STREAM GAGE SITING MEMORANDUM
SUPPLEMENTAL ENVIRONMENTAL PROJECT

PASO ROBLES AREA GROUNDWATER SUBBASIN
SAN LUIS OBISPO COUNTY
CALIFORNIA

Prepared for

CITY OF PASO ROBLES

NOVEMBER 2020

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1.0 BACKGROUND

The Groundwater Sustainability Agencies (GSAs) for the Paso Robles Area Subbasin of the Salinas Valley Groundwater Basin include the County of San Luis Obispo, the Shandon-San Juan Water District, the City of Paso Robles, and the San Miguel Community Services District. These GSAs adopted a Groundwater Sustainability Plan (GSP) for the Subbasin[1], which has been submitted to the California Department of Water Resources (DWR) in compliance with the Sustainable Groundwater Management Act (SGMA).

The GSP identified a need to expand the network of stream gages and monitoring wells within alluvial deposits associated with the major drainages in the Subbasin. Per the recommendations set forth in the GSP, "*Definitive data delineating any interactions between surface water and groundwater or a lack of interconnected surface waters is a data gap that will be addressed during implementation of this GSP*".

A critical component of the current groundwater model is streamflow, and available streamflow data is very limited as there are only two existing stream gages operating in the Subbasin. This Supplemental Environmental Project (SEP) will begin expanding the network of both stream gages and adjacent monitoring wells in order to better assess the potential for interconnected surface water and groundwater across the Subbasin. Monitoring well construction for the SEP is addressed in a separate Monitoring Well Work Plan.

The SEP will install stream gages that record stream stage; rating curve development is not part of this project. Stage data without a rating curve is useful for identifying flow/no flow conditions and the timing of stormwater runoff (when analyzed with rain gages and other stream gages in a watershed). The stage data may also be used to evaluate the inteconnectivity of surface water and groundwater. A rating curve would be needed to convert stage data to streamflow for water budget and groundwater model analyses. A brief summary of streamflow measurement in natural channels is include in Appendix A.

2.0 SITE SELECTION PROCESS

Ten locations were identified by the Subbasin GSAs that would help provide hydrologic, geologic and hydrogeologic data with appropriate monitoring equipment installations[2]. These locations

[1] Montgomery & Associates, 2020. Paso Robles Subbasin Groundwater Sustainability Plan dated January 31, 2020.

[2] Monsoon Consultants, 2019. Figure 1 - Paso Robles Groundwater Basin - Proposed Monitoring Sites, Paso Robles GSP Data Gap Assessment dated September 6, 2019.

represent sites where a stream gage, coupled with a set of nested or paired monitoring wells, would help to fill in data gaps related to surface water/groundwater interactions throughout the Subbasin. The original locations are shown in Figure 1.

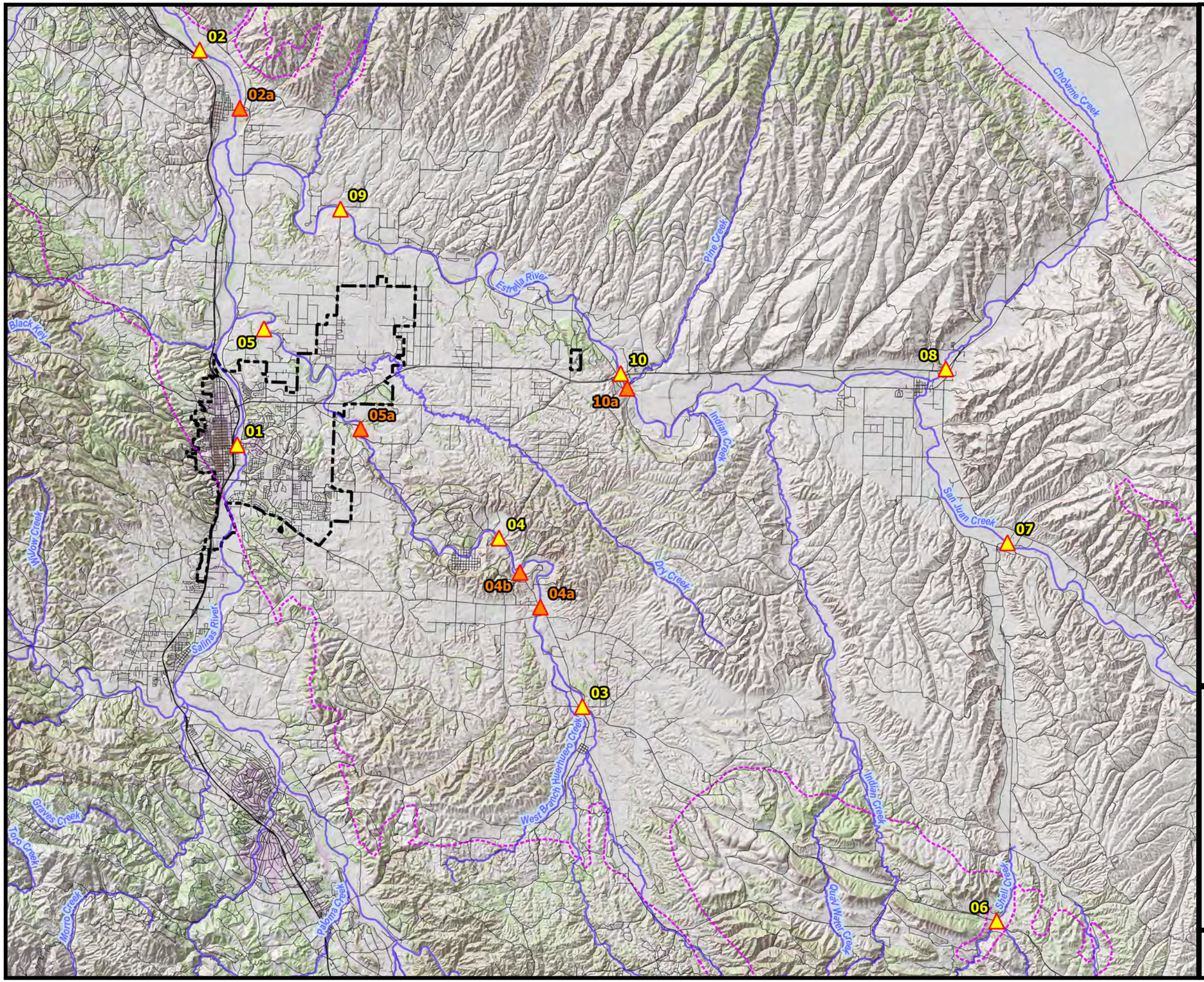
Two of these ten sites (Site 1 and Site 9) currently have U.S. Geological Survey (USGS) stream gages installed and will have monitoring wells installed as part of this SEP project. Of the eight potential stream gage sites, three sites are located in the upper Estrella River watershed: on Shell Creek (Site 6), San Juan Creek (Site 7), and Cholame Creek (Site 8). The Shandon-San Juan Water District GSA is currently pursuing stream gage placement in this area under a separate project with DWR. Therefore, this SEP project is focused on siting stream gages at/near three or more of the following five remaining sites: the Salinas River (Site 2), Huer Huero Creek (Sites 3, 4 and 5), and the Estrella River at Whitley Gardens (Site 10).

2.1 Replacement and Alternate Sites

Due to the funding requirement for installation before the end of the year, an initial key criterion that was used in the site selection process was ease of installation. For this project, non-contact radar sensors installed on bridges are preferred over bubbler or stilling well systems, as no actual work in the stream bed is needed, making the permitting and installation process significantly quicker. Radar sensors also require less maintenance than traditional water-level sensors as they are not susceptible to being obstructed by sediment or debris during high flow events. USGS testing and field experience has proven that radar water level sensors can be used at many sites to provide water level measurements that have accuracy similar or better than that of the older water level instruments[3].

Radar sensors have proven reliable and are being widely used by the County of San Luis Obispo. An example of a local radar sensor installation is shown in Figure 2.

[3] Fulford, J.M., 2016, Testing and Use of radar Water Level Sensors by the U.S. Geological Survey *in* Manual on sea level: Measurement and Interpretation Vol. V: Radar Gauges, JCOMM Technical Report No.89, pp. 121-124.



Explanation

- Paso Robles City Limits
- Paso Robles Groundwater Subbasin Boundary
- Major Stream

Stream Gage Site

- Original
- Replacement/Alternate

0 2.5 5 mi

N

Figure 1
Site Locations

Stream Gage Siting Memo
Paso Robles Groundwater Basin
Supplemental Environmental Project

City of Paso Robles

Cleath-Harris Geologists

Figure 2. San Luis Obispo County radar sensor stream gage installation

Bridge sites are ideal for radar sensors and do not require cableway infrastructure for velocity measurements during rating curve (stage-discharge relation) development, therefore, sites with bridges were prioritized for this project. Bridge plans often have historic topographic information that can be compared to existing or future streambed topography. Bridge sites that are located on County roads or private property (with cooperative owners) were preferred over State of California (Caltrans) owned bridges to avoid administrative delays.

After review of the five remaining original sites under consideration for this project (Sites 2, 3, 4, 5, and 10) only Site 5 was located on a bridge not controlled by Caltrans. In order to provide a viable project and meet the SEP implementation schedule, replacement sites on County bridges were identified as close to the original sites as possible.

The site selection process also includes alternative site pairs. An alternative site pair consist of two stream gage sites that are viable but redundant with respect to general location, so only one of the two would be completed. Alternative sites offer an opportunity for broader agency input on final site selections.

A total of six potential stream gage sites have been identified as viable for this SEP phase (the SEP sites). Two of the sites considered for the SEP are replacements for original sites (Site 2a and Site 10a), and four SEP sites are alternative pairs, from which two sites could be selected (Site 4a or 4b, and Site 5 or 5a). Therefore, prioritization of these six SEP sites would result in four locations for potential stream gage installation.

2.2 SEP Site Prioritization

The basis for site prioritization is a simple ranking system. Five criteria are used to rank the sites, with three possible scores:

1 – Lower than average benefit
2 – Average benefit
3 – Greater than average benefit

The criteria for ranking stream gage sites included environmental considerations, hydrologic considerations, and constructability considerations, with emphasis on ease of installation due to the project time constraints. The criteria used to rank each site include the following:

- Proximity to indicators of Groundwater-Dependent Ecosystems (iGDEs) – closer for greater benefit
- Depth to groundwater – shallower for greater benefit
- Access for adjacent monitoring wells – easier for greater benefit
- Subbasin flow model – broader coverage for greater benefit
- Channel definition and future rating curve development – narrower for greater benefit

The first three criteria listed above are associated with evaluating the interconnectivity of surface water and groundwater, which is the primary data gap beginning to be addressed by the SEP. The last two criteria relate to improving the groundwater model by considering the overall distribution of gage sites for broader water budget determination, and also the suitability of the sites for flow channel consistency and ease of future rating curve development.

2.2.1 Proximity to iGDEs

Proximity to iGDEs was evaluated using the same tool used in Appendix C (Methodology for Identifying Potential Groundwater Dependent Ecosystems) of the Paso Basin GSP. Geospatial data showing iGDEs were downloaded from The Nature Conservancies website for Natural Communities Associated with Groundwater (NCCAG)[4]. Figures showing each of the six SEP sites and nearby iGDEs (if any) are in Appendix B.

2.2.2 Depth to Groundwater

Depth to groundwater was evaluated using the Spring 2019 groundwater elevation contour map from the 2019 Annual Report for the Subbasin[5]. The contoured groundwater elevation at each SEP site was compared to ground surface elevation in the stream bed at the SEP sites to determine an estimated depth to water. Depth to groundwater in the alluvial deposits could be shallower than the 2019 basin contour map indicates.

2.2.3 Access for Adjacent Monitoring Wells

Property ownership and County right-of-way were reviewed at each of the six SEP sites. Most sites were surrounded by private property, with variable right-of-way conditions. Sites with wide right-of-way or public parcels in vicinity were considered easier for future monitoring well construction.

2.2.4 Subbasin Flow Model

Filling data gaps with respect to the interconnectivity of surface water and groundwater is the primary driver for the SEP and can be accomplished with the raw stage data. However, once the stage data is converted to streamflow data using a rating curve (not part of this project), the information can also be used to develop water budget information and refine groundwater model estimates for surface water inflow, stream bed conductance, and recharge areas. Sites with historical streamflow data can also provide useful comparison to new data, and provide a better calibration for the model streamflow input.

[4] https://data.cnra.ca.gov/dataset/natural-communities-commonly-associated-with-groundwater

[5] GSI Water Solutions, 2020. Paso Robles Subbasin First Annual Report (2017-2019), Draft Final dated February 26, 2020.

2.2.5 Channel Suitability and Rating Curve Development

Radar is a non-contact method of measuring stage at one location over time, and is best suited to channels where low flow consistently appears in a specific area of the channel, which also means the lowest point in the channel does not change from year to year. Other in-stream (contact) methods, such as bubble gages or stilling wells, are set into the channel bottom and can record stage from any location in the channel, with surface flow interpreted to occur when the stage rises above a predetermined channel or pool elevation. As previously noted, this SEP proposes radar sensor equipment installation. Some of the sites appear better suited for low flow detection than others, based on site reconnaissance. Stream bed profiles with anticipated placement of the radar gage are shown in Appendix C.

Future rating curve development, which will be needed to convert raw stage measurements to streamflow data for the groundwater model, require in-stream depth profiles and flow velocity surveys. Measuring rating curves during high flow conditions can be challenging, especially when the stage is rising or falling fairly quickly.

3.0 SEP SITE DESCRIPTIONS

There are six sites under consideration for stream gage installation. Descriptions of these SEP sites are provided below.

3.1 Site 2a – Salinas River, River Road Bridge at San Miguel

Site 2a is a replacement for Site 2, which was two miles further downstream where no bridge or road crossing exists. Site 2a encompasses a watershed area of 1,986 square miles (compared to 2,047 square miles at the original Site 2). The replacement site is on River Road bridge in San Miguel, a 1,000-foot structure that spans the roughly 700-foot wide Salinas River, with a bridge deck 50-60 feet above the channel. Historical imagery shows a relatively consistent and distinct 60-foot wide subchannel towards the east end of the bridge that appears suitable for a radar gage, but there are often multiple channels when the river is flowing. There are abundant iGDEs in the site vicinity. Depth to water below the stream channel was approximately 15 feet in Spring 2019. There is currently a nested monitoring well at the east end of the bridge (intermediate and deep piezometers) and a private well off the west end of the bridge. There are locations for additional monitoring wells in a wide County right-of way. A significant disadvantage for Site 2a is the difficulty in future development of an accurate rating curve due to the wide, braided channel.

3.2 Site 4b – Mid Huer Huero Creek, Geneseo Road Bridge

Site 4b is the closest replacement option to the original Site 4 (an unpaved road crossing) and is located on the newly constructed (2019) Huer Huero Creek bridge on Geneseo Road near Eagle Oak Ranch Way. Site 4b encompasses a watershed area of 101 square miles (compared to 103 square miles at the original Site 4. The bridge deck is roughly 15 feet above a swale-shaped 30-foot wide channel with gently sloping banks. The channel is straight and constrained immediately upstream and through about 300 ft downstream where a large bend occurs towards the northwest. This site is also located at an inactive USGS stream gage (11147600) with data from 1958 to 1972. There are no reported iGDEs close to this site. Depth to water below the stream channel was approximately 65 feet in Spring 2019. Monitoring wells could likely be placed in the right-of-way adjacent to the bridge.

3.3 Site 4a – Mid Huer Huero Bridge, Creston Road Bridge at Geneseo Road

As an alternative to site 4b, the older concrete bridge on Creston Road by the intersection of Geneseo Road is another potential location for a stream gage on upper Huer Huero Creek. Site 4a encompasses a watershed area of 98 square miles. The bridge deck is roughly 15 feet above a flat, 100-foot wide channel below, and is the first bridge downstream of the confluence of the West, East and Middle branches of Huer Huero Creek. Depth to water below the stream channel was approximately 85 feet in Spring 2019. The bridge is just upstream of where surface flow was identified to stop in the wet winter of 2016-17[6]. There is an adjacent County parcel to the southeast of the bridge that would be an ideal place for monitoring well installations.

3.4 Site 5 - Lower Huer Huero Creek / Buena Vista Drive

Site 5 is located at a bend on lower Huer Huero Creek about 1.5 miles upstream of the confluence with the Salinas River. The bridge is located on private property but could be used with an agreement with the landowner. Site 5 encompasses a watershed area of 159 square miles. The steel and wood bridge has a deck approximately 7 feet above a flat 50-foot wide channel below. Data from this site would record runoff from the entire Huer Huero Creek watershed. Depth to water below the stream channel was approximately 35 feet in Spring 2019. Monitoring wells would be need to located on private property, where there are vineyards and two nearby irrigation wells.

[6] Todd Groundwater et al., 2018, Paso Robles Basin Recharge Feasibility Study for the Huer Huero Creek, prepared for San Luis Obispo County Flood Control and Water Conservation District.

3.5 Site 5a – Lower Huer Huero Creek, Union Road Bridge near Kit Fox Lane

An alternative gage site to the originally proposed Site 5 on lower Huer Huero Creek is at the bridge on Union Road approximately 5 miles upstream of Site 5. Site 5a encompasses a watershed area of 130 square miles. The 15-foot-high bridge is narrow with very narrow shoulders and has a relatively blind curve to the north. The roughly 60-foot wide channel is flat and straight with minimal vegetation. There are no iGDEs identified in the area. Depth to water below the stream channel was approximately 190 feet in Spring 2019 (within a major Subbasin pumping depression). Its southeastern banks are mildly sloping and northwestern banks are steep and high (~150 feet). An irrigation well is present near the southeastern bank roughly 75 feet from the center of the bridge. The right-of-way is narrow along that part of Union Road and monitoring wells would need to be located on private property.

3.6 Site 10a: Estrella River, Whitley Gardens / River Grove Drive Bridge

Site 10a is a replacement site for Site 10, which wa 0.4 miles downstream at State Highway 46. The one-lane steeltruss River Grove Drive bridge in Whitley Gardens was renovated in November 2019. Site 10a encompasses a watershed area of 1,210 square miles. The bridge deck is 15-20 feet above the roughly 40-foot-wide channel, with gently-sloping banks. The upstream and downstream reaches are straight and constrained and the main channel under the bridge has a distinct center channel. There are iGDEs both upstream and downstream of the site. Depth to water below the stream channel was approximately 40 feet in Spring 2019. Site 10a is also the location of an inactive USGS stream gage that has limited streamflow data from 1939 to 1941. There appears to be sufficient width in the right-of-way to install monitoring wells east of the bridge.

4.0 SITE RANKING CRITERIA

Table 1 presents the results of site criteria evaluation. Descriptions of these criteria and scoring are described in the Section 2.2 above (SEP Site Prioritization).

Table 1
Stream Gage Site Criteria Evaluation

Criteria	SEP SITE					
	2a	4a	4b	5	5a	10a
Proximity to iGDEs	3	2	2	2	2	3
Depth to Groundwater	3	2	2	3	1	3
Access for monitoring wells	3	3	2	3	1	2
Hydrologic Value*	3	3	3	2	2	3
Channel morphology/Rating curve dev.	1	2	3	2	2	3
Score (higher = more benefit)	**13**	**12**	**12**	**12**	**8**	**14**

*requires rating curve to achieve full benefit

5.0 SITE RANKING RECOMMENDATION

Site 10a (Estrella River at Whitley Gardens) has the highest ranked score for a gage location under the criteria used, with a greater than average relative benefit of all criteria except access for monitoring wells (average rank). Site 2a (Salinas at San Miguel) is second in the rankings, with a greater than average relative benefit of all criteria except channel morphology/rating curve development (below average rank).

The remaining locations are all on Huer Huero Creek, with a tie between Sites 4a, 4b, and 5. All three sites have greater than average benefit in two criteria and average in three criteria. Site 5a (Lower Huer Huero, Union Road near Kit Fox Lane) has the lowest ranking of all sites, due to average to below average ranking for all criteria.

Mid Huer Huero sites 4a and 4b are both good options. Site 4a is the first bridge that captures all three Huer Huero branches and would experience the longest duration of seasonal flow of the two sites. Site 4a also has access to an adjacent County parcel for monitoring well siting. Site 4b is located closer the original Site 4 on a newly constructed bridge where the contoured channel is better suited to low flow measurements, and is also at an inactive historical USGS gage location which is valuable for data continuity. One or the other of these two sites could be used for stream gaging.

Assuming Site 3 (Highway 41 bridge – East and Middle Branches of Huer Huero Creek) is to be installed as the Upper Huer Huero stream gage under a future GSP project phase, then Site 4b would provide a more suitable location for the Mid Huer Huero gage. Data from a Site 3 gage (61 square miles of watershed) could be used to estimate inflow to the Subbasin on the West Branch. If Site 3 is not planned under future GSP project phases, then Site 4a would be preferred and would effectively represent Upper Huer Huero Creek.

Lower Huer Huero Site 5 would be viable if cooperation with the property owner(s) (including a permanent easement and room for monitoring well installation) can be established. The assumption is that this can be accomplished, which gives above average access for monitoring wells. The relatively shallow depth to groundwater is an indicator of potential surface water and ground water interaction, although no iGDEs exist in proximity. Site 5 could have an above average hydrologic value if paired with a Mid Huer Huero gage, which would allow a calculation of basin recharge along the Lower Huer Huero.

Assuming future GSP project phases will construct Site 3 to represent Upper Huer Huero Creek, the following stream gage site prioritization is recommended for the SEP, beginning with the top priority:

- Site 10a (Estrella River at River Grove Bridge, Whitley Gardens)
- Site 2a (Salinas River at San Miguel Bridge)
- Site 4b (Mid Huer Huero Creek at Geneseo Road Bridge near Eagle Oak Ranch Way)
- Site 5 (Lower Huer Huero Creek at private bridge near Buena vista Drive)

APPENDIX A

Streamflow Measurement in Natural Channels

Streamflow Measurement in Natural Channels

The most practical method for measuring streamflow in natural channels is the velocity-area method, which has the following computation[7]:

$$Q = \sum_{i=1}^{n} (a_i v_i)$$

where:

Q = total discharge (reported in cubic feet per second).

a_i = cross-sectional area of flow for the *i*th segment of the *n* segments into which the cross section is divided (square feet), and

v_i = the corresponding mean velocity of flow normal to the *i*th segment (feet per second).

The conceptual model for the velocity area-method is shown below. A stream is divided into segments, each with an individual area and velocity, which are then multiplied and summed using the above equation.

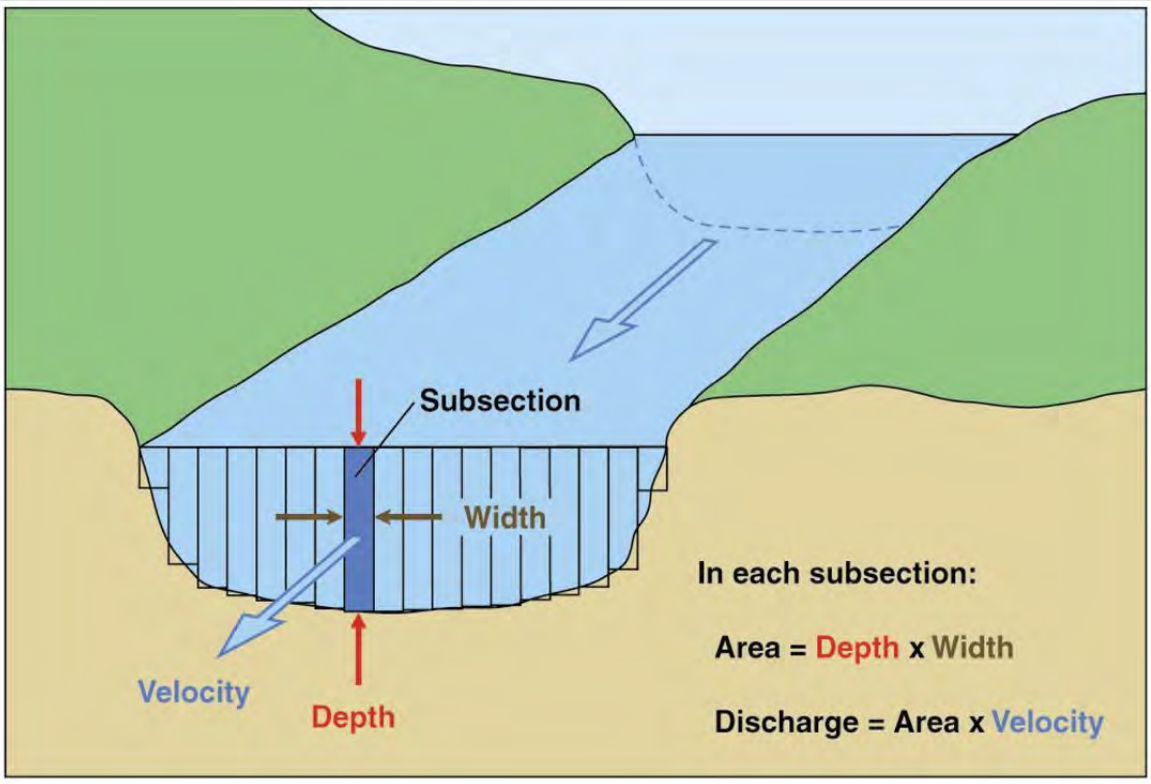


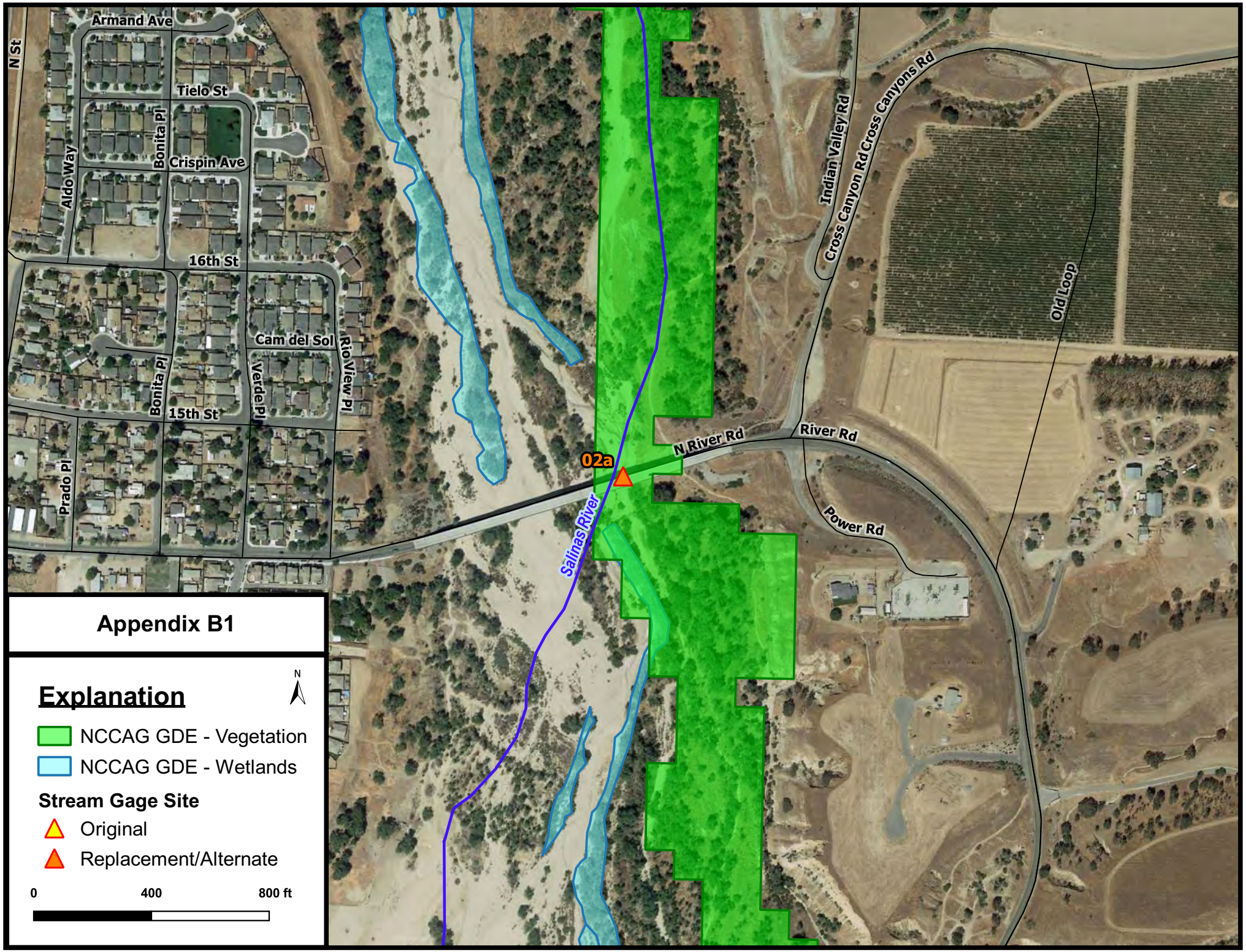
Diagram of Channel cross-section with segments for discharge computation (USGS)

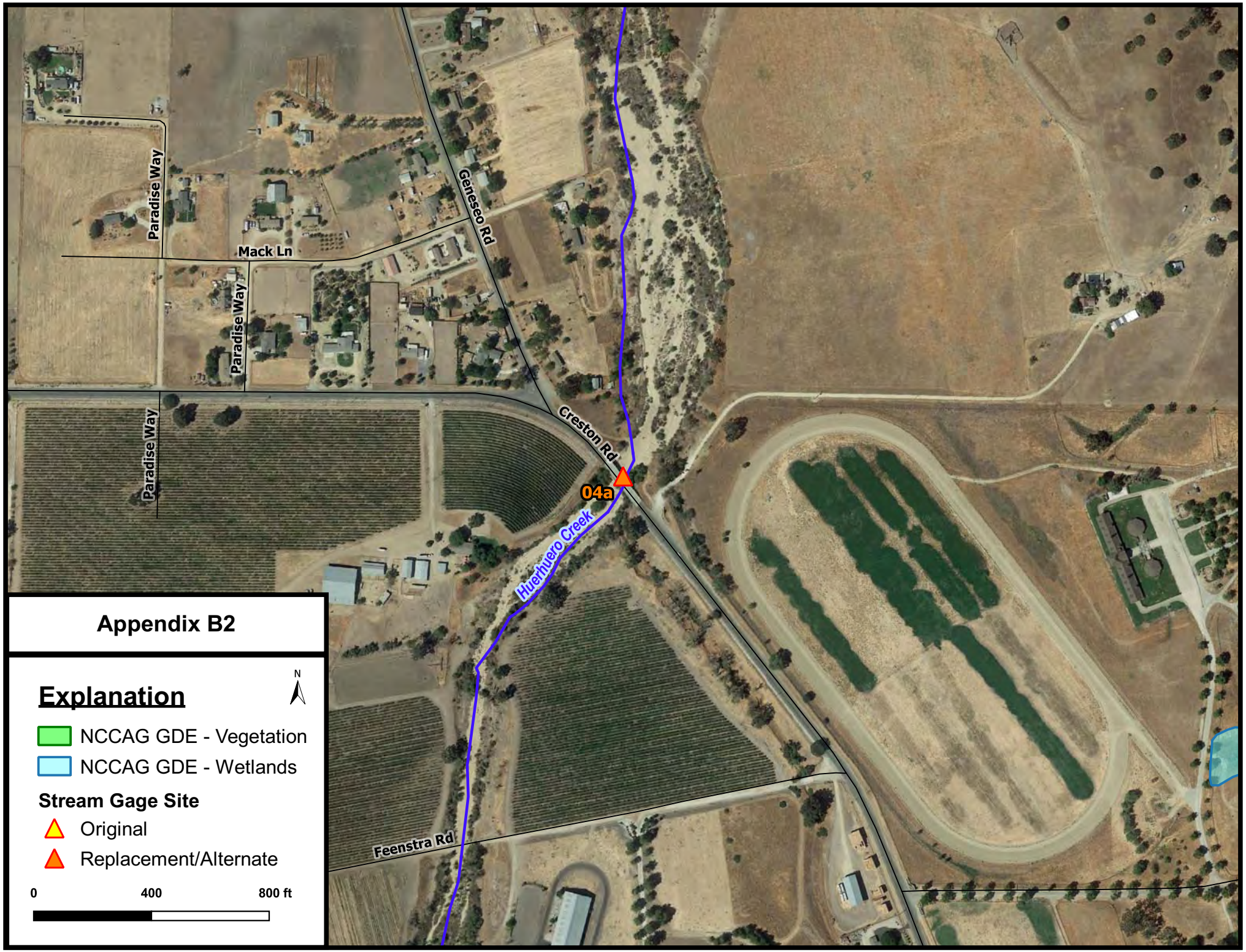
[7] Turnipseed, D.P. and Sauer, V.B., 2010. Discharge Measurements at Gaging Stations, USGS Techniques and Methods 3-A8.

In natural channels, stream gages are used to record stage (feet), which is the height of water in the stream above an arbitrary point, usually at or below the stream bed. The stage is then converted to streamflow through the use of a rating curve, or stage-discharge relation. A rating curve incorporates information collected that is specific to each site, including the cross-sectional area of the channel and the average velocity for a given flow stage. These rating curves are developed using depth profiles and average flow velocity measurements during storm-runoff events. Rating curves may need to be revised periodically as they can shift due to changes in channel geometry. Measuring average flow velocity across a channel at different stream stages is the most challenging part of developing a rating curve.

APPENDIX B

GDE Indicators in Proximity to SEP Sites


Armand Ave
N St
Tielo St
Bonita Pl
Crispin Ave
Aldo Way
16th St
Cam del Sol
Rio View Pl
Verde Pl
Bonita Pl
15th St
Prado Pl
Indian Valley Rd
Cross Canyon Rd
Cross Canyons Rd
Old Loop
N River Rd
River Rd
02a
Salinas River
Power Rd
Appendix B1
Explanation
N
NCCAG GDE - Vegetation
NCCAG GDE - Wetlands
Stream Gage Site
Original
Replacement/Alternate
0
400
800 ft


Paradise Way
Mack Ln
Paradise Way
Paradise Way
Geneseo Rd
Creston Rd
04a
Huerhuero Creek
Feenstra Rd
Appendix B2
Explanation
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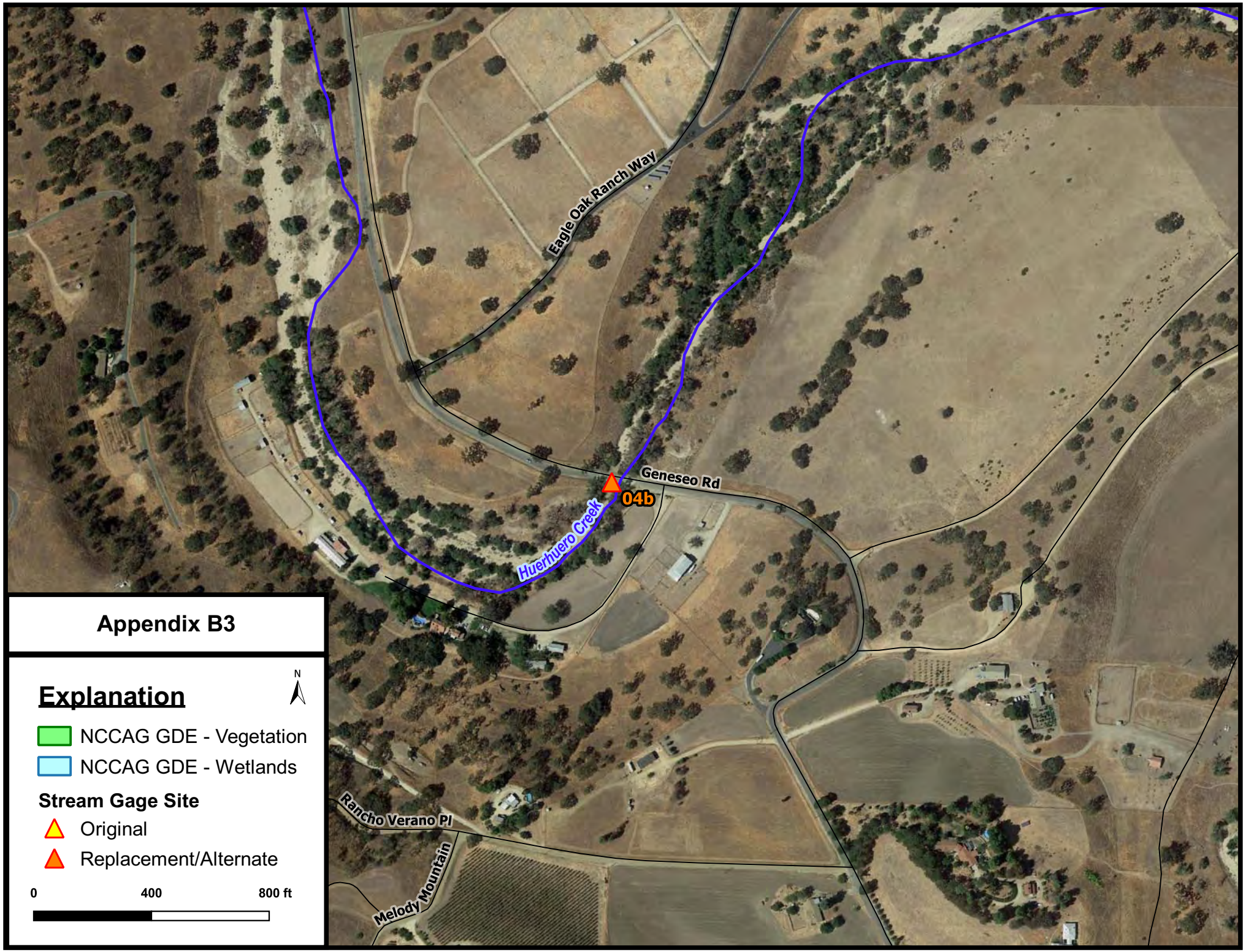
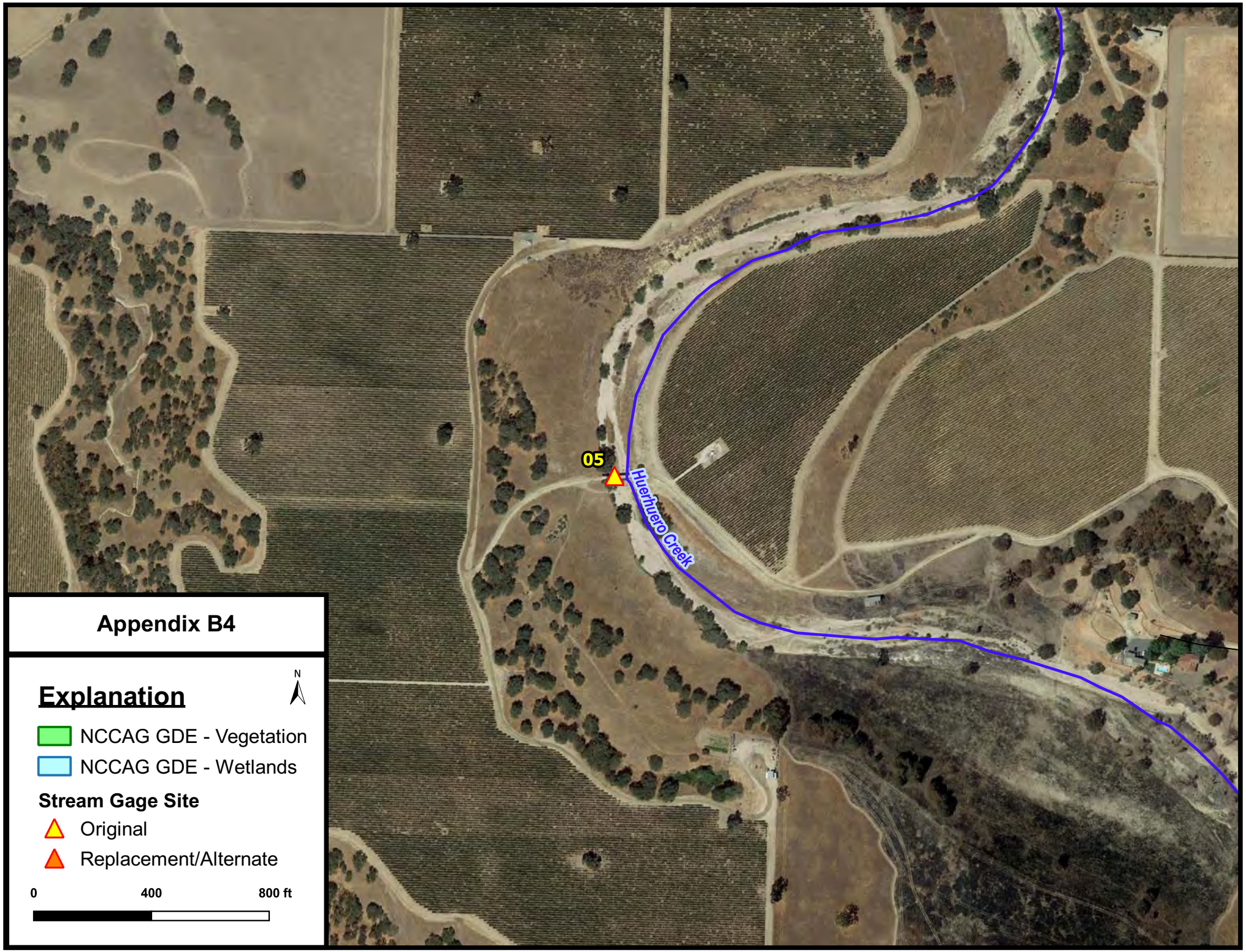
NCCAG GDE - Vegetation
NCCAG GDE - Wetlands
Stream Gage Site
Original
Replacement/Alternate
0
400
800 ft


Eagle Oak Ranch Way
Geneseo Rd
04b
Huerhuero Creek
Rancho Verano Pl
Melody Mountain
Appendix B3
Explanation
N
NCCAG GDE - Vegetation
NCCAG GDE - Wetlands
Stream Gage Site
Original
Replacement/Alternate
0
400
800 ft


05
Huerhuero Creek
Appendix B4
Explanation
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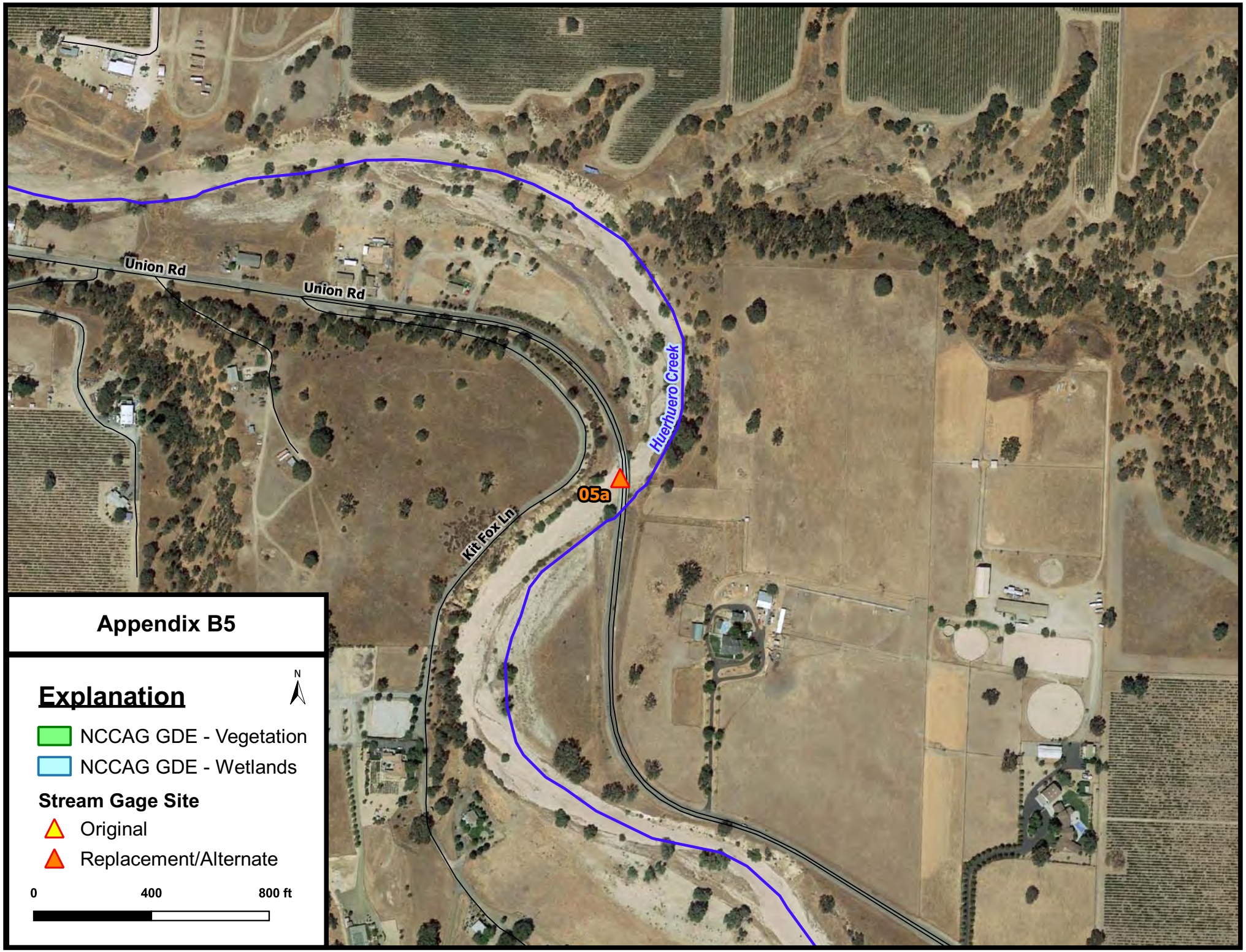
NCCAG GDE - Wetlands
Stream Gage Site
Original
Replacement/Alternate
0
400
800 ft


Union Rd
Union Rd
Huerhuero Creek
05a
Kit Fox Ln
Appendix B5
Explanation
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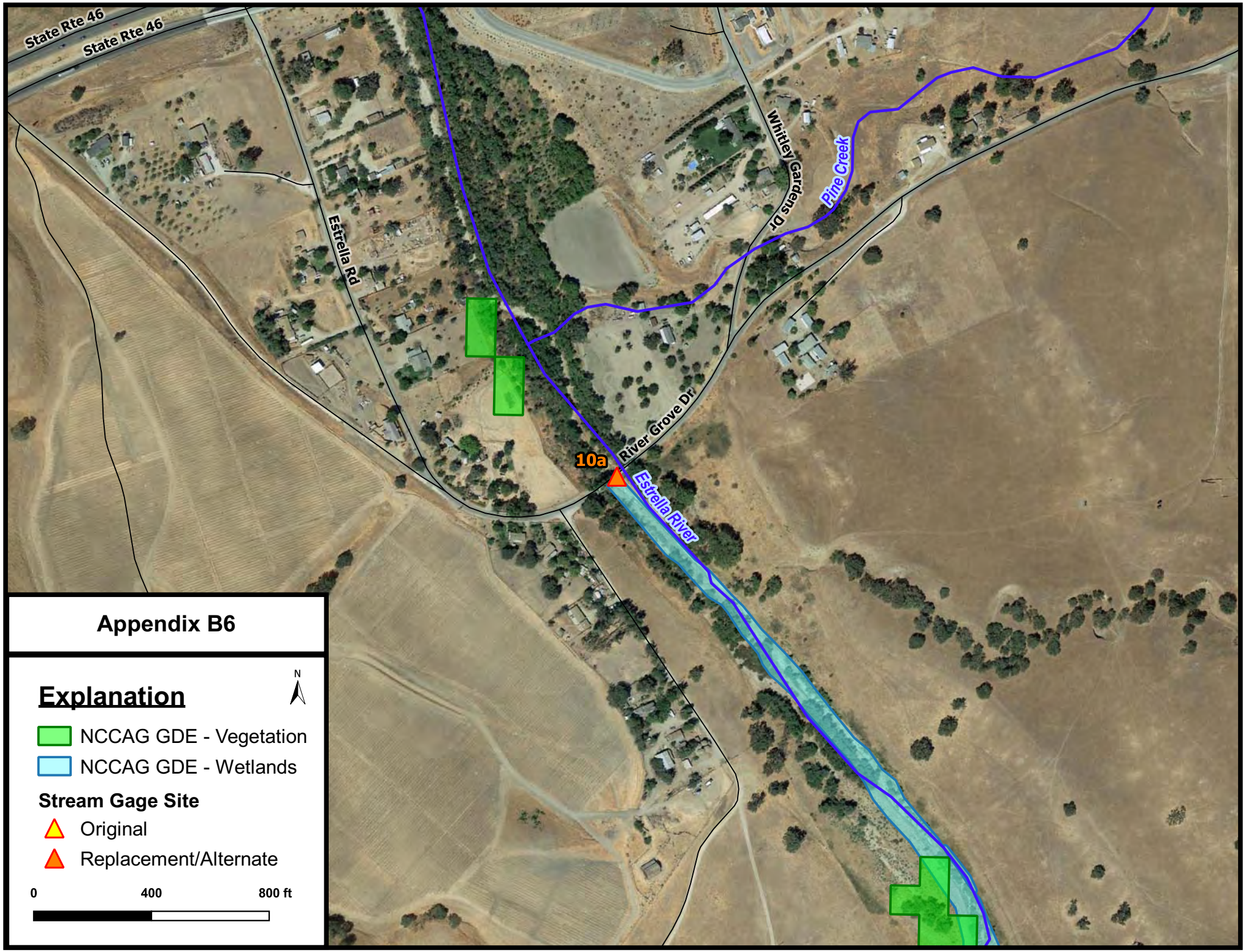
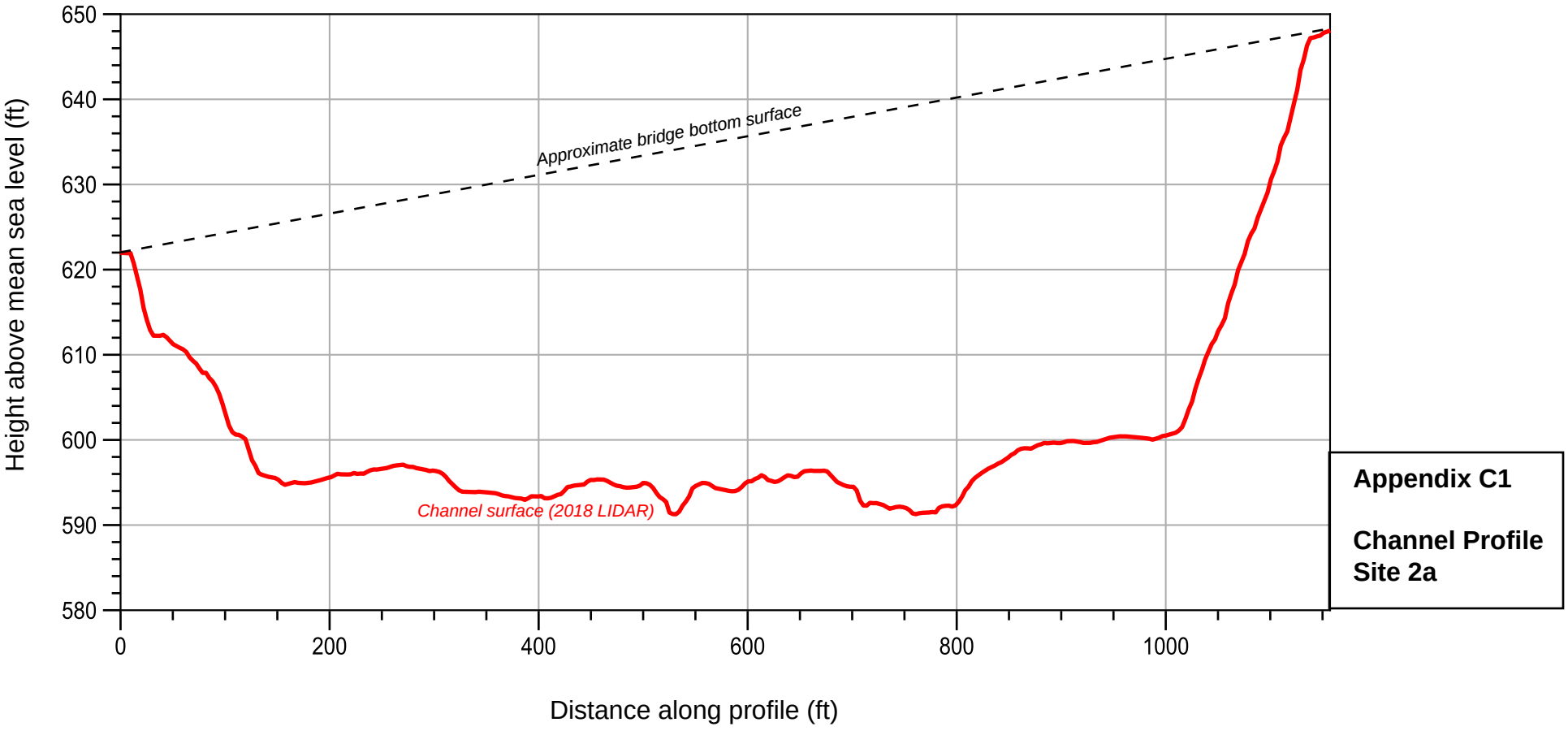
NCCAG GDE - Vegetation
NCCAG GDE - Wetlands
Stream Gage Site
Original
Replacement/Alternate
0
400
800 ft


State Rte 46
State Rte 46
Estrella Rd
Whitley Gardens Dr
Pine Creek
River Grove Dr
10a
Estrella River
Appendix B6
Explanation
N
NCCAG GDE - Vegetation
NCCAG GDE - Wetlands
Stream Gage Site
Original
Replacement/Alternate
0
400
800 ft

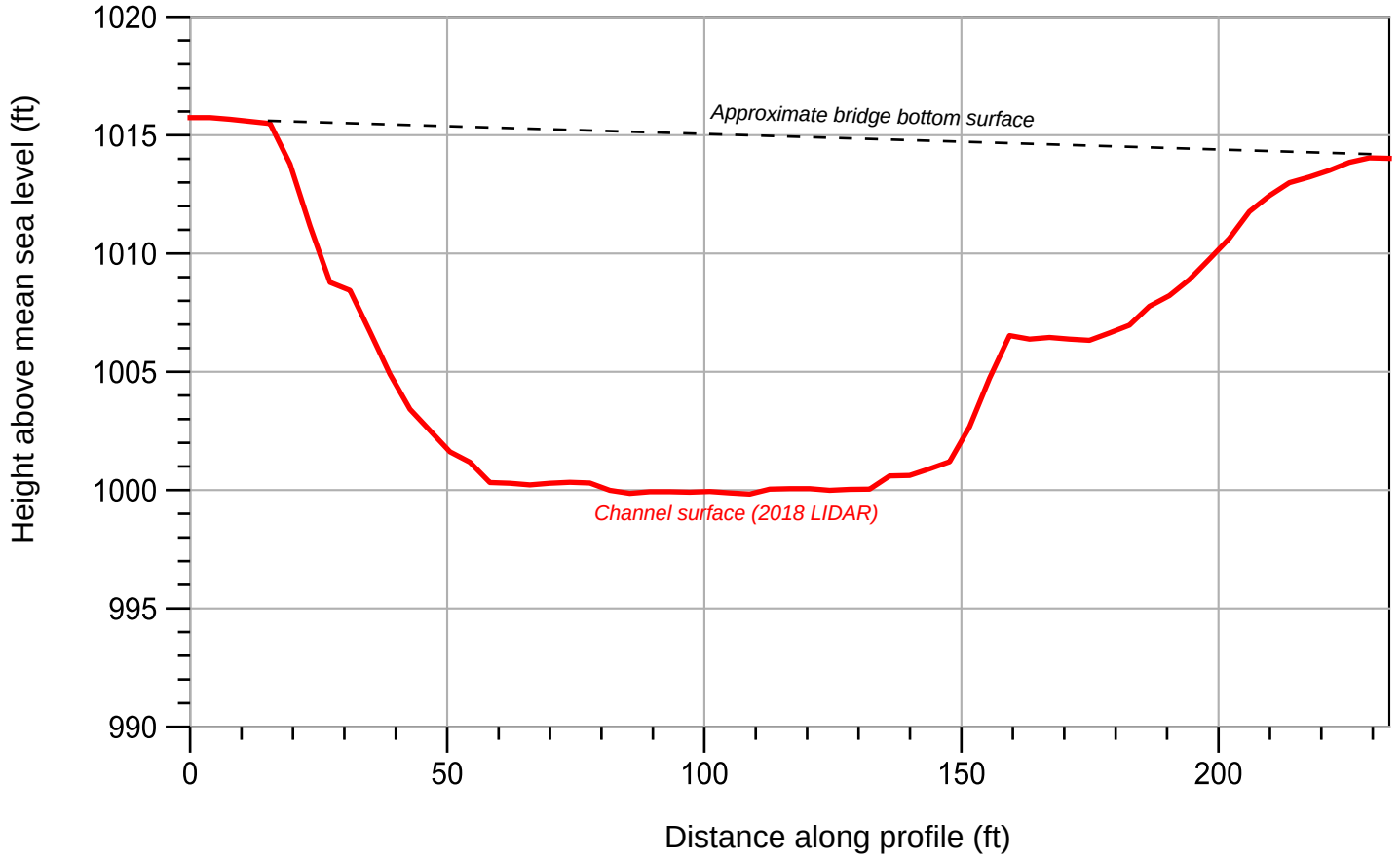
APPENDIX C

Stream Profiles at SEP Sites



Appendix C1

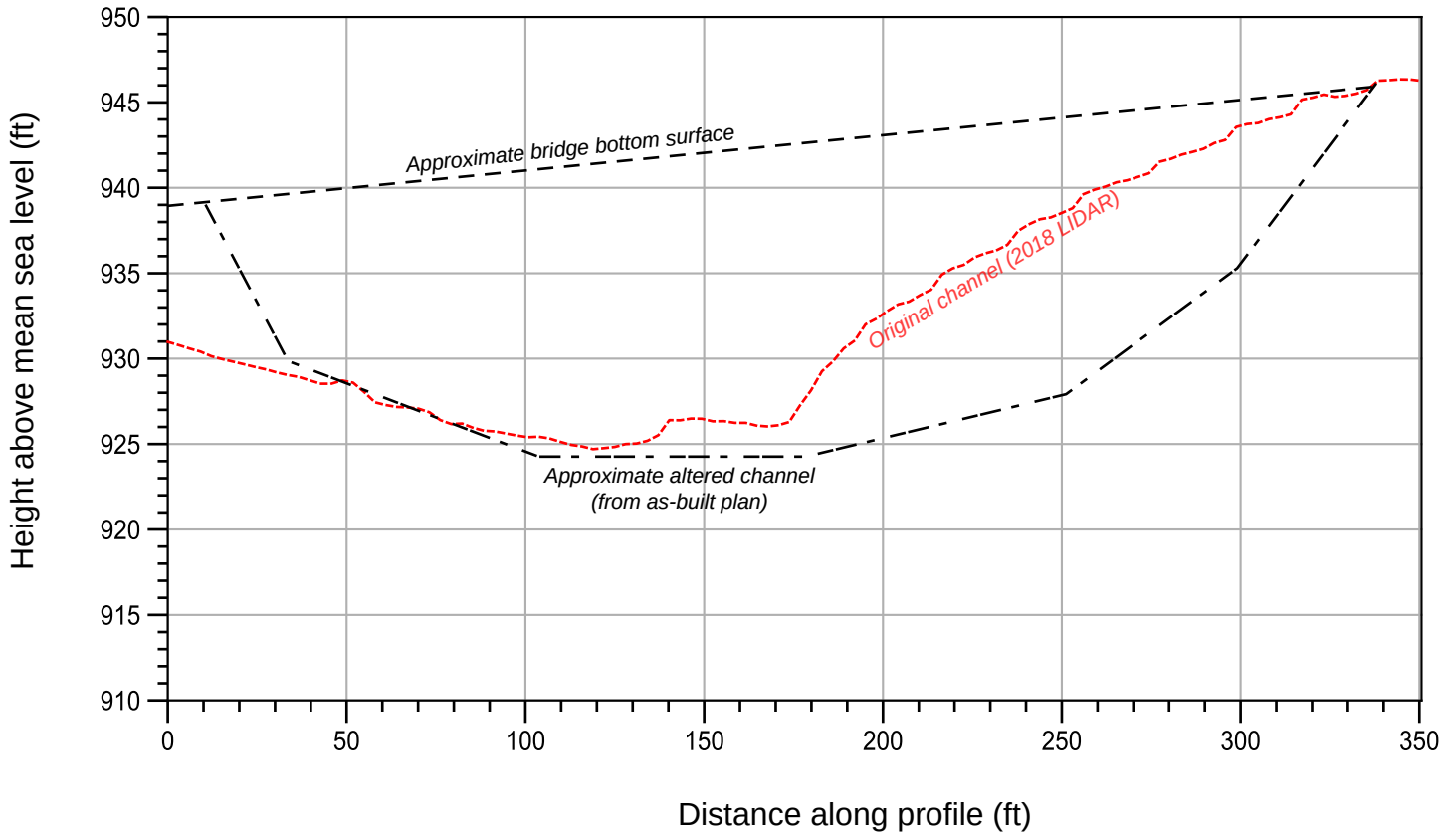
Channel Profile Site 2a



Appendix C2

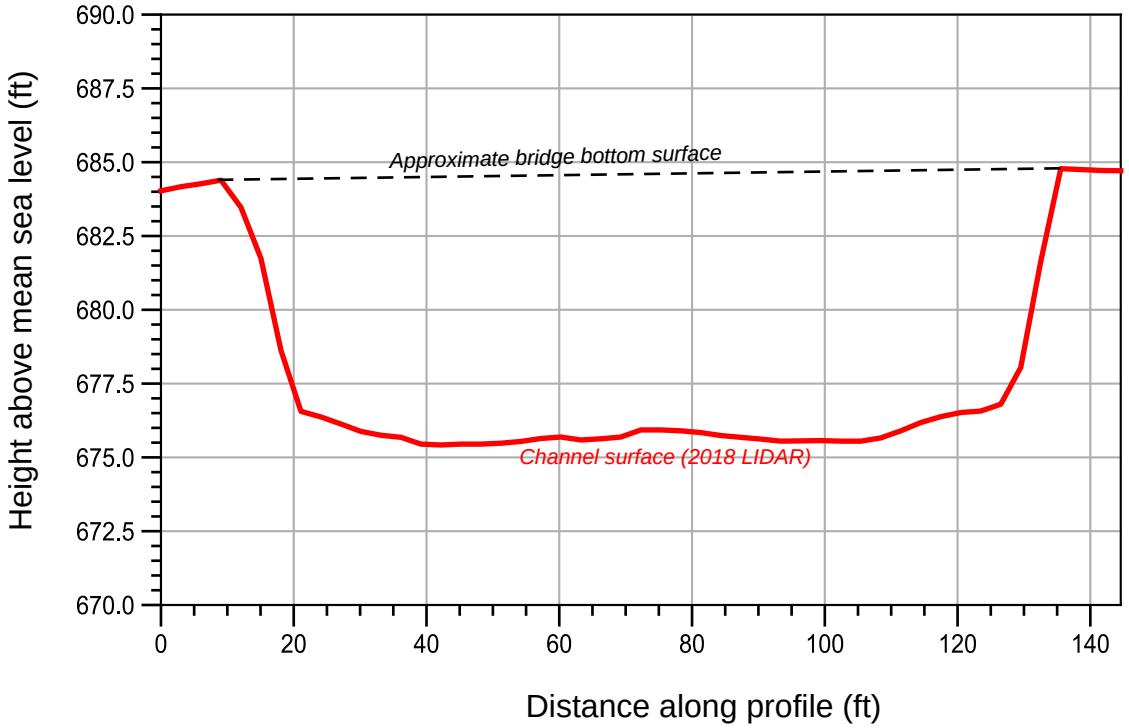
Channel Profile
Site 4a

Note: Aerial imagery reflects conditions prior to the construction of bridge 49C0431



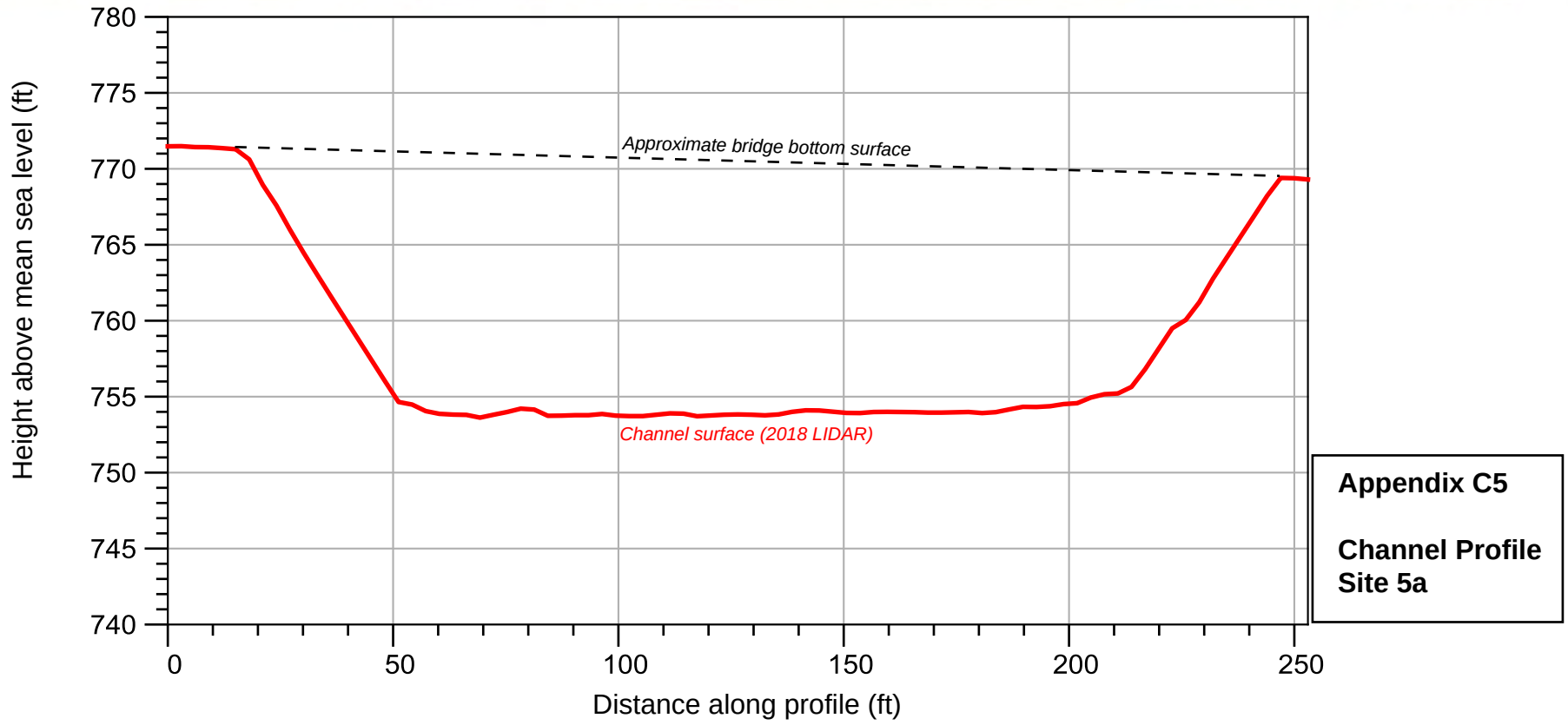
Appendix C3

Channel Profile
Site 4b



Appendix C4

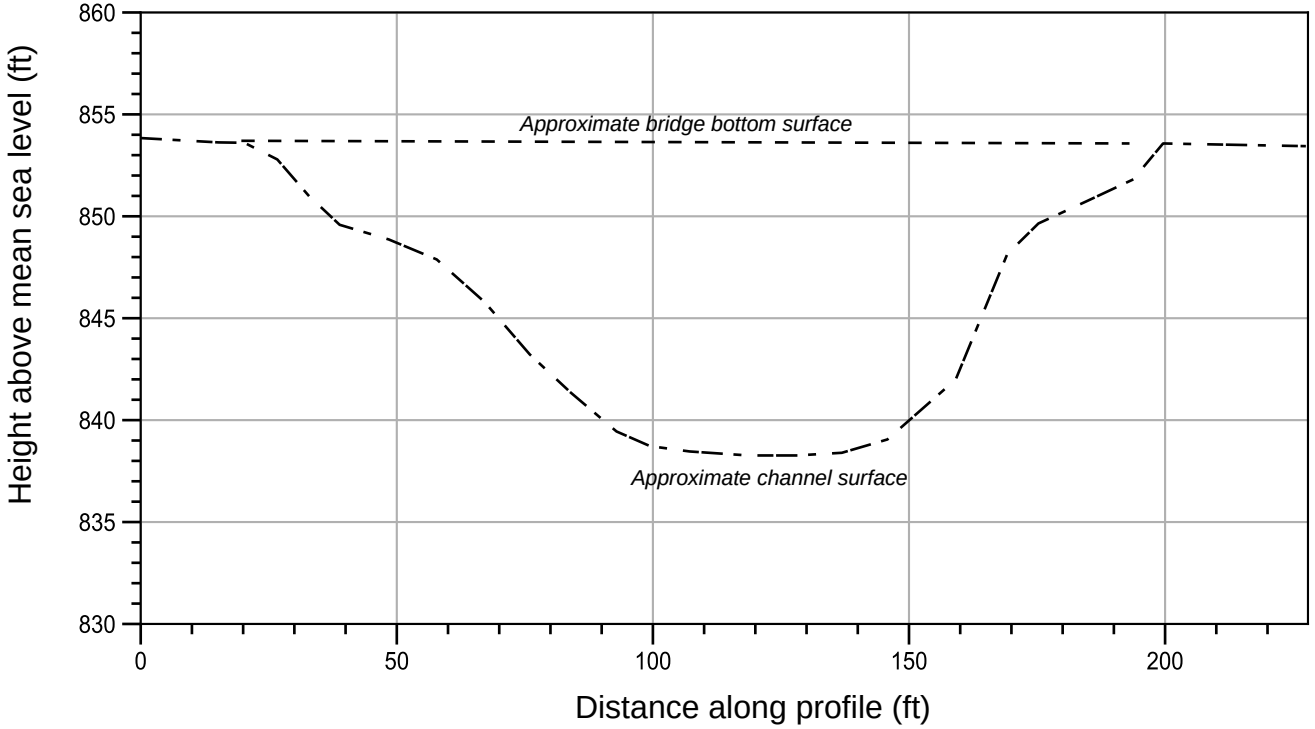
Channel Profile
Site 5



Appendix C5

Channel Profile Site 5a

Note: Aerial imagery reflects conditions prior to the renovation of bridge 49C0307



Appendix C6

Channel Profile
Site 10a