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Project: Statistical Design, Analysis and Guidance on the Pajaro and Lower Peninsula Watershed Assessments

TASK 2: Basis of Assessment Memorandum
Review Existing GIS Data & Develop Stream Assessment Study Designs for the Pajaro and Lower Peninsula Watersheds

Report prepared for the Santa Clara Valley Water District
Ecological Data Collection and Analysis Project (Priority D.5)

Agreement # A3765F

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Background

The voter-approved Safe Clean Water and Natural Flood Protection Program of the Santa Clara Valley Water District (District) includes priorities to restore wildlife habitat and provide open space. Under these priorities, the Ecological Data Collection and Analysis project (priority D.5) is using California's Wetland and Riparian Ambient Monitoring Plan[1] (WRAMP) tools as an integral part of its comprehensive, watershed approach to planning and protecting natural resources and assets. WRAMP tools are available online, and are public and non-proprietary. The toolset includes:

1. **California Aquatic Resources Inventory:** CARI (www.sfei.org/it/gis/cari) is a digital dataset of surface waters throughout the state, a standardized mapping methodology, and a classification system with crosswalks to other systems used by USFWS, CalFire, USGS, Habitat Joint Ventures, and prominent regional consortia of agencies.
2. **California Rapid Assessment Method:** CRAM (www.cramwetlands.org) is a cost-effective and scientifically defensible, standardized method for monitoring the overall ecological condition or health of wetlands and streams throughout California. According to the statewide online CRAM database, nearly a thousand trained CRAM practitioners have completed almost four thousand assessments.
3. **Online data access, visualization, and summarizing tools:** EcoAtlas (www.ecoatlas.org) is an information visualization and delivery system for environmental regulatory and management programs. The Project Tracker enables users to map and track natural resource management actions, including restoration and mitigation projects. The Landscape Profile Tool uses web-services to aggregate environmental information for any user-defined area throughout the state.

The District is applying the WRAMP framework in five watersheds in Santa Clara County (Figure 1) using the following tools:

- CARI (or the best available digital aquatic resource data) to characterize the abundance and diversity of aquatic resources;
- Probabilistic stream condition surveys using CRAM to evaluate the overall ecological condition of streams within a watershed, and
- Intensive assessment and focused studies to support specific management actions such as fish passage improvements and stream, upland, wetland and riparian habitat revitalization.

[1] http://www.mywaterquality.ca.gov/monitoring_council/wetland_workgroup/wramp/

The District began the watershed approach to stream condition assessments in 2010 and completed ambient assessments in the Coyote Creek (watershed 1 in Figure 1) and Guadalupe River (2) watersheds, in 2010 and 2012 respectively, and is currently assessing the Pajaro River (3) and Lower San Francisco Bay peninsula (4) watersheds in 2015 and 2016. The West Valley watershed assessment (5) is planned for 2017.

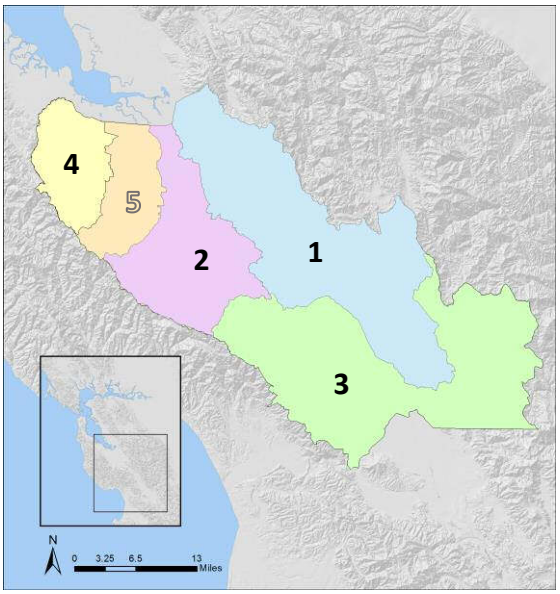

Figure 1. Map of the District's Ecological Data Collection and Analysis project's five watersheds to be assessed.

The CRAM stream condition assessments are conducted on an ongoing, rotating basis with repeat assessments over time to track change over time, and determine if ecological levels of service are maintained or improved. The District expects that their watershed approach to ecological monitoring and assessment will increase the effectiveness of its management actions by improving their coordination with positive, cumulative effects. The watershed approach using WRAMP has been shown to:

- Provide a systematic, scientific framework for actions to improve stream conditions;
- Support effective design options for capital projects;
- Maximize the return on investments in ecosystem health;
- Improve access to data and information; and
- Improve public reporting of program performance.

Under this agreement, the District contracted the San Francisco Estuary Institute (SFEI) to support the implementation of the wetland abundance and diversity characterization and the stream condition assessments in the Pajaro and Lower Peninsula watersheds using CRAM.

The District's watershed wide assessments require the use of the best, most recent, digital maps (Graphical Information System (GIS) data) of the steams and other wetlands to summarize the abundance and diversity of all wetland types within each target watershed and as the stream network sample frame for the probability based stream condition surveys using CRAM.

The most complete GIS base map of aquatic resources for most of Santa Clara County is the Bay Area Aquatic Resources Inventory (BAARI[2]), which includes all adjacent watersheds that flow into the San Francisco Bay. BAARI v.1 was completed in 2009 and has since been incorporated into the California Aquatic Resources Inventory (CARI) and includes Coyote Creek, Guadalupe River, Lower Peninsula and West Valley watersheds (in the Santa Clara County). However, BAARI does not extend to the upper Pajaro watershed within the County because those streams flow into the Monterey Bay. Therefore, for the Pajaro River watershed stream condition assessment, SFEI compared CARI and the District '*Creeks* 'datasets to determine which dataset was more complete and accurate.

[2] http://www.sfei.org/content/baari-version-20-gis-data

- *EcoAtlas CARI* v.0 – the stream network includes the BAARI (v.1) and the National Hydrography Dataset (NHDH, of the USGS at a scale of 1:2400 high definition) in the Lower Peninsula and Pajaro River watersheds respectively
- *District 'Santa Clara County Creeks' dataset* – covers the whole county and available from the District's GIS Gallery page[3].

This memorandum describes the GIS data review process and the survey design development for the watershed assessments in the Pajaro and Lower Peninsula watersheds (2015 & 2016). SFEI and District staff worked together to:

1. identify the best available digital stream network maps for each watershed,
2. determine the study area extents for each watershed and the primary areas of interest (PAIs) within each watershed,
3. decide on the target number of CRAM assessment sites for each watershed and PAI, and
4. determine the design parameters for the probability based sample draws for the CRAM field surveys in each watershed .

Based on the survey design elements described in this memo, SFEI developed the sample draws for the Pajaro and Lower Peninsula watersheds using the 'spsurvey package' in R (developed by the US EPA) and presented several alternative sample draws to the District project leads who select the final sample draw for the CRAM stream assessments. The probability based sample draw methodology for R is explained in the project's *Task 3: GRTS Survey Designs and Sample Draws Memorandum* along with annotated copies of the actual R-code used to develop the final sample draws.

Primary Areas of Interest and Summary Statistics

The geographic extents of the watershed assessments is referred to by the District as the Primary Areas of Interest (PAIs). PAIs are based on management questions that reflect resource management needs at different landscape scales such as for a watershed as a whole, a sub-watershed, or another geographic extent. The watershed based stream condition surveys (using a probability survey design and CRAM) allows the District to develop cumulative distribution function plots (CDFs) for the Pajaro and Lower Peninsula watersheds and each individual PAI within each watershed. The CDFs characterize the condition of all streams within the whole watershed and targeted PAIs with a known level of confidence. It is important to identify the PAIs prior to developing the sample draw so that one can allocate enough assessment sites to the areas of interest to achieve an acceptable confidence interval when summarizing the monitoring results.

Ecologic Service Indices (ESIs) are a numerical index of overall ecological condition based on the CRAM probability survey results and can be calculated for the whole watershed and each PAI. The ESI is calculated as the sum of individual CRAM scores times the proportion of the stream length represented by each score. ESIs can be compared within and between watersheds and/or PAIs. The District could base management priorities or set management goals by identifying target ESI thresholds that could be monitored and tracked over time.

[3] http://www.valleywater.org/Services/SCVWDGISData.aspx

Pajaro River Watershed Study Area Extent, GIS Stream Data Review and Sample Frame for the Stream Condition Assessment

1. Develop the Study Area Extent and Identify the Primary Areas of Interest (PAIs)

The District's Pajaro River watershed assessment study area includes the entire Uvas and Llagas creeks watersheds and the parts of Pacheco Creek and Pajaro River watersheds that fall within Santa Clara County. SFEI and District staff met to compare three existing GIS data layers and decide the final extent of the study area and individual PAIs of special interest to the District.

The GIS boundary data layers included:

- USGS HUC10 watersheds, California. 2012

  URL: "http://datagateway.nrcs.usda.gov" [Accessed July 11, 2014]

- District's revised "unofficial" watershed boundary layer for Uvas and Llagas watersheds

  Data layer provided to SFEI by the District on August 27th, 2014[4]

- District's GIS layer of the Santa Clara County line

  Data layer provided by the District on September 16th, 2014

The final Pajaro watershed study area encompasses about 231,000 acres and its boundary is comprised of a combination of these three GIS data layers based on the following criteria (Figure 2):

- The District's Pajaro watershed assessment study area is limited to Santa Clara County.
- The District identified three subwatersheds, within the Pajaro watershed, as PAIs:
  - Pacheco Creek watershed within Santa Clara County
  - Llagas Creek watershed
  - Uvas-Carnadero Creek watershed
- The extents of the Uvas and Llagas Creek subwatershed PAIs are defined by the District's revised (unofficial) watershed boundary (as depicted in Figure 2). Specifically, in the northeast corner of the Llagas Creek watershed, the District's revised watershed boundary extent differs from the USGS HUC10 boundary as follows: "The USGS HUC10 watershed boundary is incorrect at the Cochrane and Madrone channels next to Hwy 101 (watershed boundary at Half Rd on HUC10 versus actual boundary at Cochrane Rd). The HUC10 boundary misses approximately 750 acres of county land at this location[5]."
- Tequisquita Slough and Casserly Creek stream reaches that fall within Santa Clara County are not included in the District's watershed stream assessment since only very small portions of their watersheds are in the County. The vast majority of those watershed extents are located

[4] The District provided SFEI with a new, *unofficial*, watershed boundary developed by engineers from the District's Hydrology, Hydraulics, and Geomorphology Unit (scvwd_watersheds.zip, August 27th email from Jill Bernhard).

[5] Per Doug Titus (District)

in San Benito and Santa Cruz counties, respectively.

- Portions of the Pacheco and Pescadero creeks that fall within Santa Clara County are included in the stream assessment even though most of Pescadero Creek is located in other counties that are not part of this study. Note that the USGS HUC10 boundaries define the watershed extents for Pacheco Creek and Pajaro River, with everything clipped to the Santa Clara County line in the east and south.

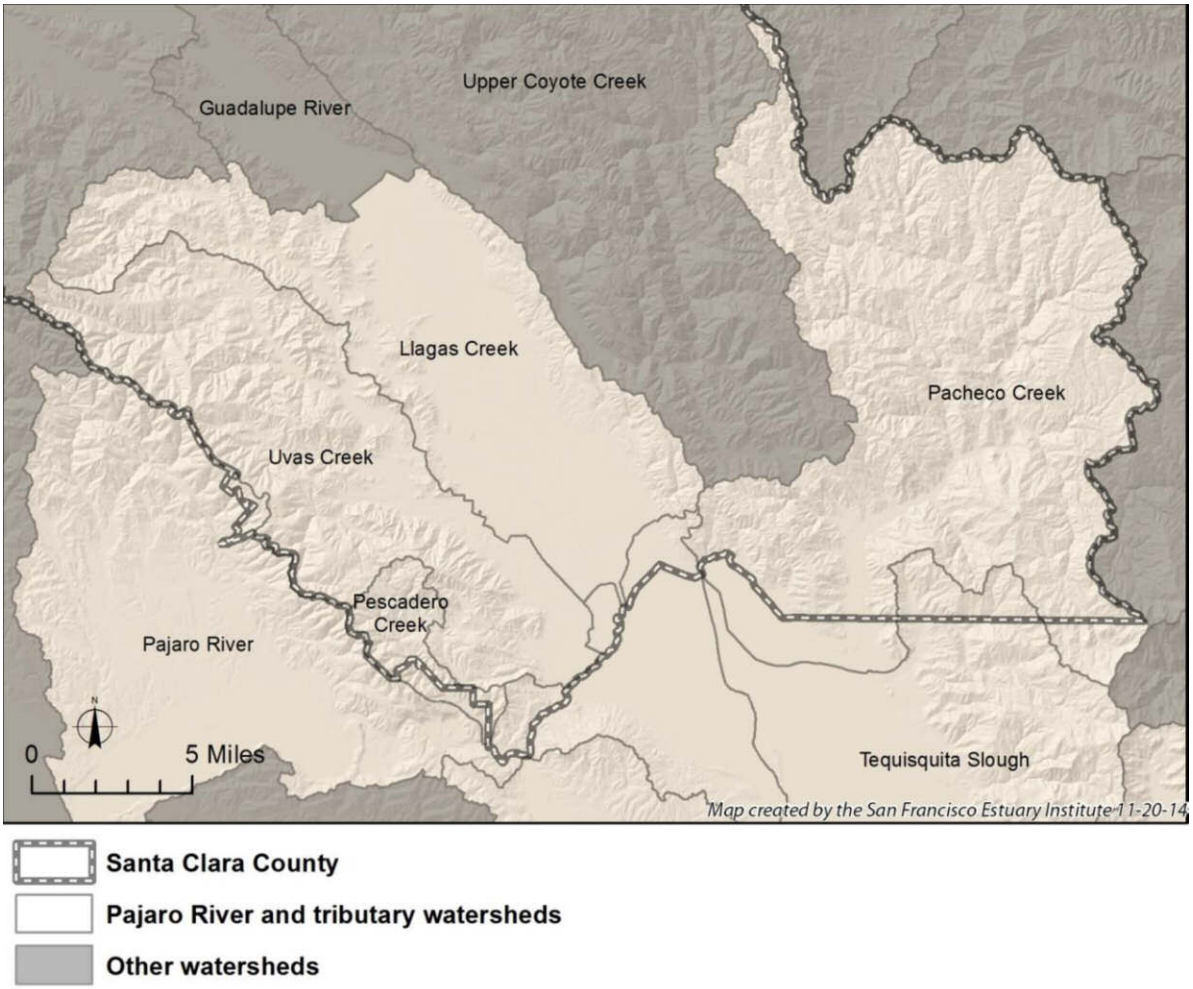

Figure 2. Map of the northern extent of the Pajaro River watershed that falls within Santa Clara County, CA. Three watershed GIS data layers comprise the extent of the District's Pajaro watershed assessment study area as described in the text and this map shows the extent of the three primary areas of interest (PAIs) of special interest to the District (Uvas, Llagas, and Pacheco Creek subwatersheds). Portions of other tributaries (such as Pescadero Creek) within the County are included in the study area and grouped as "Other" tributaries.

The rationale for selecting the three PAIs, and including small portions of the other tributaries within the study area (in order to be able to assess the condition of the watershed as a whole), were based on landscape characteristics and District priorities including:

- Uvas and Llagas Creek for District projects, programs, activities, and management (SMP, Safe Clean Water, water supply (creek flows groundwater), and flood protection),
- Llagas Creek for flood protection projects,
- Pacheco Creek as a reference of relatively pristine conditions (sycamore alluvial woodlands), water supply pipelines and other infrastructure, and
- All 3 subwatersheds, the Pajaro River and small portions of other tributaries for assessing the Pajaro watershed within Santa Clara County as a whole - in support of environmental goals and stewardship (e.g., fisheries).

2. Compare District and CARI Stream Network GIS Datasets for Accuracy and Coverage

The District's *Santa Clara County Creeks* GIS data and the CARI v0 - NHDH stream GIS data were evaluated to determine the most accurate and complete data to use for the Pajaro River watershed assessments (both abundance and diversity of wetlands and the stream condition assessment).

An overlay of District and NHDH stream data layers, within the Pajaro study area, indicated that the District's *Creeks* layer is more extensive and accurate than the NHDH layer and was selected for the watershed assessment. Figure 3 shows an example of the overlaid data layers within the southeast corner of the Pajaro watershed study area in the Pacheco Creek watershed.

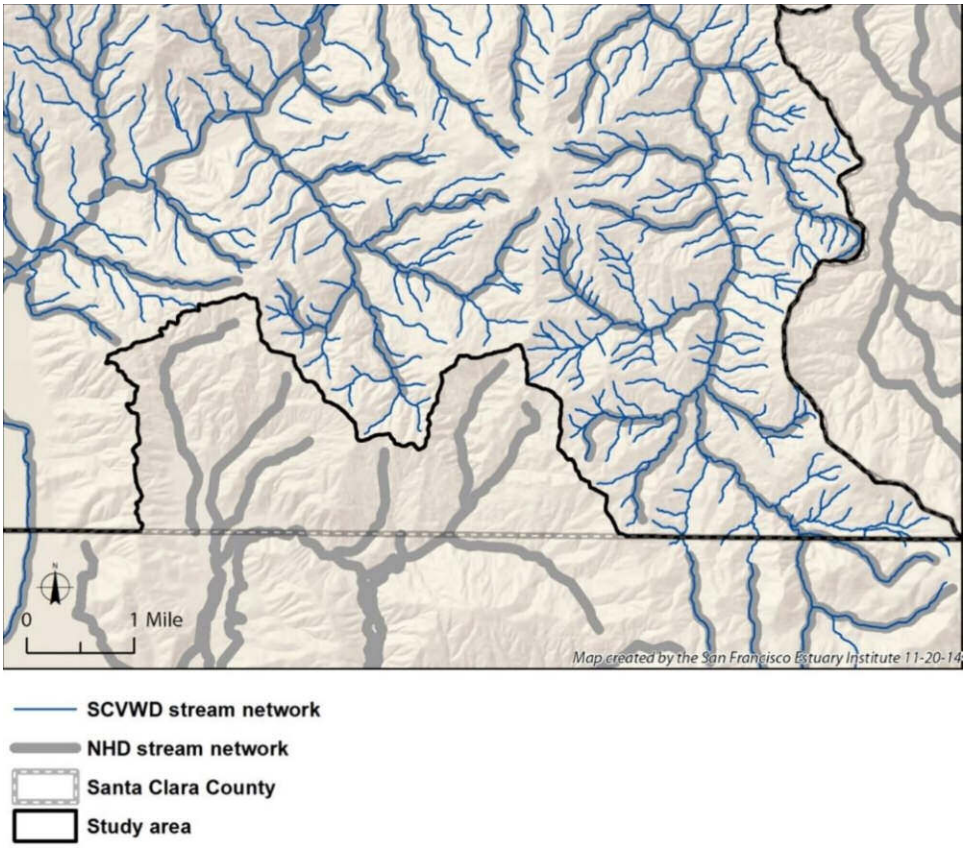

Figure 3. Southeast corner of the Pajaro study area (bold black line) comparing the District's "*Santa Clara County Creeks*" stream lines (dark blue) and USGS NHD stream lines from CARI v.0 (thick gray).

The Pajaro watershed stream condition survey is targeting a similar level of stream network detail that was employed by the District's two completed stream condition surveys conducted in the Coyote Creek and Guadalupe River watersheds. The BAARI v.1 stream data, including streams with Strahler stream orders[6] 2 and higher, were used to develop the sample draws for those surveys.

SFEI evaluated the District's *Creeks* and the BAARI v.1 data layers within the Coyote Creek watershed to further compare the differences in the level of detail in the stream networks. Comparison of the two datasets (Figure 4) indicated that 1st order streams in the District's *Creeks* data set are more similar to BAARI's 2nd and 3rd order streams. Therefore it was decided that all stream orders in *Creeks* data set will be included in the Pajaro watershed stream condition assessment.

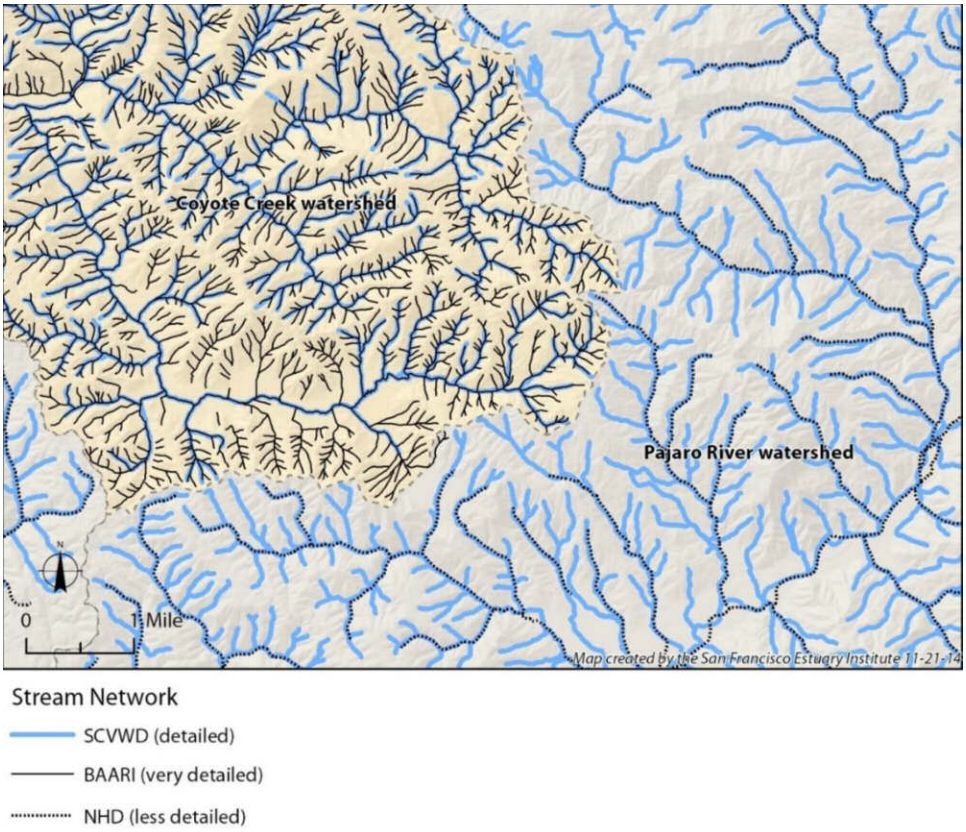

Figure 4. Map of the southeast portion of the Coyote Creek watershed adjacent to the Pajaro watershed comparing the stream network detail from three different data sources. In the Coyote Creek watershed, the District's "*Santa Clara County Creeks"* data are shown as light blue lines, and the BAARI v.1 streams data shown as fine black lines. The District's 1st order streams are generally similar to 2nd and 3rd order streams in BAARI. In the Pajaro River watershed area BAARI data do not exist, and District's "*Creeks*" map is compared with the less detailed NHDH data layer from CARI v.0, depicted as dotted black lines.

[6] Strahler, A. N. 1952. Hypsometric (area-altitude) analysis of erosional topology. Geological Society of America Bulletin 63 (11): 1117–1142.

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. Transactions of the American Geophysical Union 8 (6): 913–920.

3. Develop the Final Pajaro River Watershed Study Area Extent and Stream Network

SFEI added Strahler stream order and flow direction to the District's *Creeks* GIS attributes table as part of the study area extent and stream network development task. Figure 5 shows the final extent of the study area and complete steam network within the Pajaro watershed study area (by Strahler stream order).

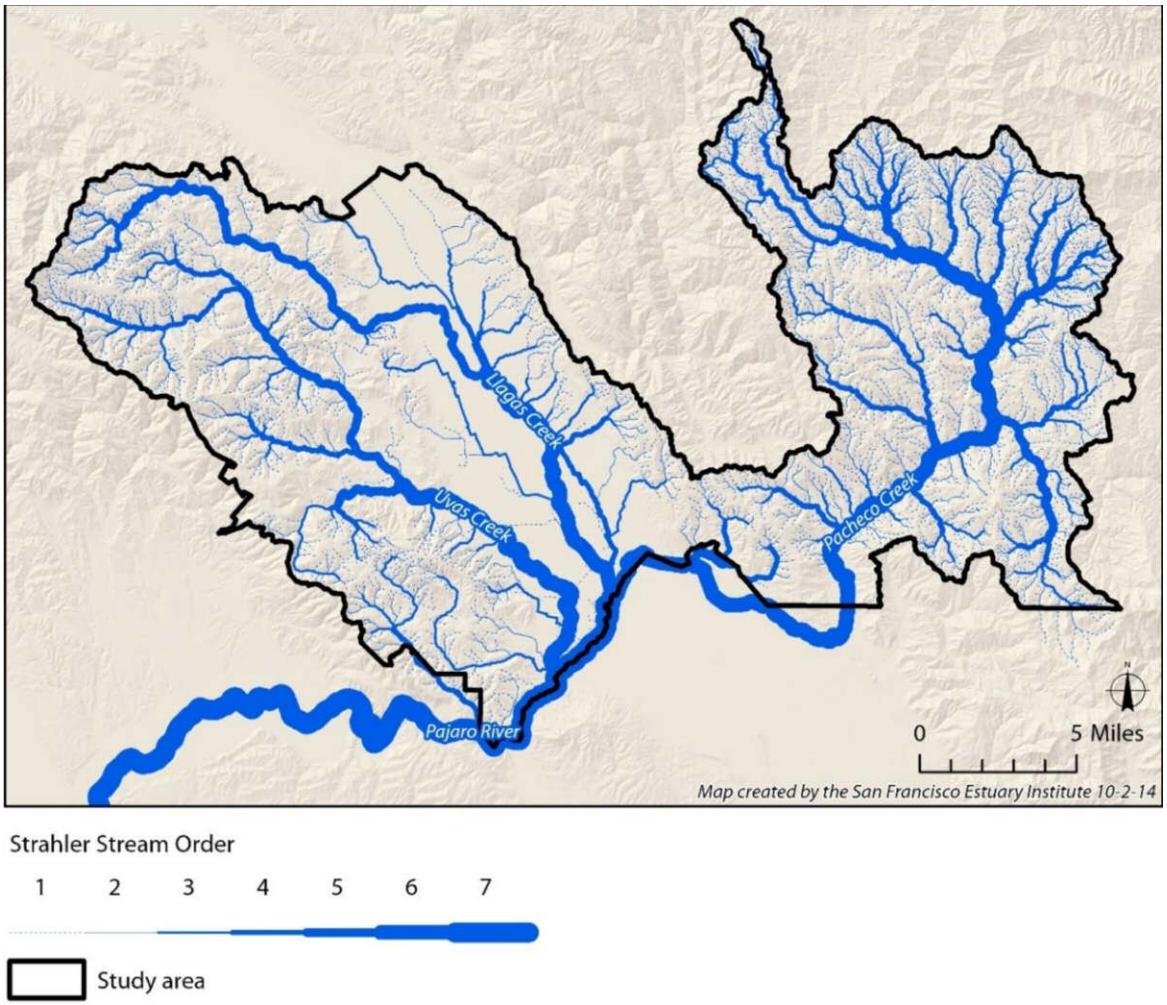

Figure 5. Map of the District's "*Santa Clara County Creeks"* GIS data layer within the Pajaro River watershed study area showing the Strahler stream orders in variable line widths.

4. Develop the Final Sample Frame for the Pajaro Watershed Stream Condition Assessment

Headwater stream reaches (as identified in the BAARI v.1 data as Strahler stream order 1) are generally not included in CRAM stream assessments because they are ecologically very simple and the CRAM Riverine Module is not currently calibrated to accurately assess the ecological condition of headwater streams. CRAM scores tend to be artificially low for 1st-order channels, and these low scores can create misleading profiles of overall stream condition.

The updated District *Creeks* data layer, including the 1st order stream reaches, was identified as the final sample frame for the Pajaro River watershed wide probability survey based on CRAM. The stream

network is the most comparable to the BAARI v.1 dataset used in Coyote Creek and Guadalupe River surveys in 2010 and 2012. The District's 1st order streams are more similar to BAARI's second order streams based on the above review (see figure 4) and therefore were not dropped from the sample frame. SFEI further updated about 50 feet of the Pajaro River stream reach (along the southern border of the study area) to make it continuous, and not fragmented. This was necessary because the *Creeks* data layer crossed over the District's County line layer in a several locations and fragmented the reach when it was 'clipped' to the County line in GIS.

The final stream condition assessment sample frame used the updated District *Creeks* data layer that included Strahler stream orders 1 through 7[7]. The survey design allocated CRAM assessment sites across three PAIs: 1) Uvas Creek watershed, 2) Llagas Creek watershed, and 3) most of the Pacheco Creek watershed, and included small portions of 'other tributaries' including part of the Pajaro River mainstem that falls along Santa Clara County's southern border to be able to assess the condition of streams within the watershed as a whole.

The *Task 3: GRTS Survey Design and Sample Draw Memorandum* describes the site selection process and final sample draw.

Lower Peninsula Watershed Study Area Design and Sample Frame for the Stream Condition Assessment

1. Develop the Study Area Extent and Identify the Primary Areas of Interest (PAIs)

The Lower Peninsula watershed is located in the northwest corner of Santa Clara County and includes a small portion of the San Francisquito Creek watershed that falls within the County, Adobe, Barron, and Matadero Creeks watersheds, and Stevens and Permanente Creeks watersheds. The best available digital aquatic resource dataset for this region is BAARI v.1 so no comparison to the District's *Creeks* dataset was warranted.

The District's original '*Santa Clara County Watersheds'* data layer available on the District's GIS Gallery page[8] (Figure 8) and the BAARI streams dataset were reviewed by SFEI and District project leads to identify the Lower Peninsula watershed study area extent and PAIs.

[7] Note that 1st order streams in the District's '*Creeks'* data layer are more similar to BAARI v.1 stream orders 2 and higher making this sample frame more similar to the sample frames from the other District stream condition assessment surveys.

[8] http://www.valleywater.org/Services/SCVWDGISData.aspx

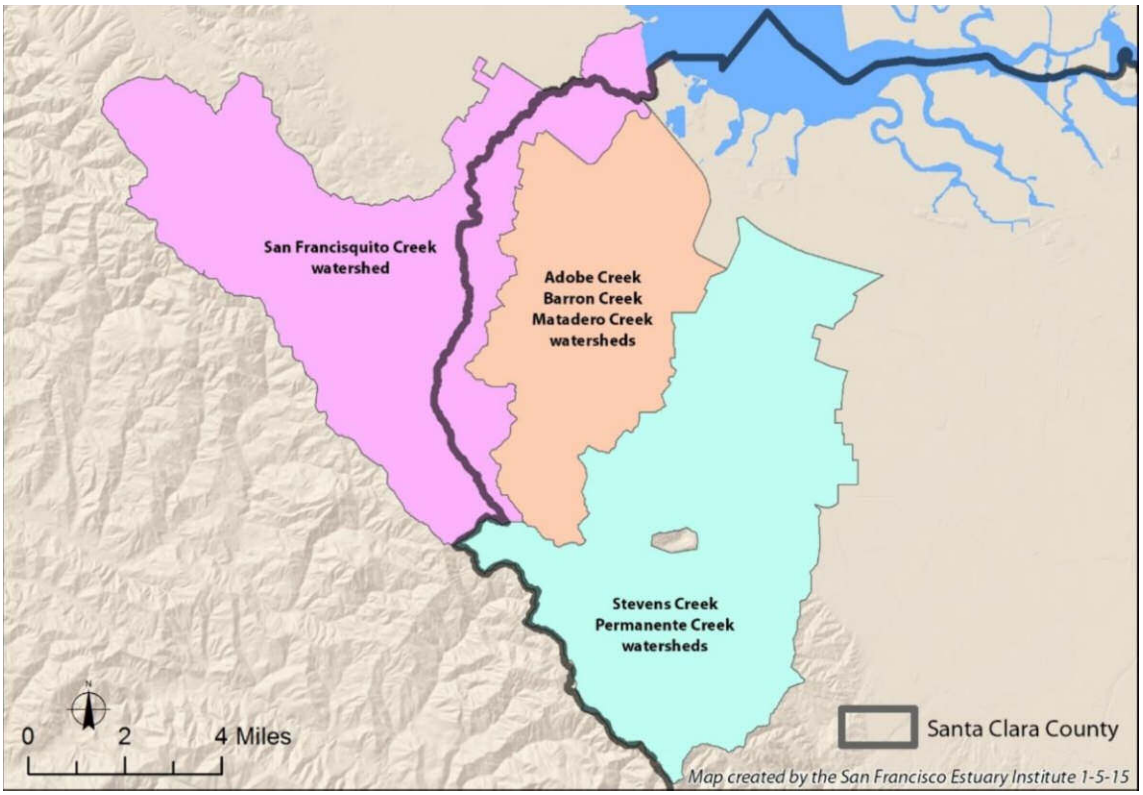

Figure 8. The District's original 'W*atersheds'* GIS data layer for the Lower Peninsula.

The review team made the following updates to the watershed extents and stream layer before finalizing the GIS datasets for the Lower Peninsula study area, PAI extents, and stream assessment sample frame:

1. The Santa Clara and San Mateo County portions of the San Francisquito watershed were separated into two parts along the County boundary so that only the Santa Clara County portion of the watershed was included in the District's study area extent and stream condition assessment. The mainstems of San Francisquito and Los Trancos Creeks were included in the Santa Clara portion of the San Francisquito PAI (along the reaches where they actually define the county boundary).
2. The L-shaped area (missing rectangle) near the bottom (north side) of the Adobe, Barron, and Matadero Creeks watershed (Figure 8) was incorporated inti the watershed extent.
3. The 'hole' in the center of the Stevens/Permanente Creek watershed, created by the quarry, was incorporated into the watershed extent.
4. The bottom of the study area extent (Bay-side lower watershed extents) were defined as the points where channels in BAARI v.1 change from Fluvial to Tidal. The watershed extents were modified slightly to intersect these points.
5. BAARI streams intersected watershed boundaries in two specific locations, indicating inconsistencies between the two datasets (Figures 9 and 10). The datasets were carefully reviewed to determine if

there were additional discrepancies besides the two identified during the review meeting. No additional discrepancies were found. The two discrepancies were further evaluated in GIS by comparing them to a DEM and ortho-imagery, and the following updates were made:

a. The first discrepancy (Figure 9), near 122.177 W, 37.416 N, was related to an over-mapping error in BAARI v.1. To correct this discrepancy, a single stream segment was removed from the sample frame. The update will also be reflected in the next published BAARI update. This was the only change made to the Sample Frame layer.

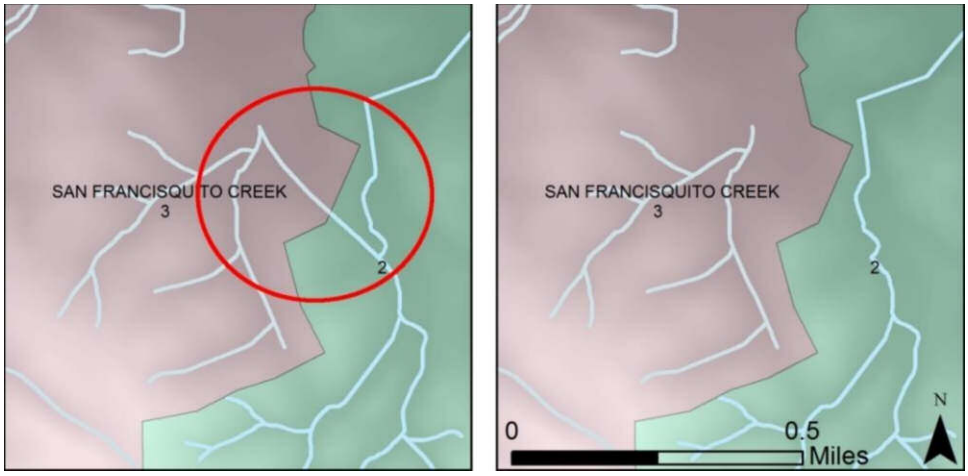

Figure 9. Original Version Updated Version

b. The second discrepancy (Figure 10), near 122.178 W, 37.397 N, probably resulted from the mapping resolution of the District's *watersheds* layer. Two first order tributaries of Matadero Creek mapped in BAARI v.1 fell into the San Francisquito watershed. In this case, the watershed boundaries depicted in the PAI layer were modified slightly so the two first order channels would fall in the correct PAI/watershed. The total area of change was very small, approximately 15 acres shifted from PAI #3 (San Francisquito watershed in Santa Clara County) into PAI #2 (Adobe/Matadero watersheds).

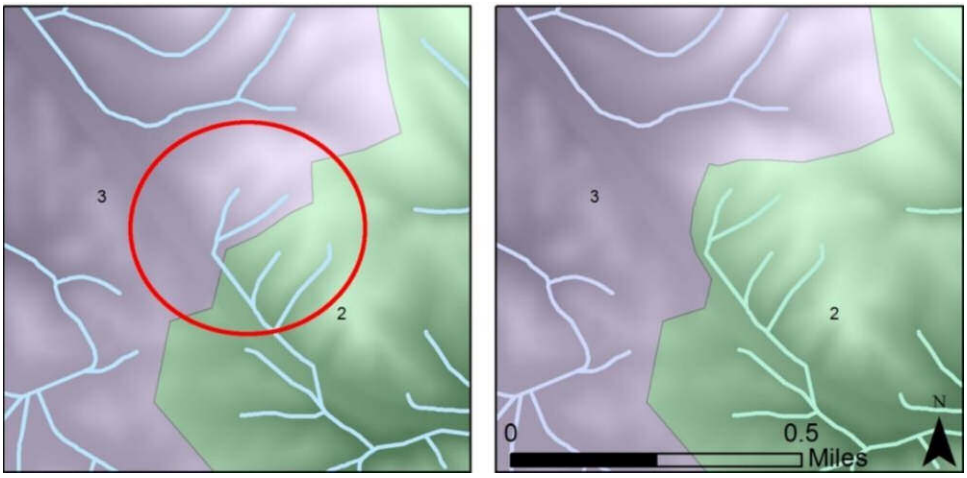

Figure 10. Original Version Updated Version

2. Develop the Final Lower Peninsula Watershed Study Area Extent and Stream Network

The final Lower Peninsula watershed study area extent and PAIs (Figure 11) were based on the updated District's *Watersheds* data layer (as described above) and included the freshwater reaches of 1) the Stevens and Permanente Creeks watersheds, 2) Adobe, Barron, and Mataderro Creeks watersheds, and 3) the portion of the San Francisquito Creek watershed that falls within Santa Clara County.

Figure 11. The Lower Peninsula watershed study area extent including the three Primary Areas of Interest (PAIs).

Figure 12 shows the entire BAARI v.1 stream network within the Lower Peninsula watershed study area by Strahler stream order (1-6). Light gray lines outline the three PAIs.

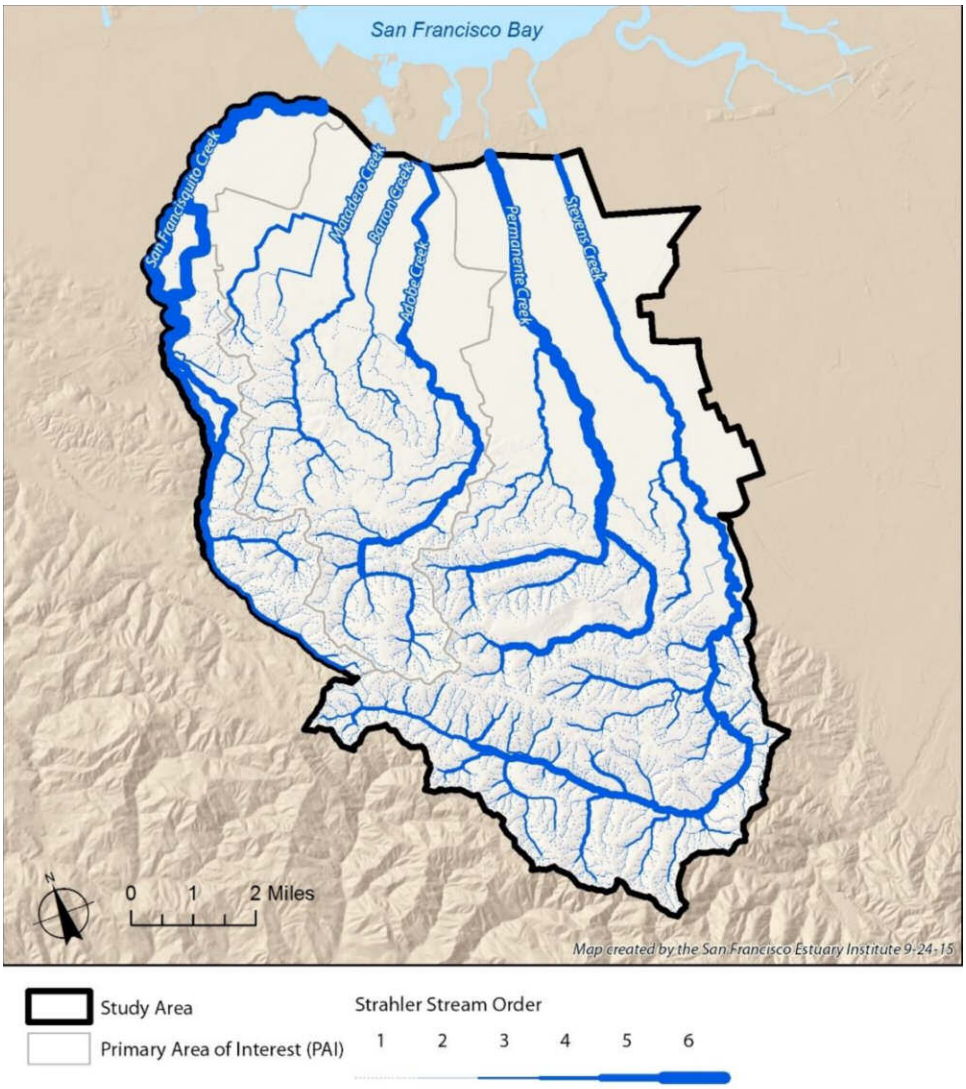

Figure 12. Map of the BAARI v.1 streams within Lower Peninsula watershed study area showing Strahler stream orders in variable line widths.

3. Develop the Final Sample Frame for the Lower Peninsula Watershed Stream Assessment

The final sample frame for the watershed wide probability survey of streams in the Lower Peninsula watershed study area used the BAARI v.1 streams data layer. The sample frame included only the freshwater stream network and Strahler steam orders 2 and higher (2-6) within the study area (as mentioned above BAARI's 1st order streams are not assessed using the Riverine CRAM Module). The survey design allocated CRAM assessment sites across three PAIs : 1) the Stevens and Permanente Creeks watersheds, 2) Adobe, Barron, and Mataderro Creeks watersheds, and 3) the portion of the San Francisquito Creek watershed that falls within Santa Clara County.

The *Task 3: GRTS Survey Design and Sample Draw Memorandum* describes the site selection process and final sample draw.