Phone: (707) 441-8855 Email: info@shn-engr.com Web: shn-engr.com
812 W. Wabash Avenue, Eureka, CA 95501-2138

Technical Memorandum

SHN Reference:	020091.170
GHD Reference:	11217388. 2.3.1
Date:	September 8, 2021
To:	Summer Daugherty, Senior Environmental Analyst, Humboldt County Department of Public Works-Environmental Services
Copy To:	Hank Seemann, Deputy Director, Humboldt County Department of Public Works-Environmental Services
From:	SHN: Mindi Curran and Jason Buck GHD: Patrick Sullivan
Subject:	**Saltwater Intrusion Technical Memorandum**

1.0 Introduction

1.1 Overview

Humboldt County Department of Public Works (County) is leading the effort to develop a groundwater sustainability plan (GSP) for the Eel River Valley groundwater basin (ERVB; Appendix 1, Figure 1), due January 31, 2022, for compliance with the Sustainable Groundwater Management Act (SGMA). This technical memorandum describes the data collection and analysis to support the delineation and evaluation of saltwater intrusion in the ERVB as defined in the scope of work for Subtask 1.7 of the County's SGMA. The specific scope of work includes:

1. Identification of data gaps from previous sampling efforts and solicitation of volunteer wells within the vicinity of the freshwater-seawater transition zone to fill those data gaps
2. Field sampling and laboratory testing of chloride concentrations at a minimum of 30 locations in Fall 2020 and again in Spring 2021 within the vicinity of the saltwater intrusion zone
3. Compilation, review, and analysis of laboratory results
4. Preparation of this technical memorandum outlining the methods, results, analysis and findings with supporting data tables and maps plotting the results

The purpose of this work is to build upon previous studies, evaluate the current position of the freshwater-seawater transition zone, and develop a better understanding of the transition zone within deeper aquifers.

1.2 Summary of Previous Work and Existing Saltwater Intrusion Data

The United States Geological Survey (USGS) published the study "Groundwater Conditions in the Eureka Area, Humboldt County, California 1975," which included an assessment of the freshwater-seawater transition zone in the Lower Eel River groundwater basin (defined as the 100 milligrams per liter [mg/L] iso-concentration line). The study concluded that the position of the freshwater-

seawater transition zone in the alluvial aquifer in 1975 was approximately the same as the position of the transition zone as documented in 1952 (USGS, 1978). The approximate location of the freshwater-seawater transition zone as mapped in 1975 is shown on Figure 2.

Almost all of the alluvial aquifer located north of the Eel River, between the Eel River and Table Bluff, is naturally degraded by seawater (USGS, 1978). This area adjoins the stretch of the Eel River that is tidally influenced and seawater in the alluvial aquifer is expected in these areas. Between the Eel River and the Salt River, the alluvial material is composed of coarse sand and gravel. which extends to the southeast to the confluence of the Eel and Van Duzen Rivers, and the freshwater-seawater transition zone in this section is moderated by the hydraulic head and subsequent recharge of the Eel River. South of the Salt River, the alluvial deposits are of low permeability (silt and clay), which deflects westward flowing groundwater to the northwest and impedes seawater movement inland.

Most of the wells sampled in the Eel River Valley in 1975 were screened within the shallow alluvial aquifer with depths generally less than 50 feet. As is expected in an unconfined coastal aquifer, it was noted that chloride concentrations at a given depth decrease with distance from the coast and generally increased with depth along the freshwater-seawater transition line (USGS, 1978). Localized temporary shifts in concentrations were observed seasonally, and this variation was attributed to the change in groundwater levels from summer to winter.

In 2016, as part of a Proposition 1 Sustainable Groundwater Planning Grant, two large-scale chloride sampling campaigns were carried out, one in the Fall of 2016 and one in the Spring of 2017. The results of those studies indicated that the freshwater-seawater interface had not moved significantly since 1975. The results from the Fall 2016 and Spring 2017 are provided as Figures 3 and 4, respectively. As part of the commitments made in the 2016 Groundwater Sustainability Plan Alternative biannual chloride sampling was continued within two of the paired County monitoring well locations (MW-5s/d and MW-7s/d; SHN, 2016).

2.0 Fall 2020 and Spring 2021 Chloride Sampling

2.1 Well Selection

SHN collaborated with the County and the Humboldt County Resource Conservation District (HCRCD) to develop a list of at least 30 wells for chloride sampling. Four municipal wells and five existing County monitoring wells within the vicinity of the freshwater-seawater transition zone were selected. The County and HCRCD reached out and coordinated with volunteer landowners for access to private irrigation and domestic wells. A similar chloride sampling campaign had been carried out in Fall 2016 and Spring 2017, and to maintain consistency with previous work, a special effort was made to include the wells that had been sampled during those events.

The geographic area of interest for data collection on saltwater intrusion was generally focused on the western half of the lower Eel River Valley within the vicinity of the mapped 100 mg/L iso-concentration line. Most wells within the alluvial valley are shallow and historical data useful for understanding the saltwater intrusion conditions has primarily come from the shallow alluvial aquifer. The configuration of the freshwater-seawater transition at depth is a known data gap and deeper wells that are screened within confined or semi-confined portions of the lower alluvial

aquifer or the Carlotta were sought out to gain better understanding of the conditions at depth. Two new additional volunteer wells were identified and two of the new County monitoring wells installed in 2021 were specifically located to explore saltwater intrusion conditions at depth.

2.2 Field Methods

Two chloride sampling campaigns were carried out, one in Fall 2020 and one in Spring 2021. The campaigns were scheduled to coincide with the water levels field effort and as closely as possible with the Division of Water Resources (DWR) field measurements of California Statewide Groundwater Elevation (CASGEM) wells. In preparation for the fieldwork, a tabulated list of wells was developed that included information on location, ownership and contact information, access and coordination needs, and any known well attributes. Many of the locations had been sampled in the 2016/2017 campaigns and information from those efforts was reviewed and included.

County monitoring wells and private wells with open casing were sampled using either a peristaltic pump or a downhole Grundfos pump and clean polyethylene tubing. Open wells were sampled following low-flow sampling protocols outlined in the U.S. Environmental Protection Agency (EPA) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. As described in the guidelines, temperature, pH, electrical conductivity, and turbidity were measured every two to five minutes depending on the purge rate. Each team documented the sampling methods and field parameter measurements on "Groundwater Monitoring Forms" and "Daily Field Forms." The municipal wells and many of the private wells were sealed and samples were collected from a nearby spigot or hose following a flushing routine.

Equipment used during the field program consisted of dedicated single-use disposable items, select hand tools, and mechanized equipment. Groundwater sampling equipment was cleaned prior to its use and between each monitoring well using the triple-wash system (a Liquinox® solution wash followed by two distilled water rinses).

Groundwater samples were collected in containers supplied by the analytical laboratory, placed in an iced cooler, and sent to the analytical laboratory under appropriate chain-of-custody documentation. Groundwater samples were analyzed for chloride using EPA method 300.0 Rev 2.1 (1993). Chloride analysis was conducted by North Coast Laboratories, a State of California-certified analytical laboratory located in Arcata, California.

2.3 Fall 2020 Chloride Sampling Results

The Fall 2020 chloride sampling event was conducted during the week of October 26, 2020, in tandem with the water levels measurement campaign. A total of 30 wells were sampled for chloride, including 5 County monitoring wells, 4 municipal wells, and 21 private wells. A map of all wells sampled along with the results from the Fall 2020 sampling event is shown on Figure 5 (Appendix 1) and tabulated details of the wells, sampling dates and results are provided in Table 1 (Appendix 2).

For the purposes of mapping chloride concentrations at depth, it was necessary to separate wells screened within the shallow interconnected aquifers from those screened within deeper, confined to semi-confined water bearing units of the lower alluvium or the underlying Carlotta formation. Chloride concentrations associated with the Fall 2020 sampling event for wells screened in the shallow interconnected alluvial aquifers (alluvial and near-surface, unconfined Carlotta) are

presented on Figure 6 (Appendix 1). Chloride concentrations associated with the Fall 2020 sampling event for wells that are screened within deeper confined to semi-confined aquifers are presented on Figure 7 (Appendix 1).

2.4 Spring 2021 Chloride Sampling Results

The Spring 2021 chloride sampling event was conducted during the week of April 5, 2021, in tandem with the water levels measurement campaign. A total of 30 locations were sampled for chloride, including 6 County monitoring wells, 2 municipal wells, and 22 private wells. In addition to the Spring 2021 sampling event, chloride samples were also collected from a subset of the newly constructed County monitoring wells during the groundwater quality sampling event that occurred July 8-13, 2021 (SHN, 2021). A map of all wells sampled along with the results from the Spring 2021 and July 2021 sampling events is shown on Figure 8 (Appendix 1) and tabulated details of the wells, sampling dates and results are provided in Table 1 (Appendix 2).

Chloride concentrations associated with the Spring 2021 sampling event for wells screened in the shallow interconnected alluvial aquifers (alluvial and near-surface, unconfined Carlotta) are presented on Figure 9 (Appendix 1). Chloride concentrations associated with the Spring 2021 sampling event for wells that are screened within deeper confined to semi-confined aquifers are presented on Figure 10 (Appendix 1).

3.0 Summary of Findings

The 100 mg/L iso-concentration line was used to define the landward edge of the freshwater-seawater transition zone in 1975 (USGS, 1978) (Figure 2). Prior to 2016, this was the last time that a broad sampling of chlorides suitable enough to map the transition zone was completed. A comparison of the current position of the transition zone with that was mapped in 1975 provides the best opportunity to assess any long-term changes that may have occurred over that timeframe (45 years). Figures 3 and 4 show the chloride concentrations from wells sampled during the Fall 2016 and Spring 2017 campaigns, respectively. A review of the chloride concentrations indicates that the 100 mg/L iso-concentration line developed in 1975 remains applicable, with the only value on the east side of the line above 100 mg/L is private well #25 at the edge of the alluvial valley in Loleta. Continued sampling of this well has consistently maintained chloride concentrations indicative of an intruded condition with values ranging from 280 to 320 mg/L.

Figures 6 and 9 show the chloride concentrations from shallow wells sampled during the Fall 2020 and Spring 2021 sampling campaigns, respectively. In addition to plotting the 100 mg/L and 30 mg/L iso-concentration lines from 1975, a more refined interpretation of the 100mg/L and 30 mg/L lines are plotted for this study. The revised 100 mg/L lines plotted for each do not show significant variation from that mapped in 1975, with the exception of moving the northern extent of the line eastward near Loleta to encompass private wells #24 and #25. The revised 30 mg/L lines plotted for the current study extend further eastward based on results from private well J and the new County monitoring well MW-14s.

MW-28 is a new County monitoring well screened from 35-45 feet below grade that was sampled in July 2021. The chloride concentration measured at that location was 94 mg/L, which is anomalous for the location of MW-28 relative to other nearby shallow concentrations (see Figure 9). Water quality sampling results from MW-28 (SHN, 2021) indicate detections of fluoride and other

constituents that may be attributed to the Ferndale wastewater treatment plant (WWTP), located 1,500 feet to the east. An additional consideration is the recently restored intertidal channels of the Salt River, located approximately 300 feet to the north. It's feasible that the renewed tidal exchanges in this area could have an influence on chloride concentrations within the shallow aquifer. At this time, until further evaluation, the chloride concentration is not considered reflective of the influence of seawater, and is, therefore, not used in our contour mapping.

The most recent sampling campaigns conducted in the Fall 2016/Spring 2017 and the Fall 2020/Spring 2021 provide an opportunity to look at the range of fluctuation that occurs between subsequent seasons (fall and spring) and water year types (dry, normal, wet). Spring of 2017 was a wet season, with a major flood occurring only three months prior to the sampling campaign, whereas the sampling campaign conducted in Spring of 2021 was on the heels of two consecutive seasons of drought conditions. Table 2 (Appendix 2) provides a comparison of chloride concentrations in Fall (2016-2020) and in Spring (2017-2021). Changes in concentrations over the 4-year period range from a decrease of 450 mg/L at private well #29 (Fall season comparison) to an increase of 500 mg/L for private well #2s (Spring season comparison). Five private well locations that show increases greater than 100 mg/L are plotted on Figure 11. Of the five locations, three occur on the south side of, and in close proximity to, the Salt River (H, #2, and #5), one is on Cock Robin Island (#29), and one is near Loleta (#24). Two of the locations (#2 and #5) are deep screened wells. It is not clear if these increases are related to the natural fluctuations associated with extreme wet and dry water year types or if they record a more permanent advancement of the freshwater-seawater transition zone in those areas. A longer period of record under varying water year types will be necessary to make that assessment.

It's important to note that the data sets discussed above are largely derived from shallow wells. To date, the mapping of the orientation and vertical profile of the freshwater-seawater transition zone at depth has yet to be completed. The results from this study provide valuable insight into what's happening at depth, but data remains limited and the stratigraphy and aquifer conditions at depth are complex, particularly in the vicinity of Ferndale, where most available data exist. Figures 7 and 10 show the chloride concentrations from deep-screened wells that have been sampled during the Fall 2020 and Spring 2021 campaigns, respectively. A plot of the 100 mg/L iso-concentration line on both maps indicates that the interface extends furthest inland along the general alignment of the Salt River. Relatively low chloride concentrations along the foothills to the south and west in private wells #52 (35 mg/L) and G (37 mg/L) and in the Riverside CSD municipal well (47 mg/L) may be associated with freshwater recharge from the Carlotta underlying the Wildcat Hills. Not enough data exists at this time to map the 100 mg/L line north of MW-5D.

Two sets of paired County monitoring wells (MW-5s/d and MW-7s/d) were installed in 2016 for the purposes of monitoring the freshwater-seawater transition zone. Two new paired County monitoring wells and three single wells (MW-14s/d, MW-15s/d, MW-26, MW-27, and MW-28) were added to the saltwater monitoring well network in 2021. All seven of these wells are shown on Figure 12 and are good candidate wells for regular chloride monitoring into the future.

4.0 References

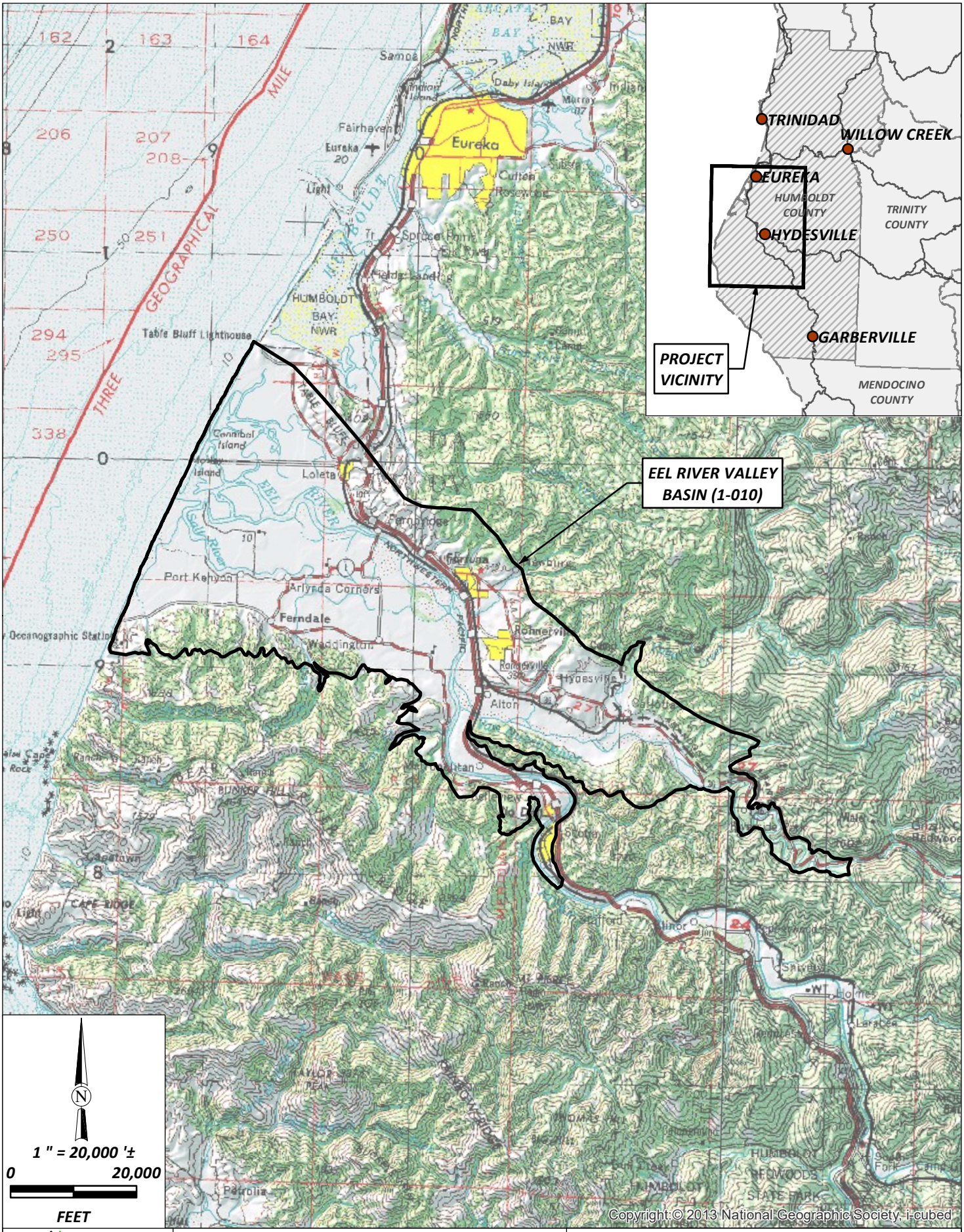
SHN Consulting Engineers & Geologists, Inc. (2016). "Eel River Valley Groundwater Basin, Sustainability Plan Alternative." Eureka, CA:SHN.

SHN. (2021). "Groundwater Quality Tech Memo." Eureka, CA:SHN.

United States Geological Survey. (1978). "Ground-water Conditions in the Eureka Area, Humboldt County, California, 1975." U.S. Geological Survey Water Resources Investigations 78-127.

Appendices:
1. Figures
2. Tables

Figures 1



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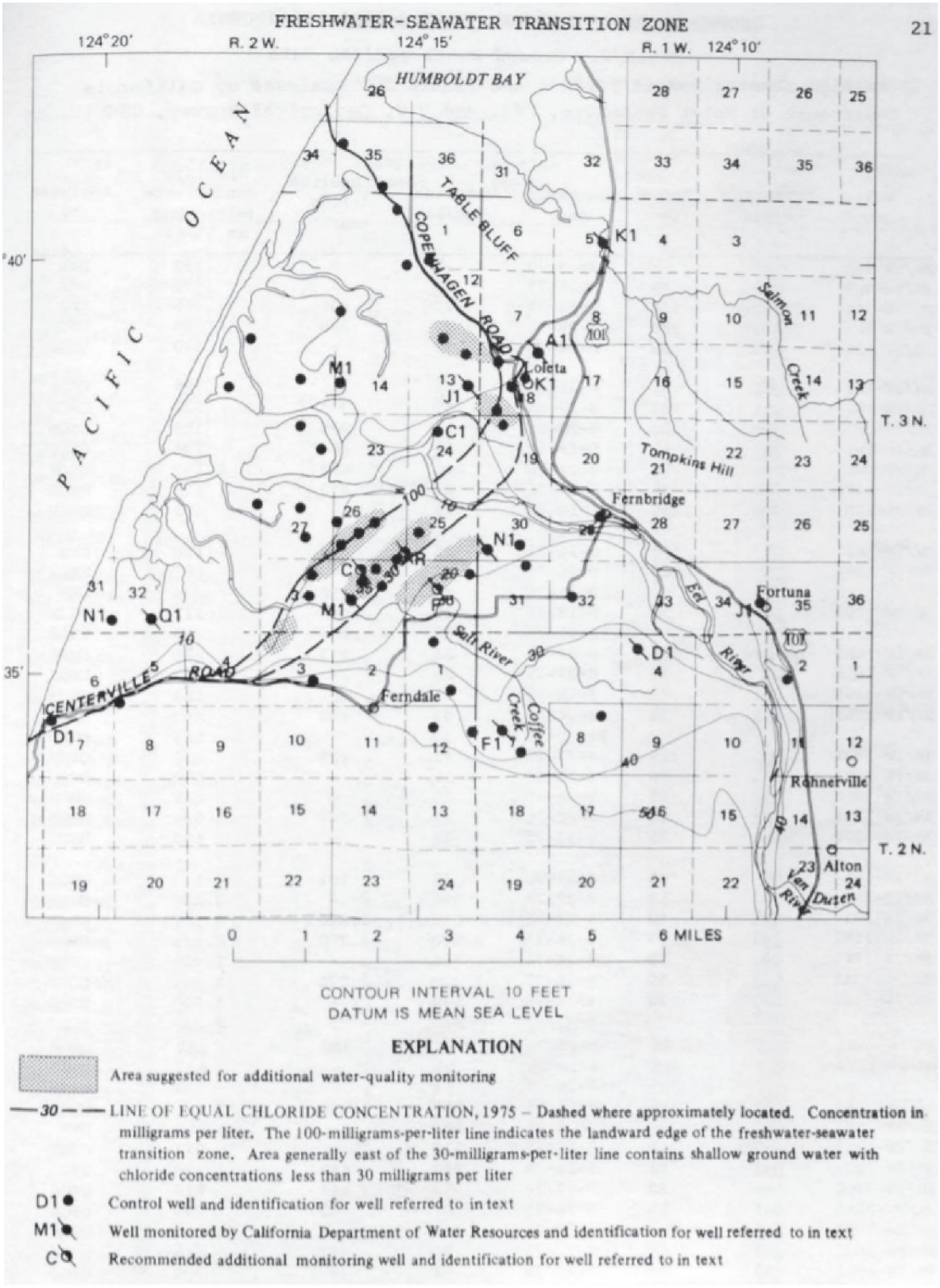
SHN	Humboldt County Public Works Eel River Valley Basin (1-010) Humboldt County, California	Project Location SHN 020091.170
	September 2021 | Figure1_ProjectLocationMap	Figure 1



NOTE: FROM USGS, 1978

	Humboldt County Public Works Eel River Valley Basin (1-010) Humboldt County, California	Freshwater/Seawater Transition Zone in Alluvial Aquifer, Eel River Valley-1975 SHN 020091.170
September 2021	Figure2_FreshwaterSeawaterTransitionZone	Figure 2

EXPLANATION

- CERTAIN LINE OF EQUAL CONCENTRATION (JOHNSON, 1975)
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- 2016 CHLORIDE DATA VALUES (MG/L)
- INDICATES WELL DEPTH >100 FEET
- 23/20 INDICATES SHALLOW/DEEP CONCENTRATIONS

N

0 3,000

1"=3,000'±

1500
320
680
100 MG/L
250
33
38
180
28
25
16/19
62/61
32
67
41
62
89
2600
130
30/240
39
49
87
47
49

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NOTE: FIGURE TAKEN FROM SHN, 2017

Humboldt County Public Works
Eel River Valley Basin (1-010)
Humboldt County, California

Fall 2016 Chloride Concentration

SHN 020091.170

September 2021 | Figure3_Fall2016_ChlorideConcentrations | Figure 3

Path: \\eureka\projects\2020\020091-Eel-River-GSP\GIS\PROJ_MXD\170-SaltWaterIntrusion\Figure3_Fall2016_ChlorideConcentrations.mxd User Name: pix4d DATE: 9/1/21, 3:14PM

EXPLANATION

- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- SPRING 2017 CHLORIDE DATA VALUES (MG/L)
- INDICATES WELL DEPTH >100 FEET
- 23/20 INDICATES SHALLOW/DEEP CONCENTRATIONS

N

0 3,000

1"=3,000'±

1600
280
75
100 MG/L
120
28
140
4
28
22
16/19
62/61
29
40
30
62
38
2100
97
30/240
33
43
290
51
43

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NOTE: FIGURE TAKEN FROM SHN, 2017

Humboldt County Public Works
Eel River Valley Basin (1-010)
Humboldt County, California

Spring 2017 Chloride Concentrations

SHN 020091.170

September 2021 | Figure4_Spring2017_ChlorideConcentrations | Figure 4

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ALL WELLS SAMPLED IN FALL 2020

26
260

LOLETA CSD 4
17

LOLETA

34
320

R
1400

25
280

100 MG/L

30 MG/L

29
230

Q
140

L
110

51
110

7
25

59
30

MW-1S
24

MW-5S/D
55/68

53
3300

3
33

6
30

11
72

J
23

H
240

2
2600

4
49

5
460

PALMER CREEK CSD 2
21

MW-7S
25

52
36

G
37

RIVERSIDE CSD 6
47

DEL ORO WATER COMPANY
41

FERNDALE

EXPLANATION

- COUNTY MONITORING WELLS
- MUNICIPAL WELLS
- PRIVATE WELLS
- INDICATES WELLS SCREENED IN DEEPER, CONFINED AQUIFERS
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- ALLUVIAL VALLEY/TARGETED AREA OF INTEREST
- EEL RIVER VALLEY GROUNDWATER BASIN (1-010)
- WELL ID
  CHLORIDE CONCENTRATION (MG/L)
  55/68 INDICATES SHALLOW/DEEP CONCENTRATIONS AT PAIRED WELLS

N

0 5,000

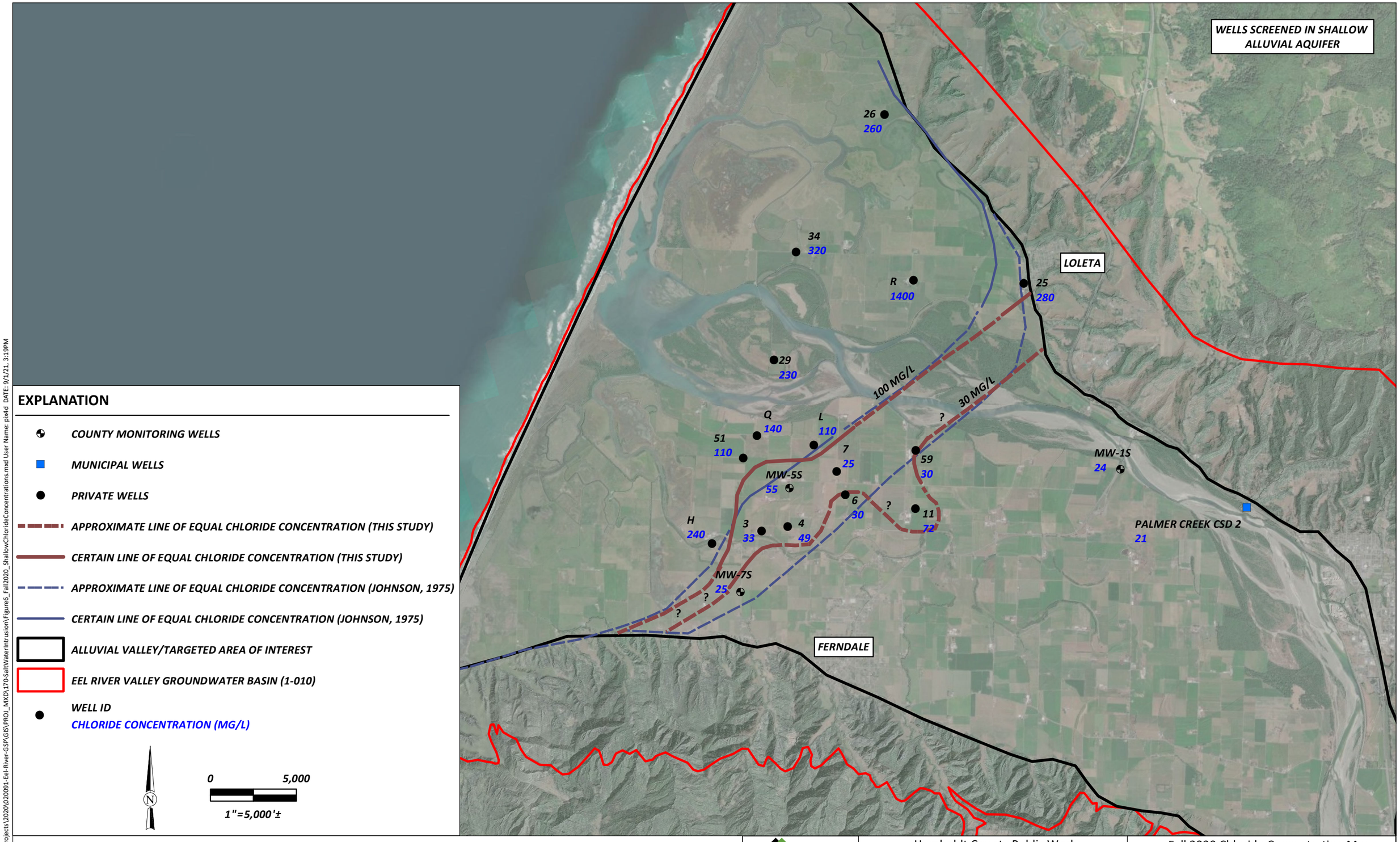
1"=5,000'±

Path: \\eureka\projects\2020\020091-Eel-River-GSP\GIS\PROJ_MXD\170-SaltWaterIntrusion\Figure5_Fall2020_ChlorideConcentrations.mxd User Name: pix4d DATE: 9/1/21, 3:32PM

Humboldt County Public Works
Eel River Valley Basin (1-010)
Humboldt County, California

Fall 2020 Chloride Concentration Map
(All Wells)
SHN 020091.170

September 2021 | Figure5_Fall2020_ChlorideConcentrations | Figure 5



EXPLANATION

- COUNTY MONITORING WELLS
- MUNICIPAL WELLS
- PRIVATE WELLS
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (THIS STUDY)
- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (THIS STUDY)
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- ALLUVIAL VALLEY/TARGETED AREA OF INTEREST
- EEL RIVER VALLEY GROUNDWATER BASIN (1-010)
- WELL ID
- CHLORIDE CONCENTRATION (MG/L)

N

0 5,000

1"=5,000'±

Humboldt County Public Works
Eel River Valley Basin (1-010)
Humboldt County, California

Fall 2020 Chloride Concentration Map
(Shallow Aquifer)
SHN 020091.170

September 2021 | Figure6_Fall2020_ShallowChlorideConcentrations | Figure 6

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WELLS SCREENED IN DEEPER CONFINED TO SEMI-CONFINED AQUIFERS

LOLETA CSD 4
17

LOLETA

100 MG/L ?

MW-5D
68

53
3300

2
2600

5
460

?

J
23

?

52
36

G
37

RIVERSIDE CSD 6
47

DEL ORO WATER COMPANY
41

FERNDALE

EXPLANATION

- COUNTY MONITORING WELLS
- MUNICIPAL WELLS
- PRIVATE WELLS
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (THIS STUDY)
- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (THIS STUDY)
- ALLUVIAL VALLEY/TARGETED AREA OF INTEREST
- EEL RIVER VALLEY GROUNDWATER BASIN (1-010)
- WELL ID
  CHLORIDE CONCENTRATION (MG/L)

N

0 5,000

1"=5,000'±

Humboldt County Public Works
Eel River Valley Basin (1-010)
Humboldt County, California

Fall 2020 Chloride Concentration Map
(Deeper Aquifer)
SHN 020091.170

September 2021 | Figure7_Fall2020_DeepChlorideConcentrations | Figure 7

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ALL WELLS SAMPLED IN SPRING 2021

26
330

MW-27
9,300

MW-26
150

R-SHOP
1500

25
290

LOLETA

24
130

100 MG/L

30 MG/L

29
240

Q
120

L
160

51
140

59
36

7
26

MW-5S/D
56/72

MW-14S/D
35/16

MW-1D
23

J
24

6
33

11
51

3
35

4
59

53
520

H
280

2
2600

5
270

MW-28
94

MW-15S/D
28/15

MW-7S
41

MW-25
12

I
190

52
33

G
42

RIVERSIDE CSD 6
48

DEL ORO WATER COMPANY
44

FERNDALE

MW-8
21

MW-30
18

EXPLANATION

- COUNTY MONITORING WELLS
- MUNICIPAL WELLS
- PRIVATE WELLS
- INDICATES WELLS SCREENED IN DEEPER, CONFINED AQUIFERS
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- ALLUVIAL VALLEY/TARGETED AREA OF INTEREST
- EEL RIVER VALLEY GROUNDWATER BASIN (1-010)
- WELL ID
  CHLORIDE CONCENTRATION (MG/L)
  55/68 INDICATES SHALLOW/DEEP CONCENTRATIONS AT PAIRED WELLS

N

0 5,000

1"=5,000'±

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Humboldt County Public Works
Eel River Valley Basin (1-010)
Humboldt County, California

Spring 2021 Chloride Concentration Map
(All Wells)
SHN 020091.170

September 2021 | Figure8_Spring2021_ChlorideConcentrations | Figure 8

WELLS SCREENED IN SHALLOW ALLUVIAL AQUIFER

26
330

MW-27
9,300

MW-26
150

R-SHOP
1500

25
290

LOLETA

24
130

100 MG/L

30 MG/L

?

29
240

Q
120

L
160

59
36

51
140

7
26

MW-5S
56

MW-14S
35

MW-1D
23

6
33

4
59

11
51

H
280

3
35

?

MW-28
94

MW-15S
28

MW-7S
41

?

MW-25
12

FERNDALE

MW-30
18

EXPLANATION

- COUNTY MONITORING WELLS
- PRIVATE WELLS
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (THIS STUDY)
- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (THIS STUDY)
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- ALLUVIAL VALLEY/TARGETED AREA OF INTEREST
- EEL RIVER VALLEY GROUNDWATER BASIN (1-010)
- WELL ID
  CHLORIDE CONCENTRATION (MG/L)

N

0 5,000

1"=5,000'±

Humboldt County Public Works
Eel River Valley Groundwater Basin
Humboldt County, California

Spring 2021 Chloride Concentration Map
(Shallow Aquifer)
SHN 020091.170

September 2021 | Figure9_Spring2021_ShallowChlorideConcentrations | Figure 9

Path: \\eureka\projects\2020\020091-Eel-River-GSP\GIS\PRO_MXD\170-SaltWaterIntrusion\Figure9_Spring2021_ShallowChlorideConcentrations.mxd User Name: pix4d DATE: 9/1/21, 3:31PM

WELLS SCREENED IN DEEPER CONFINED TO SEMI-CONFINED AQUIFERS

LOLETA

100 MG/L ?

MW-5D
72

MW-14D
16

J
24

53
520

2
2600

5
270

MW-15D
15

I
190

52
33

G
42

RIVERSIDE CSD 6
48

DEL ORO WATER COMPANY
44

FERNDALE

MW-8
21

EXPLANATION

- COUNTY MONITORING WELLS
- MUNICIPAL WELLS
- PRIVATE WELLS
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (THIS STUDY)
- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (THIS STUDY)
- ALLUVIAL VALLEY/TARGETED AREA OF INTEREST
- EEL RIVER VALLEY GROUNDWATER BASIN (1-010)
- WELL ID
  CHLORIDE CONCENTRATION (MG/L)

N

0 5,000

1"=5,000'±

Humboldt County Public Works
Eel River Valley Basin (1-010)
Humboldt County, California

Spring 2021 Chloride Concentration Map
(Deeper Aquifer)
SHN 020091.170

September 2021 | Figure10_Spring2021_DeepChlorideConcentrations | Figure 10

Path: \\eureka\projects\2020\020091-Eel-River-GSP\GIS\PROJ_MXD\170-SaltWaterIntrusion\Figure10_Spring2021_DeepChlorideConcentrations.mxd User Name: pix4d DATE: 9/1/21, 3:33PM

WELLS WITH >100 MG/L INCREASE IN CHLORIDE CONCENTRATION FROM FALL 2016 TO 2020 OR SPRING 2017 TO 2021

LOLETA

FERNDALE

24

29

H

2

5

100 MG/L

30 MG/L

EXPLANATION

- INDICATES WELL SCREENED IN SHALLOW ALLUVIAL AQUIFER
- INDICATES WELL SCREENED IN DEEPER CONFINED AQUIFER
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- ALLUVIAL VALLEY/TARGETED AREA OF INTEREST
- EEL RIVER VALLEY GROUNDWATER BASIN (1-010)

N

0 5,000

1"=5,000'±

From Table 2 (Appendix B)

Fall 2020 and Spring 2021 Chloride Concentrations (mg/L)

Well ID	Fall 2016-2020 Comparison			Spring 2017-2021 Comparison		
	Fall 2016	Fall 2020	Change in concentration	Spring 2017	Spring 2021	Change in concentration
2	2600	2600	0	2100	2600	500
5	130	460	330	97	270	173
24	22	-	-	-	130	108*
29	680	230	-450	75	240	165
H	89	240	151	38	280	242

*Change value is a comparison from fall to spring

NOTE: SEE TABLE 2 FOR CONCENTRATION COMPARISONS

Humboldt County Public Works
Eel River Valley Basin (1-010)
Humboldt County, California

Fall 2020 and Spring 2021 Chloride Concentration Comparison
SHN 020091.170

September 2021 | Figure11_ChlorideConcentrationChange | Figure 11

Path: \\eureka\projects\2020\020091-Eel-River-GSP\GIS\PROJ_MXD\170-SaltWaterIntrusion\Figure11_ChlorideConcentrationChange.mxd User Name: pix4d DATE: 9/1/21, 3:34PM

ALL WELLS SAMPLED IN SPRING 2021

MW-27

MW-26

LOLETA

100 MG/L

30 MG/L

MW-5S/D

MW-14S/D

MW-15S/D

MW-28

MW-7S/D

FERNDALE

EXPLANATION

- COUNTY MONITORING WELLS
- APPROXIMATE LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- CERTAIN LINE OF EQUAL CHLORIDE CONCENTRATION (JOHNSON, 1975)
- ALLUVIAL VALLEY/TARGETED AREA OF INTEREST
- EEL RIVER VALLEY GROUNDWATER BASIN (1-010)

N

0 5,000

1"=5,000'±

Humboldt County Public Works
Eel River Valley Basin (1-010)
Humboldt County, California

County Monitoring Wells for Saltwater Intrusion

SHN 020091.170

September 2021 | Figure12_CountyMonitoringWells | Figure 12

Path: \\eureka\projects\2020\020091-Eel-River-GSP\GIS\PRO)_MXD\170-SaltWaterIntrusion\Figure12_CountyMonitoringWells.mxd User Name: pix4d DATE: 9/1/21, 3:34PM

Tables 2

Appendix 2
Explanations
Eel River Valley Basin, Humboldt County, California

Glossary

Term	Definition
BGS	below ground surface
mg/L	milligrams per liter

Explanations

For Table 1:

*Total depth (TD) is listed where screened depth is not known

**Result invalidated based on erroneous sample collection depth

***Chloride value may not be reflective of seawater

For Table 2:

*Change value is a comparison from fall to spring

Table 1 Fall 2020 and Spring 2021 Chloride Concentrations						
Well ID	**Screened Depth* (ft. BGS)**	**Screened Aquifer**	**Fall Sampling Date**	**Chloride Concentration (mg/L)**	**Spring Sampling Date**	**Chloride Concentration (mg/L)**
County Monitoring Wells						
MW-1s	30-35	Alluvial	10/28/2020	24	-	-
MW-1d	55-60	Alluvial	-	-	4/7/2021	23
MW-5s	100-110	L. Alluvial	10/28/2020	55	4/7/2021	56
MW-5d	200-210	L. Alluvial/Carlotta	10/28/2020	68	4/7/2021	72
MW-7s	30-40	Alluvial	10/30/2020	25	4/6/2021	41
MW-7d	240-250	L. Alluvial/Carlotta	10/29/2020	120**	4/6/2021	120**
MW-8	140-150	L. Alluvial/Carlotta	-	-	4/6/2021	21
MW-14s	55-65	Alluvial	-	-	7/12/2021	35
MW-14d	225-235	Alluvial	-	-	7/12/2021	16
MW-15s	40-50	Alluvial	-	-	7/12/2021	28
MW-15d	225-235	L. Alluvial/Carlotta	-	-	7/12/2021	15
MW-25	40-45	Alluvial	-	-	7/8/2021	12
MW-26	30-40	Alluvial	-	-	7/8/2021	150
MW-27	45-50	Alluvial	-	-	7/8/2021	9,300
MW-28	35-45	Alluvial	-	-	7/8/2021	94***
MW-30	50-55	Alluvial	-	-	7/13/2021	18
Municipal Wells						
Del Oro	146-166	L. Alluvial/Carlotta	10/26/2020	41	4/7/2021	44
Riverside Well 6	105 (TD)	Carlotta	10/28/2020	47	4/5/2021	48
Palmer Creek Well 2	55-65	Alluvial	10/27/2020	21	-	-
Loleta Well 4	-	Carlotta	10/28/2020	17	-	-
Private Wells						
2	250-260	Carlotta	10/29/2020	2,600	4/6/2021	2,600
3	-	Alluvial	10/27/2020	33	4/5/2021	35
4	60-80	Alluvial	10/27/2020	49	4/5/2021	59
5	>196 (TD)	L. Alluvial/Carlotta	10/27/2020	460	4/5/2021	270
6	-	Alluvial	10/27/2020	30	4/5/2021	33
7	24-35	Alluvial	10/27/2020	25	4/5/2021	26
11	69 (TD)	Alluvial	10/27/2020	72	4/5/2021	51
24	60-80	Alluvial	-	-	4/7/2021	130
25	43 (TD)	Alluvial	10/29/2020	280	4/7/2021	290
26	26-36	Alluvial	10/28/2020	260	4/7/2021	330
29	23 (TD)	Alluvial	10/29/2020	230	4/6/2021	240
34	26 (TD)	Alluvial	10/28/2020	320	-	-
51	40-60	Alluvial	10/26/2020	110	4/5/2021	140
52	250-260	L. Alluvial/Carlotta	10/28/2020	36	4/6/2021	33
53	265 (TD)	Carlotta	10/26/2020	3,300	4/7/2021	520
59	71 (TD)	Alluvial	10/26/2020	30	4/5/2021	36
G	140-160	Carlotta	10/27/2020	37	4/6/2021	42
H	60-70	Alluvial	10/26/2020	240	4/5/2021	280
I	180-200	Carlotta	-	-	4/7/2021	190
J	100-120	Alluvial	10/28/2020	23	4/5/2021	24
L	45 (TD)	Alluvial	10/27/2020	110	4/6/2021	160
Q	43 (TD)	Alluvial	10/30/2020	140	4/5/2021	120
R_Shop	-	Alluvial	-	-	4/6/2021	1,500
R	40 (TD)	Alluvial	10/28/2020	1,400	-	-

Table 2
Seasonal Chloride Concentration Comparisons

Well ID	Screened Aquifer	Fall Chloride Concentrations (mg/L)			Spring Chloride Concentrations (mg/L)		
		Fall 2016	Fall 2020	Change in concentration	Spring 2017	Spring 2021	Change in concentration
County Monitoring Wels							
MW-1s	Alluvial	23	24	1	16	-	-
MW-1d	Alluvial	20	-	-20	19	23	4
MW-5s	L. Alluvial	-	55	-	62	56	-6
MW-5d	L. Alluvial/Carlotta	63	68	5	61	72	11
MW-7s	Alluvial	36	25	-11	30	41	11
Municipal Wells							
Del Oro	L. Alluvial/Carlotta	49	41	-8	43	44	1
Riverside Well 6	Carlotta	49	47	-2	43	48	5
Palmer Creek Well 2	Alluvial	-	21	-	-	-	-
Loleta Well 4	Carlotta	-	17	-	-	-	-
Private Wells							
1	Alluvial	39	-	-	33	-	-
2	Carlotta	2,600	2,600	0	2,100	2,600	500
3	Alluvial	41	33	-8	30	35	94***
4	Alluvial	62	49	-13	62	59	-3
5	L. Alluvial/Carlotta	130	460	330	97	270	173
6	Alluvial	32	30	-2	29	33	4
7	Alluvial	25	25	0	22	26	4
8	Alluvial	33	-	-	28	-	-
9	Alluvial	28	-	-	28	-	-
10	Alluvial	38	-	-	4	-	-
11	Alluvial	67	72	5	40	51	11
12	Alluvial	-	-	-	27	-	-
24	Alluvial	22	-	-	-	130	108*
25	Alluvial	320	280	-40	280	290	10
26	Alluvial	450	260	-190	-	330	-
29	Alluvial	680	230	-450	75	240	165
G	Carlotta	47	37	-10	51	42	-9
H	Alluvial	89	240	151	38	280	242
I	Carlotta	87	-	-	290	190	-100
J	Alluvial	-	23	-	20	24	4
L	Alluvial	180	110	-70	140	160	20
Q	Alluvial	250	140	-110	120	120	0
R_Shop	Alluvial	1,500	-	-	1,600	1,500	-100
R	Alluvial	-	1,400	-	-	-	-

Decrease (mg/L)	Increase (mg/L)
0-50	0-50
50-100	50-100
>100	>100