APPENDIX A. TECHNICAL INFORMATION

A.1 Methods:

A.1.1 Ambient and Targeted Surveys of Coyote Creek (CC) watershed and the Upper Penitencia Creek (UPC) subwatershed

A total of 100 sites were assessed in the CC watershed and the UPC subwatershed using probabilistic and targeted monitoring designs (Table A-1) (Figure A-1).

Table A-1. Sites assessed using the California Rapid Assessment Method (CRAM).

Hydrologic Unit	Number of Sites	Monitoring Design Type	Purpose
Coyote Creek Watershed	47	Probabilistic: throughout watershed	Measure ambient stream ecosystem condition for the watershed
Coyote Creek Watershed	20	Targeted: on the mainstem	Measure stream ecosystem condition at sites where District sampled fish communities
Coyote Creek Watershed	1	Targeted: on the mainstem	Measure stream ecosystem condition at a District mitigation site
Upper Penitencia subwatershed	30	Probabilistic: throughout subwatershed	Measure ambient stream ecosystem condition for the subwatershed
Upper Penitencia subwatershed	2	Targeted: on the mainstem	Measure stream ecosystem condition at sites where District sampled fish communities

A.1.1.1 Sample Design

Probabilistic Design:

To measure ambient stream ecosystem condition at the watershed scale, a probabilistic design was developed (Figure A-1) using the Generalized Random Tessellation Stratified (GRTS) approach developed for USEPA's Environmental Monitoring and Assessment Program (Stevens and Olsen, 2004). The ambient survey sample frame included all possible 2^{nd} to 7^{th} order streams within the CC watershed (including the UPC subwatershed) identified using the Bay Area Aquatic Resources Inventory (BAARI) stream network data set. The boundary of the CC watershed was delineated from CalWater 2.2.1, while the boundary for the UPC subwatershed was acquired from the District.

A total of 77 sites were probabilistically selected from the ambient sample frame. Sites were selected for two strata: 1) UPC subwatershed (n = 30); and 2) the CC watershed (n = 47). For each stratum, the sample size was weighted based on the relative abundance of 2nd to 7th order streams. The GRTS design can be used to balance the number of channels of each order that are included in the sample draw by accounting for their inclusion probabilities, which is a function of their relative abundances. For example, since low-order channels are more common than high-order channels, there is a greater probability of randomly selecting low-order AAs than high-order AAs. GRTS accounts for these probabilities and uses them to weight the corresponding assessment scores. To allow for situations where sites selected in the initial 80-site sample draw could not be sampled due to access issues, an oversample selection of 300% was created. The GRTS design for the ambient surveys was created using the R system with version 2.10.0 of the psurvey analysis statistical library.

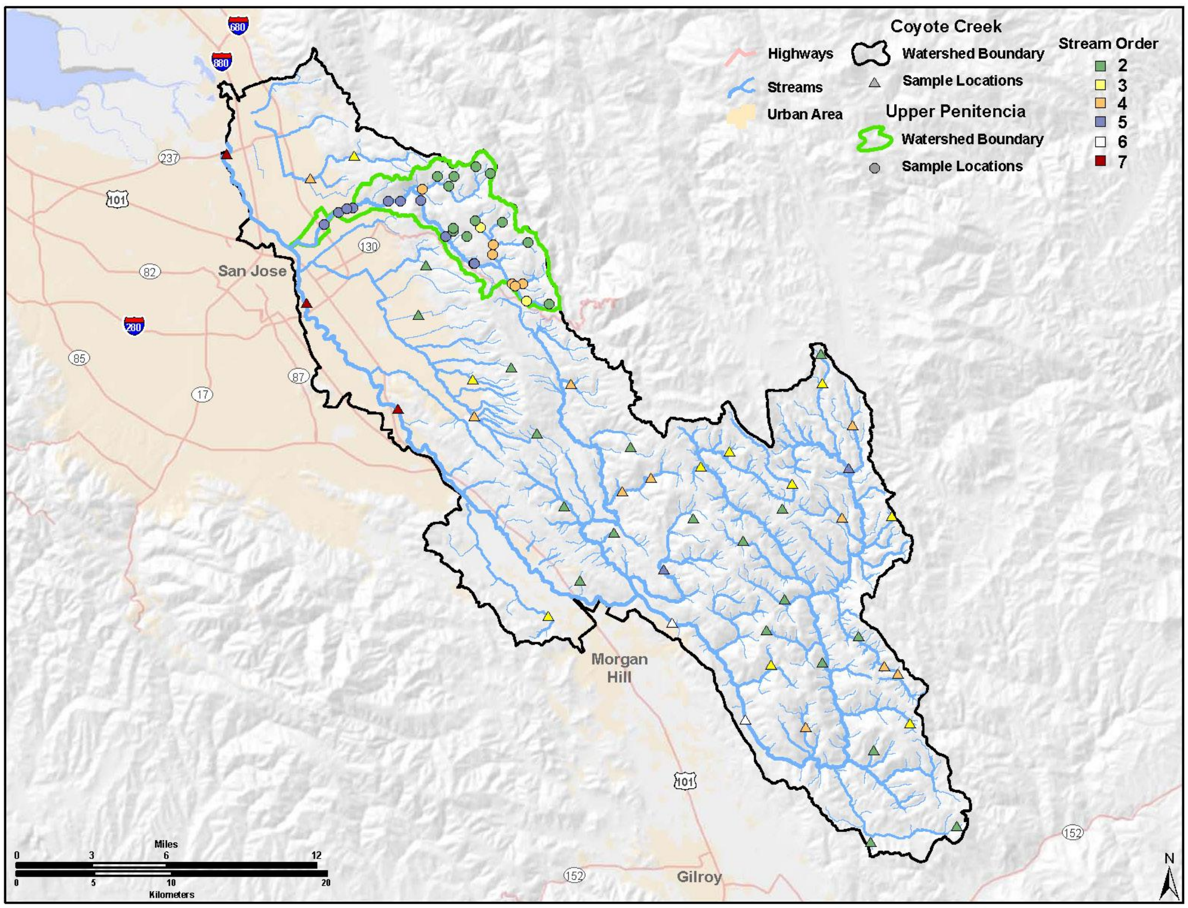

Figure A-1. CRAM ambient survey sites in the Coyote Creek watershed and the Upper Penitencia Creek subwatershed.

Targeted Design:

Targeted sites were located where either District biologists had sampled fisheries on the CC and UPC mainstems as part of the Mid-Coyote Flood Protection Project baseline fisheries survey (SCVWD 2008), and at a selected mitigation site. The twenty-three fisheries sites represented in the MCCFPP were targeted for assessment using CRAM. One of the CC sites could not be accessed due to safety issues and therefore was not sampled, reducing the total number of sites in the targeted assessment to 22. Twenty (20) of these sites were located along the main-stem of Coyote Creek (CC) and two sites were in the Upper Penitencia Creek watershed (UPC). One mitigation site was included for the purpose of being able to demonstrate how CRAM data may be used to evaluate mitigation site performance.

A.1.1.2 Site Access

For each site, the field team requested permission from the landowner to enter the property and spend time in the creek. Land ownership for each site in the sample draw was identified using existing park and open space maps and the Santa Clara County's parcel database (http://sccplanning.org/gisprofile/). Obtaining permission to access creek sites included in both the probabilistic and targeted samples was streamlined because 1) many sites were owned by the same landowners (e.g., Henry Coe State Park, Joseph Grant County Park, other various Santa Clara County Parks and Recreation District properties, City of San Jose's Alum Rock Park, University of California's Blue Oaks Ranch Reserve, and Santa Clara County Open Space Authority); and 2) many of the sites located on the Coyote Creek mainstem are held by the District in fee title or the District has access via easements. Field staff coordinated closely with landowners to inform them of field team on-site activities.

The field team relied heavily upon the parcel database to obtain assessor parcel numbers. The landowner's name or mailing address, however, was not always listed in the database, thus requiring additional internet searches to identify contact information. Once contact information was gathered, a letter was sent to landowners describing the project and requesting access to the site. Some letters resulted in successfully obtaining access permission. In the Upper Penitencia Creek watershed, one particular landowner was very cooperative and helpful, and provided names of adjacent owners, and even made phone calls to them. In other cases permission to access sites required follow-up phone calls. In some cases permission to access sites was not obtained either because the land owners were never identified or because they denied access. Unfortunately, a large track of private land in the south-central Coyote Creek watershed (Hall Valley) was not sampled because the field team was denied access. When permission to access a site was denied, a new site was selected from the oversample draw. New sites were selected in the order that they were originally drawn into the sample. All of the landowner contact information and communications to obtain site access were documented in an excel spreadsheet.

A.1.1.3 Fieldwork

California Rapid Assessment Method:
Stream ecosystem condition at all sites was assessed using the California Rapid Assessment Method (CRAM) (Collins et al. 2008) (http://www.cramwetlands.org/documents). CRAM surveys were conducted by field teams consisting of two or more CRAM technicians. The field team assessed each site based on four attributes (Table A-2): buffer and landscape context, hydrology, physical structure, and biotic structure. Each attribute was evaluated by 2-4 Metrics, which were assigned a letter grade A-

D to reflect relative condition ("A " indicating better condition). Numerical scores were generated for each of the four attributes and for the overall site score using the CRAM scoring method (Collins et al. 2008) (Figure A-2). The Metric scores for each Attribute are summed into an Attribute score, and the Attribute scores are averaged to derive a single Index score for each site.

Table A-2. Attributes and Metrics in the California Rapid Assessment Method (Collins et al. 2008).

Attributes		Metrics
Buffer and Landscape Context		Landscape Connectivity
		Buffer:
		Percent of AA with Buffer
		Average Buffer Width
		Buffer Condition
Hydrology		Water Source
		Hydroperiod or Channel Stability
		Hydrologic Connectivity
Structure	Physical	Structural Patch Richness
		Topographic Complexity
	Biotic	Plant Community:
		Number of Plant Layers Present or Native Species Richness (vernal pools only)
		Number of Co-dominant Species

The location of the CRAM assessment area (AA) for each site was determined using the GRTS-selected location to define the downstream origin of each AA. The AA extended 100-200m upstream from its downstream origin. The exact length of the AA was determined by approximating 10x the average bankfull width. Exceptions to this method were made for fish sites. For these locations, the AA was moved, whenever possible, to overlap with District fisheries project locations of the Mid-Coyote Creek Flood Protection Project (SCVWD 2008). Occasionally the location of an AA was shifted slightly upstream or downstream to prevent major changes in hydrology or geomorphology from occurring within the AA. For example, if a large tributary entered in the middle of the AA, the AA would be shifted either entirely up or downstream of that tributary junction. Sampling locations were sometimes moved up to 200m when a location could not be accessed safely. In other instances, sampling locations were moved to the closest reach. Specifically, two of the sites fell within the middle of a large reservoir; for these sites the field team assessed the closest fluvial reach upstream of the reservoir. The lateral extent of the AA was defined to include the extent of the riparian area that likely contributed allochthonous material directly to the channel.

Fisheries:

The District's baseline fisheries study focused on a 6.1 mile stretch of the Coyote Creek mainstem between Montague Expressway and Highway 280. Sites were also sampled on Upper Penitencia Creek and Lower Silver Creek, since they have confluence points within the project area. Additional sites, either upstream or downstream of the project reach, were sampled to correspond to previous or current sites of monitoring by the Santa Clara Valley Urban Runoff Pollution Prevention Plan (SCVURPPP).

Overall, District biologists sampled twenty-five fisheries monitoring stations between 2007 and 2009. Project reaches were separated into segments of 200 feet, and individual sampling locations selected by random number within each reach. All sampling sites were 200 linear feet or greater depending on sampling net placement. Detailed field methods are documented in previous District reports (SCVWD 2007, 2008).

A.1.1.4 Data Quality Assurance and Management

CRAM data collected at each site were reviewed using the standard CRAM quality assurance (QA) procedure. Before leaving the site, the field team confirmed that all necessary fields were complete on the data sheet, and all photographs had been taken. On the evening of the assessment, the field team lead technician reviewed the data sheet again to confirm that scores were written and calculated accurately. The AA polygon was drawn in eCRAM by the field team lead technician each evening. The eCRAM is the online version of CRAM used to exchange CRAM results with the statewide CRAM database. The data were subsequently entered into eCRAM. The field team lead technician compared the paper copy to the electronic copy, including each individual worksheet, plant list, and stressor list and fixed any errors. Any unidentified plant samples were added to a master plant identification list, with the sample placed in a single binder. The field team was assisted by a District botanist, Janell Hillman, to identify some plant species. After all of the sites were assessed, the field team lead technicians again reviewed the data for each site, and "finalized" site scores. The dates of each of these QA steps are listed in a spreadsheet detailing the steps implemented for each site. Once all site data were finalized, the data management team completed one final QA review, looking specifically at site codes and grouping codes, to ensure correct grouping of the entire dataset.

Quality assurance procedures implemented for the fisheries data are documented elsewhere in the source documents (SCVWD 2007, 2008).

A.1.1.5 Data Analysis

The sampling was designed to represent the entire CC watershed. Therefore, the samples should be representative of the different areas mentioned in the interpretation sections of the Profile. CRAM attribute scores have a precision of 3-5 points. CRAM index scores have a precision of 10 points. Differences in scores of 10 CRAM points or less are within the error of the method and therefore should not be considered to represent differences in overall condition (CWMW 2009). Differences in attribute scores of 3-5 points or less are within the error of the method and, therefore, should not be considered to represent differences in condition (CWMW 2009).

CRAM index scores should always be interpreted by breaking down the overall score into its component Attribute scores and Metric scores to account for the Attribute scores and the Index scores. For interpretation of individual site scores, an examination of the Metric scores and Stressors is necessary.

Cumulative Distribution Functions

Stream ecosystem conditions for the UPC subwatershed and the entire CC watershed (e.g., including all data from the UPC subwatershed) were summarized from the CRAM ambient survey data using a probabilistic statistical approach to calculate cumulative distribution functions (CDFs). Prior to estimating CDFs, the number of sites sampled in the stream network (n = 77) relative to the number of sites selected by the GRTS design (n = 80) was accounted for. The re-weighting of sites accounted for the total length of riverine habitat that the network represented, to generate length-weighted estimates of condition. These length-weighted estimates were used to calculate CDFs for both the UPC subwatershed and the entire CC watershed. The statistical analysis is based on the assumption of the GRTS monitoring design that the streams sampled by GRTS were representative of the population of streams that could be sampled in the watershed. CDFs were calculated with version 2.10.0 of the psurvey.analysis statistical library, using the R system (Stevens and Olsen 2004). CRAM scores collected at targeted sites were plotted on the respective CDFs to evaluate them in the context of ambient watershed condition.

Approaches to Inform the District Ecological Level of Service

Ecosystem Services Index

The method selected[1] to inform the District's Ecological Levels of Service (LOS) is called the Ecosystem Services Index (ESI). The ESI statistic was calculated to summarize the CC watershed and the UPC subwatershed CDFs as follows:

ESI = $\sum$ (CRAM score x Proportion of total stream length represented by score)

The ESI statistic can vary from 25 - 100, corresponding to the possible range in CRAM scores. An ESI of 100 indicates that the surveyed area achieved the highest possible stream ecosystem condition score, whereas an ESI of 25 indicates the lowest possible stream ecosystem score.

Alternative Approaches to Establishing Ecological Levels of Service

[1] The ESI was discussed and adopted at the District EMAF Core Technical Team meeting (October 5, 2010) and the District Executive Managers meeting (November 4, 2010).

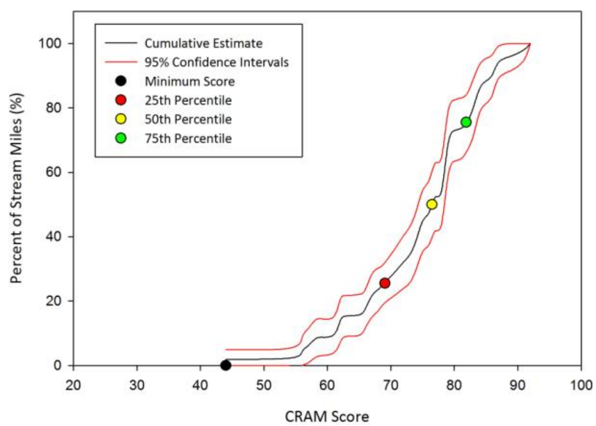

Figure A-3. Cumulative distribution function (CDF) of CRAM Index scores from ambient sites (n = 77) relative to percent of stream miles in the Coyote Creek watershed. Colored circles identify percentiles of the cumulative curve. The lowest score in this ambient survey was 44, shown by the black circle.

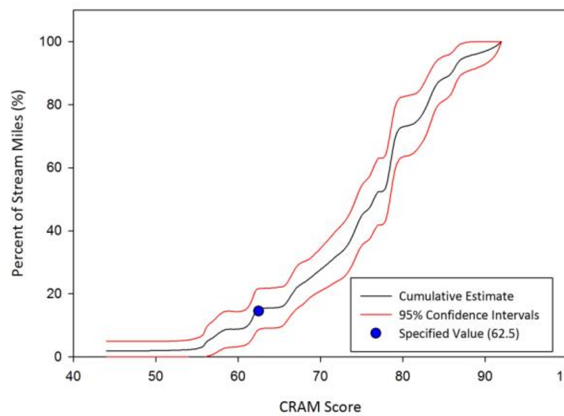

Figure A-4. Cumulative distribution function (CDF) of CRAM Index scores from ambient sites (n = 77) relative to percent of stream miles in the Coyote Creek watershed. Blue circle identifies a specified value that could be used to define an ecological LOS.

Several alternative approaches to calculate LOS were discussed with District staff, in addition to the ESI approach presented above. These other approaches that were not selected for representation in this profile report are nevertheless presented here. LOS development is an iterative process involving both scientific and management review. The District may want to refine the LOS approach presented in this Profile. Therefore, the following alternative approaches may be considered for future profiles.

1. Characterizing CDF Quartiles (Figure A-3): At least maintain existing (baseline) condition as measured by the minimum CFD value and the 25th, 50th, and 75th percentile values and their associated confidence intervals.
2. Using a median value as illustrated in Figure A-3 (50th percentile indicated by yellow circle).
3. Selecting another specified value of the CDF as the LOS. The example shown in Figure A-4 is a value of 62.5 which represents the mid-point between 50 (which equates to a CRAM Index alphabetic score of C) and 75 (which equates to a CRAM Index alphabetic score of B). The value of 62.5 represents the lower 15% of ambient condition. In other words, 85% of stream length in the watershed exhibited values greater than 62.5.

The following summarizes the pros and cons of different approaches to establishing ecological LOS.

1) **CFD shapes:**
   - Harder to track visually and quantitatively;
   - May be more difficult to explain to non-technical audience.
2) **Quartile and "Anchor" values:**
   - Provide visual and conceptual points on a CFD that
     - are easier to track quantitatively;

- may be easier to explain to non-technical staff;
- better represent range of values.

3) **Median values:**
    - Single values easy to explain and visualize;
    - Do not describe CFD shape nor the range of values
4) **Minimum values:**
    - Tend to focus subsequent management resource investment on the low tail of ecological condition distribution.
5) **Ecosystem Services Index:**
    - Single Value easy to explain and visualize;
    - Companion graphics (pie charts, bar graphs) help explain Index Value;
    - Area weighted;
    - Cumulative representation of stream ecosystem condition;
    - CRAM Steering Committee draft endorsement.

Risk Analysis

The intent of the high-risk analysis was to identify sites with low or high scores from the tails of the CDF distributions (Figure A-5). Sites with low scores would represent stream reaches with lower stream ecosystem conditions and indicate areas potentially threatening the watershed LOS. Sites with high scores would represent stream reaches that might be at-risk from stressors, and might warrant protective management actions. Low-scoring sites were those within the lowest 10% of the CDFs and the high-scoring sites were those within the highest 10% of the CDFs. These thresholds were selected because they corresponded very well to the inflection points observed in most of the CDFs. There were two exceptions for which a threshold of 25% was used: the lower tail of the Physical Structure (PS) CDF and the upper tail of the Buffer and Landscape Context (BLC) CDF. For the PS attribute, the lowest 10% of the CDF consisted of a single-value of 38, thus the 10% threshold did not represent much of the lower CDF tail. For the BLC attribute, the slope of the tail was so steep that the 10% threshold represented an extremely narrow range (99-100). Adopting the 25% threshold for this attribute expanded the range to 96 – 100. Table A-3 illustrates the relationship between the CDF inflection points and the 10% and 25% threshold values.

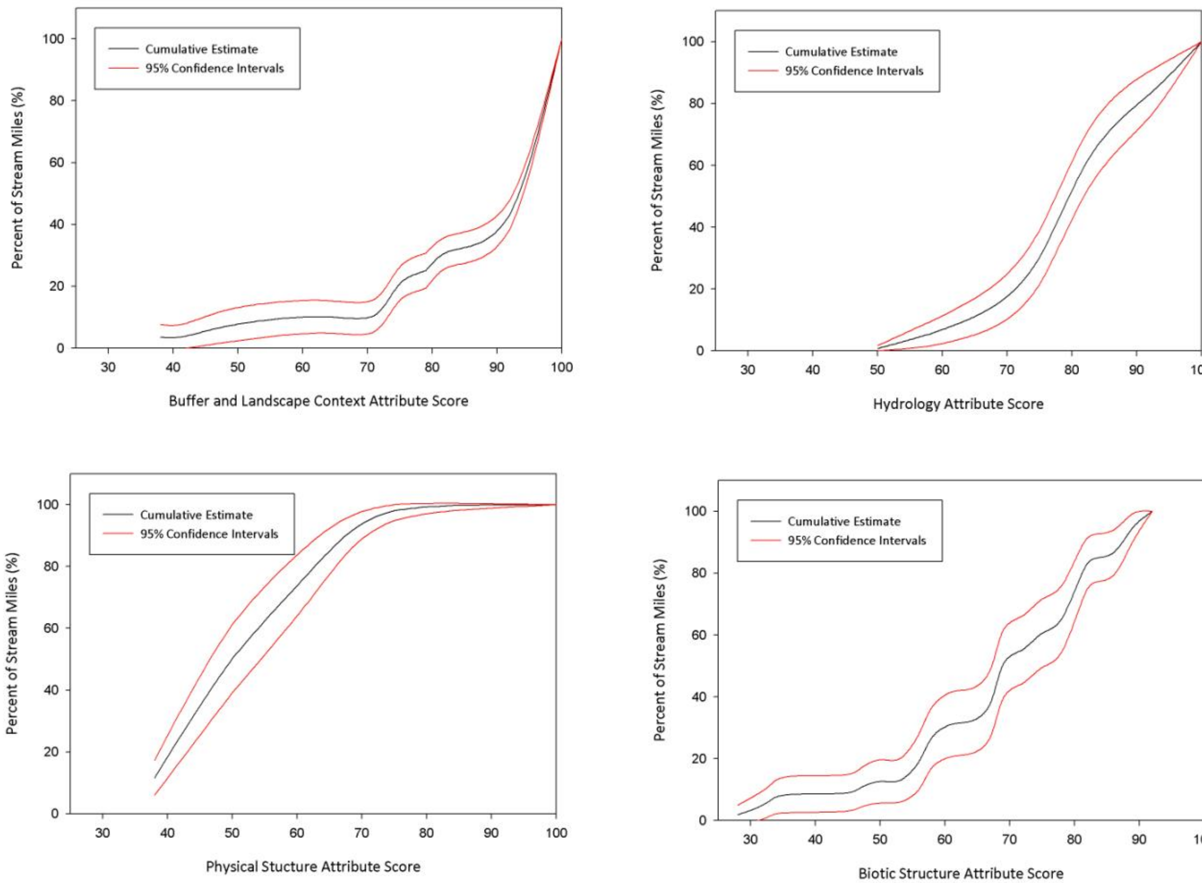

Figure A-5. Cumulative Frequency Distributions for California Rapid Assessment Method (CRAM) Attributes surveyed in the Coyote Creek Watershed using a probabilistic design.

Table A-3. CRAM attribute CDF inflection points and tails characterized by either 10% or 25% of stream miles.

Attribute	Lower 25%	Lower 10%	Lower Inflection Point (%)	Comment
Buffer and Landscape Context	38 - 79	38 - 62	38 - 71 (11%)	10% captures inflexion
Hydrology	50 - 72	50 - 63	50 - 72 (23%)	10% captures inflexion
Physical Attribute	38 - 42	38 - 38	None	10% does not capture range, use 25%
Biotic Structure	28 - 58	28 - 46	28 - 54 (12%)	10% captures inflexion
Attribute	Upper 25%	Upper 10%	Upper Inflection Point (%)	Comment
Buffer and Landscape Context	96 - 100	99 - 100	91 - 100 (60%)	Use 25%, better captures inflexion and range
Hydrology	88 - 100	95 - 100	83 - 100 (30%)	10% an 25% capture inflexion
Physical Attribute	60 - 100	69 - 100	70 - 100 (11%)	10% captures inflexion
Biotic Structure	80 - 92	87 - 92	85 - 92 (15%)	10% captures inflexion

Fisheries and Physical Habitat Conceptual Model

A conceptual model of the relationship between stream ecosystem condition, as measured by CRAM, and native fish population health was developed with District fisheries biologists (Figure A-6). This conceptual model was based on the idea that many CRAM Metrics reflect stream physical habitat, the quality of which affects fish populations. Each aspect of physical habitat that affects cold-water or warm-water fish populations and that should be reflected in a CRAM score was hypothesized to have a particular relationship with that CRAM score (Tables A-3 and A-4). Detailed hypotheses and predictions (Table A-5) were written in consultation with District fisheries biologists (Melissa Moore and Lisa Porcella) to explain the mechanistic relationships represented in the Physical Habitat/Fisheries Health (PHFH) conceptual model (see below). The PHFH conceptual model development was a way to document the *a priori* hypotheses of the District biologists about how native fish populations relate to stream condition as measurable by CRAM. The statistical analysis of CRAM and fisheries data (described below) that was done subsequent to the conceptual model development was an unbiased test of how any CRAM Metric could relate to native fish diversity. Therefore, *a priori* hypotheses were recorded but were not allowed to limit the results of the statistical analysis.

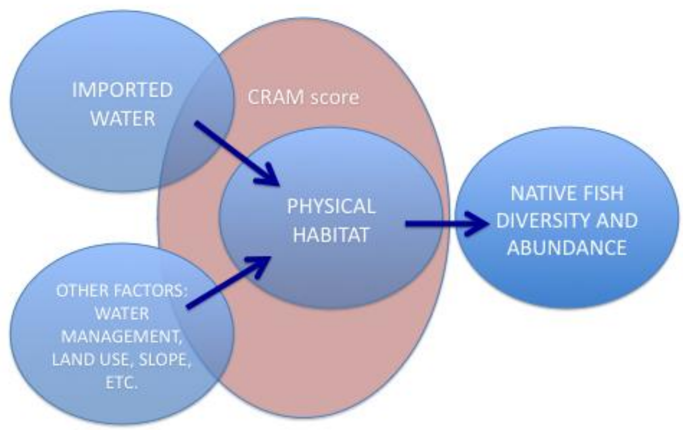

Figure A-6. Simplified graphic version of the Physical Habitat/Fisheries Health Conceptual Model, which depicts the relationship between CRAM scores, physical habitat, and the diversity and abundance of native fish.

CRAM/Fisheries Data Manipulation

Through discussions with District biologists, it was determined that the fish response variable of most interest to evaluate the conceptual model was native fish diversity. Therefore, data analysis focused on evaluating relationships between native fish diversity and CRAM Metrics. A total of 22 sites were sampled with CRAM that overlapped with the District's fisheries monitoring study. Fourteen sites had fisheries data for all three years, seven sites had data for two years, and one site (UCCB) was only sampled in 2008.

To maximize the available sample size for analysis, all sites were included, even though one site was not replicated in multiple years. To obtain a representative statistic to represent all three years of data, the fish response variable was calculated as the mean number of native species across all years. Mean number of natives reflects the overall tendency of a site to support a diverse fish population, no matter the particular conditions that year. We also investigated summing the number of unique native fish species across all three years for each site, and found the result to be very similar to the mean value. A summed value would indicate the tendency of a site to support different species over time as conditions change. In this case, the values were very similar and we chose to use the mean number of natives. The reason for the similarity may have been that all three water years when fish were collected were rather dry.

First, the number of native species was calculated by summing the number of native species per site in each year. District biologists provided the list of native species. Next, weighting was used to augment the diversity statistic when important indicator species were present. Specifically, if Pacific lamprey were present at a site, the total number of native species was increased by a weight of 1; if steelhead trout were present at a site, the total number of native species was increased by a weight of 2; and if both lamprey and trout were present at a site, the total number of native species was increased by a weight of 2. In this way, sites with either of these species present in a given year were considered more diverse (healthier) than sites without these species present but with the same number of native species total. These two indicator species were selected because they are integral to future water management activities of the District.

Statistical Analysis

Data were analyzed by Non-metric Multidimensional Scaling (NMS) with the R Statistical Software version 2.10.0, using packages “vegan” and “MASS”. NMS is an ordination technique commonly used in community ecology, when multiple variables need to be examined that occur on various distribution scales. In this study, NMS was used to identify the optimum set of CRAM Metrics and direction of response, to describe spatial patterns in mean native fish diversity. The CRAM data were distributed on an ordinal scale (3, 6, 9, 12) and the fish diversity were discrete (0 – 7 species). NMS was performed using a relative Euclidean dissimilarity (standardized to the square root) and Wisconsin double standardization using the meta MDS method (Cox and Cox, 1994). NMS runs were first evaluated by performing ordination along 1 to 5 axes and examining the stress. Stress is measured on a scale of 0 – 100, where a stress value of greater than 20 is viewed as a poor ordination with limited interpretative confidence. In simple terms, lower stress equals a better fit to the ordination structure.

Preliminary runs indicated that the stress was less than 20 when employing two axes and the 2 dimension (2D) ordination produced the largest reduction in stress. Therefore, only the 2D ordination results are represented here. The meta MDS method employs a random starting configuration to avoid local optima and identifies the global best solution. A convergent solution was obtained after 15 random starts, suggesting reasonable confidence in the final results. Once a final solution was obtained, the axes scores were examined for goodness of fit against all variables included in the analysis to determine their contribution to the underlying variance structure. The goodness of fit statistic used was the square of the correlation coefficient.

Simple (Spearman’s) rank correlation of the fish response variable to all CRAM variables (Index and Metrics) was also performed to substantiate the NMS-based inferences. The purpose of this analysis was purely as a secondary check to make sure that no major errors were made in the NMS analysis. The NMS approach has much more power than simple Spearmen’s rank correlation. Therefore, NMS is the primary analysis used to make inference for this study.

Results (AM)

The 2D NMS ordination found a significant relationship between native fish diversity and CRAM Metrics (Figure A-7). The stress value for this global NMS solution was approximately 17 indicating a 'fair' ordination, based on Clarke's rule of thumb (Clark, 1993). Most ecological data tend to have solutions with stress between 10 and 20 (McCune and Grace, 2002). The vector arrows on Figure A-7 depict the direction of the variables with significant coefficient of determination (r^2) to the NMS axes.

Axis one described an underlying variance structure related to four biotic structure Metrics and a buffer Metric. These variables did not strongly relate to native fish diversity as they plot in different ordination spaces (horizontal) to the fish response variable (vertical). The inverse relationship between percent invasion and plant layers, species, and horizontal structure may point to a disturbance gradient being picked up by the biotic structure attributes.

Axis two is described by native fish diversity, topographic complexity, and hydrologic connectivity. Both topographic complexity and native fish diversity were positively related to each other, as indicated by vectors corresponding to the same ordination space. Hydrologic connectivity is indicative of an inverse degree of entrenchment. NMS results indicated that when connectivity is low (entrenchment is high), the native fish diversity would likely be high.

For both of the two axes, native diversity had a goodness of fit statistic of 0.58 (Table A-6). The other two variables that fit the ordination best (based on r^2) were buffer width and percent invasion. However, as shown in Figure A-7, these two Metrics were not related to fish, but described a pattern in CRAM biotic structure Metrics.

The Spearman's rank correlation analysis supported the NMS inference that topographic complexity has a significant, positive correlation (0.44) to native fish diversity (Table A-7, Figure A-8). Therefore, this rank correlation analysis confirmed that the NMS analysis appeared to be correctly implemented. Table A-7 shows the rank correlations and Figure A-8 shows the relationships of the CRAM Metrics to native fish diversity.

In summary, the NMS results suggest a pattern in fish native diversity related to physical structure and entrenchment. Specifically, more topographic complexity and greater entrenchment resulted in higher native fish diversity among the three years of fisheries study. A caveat should be acknowledged that the fisheries data were collected prior to the CRAM surveys, and thus may not entirely represent current condition.

Table A-3. Detailed conceptual model of relationship between cold-water native fish community and CRAM Metric scores.

Cold Water Fish Community					CRAM	
Life Phase	Habitat Factor	Habitat Factor Attribute	Habitat Factor Attribute Detail	Habitat Relationship to Fish Abundance/ Diversity	CRAM Metric	CRAM Metric Score Prediction
Rearing	Imported Water	Increased perennial		Positive (rearing and outmigration)	Vertical Biotic Structure	Higher
					Water Source	Lower
	Physical Habitat	Riffle, run, pool		Positive	Structural Patch Richness	Higher
		Large woody debris		Positive		Higher
		Vegetation	Steep slope	Positive	Vertical Biotic Structure	Higher
			Shallow slope	Negative		Higher
		Sediment size and quantity	More fines	Negative	Channel Stability, Buffer, and Structural Patch Richness	Lower
			More gravel	Positive		Higher
			More boulders	Positive		Higher
		Sediment quality	Armoring	Negative	Topographic Complexity	Lower
		Water quality	Chemical, Temperature[1]	Positive	Water Source, Buffer, Vertical Biotic Structure	Higher
		Water quantity (year-round)		Positive	Topographic Complexity, Structural Patch Richness, and Vertical Biotic Structure	Higher

[1] Chemical measured as fewer contaminants; Temperature below 23 C

Table A-4. Detailed conceptual model of relationship between warm-water native fish community and CRAM Metric scores.

Warm Water Fish Community					CRAM	
Life Phase	**Habitat Factor**	**Habitat Factor Attribute**	**Habitat Factor Attribute Detail**	**Habitat Relationship to Fish Abundance / Diversity**	**CRAM Metric**	**CRAM Metric Score Prediction**
Rearing and Adult Survival and Reproduction	Imported Water	Increased perennial		Positive	Vertical Biotic Structure	Higher
					Water Source	Lower
	Physical Habitat	Riffle, run, pool		Positive	Structural Patch Richness	Higher
		Large woody debris		Positive		Higher
		Backwater pools, side channels		Positive	Structural Patch Richness, Hydrologic Connectivity	Higher
		Vegetation	Shallow slope	Negative	Vertical Biotic Structure	Higher
		Sediment size and quantity	More fines	Negative	Channel Stability, Buffer, and Structural Patch Richness	Lower
			More gravel	Positive		Higher
		Sediment quality	Armoring	Negative	Topographic Complexity	Lower
		Water quality	Chemical, Temperature	Positive	Water Source, Buffer, Vertical Biotic Structure	Higher
		Water quantity (year-round)		Positive	Topographic Complexity, Structural Patch Richness, and Vertical Biotic Structure	Higher

Table A-5. Hypotheses and predictions for the Physical Habitat/Fisheries Health conceptual model relating CRAM Metric scores to Coyote Creek Watershed native fish diversity and abundance.

Number	Hypotheses	Predictions
1	Riffle-run-pool sequences and large woody debris positively affect native fish rearing (both assemblages) and adult (warm-water assemblage only) life phases. These habitat features increase the CRAM Structural Patch Richness score.	Higher native fish diversity and abundance will be associated with higher CRAM scores for Structural Patch Richness.
2	Back-water pools and side channels positively affect warm-water assemblage native fish rearing and adult life phases. These habitat features increase the CRAM Structural Patch Richness and are related to higher Hydrologic Connectivity scores	Higher native fish diversity and abundance will be associated with higher CRAM scores for Structural Patch Richness and Hydrologic Connectivity.*
3	Greater amounts of vegetative cover have a positive effect on cold-water assemblage native fish rearing in steep-slope streams. This habitat feature increases the CRAM Vertical Biotic Structure score.	Higher native fish diversity and abundance will be associated with higher CRAM scores for Vertical Biotic Structure in steep-slope streams.

4	Greater amounts of vegetative cover have a negative effect on native fish rearing (both assemblages) and adult life phases (warm-water assemblage only) in shallow-slope streams. This habitat feature increases the CRAM Vertical Biotic Structure score.	Higher native fish diversity and abundance will be associated with lower CRAM scores for Vertical Biotic Structure in shallow-slope streams.
5	Greater amounts of fine sediments have a negative effect on native fish rearing (both assemblages) and adult life phases (warm-water assemblage only). This habitat feature decreases the CRAM Structural Patch Richness score and is associated with lower scores for Channel Stability and Buffer.	Higher native fish diversity and abundance will be associated with higher CRAM scores for Channel Stability, Buffer, and Structural Patch Richness.
6	Greater amounts of gravel and boulder sediments have a positive effect on native fish rearing (both assemblages) and adult life phases (warm-water assemblage only). This habitat feature increases the CRAM Structural Patch Richness score and is associated with higher scores for Channel Stability and Buffer.	Higher native fish diversity and abundance will be associated with higher CRAM scores for Channel Stability, Buffer, and Structural Patch Richness.
7	Channel armoring has a negative effect on native fish rearing (both assemblages) and adult life phases (warm-water assemblage only). This habitat feature is associated with lower scores for Topographic Complexity.	Higher native fish diversity and abundance will be associated with higher CRAM scores for Topographic Complexity.**
8	Good water quality (fewer contaminants, temperature below 23 degrees Celcius) has a positive effect on native fish rearing (both assemblages) and adult life phases (warm-water assemblage only). This habitat feature is associated with higher scores for Water Source (except in areas with imported water), Buffer, and Vertical Biotic Structure.	Higher native fish diversity and abundance will be associated with higher CRAM scores for Water Source, Buffer, and Vertical Biotic Structure.
9	Increased water quantity in each season of the year has a positive effect on native fish rearing (both assemblages) and adult life phases (warm-water assemblage only). This habitat feature is associated with higher scores for Topographic Complexity, Structural Patch Richness, and Vertical Biotic Structure.	Higher native fish diversity and abundance will be associated with higher CRAM scores for Topographic Complexity, Structural Patch Richness, and Vertical Biotic Structure.**
10	Imported water positively affects native fish rearing (both assemblages), outmigration (cold-water assemblage only), and adult survival and reproduction (warm-water assemblage only) by increasing perennial flow. Increased perennial flow supports a greater degree of vegetative cover. Artificial hydrology in the dry season is scored lower (C score) in the CRAM water source Metric.	Higher native fish diversity and abundance will be associated with higher CRAM scores for Vertical Biotic Structure and with lower CRAM scores for Water Source in areas with imported water[2].

* The NMS analysis indicated the opposite of this prediction: as native fish diversity increased, Hydrologic Connectivity decreased.
**The NMS analysis supported this prediction: as native fish diversity increased, Topographic Complexity increased. For all other predictions in this table, the NMS analysis showed no relationship.

[2] Note that Water Source Metric has opposite predictions for streams with imported water and other streams. This duality will require consideration during data analysis.

Table A-6. Goodness of fit of variables to the ordination structure shown in Figure A-7.

Variable	CRAM Attribute	r^2	Probability-value	Significance
Native Fish Diversity	--	0.578	0.001	***
Landscape Connectivity	BLC	0.108	0.333	
Percent of AA with Buffer	BLC	0.084	0.438	
Average Buffer Width	BLC	0.502	0.001	***
Buffer Condition	BLC	0.167	0.170	
Water Source	HYD	0.060	0.533	
Channel Stability	HYD	0.238	0.085	.
Hydrologic Connectivity	HYD	0.366	0.012	*
Structural Patch Richness	PHY	0.164	0.171	
Topographic Complexity	PHY	0.285	0.040	*
Horizontal Inter. and Zonation	BIO	0.168	0.189	
Vertical Biotic Structure	BIO	0.368	0.018	*
Number of Plant Layers Present	BIO	0.359	0.024	*
Number of Co-dominant Species	BIO	0.405	0.007	**
Percent Invasion	BIO	0.768	0.001	***

Significance: *** = < 0.001, ** = < 0.01, * = < 0.05, . = < 0.1

Attributes: BLC = Buffer and Landscape Context; HYD = Hydrology; PHY = Physical Structure; BIO = Biotic Structure

Table A-7. Spearman's rank correlation of CRAM Metric scores to mean native fish diversity.

CRAM Variable	CRAM Attribute	Correlation Coefficient (r)	Probability-value	Significance
Landscape Connectivity	BLC	0.298	0.178	
Percent of AA with Buffer	BLC	0.091	0.686	
Average Buffer Width	BLC	0.124	0.583	
Buffer Condition	BLC	0.053	0.815	
Water Source	HYD	0.425	0.049	N/A
Channel Stability	HYD	-0.040	0.859	N/A
Hydrologic Connectivity	HYD	-0.239	0.284	
Structural Patch Richness	PHY	0.242	0.279	
Topographic Complexity	PHY	0.441	0.040	*
Horizontal Inter. and Zonation	BIO	0.335	0.128	
Vertical Biotic Structure	BIO	-0.021	0.926	
Number of Plant Layers Present	BIO	-0.008	0.972	
Number of Co-dominant Species	BIO	-0.120	0.594	
Percent Invasion	BIO	0.118	0.601	

Significance: * = < 0.05

Attributes: BLC = Buffer and Landscape Context; HYD = Hydrology; PHY = Physical Structure; BIO = Biotic Structure

N/A: Metrics with only two levels of CRAM score (e.g., scores of 6 and 9) were not assessed, because they did not have a wide enough range of scores to support regression analysis (see Fig A-8).

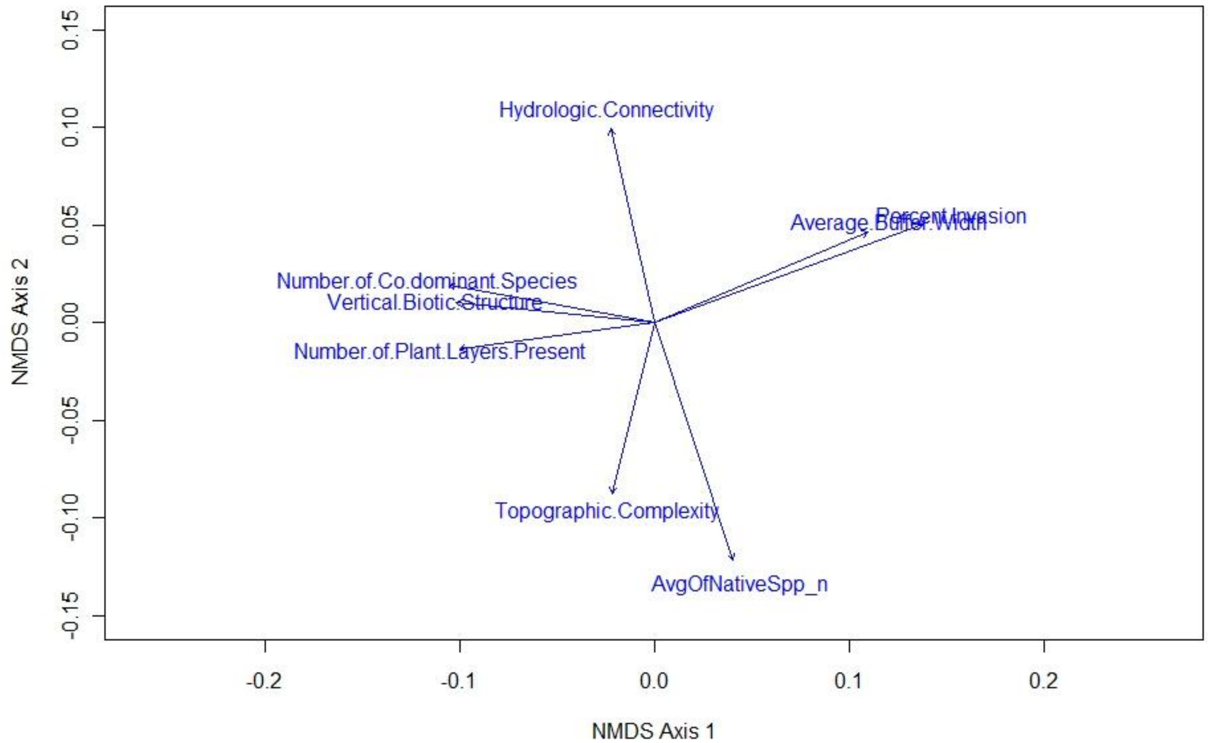

Figure A-7. Non Metric Multi-dimensional Scaling (NMS) Ordination of native fish diversity and CRAM Metrics. Vectors represent Metrics that provided a significant r2 (goodness of fit) to the two NMS axes. Table A-6 shows the contribution of each Metric to the overall ordination structure.

Stress = 17.6

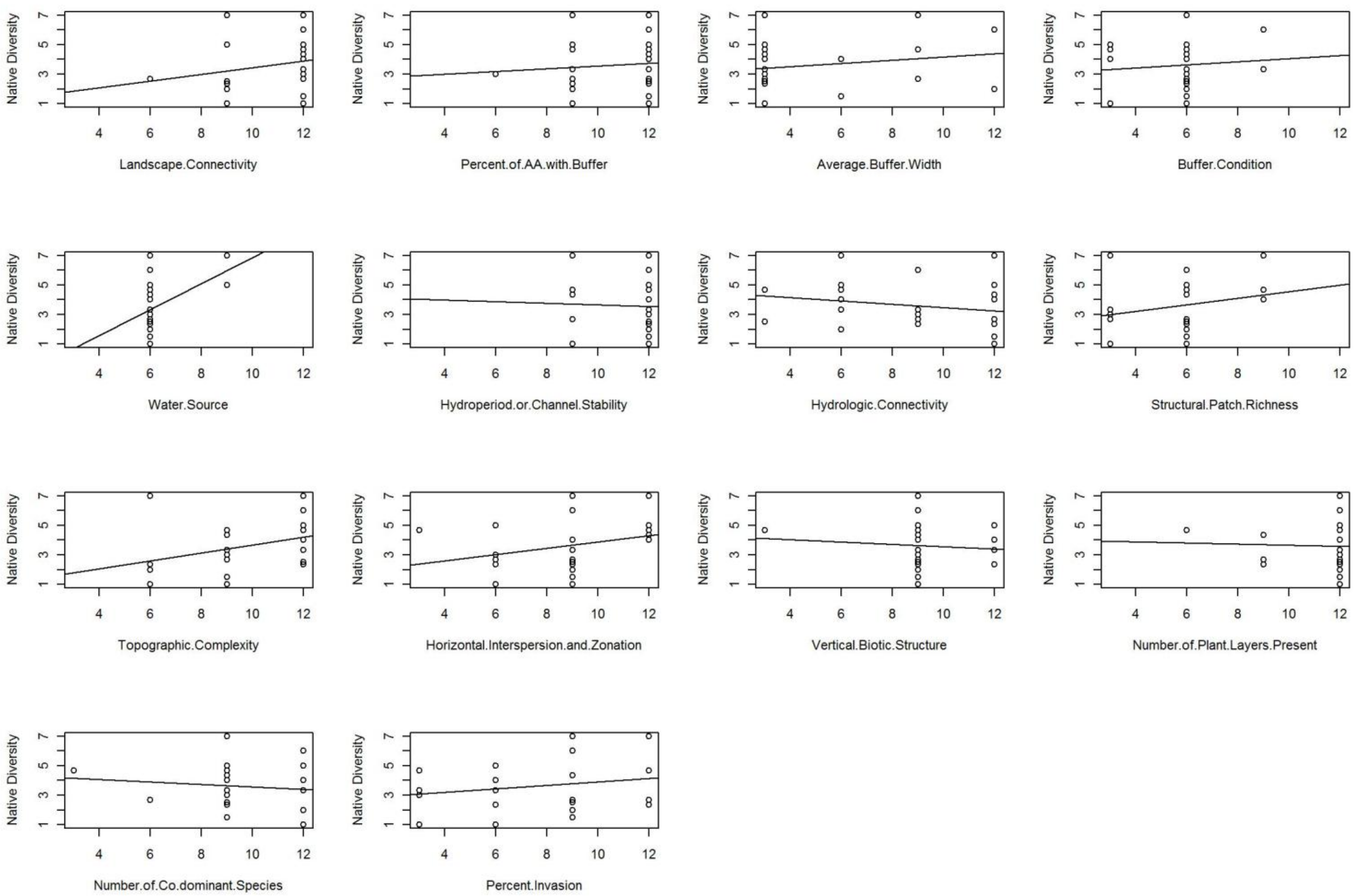

Figure A-8. Correlation of each CRAM Metric to mean native diversity. Lines represent the linear correlation in the data. Refer to Table A-7 for Spearman's rank correlation coefficients and levels of statistical significance.

Concept Pilot Level 3 Conceptual Models

This section describes Level 3 conceptual models designed during the EMAF Concept Pilot Assessment (SCVWD 2010a) to address a District-identified[3], high priority management concern: potential impacts of imported water and associated groundwater recharge operations on two target species, Steelhead (*Oncorhynchus mykiss*) and Pacific lamprey (*Entosphenus tridentata*). This conceptual model focuses on identifying factors, and associated stressors influencing different life history stages of these species. It was developed generically so that it can be applied to any watershed in which these operations and target species are present, meaning that this model was not populated to describe the relative strength of relationships[4] between stressors and life history stages specific to the Upper Penitencia Creek Watershed[5].

This section begins by describing the life history stages of both target species because the Concept Pilot Level 3 conceptual model is structured to identify how stressors may impact specific life stages of each target species. The conceptual model is then described succinctly in Table A-8, and Figure A-9, with supporting narrative text.

Life History Stages of Steelhead and Pacific Lamprey

Life history stages and habitat requirements of steelhead and pacific lamprey are described below and depicted in Figure 6-14 because they provide valuable information that can be used to understand the relative influences of various natural and anthropogenic stressors. Explicitly incorporating these life history stages into conceptual model structure facilitates identification of factors limiting the distribution and abundance of these species, and evaluation of the potential impacts as well as benefits from management operations.

<u>Steelhead Life Stages</u>

The following information was derived primarily from a single comprehensive source (Stillwater Sciences 2006). This source also provides detailed information on the linkages of physical habitat to specific life stages of steelhead.

<u>Adult</u>

Steelhead return from the ocean to spawn in the stream they were hatched, usually in their fourth or fifth year of life. Steelhead migrate to their natal stream from late-fall through spring as sexually mature adults, and spawn in late winter or spring (Meehan and Bjornn 1991, Behnke 1992). Female steelhead construct redds and lay eggs in suitable gravels, often in pool tailouts and heads of riffles, or in isolated patches in cobble-bedded streams.

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[3] This management concern was identified by the EMAF Core Technical Team.

[4] e.g., the relative size of arrows between boxes illustrated in the Level 3 conceptual model.

[5] The original Concept Project Assessment scope of work only included the development of a Level 2 conceptual model, populated to the extent feasible using existing data. This scope of work was amended in January 2010 to additionally define a generic Level 3 model and associated management questions.

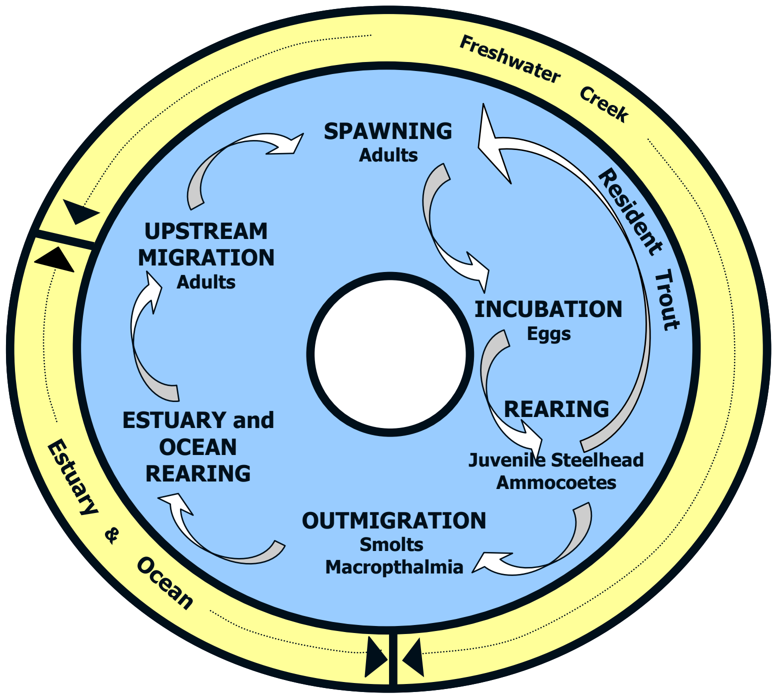

Figure A-9. Primary stages of steelhead and Pacific lamprey life histories (adapted from Stillwater Sciences 2006).

<u>Egg</u>

Eggs incubate in redds for 3–14 weeks, depending on water temperatures (Shapovalov and Taft 1954, Barnhart 1991). After hatching, alevins remain in the gravel for an additional 2–5 weeks while absorbing their yolk sacs, and then emerge in spring or early summer (Barnhart 1991).

<u>Juvenile</u>

Juvenile steelhead are characterized by two phases of growth (fry and parr) in which individuals utilize different aspects of similar rearing habitat, and one phase of outmigration (smolt), in which individuals encounter additional habitat types.

Fry

After emerging from gravels, alevins are referred to as fry (or 0+ age-class).Fry move to shallow-water, low-velocity habitats, such as stream margins and low-gradient riffles, and forage in open areas (Hartman 1965, Fontaine 1988). As fry grow and improve their swimming abilities in late summer and fall, they increasingly use areas with cover and show a preference for higher velocity, deeper mid-channel areas (Hartman 1965, Everest and Chapman 1972, Fontaine 1988).

Parr

Parr (1+ age-class) rear in freshwater habitat before outmigrating to the ocean as smolts. The duration of time parr spend in freshwater appears to be related to growth rate, with larger, faster-growing members of a cohort smolting earlier (Peven *et al.* 1994). Steelhead in warmer areas, where feeding and growth are possible throughout the winter, may require a shorter period in freshwater before smolting, while steelhead in colder, more northern, and inland streams may require three or four years before smolting (Roelofs 1985).

Juvenile (fry and parr) occupy a wide range of habitats, preferring deep pools as well as higher velocity riffle and run habitats (Bisson *et al.* 1982, Bisson *et al.* 1988). During periods of low temperatures and high flows that occur in winter months, juveniles prefer low-velocity pool habitats with large rocky substrate or woody debris for cover (Hartman 1965, Raleigh *et al.* 1984, Swales *et al.* 1986, Fontaine 1988). During high winter flows, juveniles seek refuge in interstitial spaces in cobble and boulder substrates (Bustard and Narver 1975).

Smolt

Juvenile steelhead emigration as smolts typically occurs from March through June. Emigration appears to be more closely associated with size than age, (though smolting typically manifests in the 2+ age-class), with 6 – 8 inches (15 – 20 centimeters) being most common for downstream migrants. Depending partly on growing conditions in their rearing habitat, steelhead may migrate downstream to estuaries as age 0+ juveniles or may rear in streams for up to four years before outmigrating as smolts to the estuary and ocean (Shapovalov and Taft 1954). As well, smolts may rear for one month to a year in an estuary before entering the ocean (Shapovalov and Taft 1954, Barnhart 1991).

<u>Pacific Lamprey Life Stages</u>

The following information was derived primarily from a single comprehensive source (Streif 2008). Brown et al., (2009) provides more detailed information on the linkages of physical habitat to specific life stages of Pacific lamprey.

<u>Adult</u>

After spending 1 to 3 years in the marine environment, Pacific lampreys cease feeding and migrate to freshwater between February and June. They are thought to overwinter and remain in freshwater habitat for approximately one year before spawning, where they may shrink in size up to 20 percent. Most upstream migration takes place at night. Adult size at the time of migration ranges from about 15 to 25 inches. Pacific lampreys spawn in similar habitats to salmon; in gravel bottomed streams, at the upstream end of riffle habitat, typically above suitable juvenile lamprey (ammocoete) habitat. Spawning occurs between March and July depending upon location within their range. The degree of homing is unknown, but adult lampreys cue in on ammocoete areas which release pheromones that are thought to aid adult migration and spawning location. Both sexes construct the nests, often moving stones with their mouth. After the eggs are deposited and fertilized, the adults typically die within 3 to 36 days after spawning.

<u>Egg</u>

The period of incubation is dependent on water temperature, and may range from 18 – 49 days. Egg survival is optimal in a range of 10 – 18 ° C, and sharply declines once temperatures reach 22 ° C. Within this range, at 15° C, embryos hatch in approximately 19 days (Streif 2008).

Juvenile

Juvenile Pacific lampreys are characterized by two phases of growth (ammocoete and macropthalmia) in which individuals utilize different aspects of similar rearing habitat.

Ammocoetes

After emerging from eggs, ammocoetes drift downstream to areas of low velocity and fine substrates where they burrow, grow and live as filter feeders for 3 to 7 years and feed primarily on diatoms and algae. Several generations and age classes of ammocoetes may occur in high densities. Ammocoetes move downstream as they age and during high flow events. Little is known about movement and locations of ammocoetes within the substrates. Anecdotal information suggests that they may occur within the hyporheic zone and may move laterally through stream substrates.

Macropthalmia

Metamorphosis to macropthalmia (juvenile outmigrating life stage) occurs gradually over several months as developmental changes occur, including the appearance of eyes and teeth, and they leave the substrate to enter the water column. This outmigrating life stage differs to that of steelhead smolts in two ways: it typically occurs over a longer period of time; and, during outmigration, macropthalmia utilize habitat differently than in the preceding ammocoete life stage, namely, they utilize the water column as opposed to the subsurface streambed substrate. Transformation from ammocoetes to macropthalmia typically begins in the summer and is complete by winter. Macrophthalmia slowly emigrate downstream between late fall and spring where they mature into adults and enter the ocean.

Management Operations and Potential Threats to Target Species

The District implements a variety of management operations as described in detail in Chapter 2.0. Each of these management operations can potentially threaten steelhead and/or Pacific lamprey (hereafter referred to as lamprey). This section describes how such management operations may impact the target species both in terms of the general categories of threats associated and the specific factors that impact the life stages of the target species. Management operations, threats and factors are summarized in Table 6-4, depicted in Figure 6-14, and described in further detail below.

Construction and Maintenance of Artificial Structures

The construction of physical structures in the stream channel can impede migration and movement upstream and downstream for juvenile and adult life stages of both target species to spawning and/or rearing areas. In some cases, areas that were historically accessible are no longer accessible; in other cases, areas may only be accessible seasonally or intermittently. Structures including dams, diversions, culverts, road and bridge crossings, and other grade control structures (e.g., utilities) may create physical and/or velocity barriers. Impoundments created by dams and diversions may create environmental barriers (e.g., poor water quality, predation from non-native species) that negatively impact the migration and movement of adult and juvenile stages of both target species. Impoundments may also submerge historical spawning and rearing habitat.

Upstream migration over some structures can be mitigated with fish ladders or weirs; however many designs suitable for steelhead are not suitable for Pacific lampreys. The high level of swimming energy required by adult Pacific lampreys to pass through fish ladders or culverts, combined with sharp angles and high water velocities, effectively block or restrict passage (USFWS 2008). During downstream migrations juvenile steelhead and/or lampreys may be entrained in water diversions without fish screens. Outmigrating juvenile lamprey are also susceptible to getting impinged on fish screens, potentially resulting in injury or death.

In addition to altering hydrological regime, dams and diversions may disrupt downstream transport of sediment and large woody debris, which are important components for the development of quality spawning and rearing habitat (Collins 1976) normally utilized by juvenile and adult stages of both target species. Dams can also alter nutrient cycling and food supplies to downstream fish communities.

Table A-8. Potential relationships between management operations and factors affecting life stages of two target species, *Oncorhynchus mykiss* (steelhead), and *Entosphunus tridentata* (Pacific lamprey). Bold text in the "Factors" column indicates management operations that may positively impact life stages of target species; non-bold text indicates factors that negatively impact life stages of target species.

Management Operations Potentially Threatening Target Species	Potential Threats Operations Pose to Target Species	Associated Factors Impacting Life Stages of Target Species	Steelhead				Pacific Lamprey			
			Egg	Juvenile: Parr/Fry	Juvenile: Smolt	Adult	Egg	Juvenile: Ammo-coete	Juvenile: Macro-pthalmia	Adult
Construction and maintenance of artificial structures: dams/diversions, reservoirs, instream ponds, fish ladders/screens, culverts, bridge/road crossings grade control structures	Physical and environmental barriers to migration and movement	Structures and impoundments can block migration to historically available spawning and rearing habitat; access to ocean		X	X	X		X	X	X
	Fish passage facility not maintained or properly designed	Delays in migration can cause stress, injury or mortality during passage; diversion screens can impinge movement and cause stress or injury			X	X		X	X	X
	Structures block downstream transport of sediment	Insufficient sediment quantity and/or quality for spawning and rearing habitat		X		X[1]		X		X[1]
Water Supply and/or Facility Maintenance Operations: reservoir releases, flow augmentation, diversions, dewatering for instream projects	Overall changes to natural flow regime	Altering cues that trigger upstream or downstream fish migration			X	X			X	X
	Decrease in flow	Dewatering redds, stranding juvenile fish, inadequate water depth for adult migration, reduced growth rates, poor water quality and temperature	X	X	X	X	X	X	X	X
	Increase in flow (non-imported water)	Increase sheer stress and sediment transport affecting quantity and quality of spawning and rearing habitat; flows can also displace fry and juvenile fish	X	X			X	X		
	Imported water	Introduced non-native organisms: competition (food and habit), predation, hybridization	X	X	X	X	X	X	X	X
		Disease: Reduced fitness and increased susceptibility to mortality for all life stages.	X	X	X	X	X	X	X	X
		Poor water quality (e.g., increased water temperatures, turbidity)	X	X	X	X	X	X	X	X
		Water imports can increase baseflow and lengthen downstream perennial extent resulting in increased carrying capacity	**X**	**X**			**X**	**X**		

Management Operations Potentially Threatening Target Species	Potential Threats Operations Pose to Target Species	Associated Factors Impacting Life Stages of Target Species	Steelhead				Pacific Lamprey			
			Egg	Juvenile		Adult	Egg	Juvenile		Adult
				Parr/Fry	Smolt			Ammo-coete	Macro-pthalmia	
Channel Modification and Maintenance: Channelization, levee construction, flood bypass, armored bed and banks, sediment removal, vegetation and woody debris removal, and bank protection.	Stream and floodplain degradation	Increase bed mobility/scour, lack of large woody debris and suitable substrate affecting quantity and quality of spawning, rearing and adult holding habitat, loss of side channels	X	X		X	X	X		X
	Instream erosion causing excess fine sediment deposition	Spawning gravel quality and quantity, Summer and winter rearing habitat, pool filling can reduce quality of adult holding habitat	X	X		X			X	
	Alteration to riparian vegetation, dewatering for sediment removal	Water quality and temperature	X	X	X	X	X	X	X	X
Management of Rural Areas: Road construction and maintenance; grazing, timber harvest, mining	Surface erosion and landslides causing excess fine sediment deposition	Spawning gravel quality and quantity, Summer and winter rearing habitat, pool filling can reduce quality of adult holding habitat	X	X		X			X	
Urbanization: storm water runoff, accidental spills, chemical treatment, illegal dumping, commercial shipping accidents	Chemical Contaminants	Water quality and temperature	X	X	X	X	X	X	X	X
	Poor Physical Water Quality	Water quality and temperature, environmental migration barriers	X	X	X	X	X	X	X	X
	Homelessness, trash	Poor water quality, poaching	X	X	X	X	X	X	X	X
	Increased magnitude and frequency of peak flows	Scour developing eggs, displace fry and juvenile fish, increase bed mobility affecting quantity and quality of spawning and rearing habitat	X	X			X	X		
	Estuarine Conditions	Water quality and temperature, predation, loss of estuarine habitat			X				X	
	Increased flows during dry season	**Runoff can increase baseflow and lengthen downstream perennial extent resulting in increased carrying capacity**	**X**	**X**			**X**	**X**		
Recreation: boating, fishing, swimming	Introduce non-native organisms and disease	Competition with introduced species (food and habitat competition), predation and hybridization	X	X	X	X	X	X	X	X
	Disturbance to fish	Human disturbance in adult holding habitat can stress fish				X				X
Fisheries Management	Over harvest, poaching	Removal of adult fish in ocean and freshwater holding areas				X		X		X

Management Operations Potentially Threatening Target Species	Potential Threats Operations Pose to Target Species	Associated Factors Impacting Life Stages of Target Species	Steelhead				Pacific Lamprey			
			Egg	Juvenile		Adult	Egg	Juvenile		Adult
				Parr/Fry	Smolt			Ammo-coete	Macro-pthalmia	
	Hatchery fish	Loss of genetic diversity and introduction of diseases; both can result in reduced fitness and mortality		X	X	X				
Regional Development	Ocean Conditions	Water quality and temperature				X				X
Global Development	Climate Change	Water quality and temperature	X	X	X	X	X	X	X	X

[1] Affects adult spawning life stage

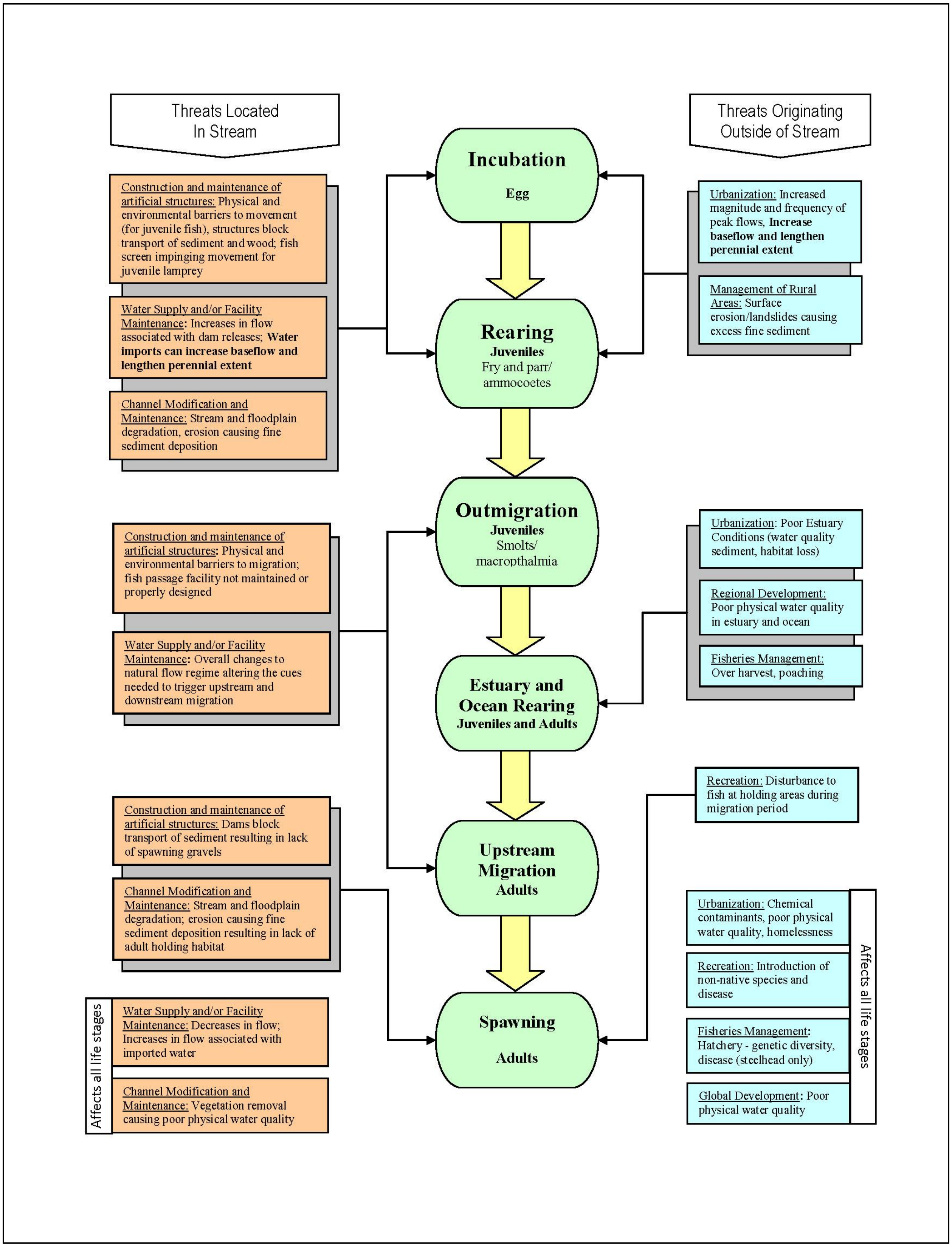

Figure 6-15. Level 3 generic conceptual model illustrating factors influencing life history stages of two target species: Oncorhynchus mykiss (steelhead), and Entosphunus tridentata (Pacific lamprey).

Water Supply and/or Facility Maintenance Operations

Operations that result in changes to hydrologic regime can affect fish migration and movement and the quality and quantity of habitat for different life stages of steelhead and lamprey. Operations discussed here that alter the natural flow regime include reservoir releases, flow augmentation, water diversions and dewatering the channel for construction projects.

Such operations may impact steelhead and lamprey populations by altering cues that trigger migration downstream (juvenile) and upstream (adults), thereby influencing when individuals attempt to migrate, and possibly where (e.g., which stream). Operations that augment springtime flows may delay juvenile outmigration by increasing the volume and velocity of base flow from the typical seasonal trend and providing a delayed flow cue. Conversely, augmented springtime flows may enhance the perennial quality of a stream, and increase the number of successful outmigrants, particularly in drought years when the stream might otherwise dry back in some reaches and prevent outmigration. The potential of imported water operations to negatively impact adult upstream migration depends on two factors: the volume of import relative to the natural hydrograph, and the chemical properties of the imported water. Imported flows that represent a relatively small proportion of the hydrograph are less likely to negatively impact the ability of adult steelhead or lampreys to cue on flow alone, however, large import volumes may alter the timing of upstream migration. Adults of both target species are known to migrate upstream in response to chemical cues (Quinn et al., 1989, Streif 2008). Though the precise mechanisms involved in this process are not well-understood, the chemical qualities of the mixed flow (imported and local) could potentially impact the ability of adults of either species to detect chemical cues that facilitate their return to their natal streams (Quinn et al., 1989, Streif 2008).

Rapid reductions in flow associated with dam operations and/or diversions can result in dewatering areas that contain redds, negatively impacting egg and alevin survival as well as stranding juvenile steelhead and lamprey (Stillwater 2006, USFWS 2008). Instream projects (e.g., sediment removal, culvert replacements) may also dry up stream reaches where juvenile steelhead and ammocoetes reside. Reduced flows can result in poor water quality and increased water temperature. Elevated water temperatures may reduce populations of all life stages of target species both directly through increased mortality and indirectly through factors such as changes to growth rates or timing of emergence and downstream migration (Stillwater 2006, Luzier 2009). Warm water may also favor non-native fish competitors or increase susceptibility to mortality from diseases (Holt *et al.* 1975). Flow reductions may also delay or stop steelhead migration if minimum water depths are not maintained (Everest *et al.* 1985), and likely lamprey as well, as they tend to travel deeper in the water column than steelhead (Streif 2008).

Sudden large increases in flow associated with dam releases can displace juvenile steelhead and lamprey, increase shear stress on channel, and can scour suitable substrate used for adult spawning and juvenile rearing (Stillwater 2006, Streif 2008). In addition to those impacts discussed above, imported water can potentially have both negative and positive impacts on target species. Imported water may negatively affect water quality, by increasing turbidity and temperatures, thereby impacting growth rates, and fitness (increasing susceptibility to disease). It may also introduce non-native fish, which can affect populations of steelhead and lamprey through competition for resources, predation and hybridization. Conversely, imported water may positively influence rearing habitat by increasing base flows and lengthening the perennial extent, thereby increasing carrying capacity of fish populations compared to historical flow conditions.

Channel Modification and Maintenance

Channel modification and stream maintenance activities that result in stream and floodplain degradation can affect the quality and quantity of spawning and rearing habitat for juvenile steelhead and lamprey. Channel modification projects include channelization, levee construction, flood bypass structures and armoring of channel bed and/or banks. Stream maintenance activities include sediment removal, vegetation and large woody debris removal and bank protection.

Channel simplification (i.e., straightening, levee construction) reduces overall roughness of channel, which can result in increased water velocities and sediment transport capacity (Stillwater Sciences 2006). Furthermore, armoring of banks combined with higher water velocities can increase sheer stress to channel bed, resulting in channel incision and bank erosion at downstream locations. Channel incision over time can lead to disconnection to flood prone areas, loss of side channels and reduction in the large woody debris in the channel. These changes in channel morphology can all greatly influence the quality of habitats that support spawning, rearing and migratory life stages for steelhead and lamprey. In addition, lack of channel-forming structure (e.g., large woody debris) combined with higher levels of fine sediment supply, can decrease the number of deep pools used by adult steelhead and lamprey for resting during migration periods.

Channel maintenance activities, such as removal of bank vegetation and large woody debris that are implemented to maintain flood design capacities, similarly affect habitat quality as described above, and impact overall water quality (e.g., lower dissolved oxygen and high water temperatures). Sediment removal activities that require dewatering the channel during dredging can also reduce water quality conditions, and lead to stress or mortality of all life stages of target species.

Urban Development

Urbanization poses several threats to both steelhead and lamprey populations. Storm water runoff can introduce chemical contamination, and degrade water quality (e.g., decrease dissolved oxygen and increase water temperature) in receiving waters. Chemical contaminants and poor water quality conditions can also result from accidental spills, chemical treatments and illegal dumping activities that occur directly in streams. Homeless encampments along streams can also contribute waste that contributes to chemical contamination and poor water quality conditions in streams. Chemical contaminants can cause acute or chronic toxicity to all life stages of both target species. Poor water quality can contribute to stress, disease, and/or mortality to all life stages of both target species.

Urban runoff can also increase channel instability due to higher and more frequent peak flows that may cause bank erosion and higher sediment supply to the channel. Such sediment loads can negatively influence the quantity and quality of habitats available to support spawning, rearing and migratory life stages for steelhead and lamprey.

Threats associated with urbanization, as described above, can also degrade estuarine habitats, which are important holding habitats for steelhead and lamprey during upstream and downstream migration. Commercial shipping accidents in the San Francisco Bay can also contribute contaminants that may impact estuarine habitats.

Land Use Disturbance in Rural Areas

Land use activities in rural areas may include construction and maintenance of rural roads, grazing, timber harvest and mining. These activities can introduce considerable volumes of excess fine sediment to streams, thereby degrading the quality of rearing habitat for juveniles, as well as spawning and holding habitat for adults of both target species.

Recreation

Human disturbance associated with recreational activities such as boating, swimming or fishing may affect adult steelhead and lamprey. These activities may especially affect fish during holding periods and can result in stress and possible mortality (Stillwater 2006, Streif 2008). Fishing activities may also result in intentional or unintentional introduction of non-native organisms. Introduction of non-native fishes (e.g., largemouth bass) can result in predation or competition for resources with target species.

Fisheries Management

Fisheries management actions can affect steelhead and lamprey populations during adult stages in the ocean and returning to natal streams. Management actions may include establishing quotas for harvest, enforcement against poaching and proper utilization of hatchery fish. Steelhead are most susceptible to poaching during holding periods when they congregate in large numbers in a small number of suitable pools (Stillwater Sciences 2006). Steelhead are typically most susceptible in streams that are more accessible to people. Introduction of hatchery steelhead can result in the loss of genetic diversity and introduction of diseases, both potentially causing reduced fitness and mortality.

Regional and Global Development

Regional and global development resulting in changes to ocean conditions can potentially impact both target species. Increases in water temperature can change the relative distribution and abundance of prey species and/or potential predators for steelhead and lamprey. Reductions in the availability of host/food species can reduce survival and growth for both target species.

A.2 Map Production

This section discusses the sources and associated accuracy of the data used to generate mapped figures as well as many of the quantitative figures in this Profile.

A.2.1 Basemap Production

The Bay Area Aquatic Resources Inventory (BAARI) comprises the main Level 1 data set used to generate the basemap. This data set consists of three component GIS layers: stream network, wetlands, and riparian functional areas. Other Level 1 data sets included in the basemap are the stormdrain network (published by the Oakland Museum – see below), the watershed boundary (CalWater 2.2.1), and several District data sets: fee title and easements, percolation ponds, and the Lower Coyote Creek Reach data set (note: the location of the District mitigation site shown as a point was estimated as the centroid of Reach 2).

All channels, ditches, stormdrains, open water features, and wetlands are derived from the BAARI (see below). All non-tidal features were mapped at a scale of 1:5,000, while tidal features were mapped at 1:2,500. The minimum mapping unit (mmu) for non-tidal and tidal wetlands was 0.1 and 0.05 hectares, respectively. The mmu for all streams was 50m. The BAARI QAQC process (see below) was applied to the entire BAARI extent.

CRAM survey points and associated data were derived from the CRAM database (California Wetlands Portal, http://www.californiawetlands.net/tracker/). All thresholds represented in the maps were derived from the data analysis section of this report.

A.2.2 Bay Area Aquatic Resources Inventory Description

BAARI is a standardized effort to map all aquatic resource features in the Bay Area, excluding groundwater, using high-resolution (1m) remotely sensed imagery from the National Agriculture Imagery Program (NAIP) and a variety of ancillary data sources, including USGS topographic maps, municipal storm drain layers, DEM-derived hillshade, Google Earth, the National Hydrography Dataset (NHD), and the National Wetlands Inventory (NWI).

The standardized BAARI mapping methodology includes quality assurance and quality control procedures (QAQC) to ensure that the map products meet minimum federal and state standards and are consistent across the region. Part of the BAARI QAQC requires that all data have an error rate less than 15% in a number of quantified parameters. QAQC scores for the Coyote Creek watershed can be found at www.californiawetlands.org. BAARI layers in this figure include the stream network, wetlands, and riparian areas. For detailed information about the BAARI mapping standards and methods visit www.wrmp.org/prop50. All other data were acquired from the Santa Clara Valley Water District and have varying mapping methods and levels of accuracy. To view BAARI data for other regions, see www.californiawetlands.net.

Surface features in the BAARI datasets were developed through interpretation of 2009 aerial imagery along with supporting ancillary datasets. QAQC of the dataset was also completed with remote sensing techniques. At the time of publication, no follow-up field work was done to ground truth the BAARI datasets. Subsurface stormdrain data incorporated into BAARI for this project are from the Creek and

Watershed Map collection published by the Oakland Museum www.oaklandmuseumofcalifornia.net/creeks. Data for this map collection were collected by William Lettis and Associates (WLA). Site-specific management questions should be supported by site verification of these data.

Figures 2-3 and 2-4 are based on the Riparian Area Mapping Tool (RAMT). RAMT is a part of the BAARI mapping methodology. It is VBA script model that calculates riparian functional width based on the BAARI data -- stream network and/or wetland boundaries plus vegetation and slope information. RAMT assigns both a left and right slope and vegetation value to each segment of the drainage network (length of channel between confluences or between them and a channel endpoint). RAMT creates a riverine polygon layer based on heads-up (on-screen) digitizing of drainage network midlines, plus polygons of channel area based heads-up digitizing of channel banks when they are visible or user-selected standard channel widths. Channel origins are modeled as variable water source areas. A similar approach is used to map wetlands riparian areas except only the upland side of a wetland is considered and wetlands lack source areas or origins.

The accuracy of RAMT outputs depend on the accuracy of the data inputs. Model inputs for modern riparian widths were from the following sources: stream network (BAARI); vegetation data (California Department of Forestry and Fire); and slope data (US Geological Survey (USGS) 10 meter National Elevation Dataset (NED)). Historical riparian widths were also calculated using the BAARI riparian model. Data inputs to the model included the historical stream network (Coyote Creek Historical Ecology Study – Grossinger et al. 2006), slope (US Geological Survey [USGS]), and vegetation (Coyote Creek Historical Ecology Study – Ibid).

Due to the automated methodology and reliance on input data from various sources, there is an expectation of some error in the riparian model output. The biggest source of error is the vegetation input data. The best available data are dated and more coarse than desired. Visual comparison between the output and aerial imagery, suggests the error is not substantial, although it has not yet been quantified. The calculated (modeled) riparian functional widths are well within the range of locally observed values.

The historical stream network was reconstructed in a GIS for the valley based on interpretation of historical records including maps, land grants, and court documents. Some validation from historical aerial photography was also conducted. The historical maps represent a time period just prior to European settlement.

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