions. However, high stream flows or rapid drawdowns during their nesting season (April to June) may increase the risk of nest failure due to inundation, bank slumping, or bank erosion.

Habitat: Bank swallows primarily live along bodies of water, such as rivers, streams, ocean coasts, and reservoirs. This species is highly colonial and breeds in nesting burrows up to 3.3 ft deep and constructed in near-vertical banks greater than 6.6 ft tall and generally more than 80 ft long.

Presence in the ERVB: This species has established breeding colonies on the Lower Eel River, upstream of Fernbridge, and reportedly on the Van Duzen River.

Yellow-billed cuckoo (*Coccyzus americanus*)

Status: Federal threatened; State endangered

Reliance on groundwater: Indirect. This species is reliant on groundwater-dependent riparian vegetation for habitat.

Habitat: This riparian obligate species uses riparian evergreen and deciduous woodland and southwestern North American wash/scrub complexes, selecting young stands of colonizing vegetation or mature riparian forests for foraging and nesting. Cottonwood and willow trees are

an important foraging habitat in areas where the species has been studied in California. Cuckoos appear to require large blocks (25 to 100 acres) of riparian habitat for nesting.

Presence in the ERVB: Yellow-billed cuckoos have been observed in the lower Eel River Valley downstream of Fernbridge.

Snowy plover (*Charadrius alexandrinus nivosus*)

Status: Federally threatened

Reliance on groundwater: Indirect. Western snowy plovers primarily congregate on coastal beaches but can nest near wetlands that may be supported by groundwater.

Habitat: These plovers breed above the high tide line on coastal beaches, sand spits, dune-backed beaches, sparsely vegetated dunes, beaches at creek and river mouths, and salt pans at lagoons and estuaries. They tend to nest near the shore, but also near freshwater or brackish wetlands (e.g., river mouths, estuaries, and tidal marshes). They also utilize use dry river gravel bars that are relatively close to the coast for breeding.

Presence in the ERVB: Confirmed breeding has been observed on gravel bars along the lower Eel River between Fernbridge and the mouth of the Van Duzen River.

3.2.3.3 Amphibians

Foothill yellow-legged frog (*Rana boylei*)

Status: State species of special concern

Reliance on groundwater: Direct. This species relies on surface water flows that may be supported by groundwater.

Habitat: Perennial streams or rivers and intermittent creeks with pools comprise this species' habitat. Breeds during May/June in low-gradient sections of rivers and large streams near junctions with tributaries due to proximity to adult overwintering habitat in tributaries and the presence of cobbles in these locations. Tadpoles show affinity to the oviposition site, remaining in edgewater habitat with interstices, vegetation, and/or detritus for cover.

Presence in the ERVB: Common within the Middle Eel, Upper Eel, and Van Duzen River and Tributaries GDE units.

Northern red-legged frog (*Rana aurora*)

Status: State species of special concern

Reliance on groundwater: Direct. This species relies on surface water that may be supported by groundwater.

Habitat: Ponds, wetlands, seeps, and upland dispersal, as well as foraging areas between those aquatic features, comprise this species' habitat. Upland habitat may be grasslands and/or woody vegetation, and even intensive croplands. Breeding occurs in ponds or quiet backwaters of watercourses. Individuals may disperse to other locations away from breeding areas.

Presence in the ERVB: Common throughout the ERVB.

3.2.3.4 Reptile

Western pond turtle (*Emys marmorata*)

Status: State species of special concern

Reliance on groundwater: Direct. This species relies on surface water flows that may be supported by groundwater.

Habitat: Ponds, lakes, rivers, streams, creeks, marshes, and irrigation ditches with basking sites comprise this species' habitat. Western pond turtles feed on aquatic plants, invertebrates, worms, frog and salamander eggs and larvae, crayfish, and occasionally frogs and fish.

Presence in the ERVB: This species has been observed in the Intertidal Zone and Tributaries and Van Duzen River and Tributaries GDE units.

3.2.4 SPWN

The ERVB supports high-quality aquatic habitats suitable for reproduction and early development of fish. The lower Eel and Van Duzen rivers commonly experience very high winter flows that mobilize the gravel bed and destroy salmonid redds in these reaches. Therefore, a more successful population survival strategy is to spawn in the good quality spawning habitat located within the upstream reaches of the Upper Eel and Van Duzen GDE units and their tributaries (e.g., Yager, Howe, Francis, Price, Monument, and Hely creeks). However, spawning of anadromous salmonids may occur within the lower mainstem reaches of the Middle Eel, Upper Eel, and Van Duzen River GDE units during dry water years when flows remain low and access to tributary streams may be limited (D. Halligan, Stillwater Sciences, pers. comm. 2021).

The amount of spawning habitat within the mainstems of the lower Eel and Van Duzen rivers varies from year to year, dependent on the previous runoff season's hydrology (Figures 5 and 6). In general, water years with relatively low intensity and short duration runoff events appear to result in lower amounts of suitable spawning habitat. This may be due less to bedload transport and gravel sorting, and more to increased deposition of sand and small gravel. Water years with high intensity and long duration runoff events result in greater bedload movement, gravel sorting, and flushing of sand from the substrate, but high flow events can also result in larger clasts depositing in what may have been suitable spawning areas in previous years, thereby rendering them too coarse for use by salmonids.

CDFW (formerly CDFG) conducted instream habitat inventories in several tributaries within the ERVB between 1992 and 2018. The stream habitat inventory protocol (Flosi et al. 1998) used an ocular estimate of the depth of embeddedness of the cobbles in pool tailout areas as an indication of spawning habitat quality. To do this, a surveyor would sample at least five small cobbles (2.5–5.0 inches in diameter) and estimate the amount of the stone buried in the sediment. The values are recorded using the following ranges: 0–25 percent (value 1), 26–50 percent (value 2), 51–75 percent (value 3) and 76–100 percent (value 4). Additionally, a value of 5 was assigned to tailouts deemed unsuitable for spawning due to inappropriate substrate like bedrock, log sills, boulders, or other considerations. Cobble embeddedness measured to be 25 percent or less (value of 1) indicates good-quality spawning substrate for salmon and steelhead. The percentage of sites with each cobble embeddedness rating recorded by CDFW for several tributaries within the ERVB is shown in Table 7. Because these measurements of habitat quality only rely on cobble embeddedness and not suitable flow, depth, water velocity, and usage, they are only a proxy for available spawning habitat.

The embeddedness values in Table 7 indicate that, for the survey years, Price and Oil creeks contained a large percentage of relatively high-quality spawning habitat. It must be noted that the values contained in Table 7 were just a snapshot in time. Embeddedness conditions in these streams could have changed in later years due to a host of factors, such as hydraulic and hydrologic, mass wasting, road, and bank stabilization conditions.

Table 7. Cobble embeddedness ratings for fish bearing tributaries to the ERVB (CDFG/CDFW 1998-2017)

Watercourse	GDE unit	Year surveyed	Embeddedness value (percentage of sites)				
			1	2	3	4	5
Howe Creek	Upper Eel	1998	0	12	73	15	0
Howe Creek	Upper Eel	2017	4	45	41	3	7
Price Creek	Upper Eel	1999	12	38	25	20	5
Price Creek	Upper Eel	2017	50	24	18	0	8
Oil Creek	Upper Eel	2002	73	14	13	0	0
Monument Creek	Upper Eel	2010	18	27	30	25	0
Barber Creek	Middle Eel	2008	1	5	19	58	17
Francis Creek	Intertidal	2003	2	19	43	32	4
Hely Creek	Van Duzen River	2006	0	14	44	17	25
Hely Creek	Van Duzen River	2017	9	21	52	10	8

3.2.5 EST

The Eel River Estuary is a sand-bar-built estuary that typically remains open to tidal exchange year-round, extending inland to at least Fernbridge where salinities of 2–11 parts per thousand (ppt) have been measured (Cannata 1994–1995 field notes, as cited in CDFG 2010).

The estuary contains five freshwater tributaries connected to 30 miles of named slough channels, not counting the Salt River watershed (CDFG 2010). Another 30 miles of unnamed sloughs (shown on USGS topographic maps) meander throughout its floodplain. Tidal flows are contained on major sloughs by levees and tide gates built by settlers to the area in the latter 1800s and early 1900s. This has resulted in the alteration of the natural tidal connectivity and drainage patterns between slough channels, freshwater streams, and their adjacent wetlands (CDFG 2010).

The ERVB Intertidal Zone and Tributaries GDE Unit supports a rich estuarine ecosystem downstream of Fernbridge. A host of mammals, waterfowl, shorebirds, fish, and shellfish utilize this GDE unit on an annual or seasonal basis. The GDE Unit also contains designated critical habitat for western snowy plover (71 acres), Chinook salmon (12 acres), coho salmon (3 acres), steelhead (3 acres), and tidewater goby (21 acres).

3.2.6 MIGR

The ERVB supports habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish. As discussed above, the lower Eel and Van Duzen rivers experience elevated water temperatures during the summer and early fall months, which significantly limits the amount of cold water habitat suitable for rearing special-status fish species. As such, these reaches are primarily used by adult and juvenile salmonids and other special-status fish species as migratory corridors for adult and juvenile life history stages.

Upstream spawning migration of adult salmon and steelhead generally begins in the fall but may be inhibited by shallow riffles until there is enough flow to allow passage (Figure 8). Chinook salmon enter the Eel River in August or early September. Steelhead also begin showing in September, followed by coho salmon generally appearing in October. A review of migration timing and riffle depth data collected from 2010 to 2020 (Stillwater Sciences 2011-2021a) showed that upstream migration by adult Chinook salmon in the Lower Eel River during the early fall is blocked by riffle depths 0.4 ft or less and inhibited by riffles that are 0.5–0.6 ft deep. Adult

Chinook salmon have generally been observed in the pool at the confluence of the Eel/Van Duzen rivers when riffle depths met or exceeded 0.7 ft deep. In addition, for most years, entry by adult anadromous salmonids into the Van Duzen River is blocked by a dry reach at the mouth of the river until there is enough runoff to breach the barrier.

Depth of water over riffles is dependent on flow, but also on riffle morphology, which can change from year to year depending on the previous winter’s high flow characteristics. In general, long oblique riffles will have shallower depths than those that have a narrower wetted cross-section. For any given flow, riffle depths will vary within a reach. For example, riffle ME-1 (first riffle downstream of the mouth of the Van Duzen River; narrow) tends to be deeper than ME-4 (downstream end of 12th Street pool; narrow to oblique), which in turn is deeper than ME-6, which is near the Boxcars (near Highway 101 southbound Mainstreet Fortuna exit; oblique) (Figure 9). The degree to which groundwater management affects critical riffle depths will be explored in the final GSP.

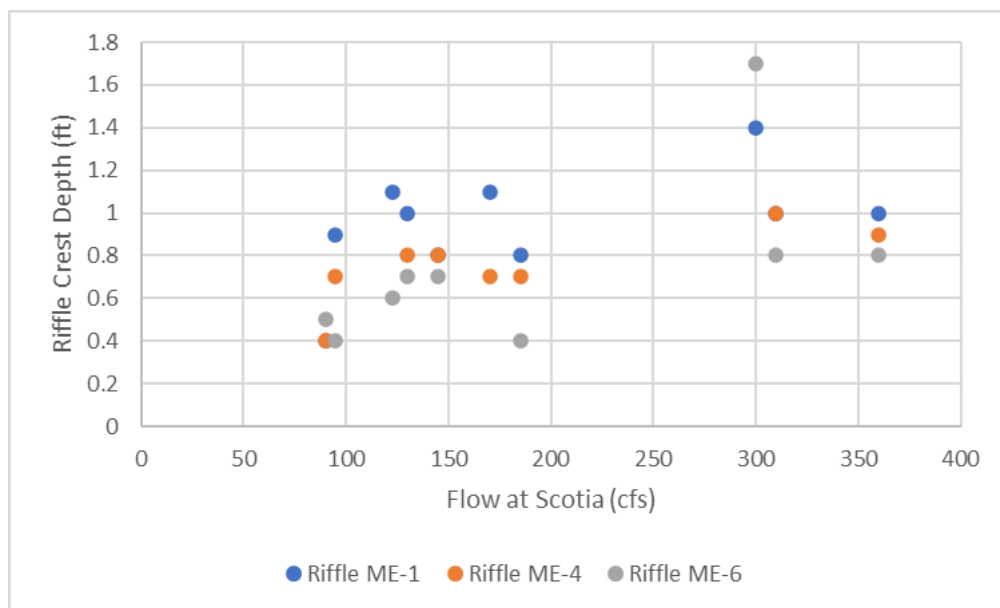


Figure 9. Riffle crest depths at selected riffle locations and flows, 2010–2020

Downstream migration by salmon and steelhead smolts occurs during late winter, spring, and early summer, when river flows are relatively high. The body depth of smolts is about 0.1 ft, which allows for relatively unencumbered passage over riffles and other shallow locations. However, low flows experienced during dry water years reduces the relatively high turbidity levels that afford smolts protection from predators.

Upstream migration by longfin smelt typically runs from the late fall and winter with spawning occurring in February through April over sandy or gravel substrate. Larvae hatch in about 40 days and are moved downstream to estuaries by high flows, but may also spend considerable time in freshwater. These upstream and downstream migration periods tend to occur outside of the agricultural groundwater extraction season and when Lower Eel River flows are relatively high. Therefore, migration by longfin smelt may not be limited by flow unless the rains are late in arriving.

Adult Northern DPS green sturgeon generally return to spawn in rivers in late winter through early summer and spawn every two to six years, with spawning intervals of three to four years being the most common. Some adult Northern DPS sturgeon move back downstream to the estuary and ocean soon after spawning when river flows are still elevated by snowmelt, but others have been observed to hold in the river until the fall when temperatures decrease and flows increase with precipitation (McCovey 2011).

Juvenile green sturgeon in the mainstem Eel River were trapped by CDFG in May through September in 1967 and 1968 during periodic downstream migrant trapping at McCann and Fort Seward (Puckett 1976). The timing corresponds to the general downstream juvenile migration that occurs primarily during summer through fall (Emmett et al. 1991 Allen et al. 2009, as cited in Moyle et al. 2018).

In general, juvenile and adult fish species that migrate through the ERVB during the summer and fall months could be affected by groundwater management (Table 8). Those that migrate during the late fall through spring would likely experience minimal groundwater management effects due to the relatively high flows that occur during those seasons.

Table 8. Fish migration timing and potential for groundwater management effects

Species	Juvenile migration timing	Juveniles potentially affected by groundwater management (Yes/No)	Adult migration timing	Adults potentially affected by groundwater management (Yes/No)
Chinook salmon	Spring to early summer	No	Late summer and fall	Yes
Coho salmon	Spring	No	Fall	Yes
Steelhead	Spring to early summer; late fall	Late fall only	Fall and winter	Yes
Longfin smelt	Winter to spring	No	Late fall to winter	No
Green sturgeon	Summer to fall	Yes	Late winter to early summer	Yes

3.2.7 REC-1

Attributes associated with REC-1 include swimming, wading, skin and scuba diving, and fishing. Recreational use of Eel River is limited, largely because there are very few access points. However, the public can access the Middle Eel River GDE Unit through East Ferry Road east of Ferndale, which connects to a web of four-wheel drive roads that run along the west bank of the river between the mouth of the Van Duzen River and Fernbridge. Swimming, wading, skin and scuba diving, and fishing are not necessarily tied to flow levels, but can be influenced by other factors.

County (Swimmers Delight and Pamplin Grove) and State (Grizzley Creek Redwoods) parks are present at the upstream end of the Van Duzen River and Tributaries GDE Unit. These parks provide public access for swimming, wading, and fishing activities.

Swimming, wading, skin, and scuba diving within the Middle Eel River GDE unit occur on a more limited basis during the summer and fall seasons due to the presence of “swimmer’s itch,” which develops through skin contact with a waterborne parasite that lives in shoreside algae. In addition, REC-1 activities are dependent on blue-green algae growth, which has increased in recent years spurred by a combination of upstream nutrient loading from land use, low flows, and warm weather. Accidental or purposeful ingestion of algae-laden water can result in illness or death of an individual. This has led to the County issuing warnings regarding contact recreation in the ERVB and upstream areas (CDFW 2014).

Principle recreational use during the fall, winter, and spring comprises recreational fishing for salmon and steelhead. In general, salmon and steelhead fishing occurs when the fall flows increase, allowing fish passage over downriver riffles. Fishing is not allowed after October 1, however, until flows are high enough to lift the CDFW-regulated low flow closure, which is set at 350 cfs for the Eel River and 150 cfs for the Van Duzen River.

3.2.8 REC-2

Attributes associated with REC-2 include picnicking, sunbathing, hiking, boating, hunting, sightseeing, and aesthetic enjoyment. Most of these activities (picnicking, sunbathing, hiking, hunting, sightseeing, and aesthetic enjoyment) are not related to flow levels in the river.

Much of the land bordering the Upper Eel and Middle Eel GDE units are private properties with limited public access, though the public can access the Middle Eel River GDE Unit through East Ferry Road, which connects to a web of four-wheel drive roads that run along the west bank of the river. In addition, drift boaters may be able to take out at the confluence of the Eel and Van Duzen rivers through access provided by Eureka Ready Mix. Paddle boarders also use the Middle Eel River GDE Unit, some of whom monitor salmon migration patterns in the fall as part of a citizens monitoring program started by the ERRP.

Boating in the ERVB is generally tied to flow levels in the rivers but can occur any time of year. Different types of watercraft require different minimum depths to allow for unobstructed passage. For example, a shallow-draft kayak may only require 0.4 ft of depth while a loaded drift boat would need more water to pass a shallow riffle.

The Intertidal Zone and Tributaries GDE Unit is frequently used by boaters, sightseers, and waterfowl hunters who access the river via the existing recreational boat ramp on the Lower Eel River at Pedrazzini Park, near Loleta.

Much of the Van Duzen River and Tributaries GDE Unit within the ERVB is bordered by private land, which limits access by the public. Residents adjacent to the river are able to enjoy its recreational benefits. There is a gated access point for hikers located underneath the north side of the Highway 101 bridge crossing the Van Duzen River. County (Swimmers Delight and Pamplin Grove) and State (Grizzly Creek Redwoods) parks are present at the upstream end of the GDE unit. These parks provide public access for picnicking, sunbathing, hiking, boating, sightseeing, and aesthetic enjoyment. Hunting is not allowed.

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