

#### 4.14 PHABSIM Study Plan

This Physical Habitat Simulation (PHABSIM) Study Plan was developed at the direction of the Aquatic TWG to address a portion of the overall plan for instream flow evaluation of the Upper American River Project. An “overarching” instream flow plan is currently in development. This PHABSIM plan provides a description of methodological details associated with site selection, field data collection, and analysis in reaches where PHABSIM has already been identified as an appropriate tool for evaluation of flow and habitat relationships. This independent plan has been developed to facilitate timely start-up of field data collection activities, and includes some background on the decision making process for arriving at the proposed study reaches.

##### 4.14.1 Pertinent Issue Questions

This PHABSIM Study Plan is directed toward the following Aquatic Issue Questions:

20. “What effect do flows have on species during critical life stages?”
36. “What are the limiting features of a natural (unimpaired/pre-project) hydrograph on aquatic species?”
37. “Are the minimum stream flows defined under the existing license adequate for protecting aquatic resources?”

##### 4.14.2 Background

Instream flows in the Upper American River Drainage have been altered by the construction and operation of the Project. In general, flows in many of the reaches during the spring period have been reduced due to storage at the reservoirs, while late summer/early fall flows have been supplemented by releases from the reservoirs. There has been concern expressed that current instream flow release requirements may be adversely affecting the fish populations, amphibians, and other aquatic species and their habitats in the Project area.

This study plan focuses on developing the information necessary to make aquatic resource decisions regarding flow in Project-affected stream reaches. Where applicable and resource values warrant, the Instream Flow Incremental Method (IFIM) is proposed, along with use of the associated PHABSIM System models. This approach provides a quantitative estimate of habitat conditions over a range of flows, and can be useful for evaluating potential flow regime effects on aquatic resource habitats. There are, however, limitations to the use of PHABSIM models. The stream reaches to be evaluated must be modelable with PHABSIM programs, which requires that certain assumptions be met regarding channel stability, flow characteristics (including sub-critical flow velocities) and associated channel gradient, predictable stage-discharge relationships, etc. An overarching consideration in identifying reaches warranting specific instream flow studies are the assumptions that 1) project operations have or are capable of influencing the quantity and/or quality of flow within a specific reach, 2) flows are controllable, and 3) controllable flows and existing minimum instream flow requirements are potentially limiting aquatic resource productivity. If the assumptions are unmet, as for example they would be for headwater streams that are above the influence of any project operations, then PHABSIM studies are not warranted. For streams and reaches where the assumptions apply, but constraints in methods application exist due to access or sampling limitations, alternate methods of analysis (or different studies) must be considered. Alternate approaches could include a more biological focus (e.g., emphasizing populations over physical habitat), emphasis on macrohabitat conditions rather than microhabitat, or a hydrologic analysis in lieu of a hydraulic focus.

Because of these sampling considerations, the TWG is applying a phased approach to performing instream flow studies in the Project-affected reaches of river. In general, the use of PHABSIM is emphasized in reaches where it is most appropriate (i.e., “Phase 1” reaches), based on a combination of modeling assumptions and requirements, watershed characteristics, project facility or operational factors, and resource importance. Other tools or analytical approaches to instream flows are proposed in areas where PHABSIM may be inappropriate, or where any studies of flow conditions might best be delayed until after other studies have been completed (i.e., “Phase 2” reaches). For amphibians and other aquatic biota, a more site-specific approach may be utilized at known sites or ideal habitat sites for their reproductive activities.

Instream flow studies to assess potential effects of flow regimes on aquatic resources have previously been conducted in the South Fork Rubicon River (EA 1982). In addition, the South Fork American River downstream of the Silver Creek confluence was included in an IFIM study conducted several years ago for the El Dorado Project (Payne 2000). Pages E3-23 through E3-30 of SMUD's Initial Information Package (SMUD 2001) summarize other current information regarding the aquatic resources in the UARP affected reaches.

Due to the different nature of the flow regime and facilities in the reach below Chili Bar Dam, it is being addressed in a separate study plan.

#### 4.14.3 Study Objectives

The PHABSIM study objectives are to:

- 1) Describe existing habitat conditions for target fish, and other aquatic species in the Project-affected stream reaches as defined in Table 1, particularly indicator species.
- 2) Determine the effects of existing streamflows on target fish, and other aquatic species in Project-affected stream reaches.
- 3) Evaluate aquatic habitat suitability in relation to a range of flows associated with the UARP project.
- 4) Identify any flow related constraints to critical life stages of target species.

#### 4.14.4 Study Area

The study area will include all Project-affected stream reaches as described in Table 1.

The suitability of each particular reach for inclusion in the instream flow study using the PHABSIM models is dependent on several factors. These factors include the following, among others: 1) availability of upstream storage and/or control (see Table 1), 2) length of the reach (see Table 1), 3) hydraulic modelability of the reach, 4) reach responsiveness to flow changes, 5) potential for controllable flows to be a limiting factor, 6) safety and accessibility of sites for study, and 7) constraints on access to sites or execution of field tasks.

The reaches listed in Table 1 were evaluated against the following sequential criteria to determine their suitability as "Phase 1" sites for PHABSIM analysis in the instream flow study.

Limited upstream control at Rubicon Reservoir restricts flow management actions in the Rubicon River Reach, Rubicon Tunnel Outlet Reach, Rockbound Dam Reach, and Buck Island Dam Reach. In addition, the Rubicon Tunnel Outlet Reach (a constructed channel) and Rockbound Dam Reach are quite short.

The Gerle Creek Dam Reach may also be too short to warrant an independent PHABSIM analysis, and may be able to be evaluated using data from upstream or downstream areas, or from other studies (e.g., fish population, invertebrates). On June 17, 2002 the Aquatic TWG decided to defer on a determination of PHABSIM suitability until after additional information on habitat mapping and fish populations is developed for this reach. In March 2003, the Aquatic TWG subsequently agreed to include a few transects in this reach to supplement a larger study site below the confluence of Gerle Creek and South Fork Rubicon River.

Reach Number	Reach	Length (mi)	Upstream Reservoir Capacity (ac-ft)	Comments
1	Rubicon Dam	5.7	1,435	Rubicon River downstream of Rubicon Reservoir. Reach extends to confluence with Miller Creek. Reservoir capacity limits downstream flow control during part of the year. Study constraints include wilderness area at upstream end of reach.
2	Rubicon Tunnel Outlet Reach	0.3	N/A	Outlet channel from Rubicon Tunnel. Reach extends to Rockbound Lake. Receives "pass-through" flow from Rubicon Reservoir during high flow periods when reservoir elevation exceeds tunnel elevation, but does not draw on "stored" water. May stay wet during non-diversion periods due to inlet leakage and/or groundwater accretion in tunnel.
3	Rockbound Dam Reach	0.3	N/A	Little Rubicon River between Rockbound Lake and Buck Island Reservoir. Rockbound Lake has no releasable storage capacity.
4	Buck Island Dam	3.0	1,070	Little Rubicon River downstream of Buck Island Reservoir. Reach extends to confluence with Rubicon River. Reservoir capacity limits downstream flow control during part of the year.
5	Loon Lake Dam	8.5	76,200	Gerle Creek downstream of Loon Lake. Flow control in the reach. No major study constraints.
6	Gerle Creek Dam	1.2	1,260	Gerle Creek downstream of Gerle Reservoir. Reach extends to confluence with South Fork Rubicon River. Flow control in the reach. No major study constraints.
7	Robbs Peak Dam	5.6	30	South Fork Rubicon River downstream of Robbs Peak Reservoir. Reach extends to confluence with Rubicon River. Robbs Peak Reservoir is a headwater forebay that receives most of its flow from Gerle Creek. Flow control in the reach. No major study constraints at upper end of reach. Lower portion of the reach is too steep and confined for safe access.
8	Ice House Dam	11.5	45,960	South Fork Silver Creek downstream of Ice House Reservoir. Flow control in the reach. No major study constraints.
9	Junction Dam	8.3	280,540*	Silver Creek downstream of Junction Reservoir. Flow control in the reach. Access limited.
10	Camino Dam	6.2	825	Silver Creek downstream of Camino Reservoir. Flow control in the reach. Access limited.
11	S.F. American River Reach	2.8	N/A	S.F. American River from Silver Creek confluence to Slab Creek Reservoir. PHABSIM study in this reach previously conducted for the EID project. Limited flow control in the reach, due to South Fork American River flows. Access limited.
12	Brush Creek Dam	2.2	1,530	Brush Creek downstream of Brush Creek Reservoir. Flow control in the reach. Safe access limited by high (over 9%) gradient.
13	Slab Creek Dam	8.0	16,600	S.F. American River downstream of Slab Creek Reservoir. Flow control in the reach.

\*Includes storage in Union Valley Reservoir

Criteria No.	Criteria	Reaches That Meet Criteria
1	Are flows in the reach affected by project facilities?	All
2	Is there sufficient upstream control of flows in the bypass reach?	Loon Lake Dam, Gerle Creek Dam, Robbs Peak Dam, Ice House Dam, Junction Dam, Camino Dam, S.F. American River, Brush Creek Dam, Slab Creek Dam
3	Is the reach sufficiently long (e.g., >2 miles) relative to the total miles of project affect streams to merit an independent analysis of flow/habitat relationships?	Loon Lake Dam, Robbs Peak Dam, Ice House Dam, Junction Dam, Camino Dam, S.F. American River, Brush Creek Dam, Slab Creek Dam
4	Is the majority of habitat in the reach sufficiently low gradient to be modelable, responsive to flow changes, and safely accessible for study?	Loon Lake Dam, upper portion of Robbs Peak Dam, Ice House Dam, Junction Dam, Camino Dam, S.F. American River, Slab Creek Dam

Portions of the Robbs Peak Dam Reach are too steep to be suitable for PHABSIM analysis, but other portions may be suitable. On June 17, 2002 the Aquatic TWG decided to defer on a determination of PHABSIM suitability until after additional information on habitat mapping and fish populations is developed for this reach. Since that time, aerial habitat mapping and ground reconnaissance have identified the upper portion of the reach (below the Gerle Creek confluence) as sufficiently low gradient and accessible to be potentially suitable for PHABSIM analysis. In March, 2003, the Aquatic TWG agreed to establish a PHABSIM site below the Gerle and South Fork Rubicon River confluence, with a few transects placed on the South Fork Rubicon River above the Gerle Creek confluence.

Much of the Brush Creek Dam Reach is over 9% gradient, and expected to be dominated by stream habitat types that are either unmodelable or unresponsive to flow change (e.g., cascades, high gradient riffles, deep pools). Habitat mapping of safely accessible portions of the reach is being considered to provide information about the suitability of the reach for application of PHABSIM methods. A site visit to the area by Aquatic TWG members will be conducted prior to any final decisions about analysis of this reach.

Reaches that met each of these criteria were, after discussion with the Aquatic TWG, identified as "Phase 1" reaches that would be most suitable for application of PHABSIM. Other reaches were considered "Phase 2" reaches where additional information such as habitat mapping data, fish survey results, or hydrologic data would be required before an assessment could be made of the suitability of the reach for PHABSIM analysis.

Based on review of topographic maps, hydrologic information, and videotape coverage of the river and canyon, reaches 9 (below Junction Dam) and 10 (below Camino Dam) are potentially similar enough in terms of channel characteristics and flow regime to be combined into one study reach. In addition, instream flow data has already been collected for the S.F. American River Reach. Thus, Phase 1 study reaches that are being considered for application of PHABSIM analysis include the following.

- Loon Lake Dam Reach (Gerle Creek downstream of Loon Lake)
- Gerle Creek Dam Reach (a few transects on Gerle Creek downstream of Gerle Reservoir)
- Robbs Peak Dam Reach (upper portion, S.F. Rubicon River downstream of the Gerle Creek confluence; and a few transects in the uppermost section above the Gerle Creek confluence)
- Ice House Dam Reach (South Fork Silver Creek downstream of Ice House Reservoir)
- Junction Dam and Camino Dam Reaches (Silver Creek downstream of Junction Reservoir and Camino Reservoir).
- Analysis of South Fork American River downstream of Silver Creek confluence.
- Slab Creek Dam Reach (S.F. American River downstream of Slab Creek Reservoir)

Certain of these reaches may require sub-reach delineation and evaluation. Sample locations will be proposed on the basis of results of the habitat mapping task (described below), input from the hydrology and geomorphology tasks, and consideration of safety and accessibility.

Reaches that are not currently considered suitable for a Phase 1 PHABSIM analysis (Rubicon Dam, Rubicon Tunnel Outlet, Rockbound Dam, Buck Island Dam, Brush Creek Dam) would be evaluated in Phase 2 after review of other study results (such as habitat mapping, fish populations, geomorphology, etc.), and are candidates for using alternative methods to PHABSIM. Alternative habitat evaluations could include review of physical habitat data from the habitat mapping task (including barriers, spawning gravel availability, stream size, habitat type, etc.), hydrologic regime evaluation, and/or biological data (fisheries, amphibian, riparian, invertebrates) assessment to provide an assessment of instream flow needs and opportunities.

#### 4.14.5 Information Needed From Other Studies

The following information will be used in conjunction with the PHABSIM studies:

- Hydrology (mean monthly flows; reach –specific project operations: existing and proposed)
- Channel Morphology (identification of response reaches, channel condition, channel morphology, substrate characteristics, etc.)
- Habitat Mapping (extent and distribution of major habitat types at base flows; identification of critical habitats)
- Fish Surveys (species composition and distribution; life stage periodicities)

#### 4.14.6 Study Methods And Schedule

Although specific methods and data collection techniques may vary by stream/reach/sub-reach, the following methods will generally be applied as part of Phase 1 PHABSIM studies:

- A) HABITAT MAPPING: Habitat types (i.e., pool, riffle, run, pocket water) and other characteristics (e.g., spawning habitat, pool depth, fish barriers, etc.) found in Project-affected stream reaches have been quantified using a combination of on-the-ground field surveys, low-level helicopter overflights, and aerial photographs combined with ground truthing, under normal summertime conditions. Mapping has been conducted for all Project-affected stream reaches, whether they are proposed for Phase 1 PHABSIM analyses or not.
- B) STUDY SITE IDENTIFICATION: Study sites will be established in a stepwise process, following guidelines from Bovee (1982). In the first step, each project reach will be reviewed for possible segmentation into subreaches. Subreach segmentation will be based primarily on changes in stream gradient (associated with geomorphic condition) and/or hydrology that may cause habitat types in one subreach to display significant hydraulic differences from the same habitat type in another subreach (e.g., low gradient riffles in one subreach have consistently greater depth or velocity than low gradient riffles in another subreach). Stream gradient will be determined using a GIS system and displayed as a longitudinal profile of elevation versus river mile within each reach. Hydrology will initially be based on the presence of significant tributary inflow within the reach. In the second step, areas for potential study sites will be identified that contain the full complement of necessary (representative) habitat unit types in a safely accessible section of stream. Within these areas, study sites will be established by randomly selecting a starting habitat unit. Candidate site locations will be identified and marked on reach maps/aerial photos and provided to the TWG for review. From the starting habitat unit, transects will be established in adjacent units (heading upstream or downstream) until the requisite transects are placed in the specified habitat units, as described below.
- C) TRANSECT SELECTION
- Select representative transects based upon percentage of existing major habitat type (e.g., length >10 -15% of reach) in the identified Project-affected stream reaches. Major habitat types include riffles, runs, pools, and pocket water. Candidate site locations will be identified and marked on reach maps/aerial photos and provided to the TWG for review.
  - Establish sufficient transects to model *approximately* three replicates of each major habitat type in each reach or subreach (the number of replicates may be modified based on the frequency of the habitat types, the amount of variation observed between habitat types, and/or any subreach segmentation). Up to three transects per habitat replicate will initially be considered, with the assumption that hydraulically homogeneous habitat types (i.e., riffles and runs) will require relatively fewer transects per replicate and relatively heterogeneous habitat types (i.e., pools and pocket water) will require relatively more transects per replicate. The final number of transects proposed for each site will depend on habitat complexity as well as target resource values. Actual transect selection will be completed as a collaborative field effort that includes members of the TWG. Transects will be placed in a stratified random manner, subject to professional judgment, with participation and concurrence of agencies and NGOs. All decisions and rationale on the number and placement of transects will be fully documented.

- “Critical” habitat transects may be placed, where warranted, in sensitive or critical habitat areas in order to analyze specific habitat/flow conditions at a desired (not random) location. The applicability, usefulness, and cost-effectiveness of two-dimensional modeling or other methods in such areas would be considered.
- Potential spawning habitat areas would be considered for alternative habitat assessment approaches, since transect and/or random placement methods are frequently inadequate for this type of habitat.

#### D) FIELD METHODS

- Conduct instream flow studies using established IFIM techniques (Bovee and Milhous 1978; Bovee 1982).
- A total of three calibration flows and associated water surface elevations will be collected per transect. Establishment of high flow calibration measurements will be limited by safety considerations. Velocity calibration at each transect will be conducted at the highest flow that is safely workable.
- Target calibration flows will be selected with the goal of having relatively even spacing of flows along a log scale, starting from the current minimum flow up to the greater of: a) approximately 4-5 times the current minimum flow (subject to safety considerations and feasibility), or b) 10-20 cfs. Suggested target calibration flows are listed in Table 3 (prior to finalizing target calibration flows, unimpaired hydrology and other factors will be reviewed). These ranges are operationally feasible, allow for some overlap of hydraulic predictions from each calibration data set, and concentrate the data collection on flow ranges where future flow regime discussions are likely to be focused. They also maximize the potential to make velocity calibration measurements at the highest flow.
- Field data collection will not enable prediction of weighted usable area during high spring flood conditions or during periods of spill. These magnitudes of flows will need to be evaluated separately.
- Study sites will be established with permanent benchmarks and transect endpoints. Transect survey points will include some additional measurements above the bank-full elevation to facilitate geomorphic analyses, and ensure that headpins are located above the water surface of the highest modeled flow. Benchmark and transect locations will be recorded with a GPS, where feasible.
- Transect cross section profiles will include closely spaced measurements in wetted areas, and in out-of-water areas with breaks in slope.
- Surveying level loops will be closed among closely grouped transects, and tied to a common benchmark.
- Velocity measurements will typically be made with electronic Marsh-McBirney flow meters, with measurements recorded at 0.6 or 0.8/0.2 of the total depth.
- Photos or video will be taken of each transect at each calibration flow.

- E) HYDRAULIC MODELING: PHABSIM models (Milhous et al. 1989) will be run for several life stages and species, based on the results of the fish surveys. The program IFG-4 will be used for hydraulic simulation using one velocity calibration flow. Other hydraulic models may be considered, depending on site conditions, but field data collection will be conducted to support an IFG-4 model.

Table 3. Proposed target calibration flows for Phase 1 PHABSIM Study Reaches <sup>1</sup>									
Reach	Stream	Current Minimum Flow	Low Flow		Middle Flow		High Flow		Dam outlet capacity
		(cfs)	(cfs)	(log)	(cfs)	(log)	(cfs)	(log)	
Loon Lake Dam	Gerle Creek	8	<b>8</b>	<i>0.90</i>	<b>18</b>	<i>1.26</i>	<b>40</b>	<i>1.60</i>	41
Ice House Dam	S.F. Silver Creek	3-15	<b>5</b>	<i>0.70</i>	<b>15</b>	<i>1.18</i>	<b>45</b>	<i>1.65</i>	47
Junction/Camino Dam	Silver Creek	5-20	<b>10</b>	<i>1.00</i>	<b>32</b>	<i>1.51</i>	<b>100</b>	<i>2.00</i>	112
Slab Creek Dam	S.F. American River	10-36	<b>36</b>	<i>1.56</i>	<b>74</b>	<i>1.87</i>	<b>150</b>	<i>2.18</i>	263
Gerle Creek Dam	Gerle Creek	4-7	<b>4 or 7<sup>a</sup></b>	<i>0.60 or 0.85</i>	<b>8 or 10<sup>a</sup></b>	<i>0.90 or 1.00</i>	<b>14</b>	<i>1.15</i>	14
Robbs Peak Dam	S.F. Rubicon River abv Gerle	1-3	--	--	<b>4<sup>b</sup></b>	--	--	--	4
Robbs Peak Dam	S.F. Rubicon River blw Gerle	5 - 10	<b>5 or 10<sup>a</sup></b>	<i>0.70 or 1.00</i>	<b>10 or 14<sup>a</sup></b>	<i>1.00 or 1.14</i>	<b>18</b>	<i>1.26</i>	18

<sup>1</sup>Log values are presented to aid in evenly spacing the target flows along the log scale that water surface and discharge relationships are computed.

<sup>a</sup>Dependent upon water year type requirements for minimum flow.

<sup>b</sup>One flow measurement only.

F) HABITAT ANALYSIS: The program HABTAV will be used for calculation of weighted usable area, based on output from the hydraulic simulation model and use of appropriate habitat suitability criteria. Weighted usable area versus flow curves will be generated for each river reach/sub-reach. A time series analysis will be conducted for summer, fall, and where possible, winter flows based on a monthly time step. The time series analysis will compare WUA by month under natural versus regulated flow regimes for different water year types.

Data tables and figures will be prepared that present the WUA versus flow curve coordinates by reach, including WUA by separate habitat types.

Proposed target species for the habitat analysis will include but are not limited to hardhead, rainbow trout, brown trout in Gerle Creek, since these species are USFS Management Indicator Species or USFS sensitive species, and the primary management species of interest for CDFG. Target species will be identified on a reach-specific basis.

G) HABITAT SUITABILITY CRITERIA: Selection of habitat suitability criteria (HSC) will continue to be discussed with the Aquatic TWG, and final criteria will be used with the hydraulic modeling results.

Additional consultation with the TWG will be necessary to review habitat mapping results, review reach-specific scoping activities, select study sites and target flows, and select transect locations. The study plan needs to be finalized in early 2003 in order to facilitate transect selection and possible initiation of Phase 1 fieldwork in spring

2003. Hydraulic data collection would begin in Spring 2003. Data analysis would occur in Fall 2003 through Winter 2004.

#### 4.14.7 Analysis

Analytical tasks will include a description of existing aquatic habitat in the Project-affected stream reaches. The information from the habitat mapping will be used for a variety of purposes, including determination of transect weighting for PHABSIM transects. Information from the Fisheries Surveys will be used to describe current fish species population presence and distribution in the Project-affected stream reaches, which will aid in selection of appropriate indicator species in each reach. Hydraulic models (PHABSIM) will be calibrated to established protocols. The PHABSIM modeling results and associated transect weighting will be combined with approved HSC curves into HABTAV program to generate Weighted Usable Area (WUA) curves for the species and life stages of interest. A set of time series tables and graphs will be generated on a monthly time step (by water year type) to depict WUA habitat values on a monthly basis under various low-to-moderate flow regimes (no attempt will be made to estimate WUA under very high, or spill, flow conditions).

#### 4.14.8 Study Output

The output of the PHABSIM study will be a written report that includes a description of the issue question(s) addressed, objectives, study area, methods, analysis, and results. The output for this study will also include PHABSIM analysis and results, weighted usable area (WUA), and time series curves for species and life stages of interest. The habitat time series analysis results will be displayed in both graphic and tabular form, including the results from Payne (2000). It is expected that the report will be prepared by early 2004, and be prepared in a format that can be directly incorporated into the Licensee's draft environmental assessment that will be submitted to FERC with the Licensee's application for a new license.

#### 4.14.9 Preliminary Estimated Study Cost

A preliminary estimated study cost will be prepared after the TWG approves the plan and prior to submittal to the Plenary Group.

#### 4.14.10 TWG Endorsement

The Aquatics TWG approved this plan on April 22, 2003. There were no participants at the meeting who indicated they could not "live with" this plan. The Plenary Group approved the plan on May 7, 2003. The participants at the meeting who said they could "live with" the study plan were: Taxpayers of EDC, Friends of EDC, ENF, Camp Lotus/ARRA, EDC Water Agency, SMUD, PG&E, EDC Citizens for Water, Placer County Water Agency, NPS, California Outdoors, City of Sacramento and Paul Helman. None of the participants at the meeting said they could not "live with" the study plan.

#### 4.14.11 Literature Cited

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