



# *Technical Memorandum*

Reference: 016219  
Date: October 11, 2019  
To: Hank Seemann, Humboldt County Public Works  
From: Jason Buck, SHN  
Subject: **Preliminary Analysis of Surface Water/Groundwater Interaction Monitoring;  
Eel River Valley Groundwater Basin**

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## **Purpose**

The 2014 Sustainable Groundwater Management Act (SGMA) defines sustainable groundwater management as the management and use of groundwater in a manner that can be maintained without causing undesirable results. Potential undesirable results caused by groundwater conditions include depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water. Prior to the implementation of SGMA, no focused studies on the interaction of the surface water and the groundwater within the Eel River Valley Groundwater Basin (Basin) had been conducted. In 2016, several studies were initiated as part of a Proposition 1 Grant (DWR, 2016) to begin developing a baseline understanding of the groundwater exchanges associated with the Eel and Van Duzen rivers. Some of the initial findings were included in the groundwater sustainability plan alternative submitted by Humboldt County in December 2016 (SHN, 2016). One of the ongoing monitoring activities includes continuous monitoring of water levels using pressure transducers installed in and adjacent to the two rivers. The purpose of this technical memorandum is to provide a review and preliminary analysis of the continuous monitoring data collected for the surface water/groundwater (SW/GW) interaction from October 2016 to 2019. This memorandum expands on materials presented in the annual reports prepared for the 2017 and 2018 water years (SHN, 2018, 2019).

## **Surface and Groundwater Monitoring using Pressure Transducers**

Since the fall of 2016, pressure transducers have been maintained within stations in both the Eel and Van Duzen rivers. River and well locations that have been part of the SW/GW monitoring program to date are shown on Figures 1 through 4. Table 1 summarizes the timeframe of monitoring at each of the locations. Table 2 provides precipitation totals for the 2017, 2018 and 2019 water years (WY). Currently, as part of the ongoing monitoring commitments outlined in the alternative plan submittal (SHN, 2016), transducers are maintained within temporary installations at two locations within the rivers (R-3 and R-4), and within two county monitoring wells (MW-2 and MW-9).

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**Table 1. River and Groundwater Monitoring Sites  
Eel River Valley Groundwater Basin**

Location	Field ID	Date(s) Monitored	Well Depth (ft)	Notes
<b>River Sites</b>				
Eel River	River 1	9/30/16–12/10/16	--	Destroyed in January 2017 Flood
Eel River	River 2	9/30/16–12/10/16	--	Destroyed in January 2017 Flood
Eel River	River 3	9/30/16–12/10/16 and 7/5/17–Present	--	Destroyed in January 2017 Flood (Replaced in July 2017)
Van Duzen	River 4	9/30/16–Present	--	Thalweg silted in at installation in January 2017
Van Duzen	River 5	8/10/17–11/16/17	--	Not Used
<b>Private Wells</b>				
02N01W 22H002H	20	10/12/16–11/16/17	110	
02N01W 24E001H	22	10/12/16–11/16/17	60	Pumped during summer
02N01E 19L001H	23	10/12/16–11/16/17	80	Pumped during summer
<b>County Monitoring Wells</b>				
03N01W 29Q001H	MW-1s	10/30/16–12/9/16 and 3/9/17–11/17/17	35	Period of dry transducer in fall 2017
03N01W 29Q002H	MW-1d	10/30/16–2/28/17	60	
02N01W 10R002H	MW-2s	10/30/16–11/17/17 and 10/31/18–Present	35	Period of dry transducer in fall 2017
02N01W 10R002H	MW-2d	10/30/16–Present	60	Period of dry transducer in fall 2017
02N01W 22H001H	MW-3d	10/31/16–11/17/17	60	Period of dry transducer in fall 2017
02N01E 19Q001H	MW-9s	10/30/16–11/16/17 and 10/31/18–Present	25	
02N01E 19Q001H	MW-9d	10/30/16–Present	48	

**Table 2. Water Year Statistics  
Eel River Valley Groundwater Basin**

Water Year	Dates	Precipitation Total <sup>1</sup>	Notes
2017	10/1/16 to 9/30/17	75.85 inches	Wet Year (overall); Wet Year (Irrigation Season)
2018	10/1/17 to 9/30/18	33.72 inches	Dry Year (overall); Normal Year (Irrigation Season)
2019	10/1/18 to 9/30/19	57.26 inches	Wet Year (overall)

1: As measured at the Western Regional Climate Center Scotia Station 048045



## **Eel River**

### **Surface Water**

Three temporary surface water stations (stilling wells) were constructed on the margins of the river channel (R-1, R-2, and R-3) to monitor river levels. Pressure transducers (Solinst Leveloggers) were mounted and housed in a polyvinyl chloride (PVC) pipe and secured in locations where deep pools would accommodate the yearly water level fluctuation. Locations also needed to be secure from vandalism, stable, and accessible. Each installation was outfitted with a pressure transducer that was set to record water levels at 30 minute intervals. Data is stored on the device and downloaded periodically, as necessary.

All three river installations were destroyed during the January 2017 flood. A significant amount of bank erosion occurred at the R-1 location, so it is no longer a suitable site. R-1 was, therefore, not reconstructed and the Fernbridge United State Geological Survey (USGS) river gauging station (USGS Streamgage 11479560) maintained in the vicinity is used as a proxy. R-2 was also not reconstructed because the data collected from the R-3 location is suitable for comparison with both the MW-2 and MW-3 groundwater monitoring stations.

R-3 was reinstalled in July 2017 and has since served as a representative river installation for pairing with MW-2s/d and MW-3s/d. The hydrograph of surface water elevations collected at R-3 from July 2017 to April 2019 is provided as Figure 5. Figure 6 shows a comparison of the 2017 and 2018 dry season river level hydrographs (measured at R-3) with the respective river discharge values measured at the USGS Scotia Streamgage (near where the Eel River enters the basin). The 2017 surface water levels were on the order of 2 to 3 inches higher than those of 2018, which is reflective of the 2017 discharge values being on the order of 30 to 40 cubic feet per second (cfs) higher than those of 2018.

### **Groundwater**

Three monitoring wells (MW-1, MW-2, and MW-3) were installed adjacent to the Eel River on the left bank. These were installed to monitor the aquifer levels at the head of the Lower Eel River Valley. Wells consisted of two, nested, 1-inch PVC pipes screened at two different intervals: one shallow (~30-35 feet below grade) and one deep (~55-60 feet), designated with "s" or "d", respectively (i.e. MW-1s). Although set at different elevations, both the deep and shallow wells are still screened within the shallow alluvial aquifer. Well locations were chosen based on a good spatial distribution along the river, accessibility, and security. All were installed adjacent to roads within the county right-of-way. A private well (Well 20) located near MW-3 was also continuously monitored using a pressure transducer.

The groundwater monitoring wells were generally designed to be paired with the nearest river locations; MW-1 with R-1, MW-2 with R2 and/or R3, and MW-3 with R3. After the river installations were lost to the flood, only R3 was reconstructed. Water levels recorded at the USGS Streamgage located on the right bank at Fernbridge are used for comparison with water levels in MW-1. The water levels recorded at R-3 are used for comparison with water levels in both the MW-2 and MW-3 groundwater monitoring wells.

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To facilitate comparison between the hydrograph of the surface water recorded at R-3 and groundwater elevations at each well location, a field survey of the river level immediately adjacent to the monitoring well is conducted using a leveling rod. The R-3 hydrograph is later adjusted to match the field-measured water level elevation at each respective well location.

Representative hydrographs for each of the three groundwater monitoring locations along the Eel River (MW-1, MW-2 and MW-3) are provided as Figures 7 through 11. A brief description of each location and a review of the data collected are discussed below.

**MW-1**

MW-1 is located approximately 500 feet from the riverbank adjacent to the southern abutment of the Fernbridge (Figure 2). Fernbridge is located along a stretch of river that is subject to tidal impacts, with at least another mile of river upstream that is tidally influenced. The tidal influence on water levels within the river and aquifer is greatest during the dry season when the river elevations have dropped into the tidal range (see Figures 7 and 8).

MW-1, like all monitoring well locations adjacent to the river, show a strong connectivity between the surface water and groundwater, evidenced by the rapid response of aquifer levels as river levels change during precipitation events (Figure 7). Rain events and associated rises in the river generally produced losing stream conditions (flow toward the aquifer) that recharge the aquifer and periods between rain events produced gaining stream conditions (flow toward the river).

The groundwater gradient is towards the river (gaining stream) on the falling limb of the hydrograph as surface water elevation recedes. Stream gage readings from the USGS station show that during the dry season, the river level fluctuates as much as 1.5 feet or more in response to the tidal cycles. These fluctuations cause localized transitions between gaining and losing stream conditions. The margins of the aquifer fill during high tide and subsequently discharge back into the river during low tide. This tidal condition acts as a control on the aquifer levels in the vicinity of the river. Figure 8 shows a comparison of the hydrographs for MW-1 and R-1 in November 2016 in which the tidal influence on the aquifer is visible. Data is not available to evaluate the more regional or net gaining/losing relationship during the dry season along this stretch of the river.

Static groundwater level measurements taken within the nested shallow and deep screened intervals of MW-1 during the fall and spring California Statewide Groundwater Elevation Monitoring (CASGEM) sampling events generally indicate a very small upward vertical gradient, with the exception of spring 2017 that had a downward gradient.

**MW-2**

The MW-2 well pair is situated at the eastern edge of the Lower Eel River Valley, approximately 200 feet from the left bank of the Eel River (see Figures 1 and 3). Because of its central location at the head of the valley, MW-2 is well positioned to monitor the interaction between the river and the shallow aquifer



of the valley. The R-3 river installation is situated approximately 3,500 feet upstream within the right bank and has been maintained as the primary river installation for comparing levels with MW-2. A plot of the surface water and groundwater levels between February and December 2018 is provided as Figure 9. Gaining stream conditions persist as water levels decline into late spring and early summer. The transition from gaining to losing stream conditions occurred the first week in July. Losing stream conditions remained until late November when the initial storm systems of the 2018/2019 wet season begin. The groundwater gradients during the late summer and fall are very gentle with maximum elevation differences between the surface water and the aquifer generally less than 6 inches.

The hydrographs of both the river and MW-2 water levels exhibit a smooth transition into the dry season, typical of a standard recession curve. The irrigation season, which generally occurred between May 15 and October 1 (based on a normal year designation [Humboldt County Resource Conservation District, 2016]), is shown on Figure 9. Qualitatively, there does not appear to be an influence on water levels associated with the starting and ending of the irrigation season. Neither daily fluctuations of water levels (that may be attributable to a localized pumping influence) nor a more subdued inflection of the hydrograph coincident with the irrigation season are apparent in the MW-2 hydrograph or the R-3 hydrograph. The R-3 hydrograph adjusted to the field-measured water levels adjacent to MW-2 show that the river level stabilized at an approximate elevation of 19 feet (Figure 9).

### **MW-3**

The MW-3 well pair is situated at the base of the foothills that define the southern edge of the Lower Eel River Valley, near where the Eel River enters the Lower Eel River Valley, and across from its confluence with the Van Duzen River. This is an important geologic and geomorphic transition because the underlying alluvial aquifer thickens considerably, and the active river channel widens and is joined by the Van Duzen River.

MW-3s (25 feet deep) has been consistently dry, except for the wettest times of the year. Continuous monitoring of MW-3d was conducted between October 2016 and July 2017. Private Well 20, situated between MW-3 and the Eel River was also monitored through the dry season into November 2017. Water levels recorded in the river installation R-3 were adjusted to measured surface water elevations adjacent to MW-3 and Well 20. A comparison of the 2017 dry season elevations for the surface water and Well 20, as shown on Figure 11, show that a consistent losing stream condition exists at this location for the period that river data was available. This is interpreted to exist because of the geologic and geomorphic transition as the Eel River enters into the Lower Eel River Valley. The river bed and surface flows come into the Lower Eel River Valley at a higher elevation than the valley's shallow alluvial aquifer. The added surface water flow associated with the Eel River's confluence with the Van Duzen River may also play a role in the localized gradients.

### **Van Duzen River**

The Van Duzen River and the tributary Yager Creek constitute the primary surface waters within the eastern half of the Basin. Similar to the Eel River, the Van Duzen River transports and deposits a significant quantity of gravel; as such, there is a shallow alluvial aquifer consisting of older active channel deposits that generally encompasses and underlies the low-lying Van Duzen River valley floor. This

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alluvial aquifer is believed to be in contact with the older underlying Carlotta formation. The Carlotta formation is exposed in much of the upland slopes adjacent to the Van Duzen River valley floor and is an important source of recharge into the underlying aquifers. The elevation profile of the Van Duzen River is relatively steep as compared to the Eel River. The groundwater gradients reflect this topographic profile with a relatively steep groundwater gradient toward the west.

Monitoring of the Van Duzen River and adjacent aquifer has been facilitated with monitoring well MW-9 and the river installation R-4. In addition, continuous monitoring of two private wells, Well 22 and 23, was conducted during the 2016 wet season and through the 2017 dry season. MW-9 is situated approximately 1,300 feet north of the active channel of the river within the central portion of the Van Duzen River valley floor (see Figures 1 and 4). It's important to note that MW-9 and the R-4 installation are aligned in a north-south direction, whereas the regional groundwater flow is in an east to west direction. The water levels observed in MW-9 have a more complex relationship with R-4 levels as they are also influenced by SW/GW interactions immediately up valley, including the Van Duzen River's confluence with Yager Creek.

Comparison of the hydrographs of MW-9 and R-4 indicate the river recharges the aquifer relatively quickly during the initial peak river flows of the wet season (Figure 12). Water elevations within the aquifer are relatively slow to recede following these peak flows and result in consistent gradients toward the river in all but the earliest parts of the wet season. Toward the end of the wet season, the groundwater elevations at MW-9 generally remain above the elevation of the surface water at R-4, even during elevated river levels associated with precipitation events. This is a condition interpreted to be controlled by groundwater flows coming from up valley.

Over the course of the 2018 dry season, as shown on Figure 13, the relative water levels in MW-9 and at R-4 indicate a transition from gaining to losing stream conditions in mid-June. In 2018, groundwater elevations at MW-9 remained below the surface water elevations (up to 1.3 feet) until the wet season began again in late November. Similar to the surface water elevations in the Eel River, the 2018 water elevations in the Van Duzen River appear to generally stabilize during the months of August and September at similar elevations of that measured during the 2017 dry season.

Unlike the MW-2 profile, the groundwater levels at the MW-9 location appear to have been affected by nearby pumping during the irrigation season. Between May 24 and September 27, the 2018 hydrograph shows daily fluctuations on the order of 0.1 to 0.2 feet (see Figure 14), interpreted to represent daily irrigation of the surrounding fields, likely from one of the active wells located in the vicinity of MW-9. Qualitatively, the groundwater elevation profile appears to deviate slightly from a smooth, natural recessional curve. An overall lowering of the aquifer in the vicinity of MW-9 on the order of 0.5 to 0.8 feet may be interpreted to have occurred during the course of the irrigation season. The surface water profile at R-4, on the other hand, does not appear to have been influenced by the irrigation season.



## Findings and Conclusions

Monitoring initiated by the county in 2016 represents the first continuous paired groundwater and surface water data sets available for analysis. Groundwater within the shallow alluvial aquifers of the Eel River Valley Groundwater Basin is shown to have a strong connection with the surface waters of the Eel and Van Duzen rivers, largely because the shallow alluvial aquifers are made up of thick river deposits of high hydraulic conductivity. Winter rains and elevated river levels quickly recharge the aquifer over the course of the wet season, and the groundwater and surface water elevations appear to remain in close contact through the dry season.

In terms of SW/GW interaction, the most important section of the Eel River is the approximate 5-mile stretch between the location where it enters the Lower Eel River Valley and the point at which it becomes influenced by the tides. A losing stream condition is interpreted to naturally exist along the west bank of the Eel River at the location of MW-3 through much of the year, particularly during the dry season. The groundwater exchange along the left bank of the Eel River transitions in the downstream direction as the river elevation drops, and gaining stream conditions are typical during the winter season, persisting into early summer as observed at MW-2.

Exchange conditions along the right bank of the Eel River near MW-3 and downstream toward the R-3 location is heavily influenced by the incoming surface water and associated underflow of the Van Duzen River as well as the groundwater flowing within the shallow alluvial aquifer of the Van Duzen river valley. The Eel River forms a hinge point in the east-west longitudinal profile of the groundwater surface (Figure 15), separating the relatively steep gradient within the Van Duzen River alluvium and the shallower gradient of the Lower Eel River Valley.

Due to the steep groundwater gradient toward the Eel River from the east, the right bank of the Eel River within the vicinity of R-3 and MW-2 is interpreted to remain in a gaining stream condition throughout the year, including the dry season. The closest well continuously monitored on the east side of the Eel River was Private Well 22. Water levels during the lowest flows of 2017 (late October) in Well 22 were over 10 feet higher than the Private Well 20 on the west side of the River, and over 15 feet higher than the surface waters at the location of R-3 (see Figure 16).

The groundwater conditions within the vicinity of the Van Duzen River drainage are not as well understood as those in the Lower Eel River Valley. No long-term monitoring, as in the CASGEM program, has been conducted, and the surface water-groundwater exchange is somewhat complicated by the steep groundwater gradient of the shallow alluvial aquifer, the inflow of the Yager Creek, and the recharge relationship with the underlying Carlotta formation.

The data collected to date is limited. The data, however, will be useful in refining the conceptual model of the Basin; will provide a baseline of understanding for developing additional studies; and, ultimately, will provide data that can be input into an integrated groundwater model, if that becomes necessary in the future. Yearly comparisons of the spatial and temporal exchange conditions will be informative about the relative stability of the groundwater system as a whole and the sensitivity of those exchange conditions to environmental factors (such as, variations in precipitation and inflow of surface water from the watersheds upstream).

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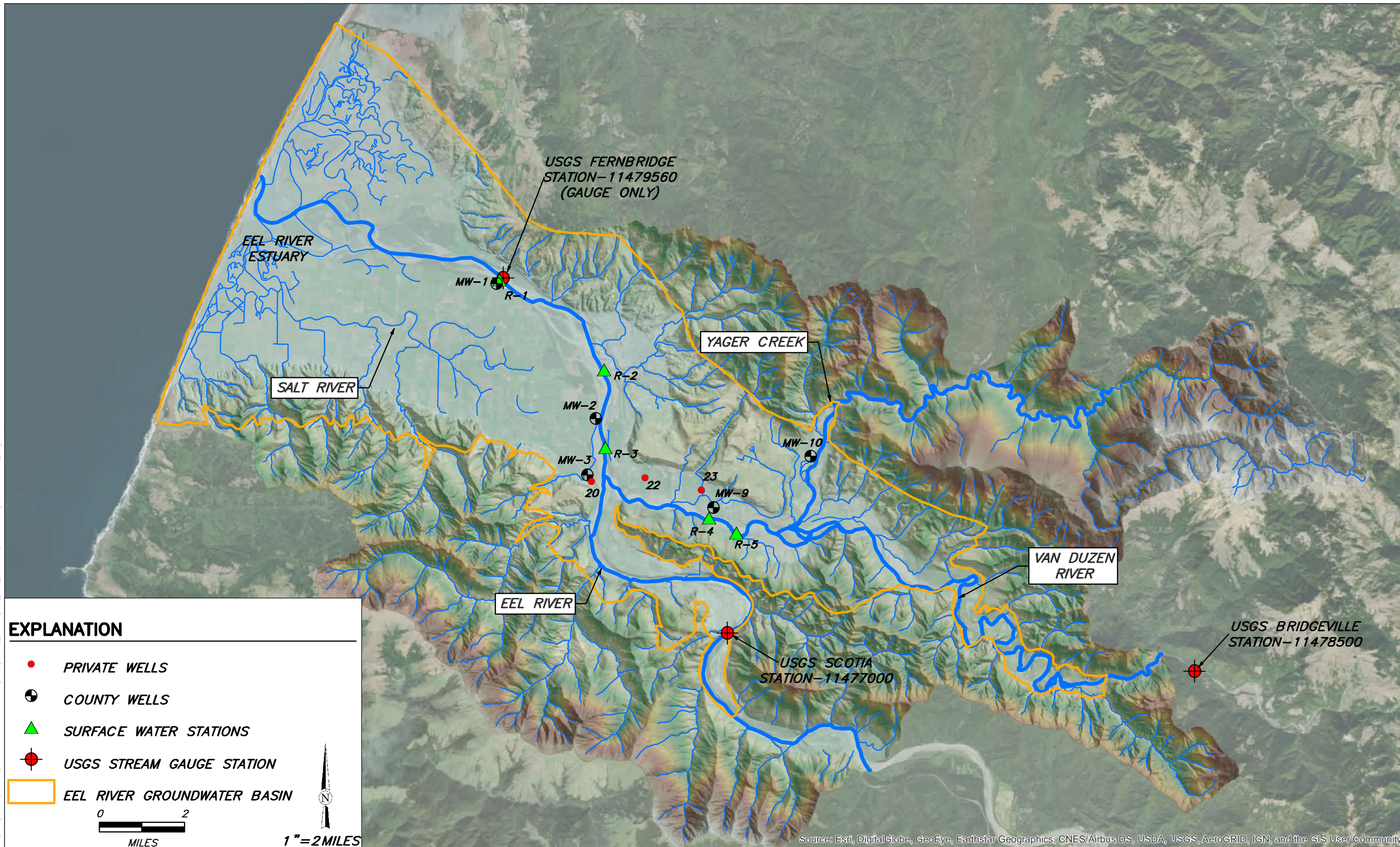
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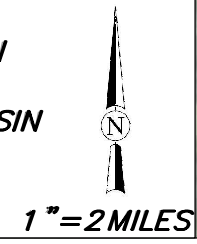


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**EXPLANATION**

- PRIVATE WELLS
- COUNTY WELLS
- ▲ SURFACE WATER STATIONS
- ⊕ USGS STREAM GAUGE STATION
- EEL RIVER GROUNDWATER BASIN



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

Humboldt County Public Works  
 Eel River Groundwater Assessment  
 Humboldt County, California

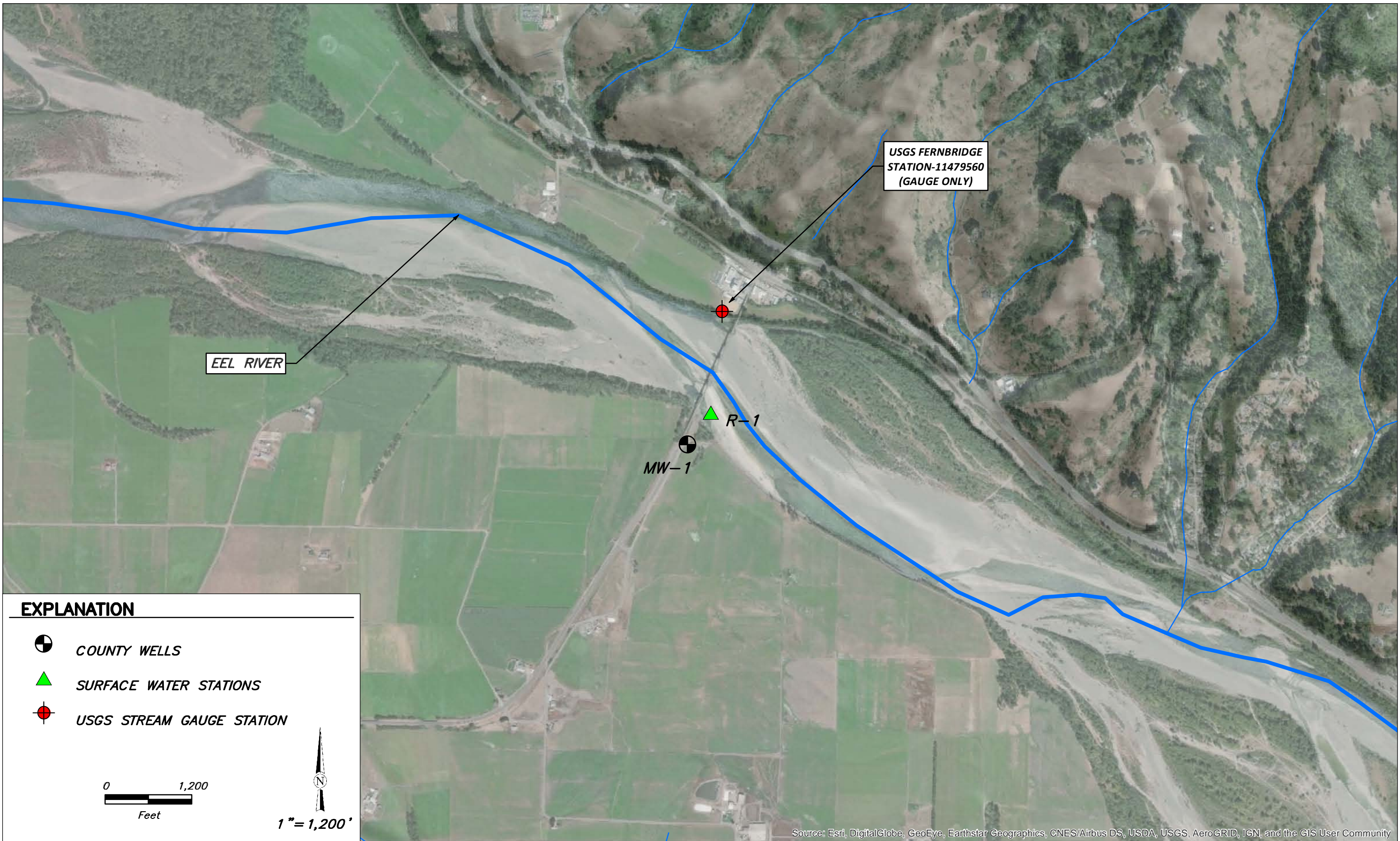
Monitoring Locations  
 SHN 016219

August 2019




Monitoring Locations\_Figure1

Figure 1


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**EXPLANATION**

-  COUNTY WELLS
-  SURFACE WATER STATIONS
-  USGS STREAM GAUGE STATION

0 1,200  
Feet

  
1" = 1,200'

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

Humboldt County Public Works  
Eel River Groundwater Assessment  
Humboldt County, California

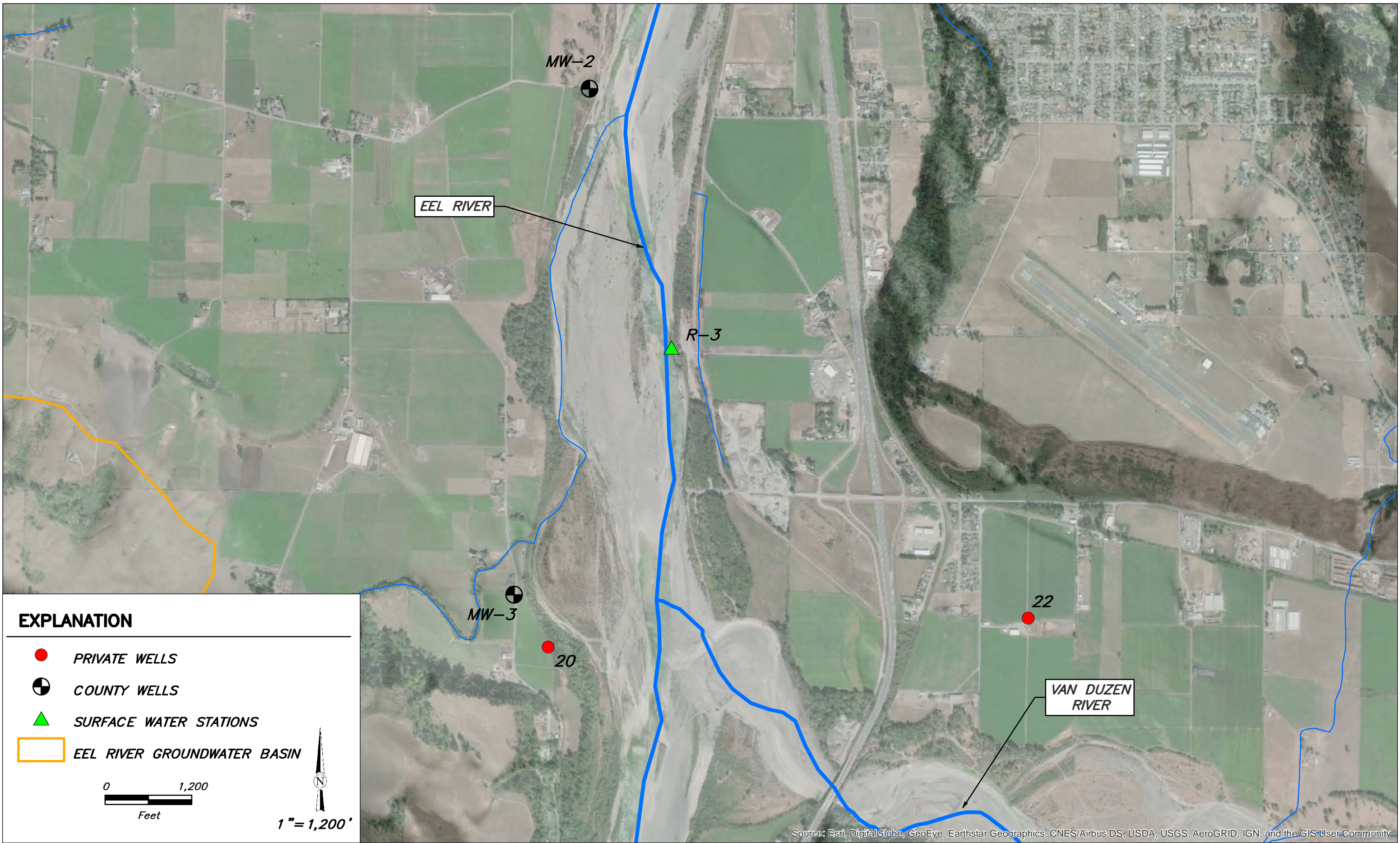
Monitoring Locations  
MW-1 and R-1  
SHN 016219

September 2019

Monitoring Locations\_MW1\_Figure2

Figure 2

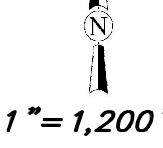
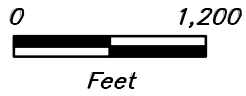
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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

**EXPLANATION**

- PRIVATE WELLS
- ⊕ COUNTY WELLS
- ▲ SURFACE WATER STATIONS
- EEL RIVER GROUNDWATER BASIN



Humboldt County Public Works  
Eel River Groundwater Assessment  
Humboldt County, California

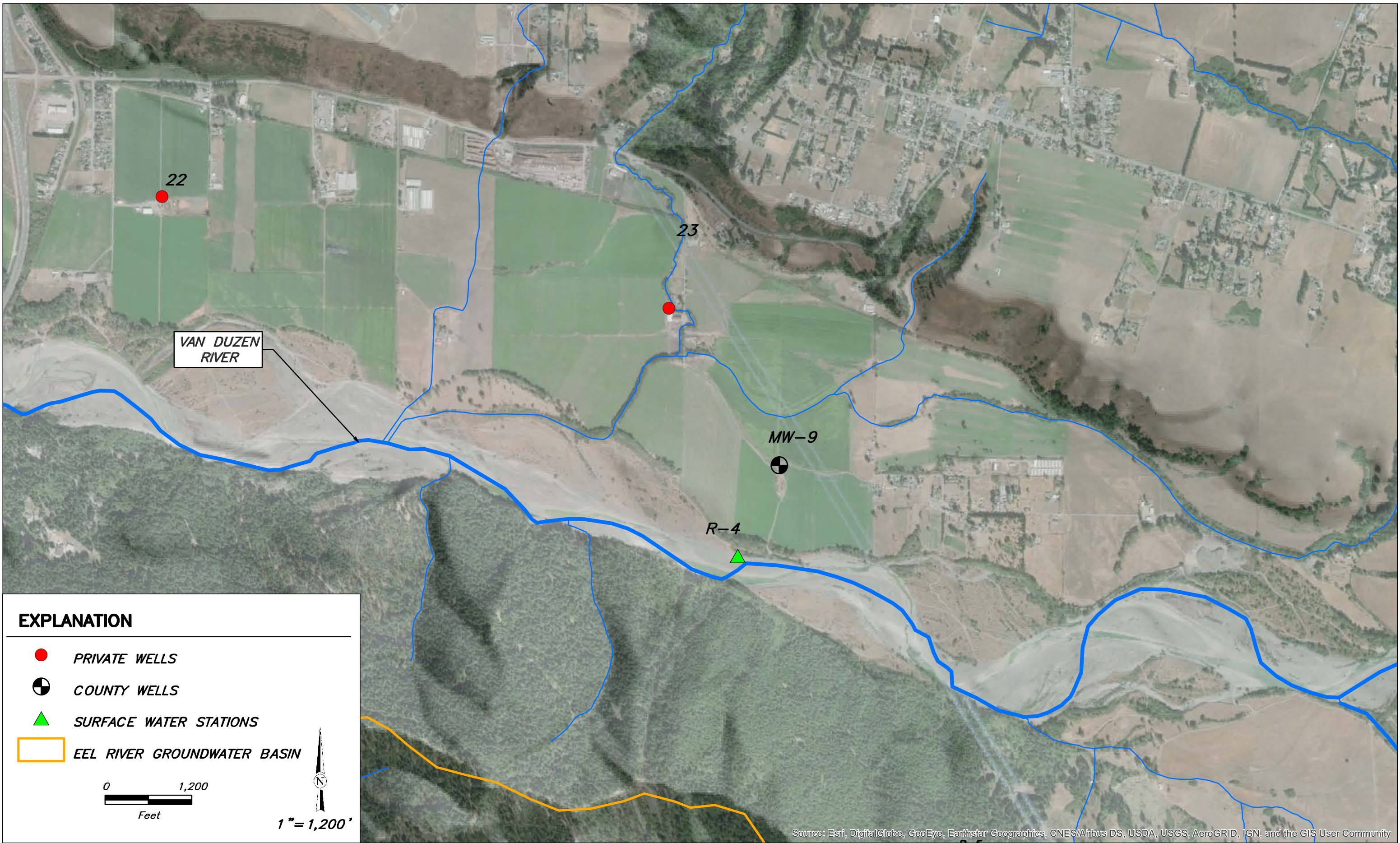
Monitoring Locations  
MW-2, MW-3 and R-3  
SHN 016219

September 2019

Monitoring Locations\_MW2and3\_Figure3

Figure 3

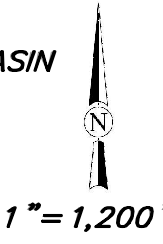
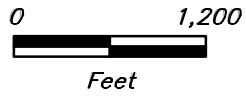
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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

**EXPLANATION**

- PRIVATE WELLS
- + COUNTY WELLS
- ▲ SURFACE WATER STATIONS
- EEL RIVER GROUNDWATER BASIN



1" = 1,200'

Humboldt County Public Works  
Eel River Groundwater Assessment  
Humboldt County, California

Monitoring Locations  
MW-9 and R-4  
SHN 016219

September 2019

Monitoring Locations\_MW9\_Figure4

Figure 4

# Eel River Surface Water Elevation at R-3

## July 2017 to April 2019

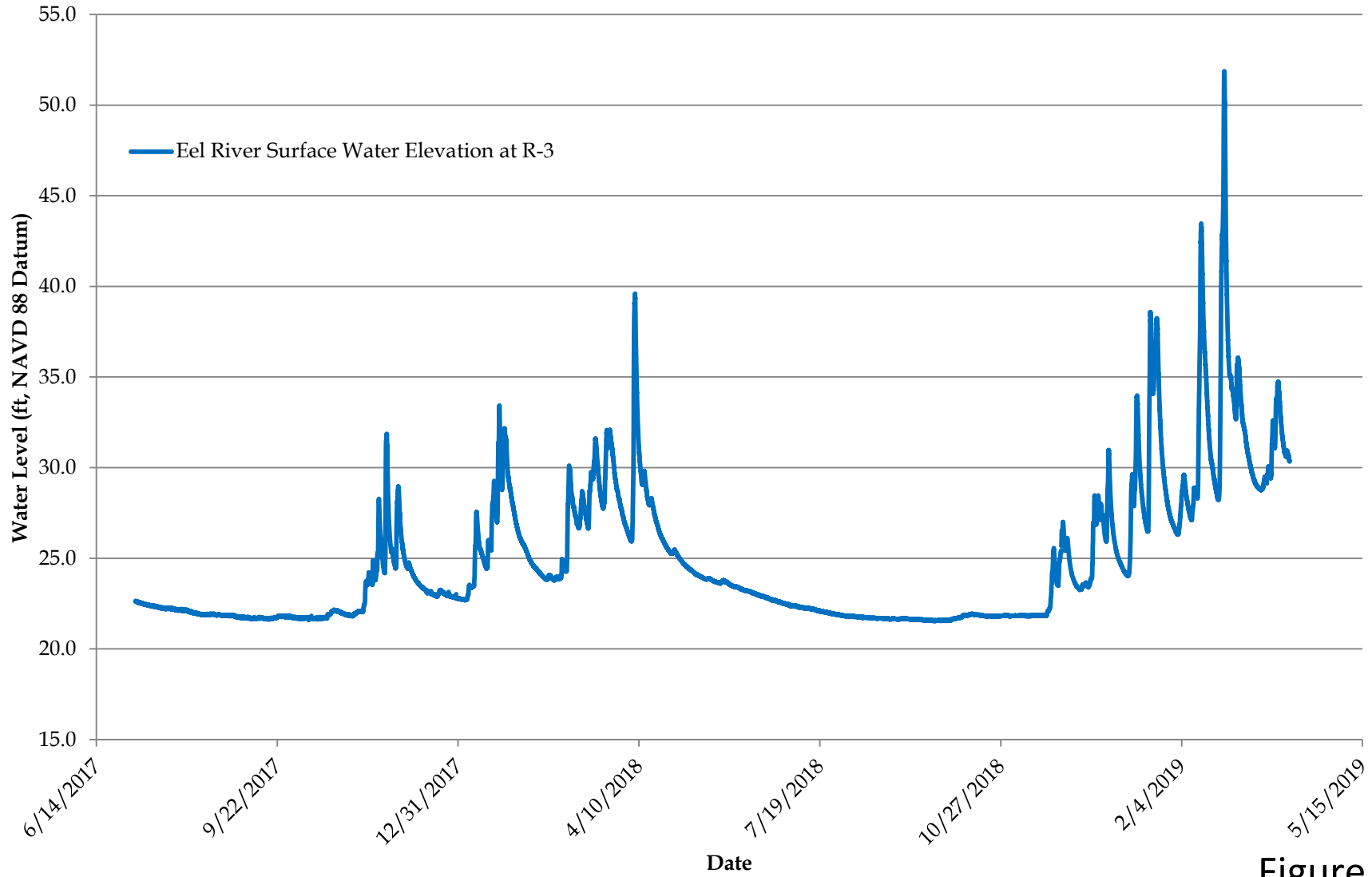
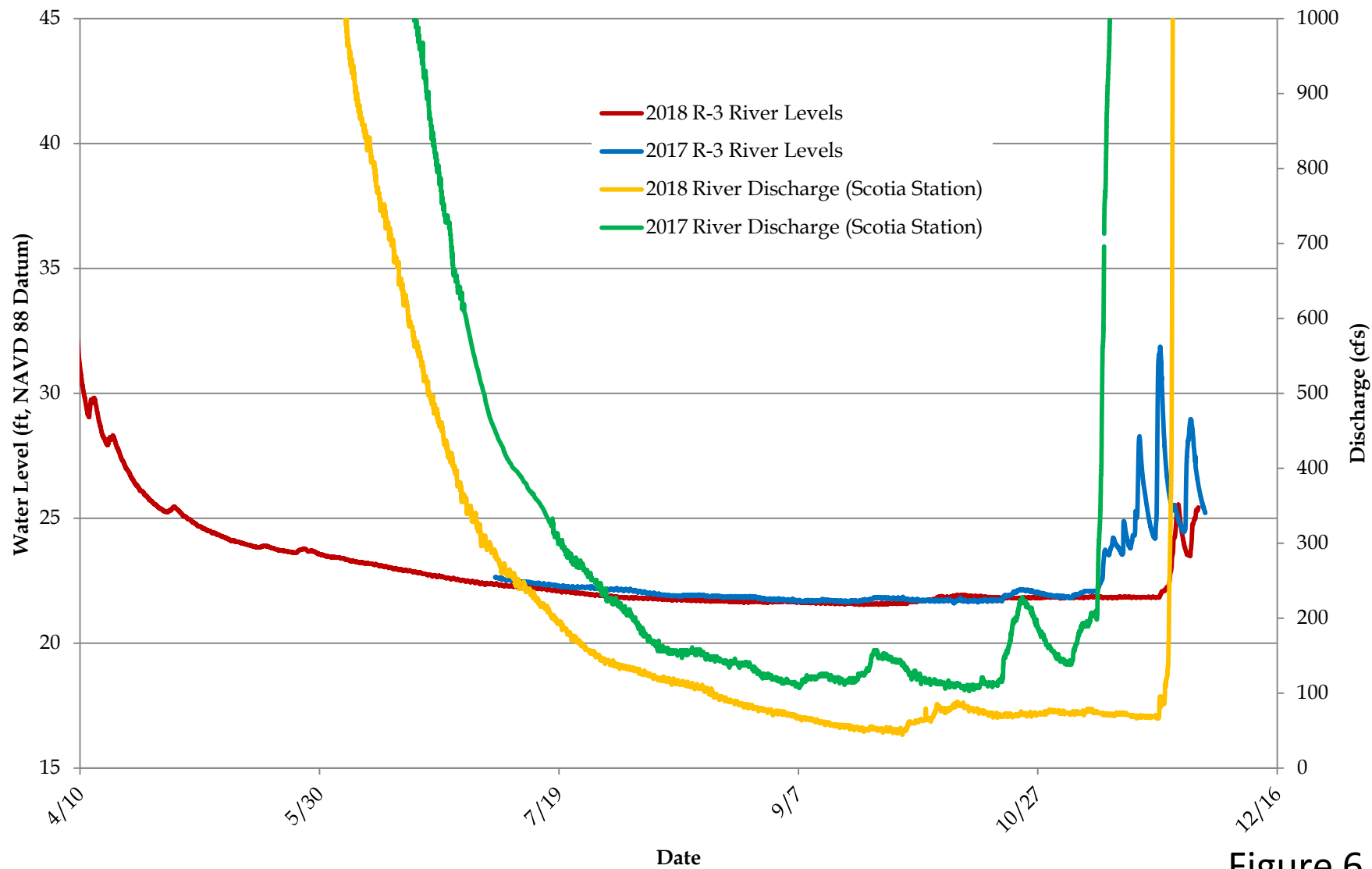


Figure 5

# River 3 Levels - 2017/2018 Comparison with USGS Scotia Station Discharge



# MW-1 versus Eel River

Oct 2016 - Jan 2017

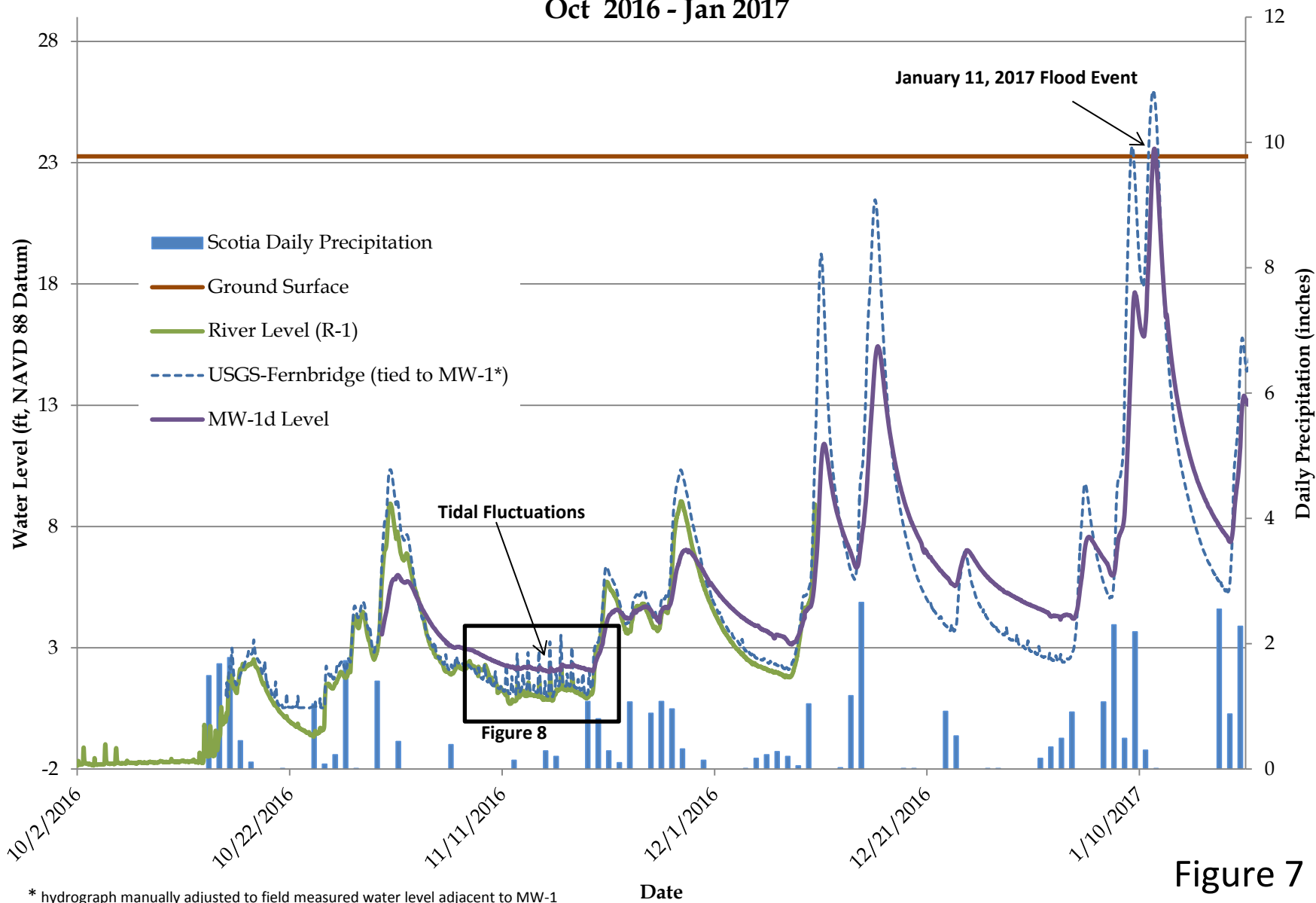


Figure 7

\* hydrograph manually adjusted to field measured water level adjacent to MW-1

# MW-1 versus Eel River

## November 2016

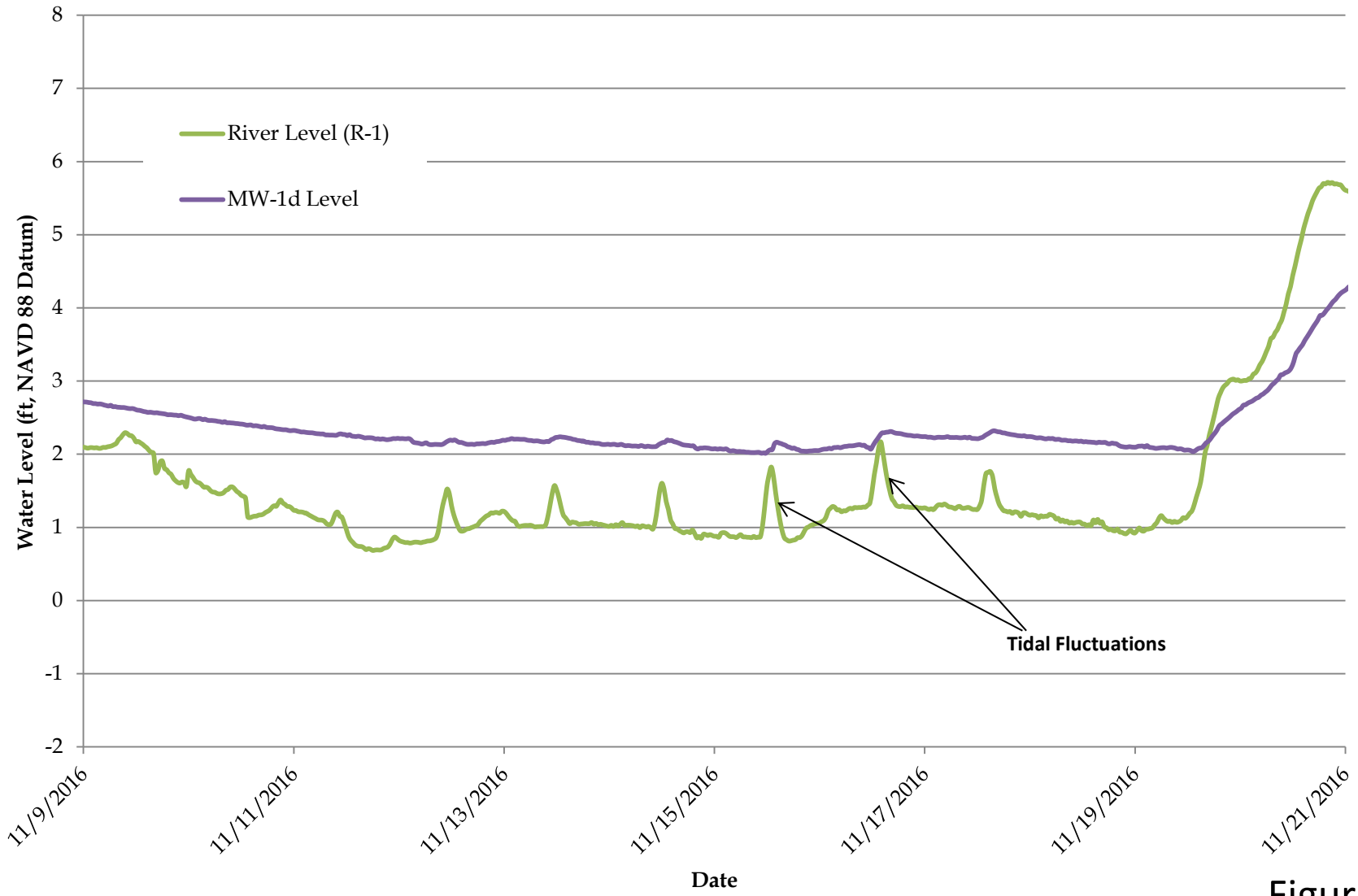
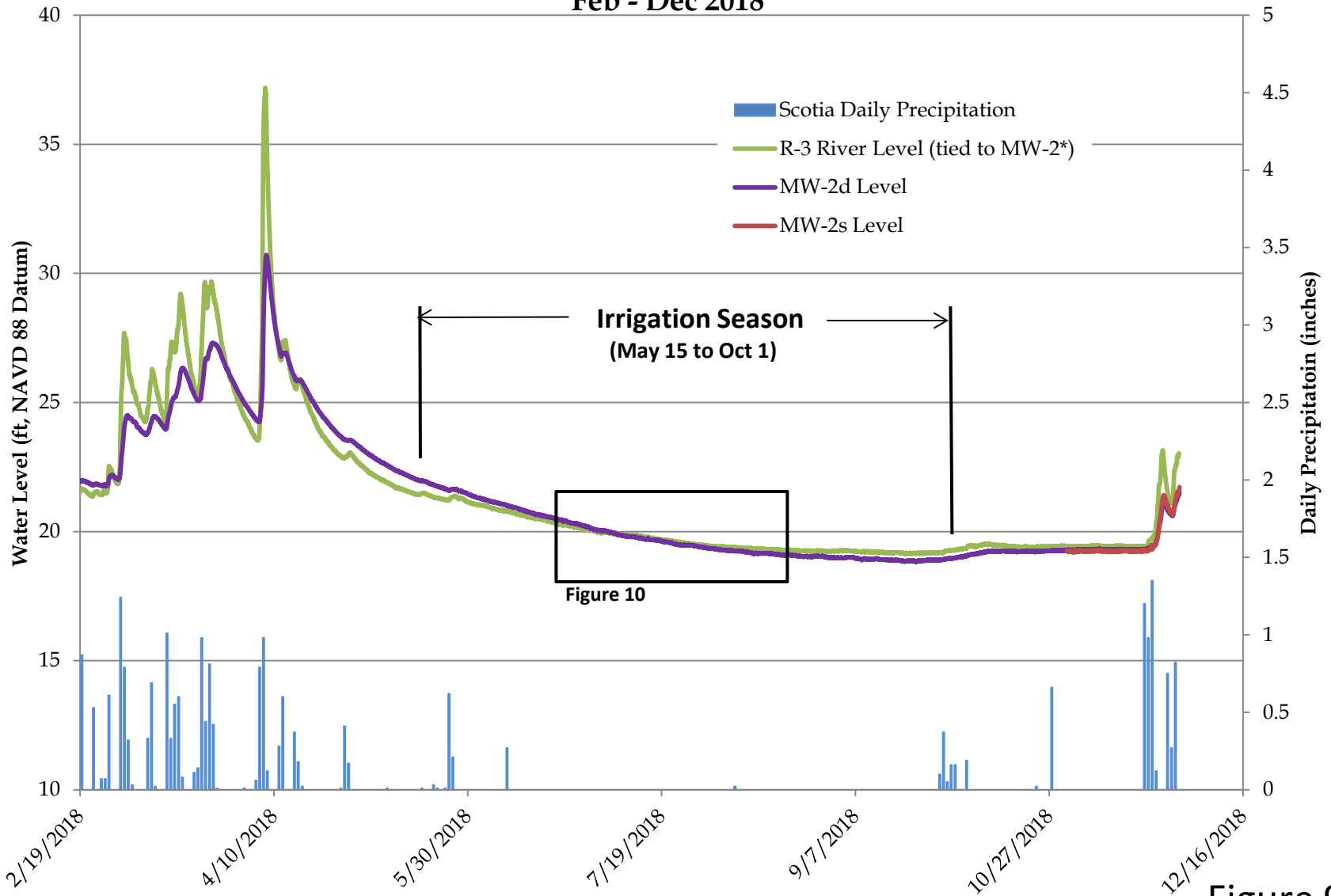


Figure 8

# MW-2 versus Eel River

## Feb - Dec 2018



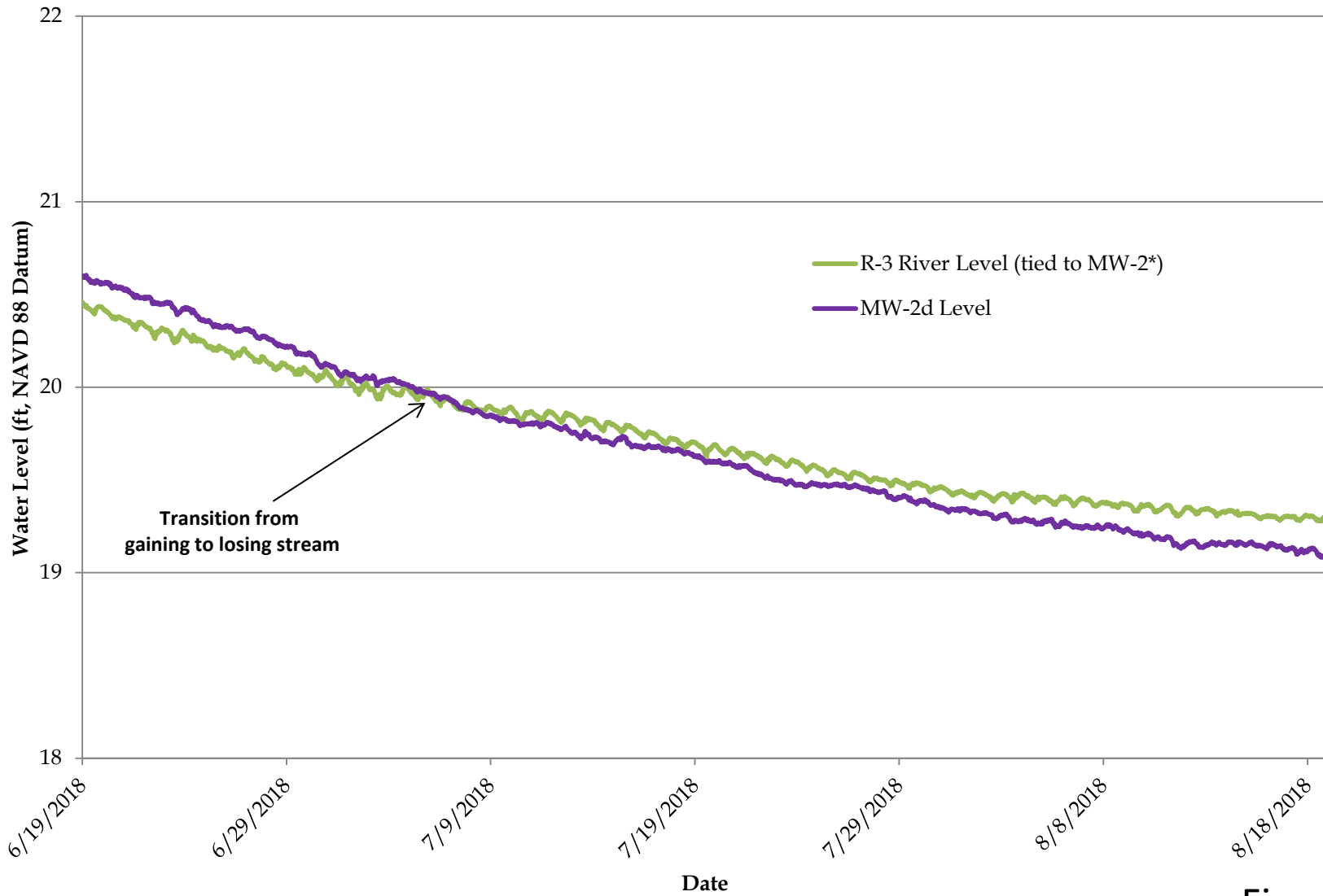
\* hydrograph manually adjusted to field measured water level adjacent to MW-2

Date

Figure 9

# MW-2 versus Eel River

## June - August 2018

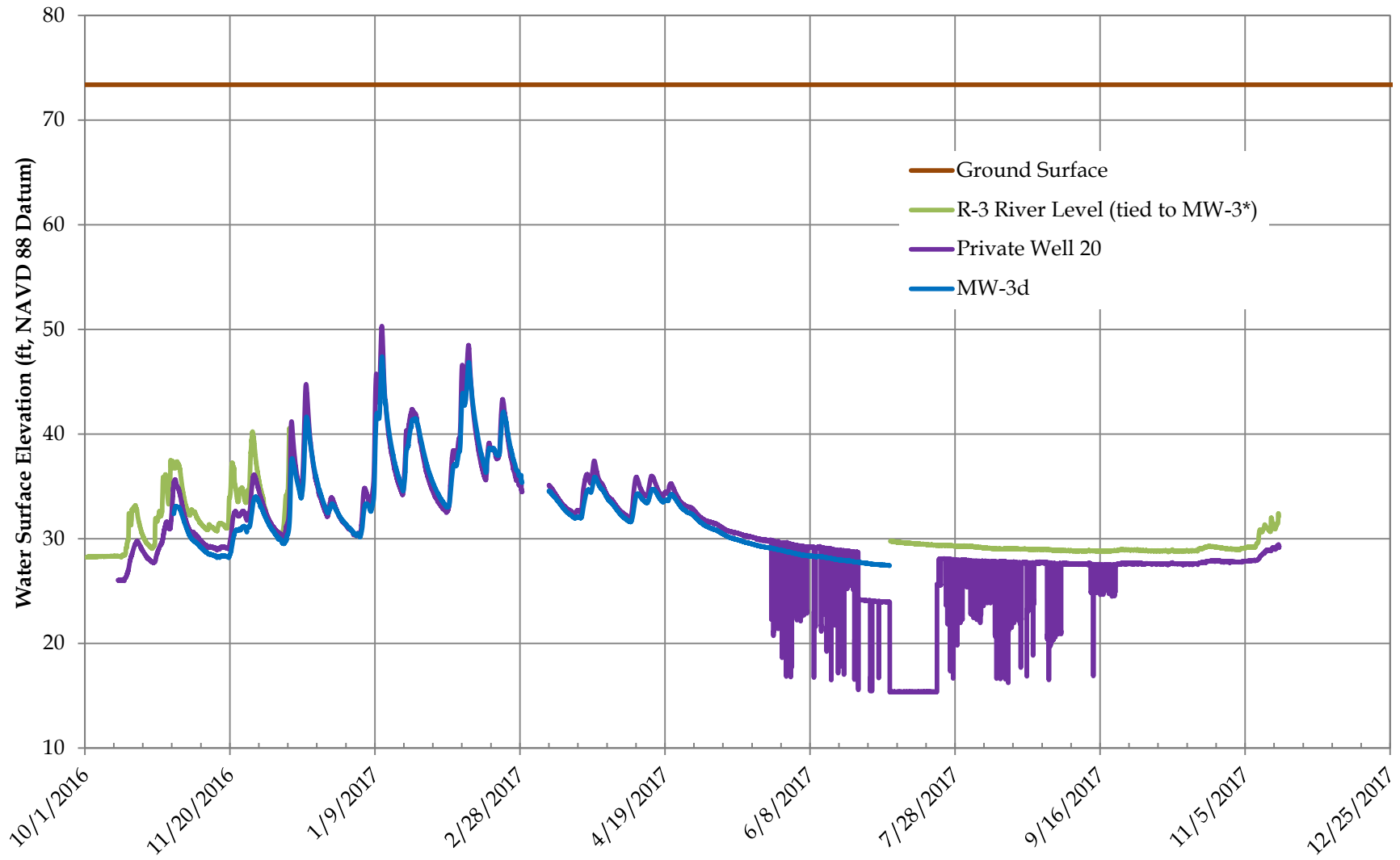


\* hydrograph manually adjusted to field measured water level adjacent to MW-2

Figure 10

# MW-3 and Private Well 20 versus Eel River

Oct 2016 to Dec 2017



\* hydrograph manually adjusted to field measured water level adjacent to MW-3

Figure 11

# MW-9 versus Van Duzen River

Sept 2017 - Dec 2018

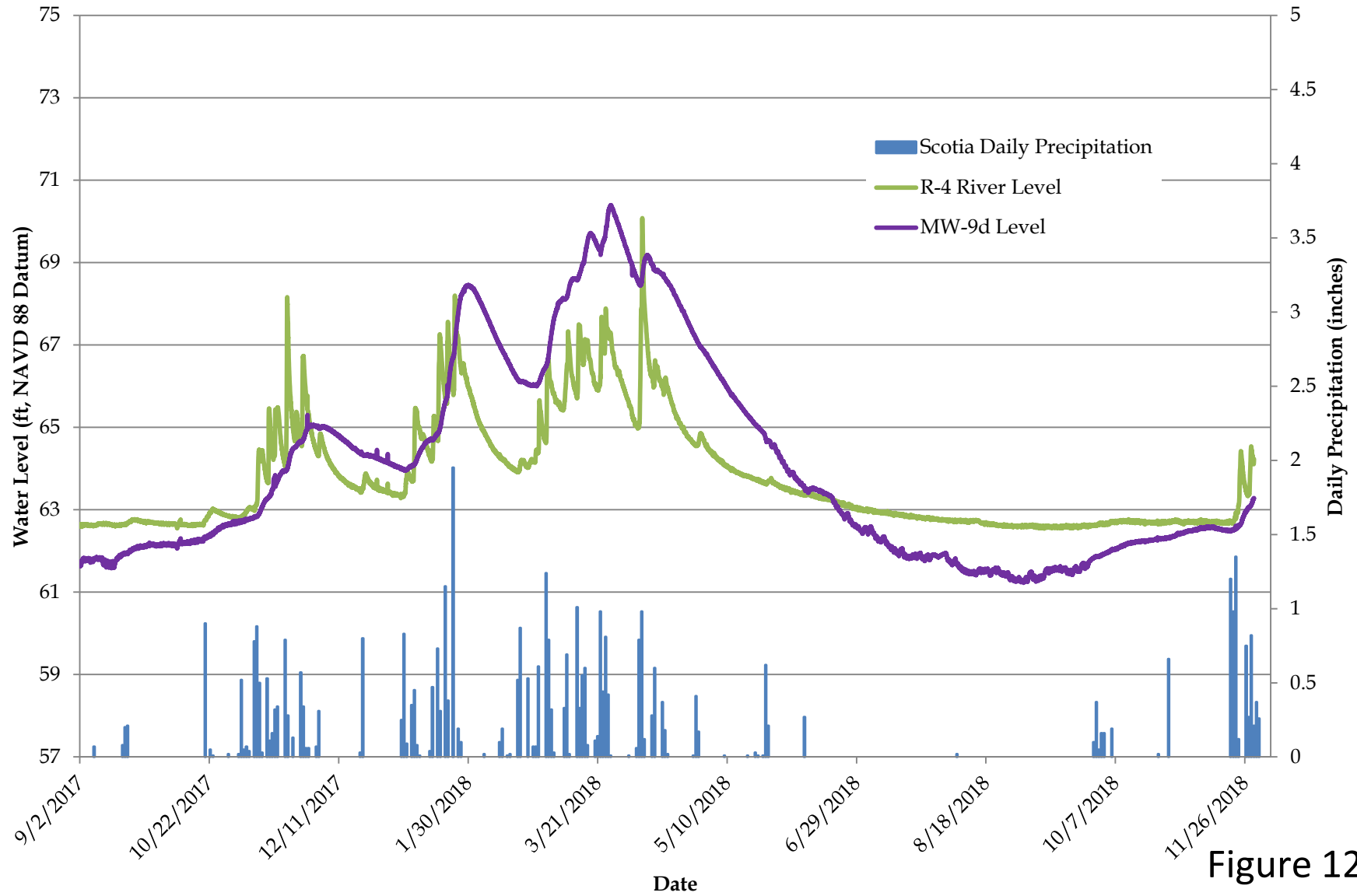


Figure 12

# MW-9 versus Van Duzen River

Mar - Dec 2018

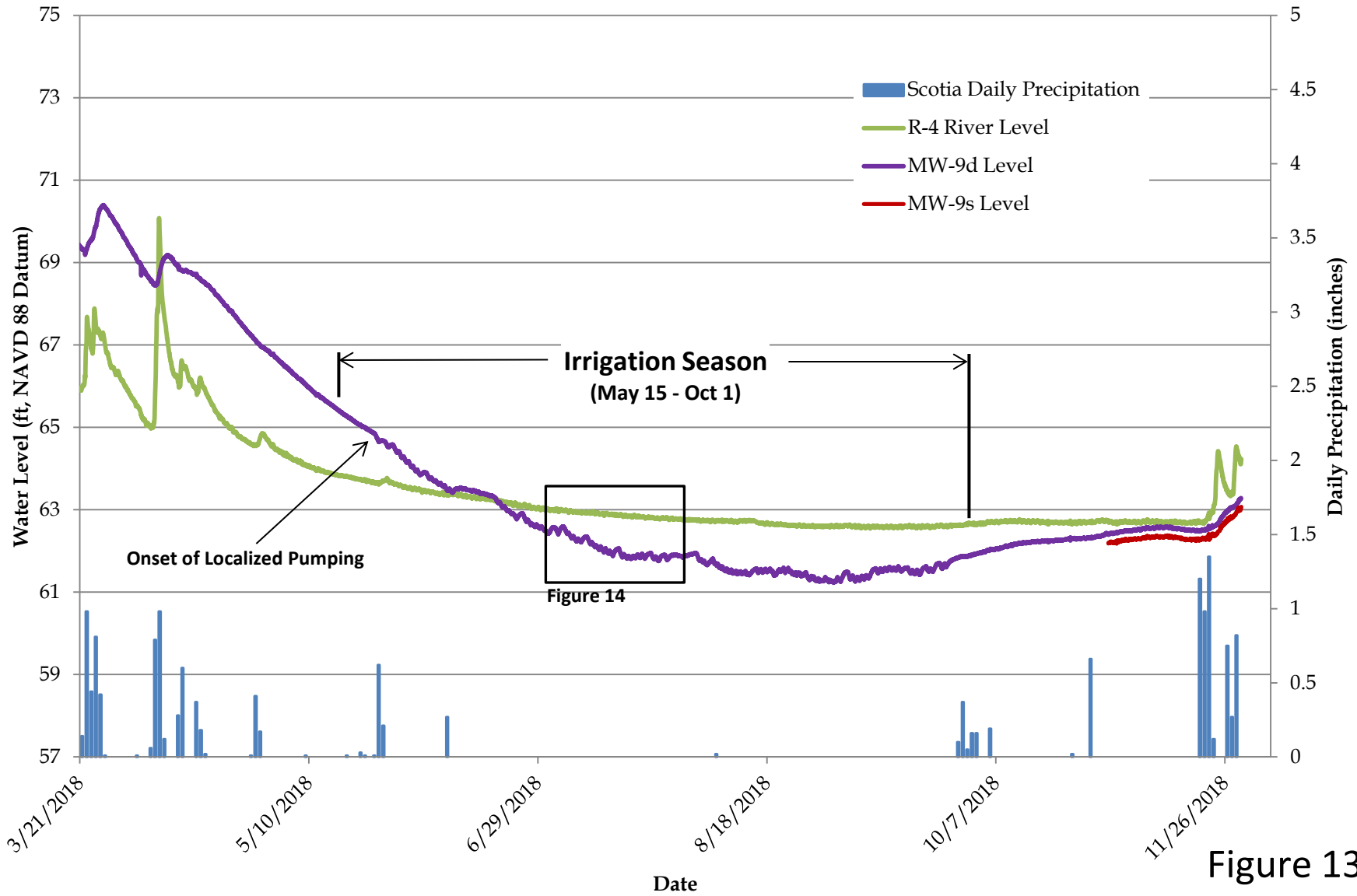


Figure 13

# MW-9 versus Van Duzen River

## July 2018

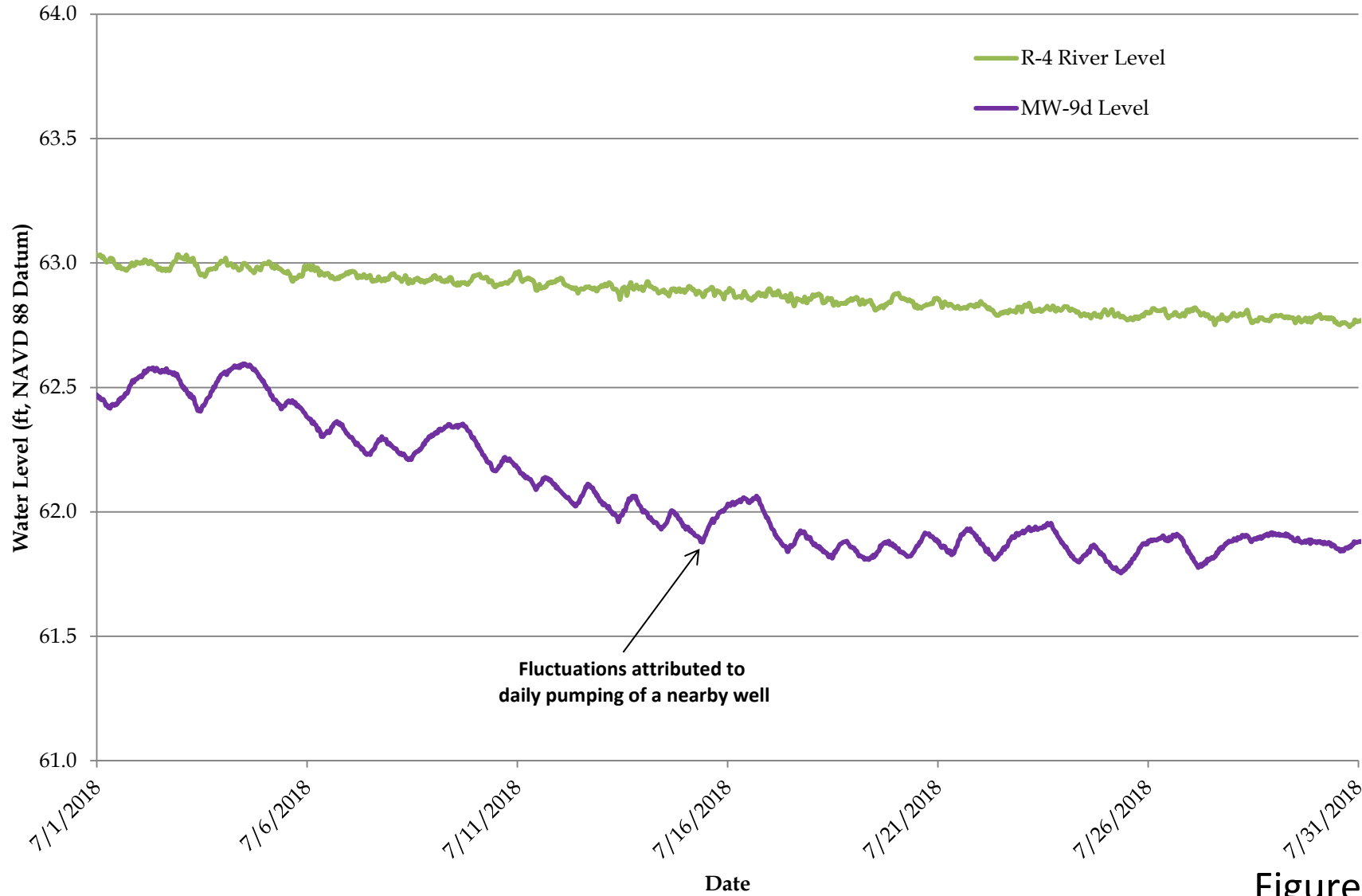
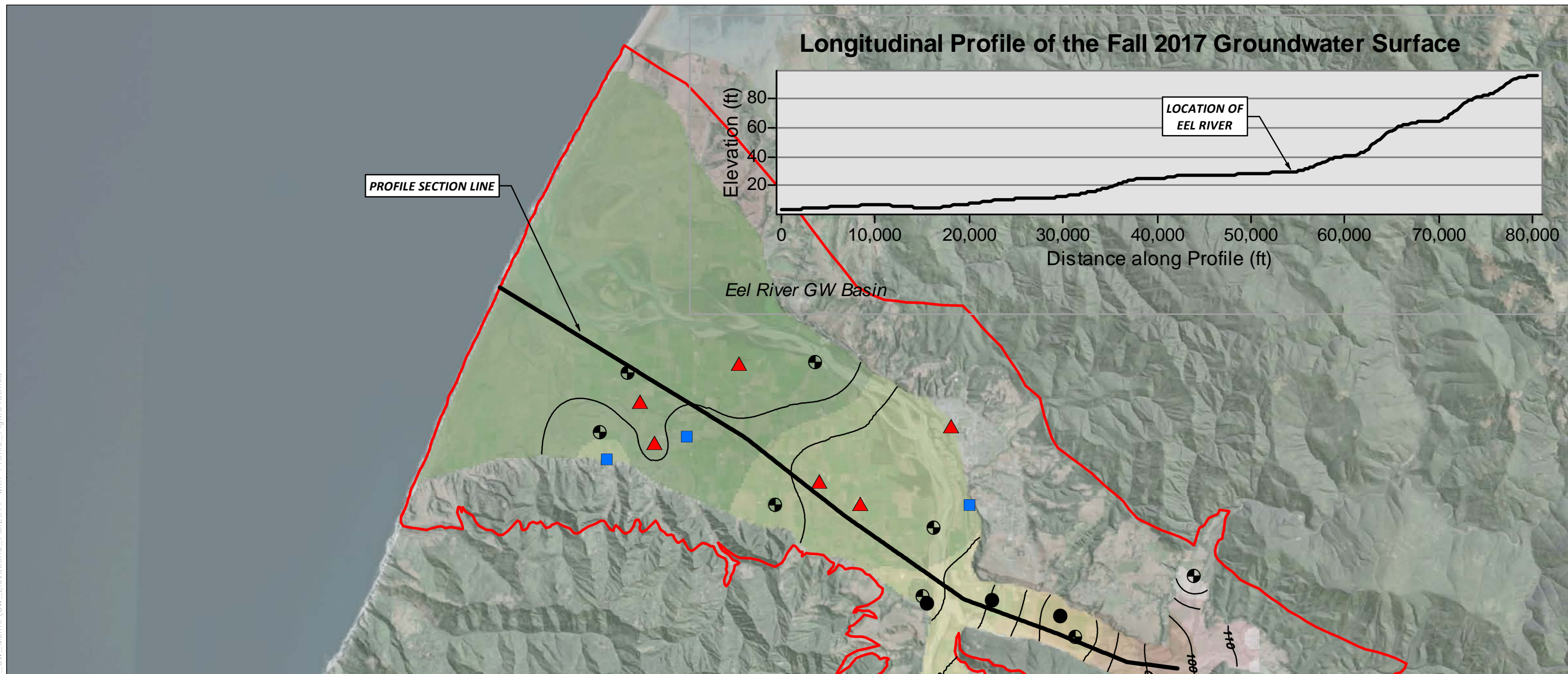


Figure 14

Path: \\eureka\projects\2016\016219-EelRiverGW\GIS\PROJ\_MXD\SW\_CW\_Memo\GW\_Elevations\_Fall2017 with Profile\_Figure15.mxd



**EXPLANATION**

EEL RIVER GROUNDWATER BASIN

**WELLS**

- CASGEM WELLS
- MUNICIPAL WELLS
- PRIVATE WELLS
- COUNTY MONITORING WELLS

1" = 10,000' ±  
 0 10,000  
 FEET

FALL 2017 GROUNDWATER CONTOUR MAP

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

# Relative Elevation Comparison of Private Wells 22, 20 and the Eel River at R-3

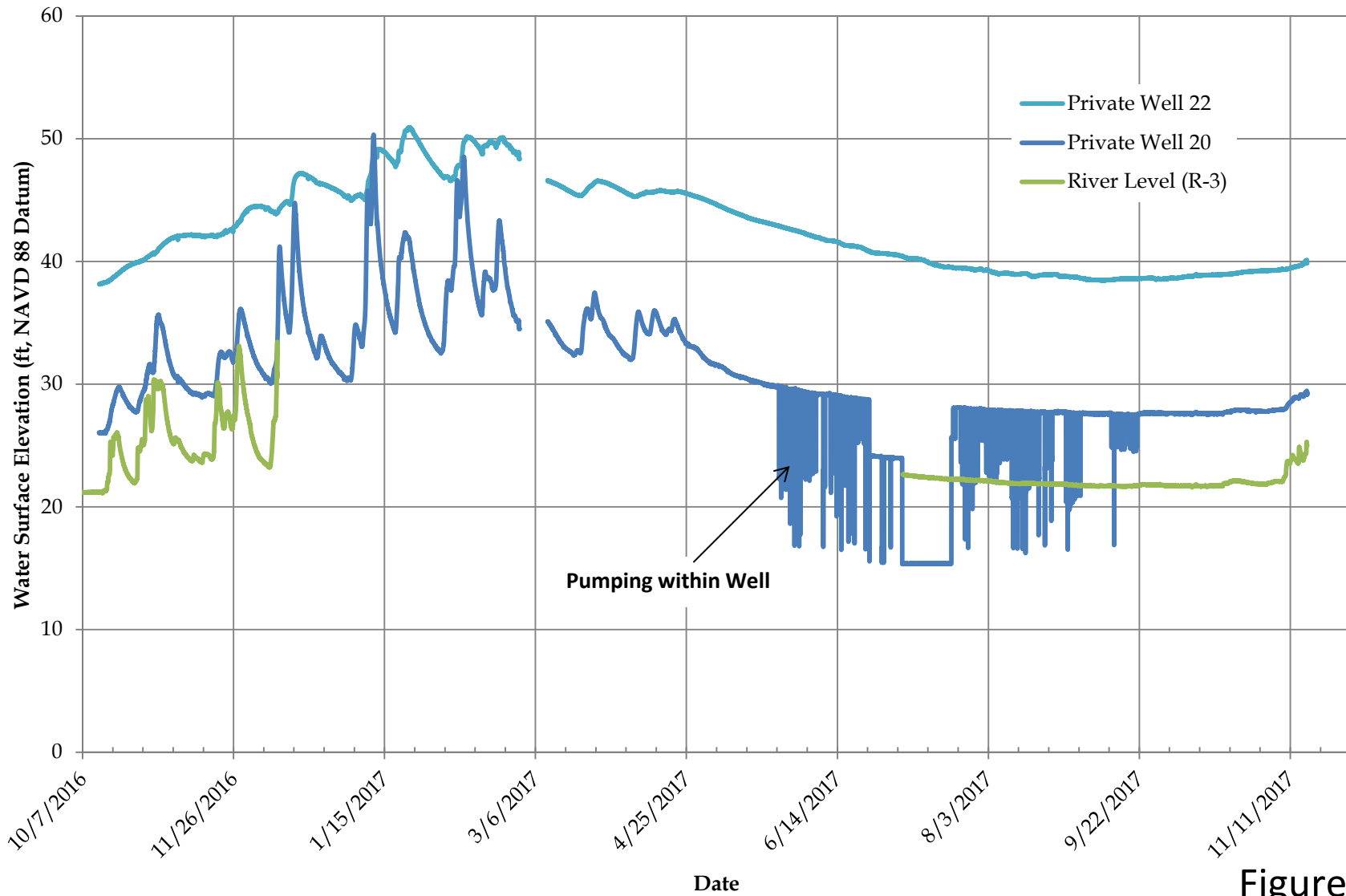


Figure 16