

Draft Proposed CVPIA Science Integration Team Monitoring Guidelines

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Project-related monitoring

Rather than specify a one size fits all monitoring guidelines for CVPIA restoration projects, we propose tiers of monitoring for ongoing or proposed restoration activities based on the degree of uncertainty reduction. Ideally, a subgroup of the SIT with technical expertise and the Science Coordinator would review proposed or ongoing CVPIA restoration activities and place them into categories based on the potential of each project to reduce key uncertainties. These categories would map into monitoring tiers each with increasing levels of detail, effort, and costs. Here we propose three tiers with the lowest, *minimum expected effort*, that includes monitoring that all restoration-related projects would have to complete. The next two tiers *moderate effort* and *high effort* monitoring that would provide more information targeted at reducing key uncertainties. Below, we propose the following monitoring specifications for three tiers for five potential restoration actions that have been identified by the SIT.

Spawning habitat restoration

MINIMUM EXPECTED

Physical feature monitoring

One pre-action and post action surveys that quantify existing spawning habitat at project site at range of flows experienced during spawning. Monitoring data should include expected amount of habitat created (pre-action), date of measurement, discharge, and estimated spawning habitat available. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of habitat added per charter and partial controllability, some information on stage-habitat relationships.

Biological monitoring

One pre-action and post action surveys that quantify the number of spawning adults (or redds) using the project site on several occasions during the spawning season to estimate peak spawning counts. The dimensions of a random selection of redds should be measured on at least one occasion. Monitoring data should include date of measurement, discharge, and water temperature during spawning, redd counts in the restoration area,

and the dimensions of the randomly selected redds. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented and fish spawned the area, better information on redd size and redd distribution within a spawning area (improve the model).

MEDIUM EFFORT

Physical feature monitoring

One year pre-action and a minimum of 5 years post-action surveys that quantify existing spawning habitat at project site at range of flows typically experienced during spawning with the post-action monitoring extending for a minimum of 5 years. Monitoring data should include date of measurement, discharge, and estimated spawning habitat available. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of habitat added per charter and partial controllability, some information on stage-habitat relationships, and information on habitat persistence following restoration.

Biological monitoring

At least 2 years pre-action and 3 years post action surveys that quantify the number of spawning adults (or redds) using the project site and the nearest known spawning locations up and downstream of the project area. Each year, these sites should be visited on several occasions during the spawning season to estimate peak spawning counts. The dimensions of a random selection of redds should be measured on at least one occasion. Monitoring data should include monitoring locations, GPS redd coordinates, date of measurement, discharge, and water temperature during spawning, redd counts, and the dimensions of measured redds. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented and fish spawned the area, better information on redd size and redd distribution with a spawning areas (improve the model), information on the effect of habitat improvement on the distribution of spawners across a range of return sizes (evaluate model assumptions).

HIGH EFFORT

Physical feature monitoring

One year pre-action and a minimum of 5 years post-action surveys that quantify existing spawning habitat at all known or suspected spawning sites (including the project site) in the tributary over a range of flows experienced during spawning with the post-action monitoring extending for a minimum of 5 years. Monitoring data should include georeferenced known or suspected spawning site locations, date of measurement, discharge, and estimated spawning habitat available. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of habitat added per charter and partial controllability, information on habitat availability throughout the tributary and stage-habitat relationships (model input improvement), information on habitat persistence following restoration and at non restoration sites (model improvement).

Biological monitoring

At least 2 years pre-action and 3 years post action surveys that quantify the number of spawning adults (or redds) using the project site and the nearest known spawning locations up and downstream of the project area. Each year, these sites should be visited on several occasions during the spawning season to estimate peak spawning counts. At each location, a random selection of redds should be selected and monitored till fry emergence and the number of emerging fry estimated. Water temperatures should be monitored at each spawning site from the initiation of spawning surveys till fry emergence. Monitoring data should include georeferenced monitoring locations, GPS redd coordinates, date of measurement, and number of fry emerging, date of emergence, and discharge and water temperature during the monitoring period. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented and fish spawned the area, better information on redd size and redd distribution with a spawning areas (improve the model), information on the effect of habitat improvement on the distribution of spawners across a range of return sizes (evaluate model assumptions about

habitat use), information on egg to fry survival (improve the egg-to-fry estimates in the model).

Juvenile rearing habitat restoration (perennially and periodically inundated)

MINIMUM EXPECTED

Physical feature monitoring

One pre-action and post action survey that quantify existing rearing habitat at the project site at range of flows experienced during potential juvenile rearing period (run-specific). Monitoring data should include expected amount of habitat created (pre-action), expected frequency and duration of inundation for periodically inundated habitats, dates of measurement, discharge during measurement, and estimated rearing habitat available. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of habitat added per charter and partial controllability, some information on stage-habitat relationships.

Biological monitoring

One pre-action and post action survey that quantify the number of juvenile fish using the project site on several occasions during the juvenile rearing. The site should be visited on at least 3 occasions during the juvenile rearing period to estimate juvenile fish abundance. The surveys should be conducted using the appropriate American Fisheries Society(AFS) standardized methods (Bonar et al. 2009) and the proper statistical design and estimator to allow the unbiased estimation of the number of juvenile salmonids using each site. Examples of estimators include capture-mark-recapture, mark-resight, and occupancy estimation. Monitoring data should include dates of measurement, discharge during surveys, and water temperature, turbidity, specific conductance, sample unit size, and juvenile abundance (occupancy) estimates (Williams et al 2002, Powell and Gale 2015). Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented and juvenile fish used the area, better information habitat use and habitat capacity (improve the model).

MEDIUM EFFORT

Physical feature monitoring

One year pre-action and a minimum of 5 years post-action surveys that quantify existing rearing habitat at project site over the range of flows typically occurring during juvenile rearing period. Monitoring data should include date of measurement, discharge, and estimated rearing habitat available. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of habitat added per charter and partial controllability, some information on stage-habitat relationships, information on habitat persistence/evolution following restoration.

Biological monitoring

At least 2 years pre-action and 3 years post action surveys that quantify juvenile fish abundance at the project site and the nearest juvenile habitats up and downstream of the project location. Each year, these sites should be visited on at least 3 occasions during the juvenile rearing period to estimate juvenile fish abundance. The surveys should be conducted using the appropriate AFS standardized methods (Bonar et al. 2009) and the proper statistical design and estimator to allow the unbiased estimation of the number of juvenile salmonids using each site. Monitoring data should include dates of measurement, habitat measurement (depth, current velocity, substrate, and cover) at each site, site GPS coordinates, discharge during surveys, and water temperature, turbidity, specific conductance, sample unit size (ha), and juvenile abundance (occupancy) estimates. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented and juvenile fish used the area, better information habitat use and habitat capacity (improve the model), information on the effect of habitat improvement on the distribution of juvenile across a range of juvenile abundances (evaluate model assumptions).

HIGH EFFORT

Physical feature monitoring

One year pre-action and a minimum of 5 years post-action surveys that quantify existing juvenile rearing habitat at the project site and the tributary 0.5km up and downstream of the project site over the range of flows typically occurring during juvenile rearing period. Monitoring data should include georeferenced habitat measurements, date of measurements, discharge during measurements, and estimated juvenile habitat available. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of habitat added per charter and partial controllability, information on juvenile habitat availability throughout the tributary and stage-habitat relationships (model input improvement), information on habitat persistence/evolution following restoration and at non restoration sites (model improvement).

Biological monitoring

At least 2 years pre-action and 3 years post action surveys that quantify, the abundance, survival, and growth of juveniles at the project site the nearest juvenile habitats up and downstream of the project location. Each year, these sites should be visited on at least 3 occasions during the juvenile rearing period to estimate juvenile fish abundance and more frequently to estimate the survival and growth of tagged wild juvenile fish. The surveys should be conducted using the appropriate AFS standardized methods (Bonar et al. 2009) and the proper statistical design and estimator to allow the unbiased estimation of the number of juvenile salmonids using each site, survival and growth. Example of proper estimators include (multistrata) Cormack-Jolly-Seber (survival, growth, movement), open and closed Robust Design (survival, abundance, emigration/immigration), and (multistrata) recapture-resight-recovery models (survival, growth, movement). Williams et al 2002, Powell and Gale 2015). Water temperatures should be monitored at survey site from fry emergence until the end of the rearing period. Monitoring data should include georeferenced monitoring locations, dates of measurement, habitat measurements (depth, current velocity, substrate, and cover) at each site, site GPS coordinates,

discharge during surveys, and water temperature, turbidity, specific conductance, sample unit size (ha), and juvenile survival, growth, and abundance estimates, capture/detection histories and body size measurements for tagged fish and water temperature during the monitoring period. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented and juvenile fish used the area, better information habitat use and habitat capacity (improve the model), information on the effect of habitat improvement on the distribution of juvenile across a range of juvenile abundances (evaluate model assumptions about habitat use), information influence of habitat on juvenile survival and growth (improve the estimates in the model)

Passage improvement (adult or juvenile)

MINIMUM EXPECTED

One pre-action and post action survey that documents the existence and removal/modification of the passage obstruction. If flow related passage obstruction, monitoring should include at least 3 discharge measurements during the migration/movement period. Monitoring data should include before and after measurements of passage structure (if applicable), discharge during measurements, and dates of measurement. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of charter success and partial controllability.

Biological monitoring

One pre-action and post action survey that quantifies the number of fish passing the obstruction. The site should be visited on at least 3 occasions during the movement/migration period to estimate the number of fish passing the obstruction. Monitoring data should include dates of measurement, method for estimating fish passage, discharge during surveys, and estimates of the number of fish passing over a 24-h period. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented and fish passed the obstruction, better information on fish passage (improve the model).

MEDIUM EFFORT

Physical feature monitoring

One year pre-action and a minimum of 2 years post action surveys that documents the existence and removal/modification of the passage obstruction and estimates spawning and/or rearing habitat availability under base flow conditions upstream of the obstruction. If flow related passage obstruction, monitoring should include at least 3 discharge measurements during the migration/movement period. Monitoring data should include before and after measurements of passage structure (if applicable), estimates of habitat availability upstream of the obstruction under base flow, discharge at obstruction, discharge during habitat surveys, and dates of surveys. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of charter success and partial controllability, estimates of habitat availability and stage-habitat relationships (model input improvement)

Biological monitoring

One year pre-action and a minimum of 2 years post action surveys that quantify the number of fish passing the obstruction and documents the use of habitats upstream of the passage barrier. The restoration site should be visited on at least 3 occasions during the movement/migration period to estimate the number of fish passing the obstruction. Spawning ground surveys should be conducted to quantify the number of spawning adults (or redds) using the areas above the obstruction. Each year, potential spawning locations should be visited on several occasions during the spawning season to estimate peak spawning counts. Juvenile fish sampling should be conducted in a random selection of a minimum of 10 juvenile habitats using the appropriate AFS standardized methods (Bonar et al. 2009) and the proper statistical design and estimator to allow the unbiased estimation of the number of juvenile salmonids using each site. Monitoring data should include dates of measurement, method for estimating fish passage, discharge during surveys, and estimates of the number of fish passing over a 24-h period habitat measurement (depth, current velocity, substrate, and cover) at each site, peak red counts,

site GPS coordinates, discharge during surveys, and water temperature, turbidity, specific conductance, sample unit size (ha), and juvenile abundance (occupancy) estimates. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented and fish passed the obstruction, better information on fish passage (improve the model), better information on redd size and redd distribution with a spawning areas (improve the model), information on the effect of habitat improvement on the distribution of spawners across a range of return sizes (evaluate model assumptions), better information habitat use and habitat capacity (improve the model), information on the effect of habitat improvement on the distribution of juvenile across a range of juvenile abundances (evaluate model assumptions)

HIGH EFFORT

Physical feature monitoring

One year pre-action and a minimum of 3 years post action surveys that documents the existence and removal/modification of the passage obstruction and estimates spawning and rearing habitat availability under a range of stream discharges upstream of the obstruction. If flow related passage obstruction, monitoring should include at least 3 discharge measurements during the migration/movement period. Monitoring data should include before and after measurements of passage structure (if applicable), estimates of habitat availability upstream of the obstruction a range of flows that typically occur during spawning and rearing periods, discharge at the obstruction, discharge during habitat surveys, and dates of surveys. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of charter success and partial controllability, estimates of habitat availability and stage-habitat relationships (model input improvement)

Biological monitoring

One year pre-action and a minimum of 3 years post action surveys that estimates the probability of passage and survival above and below the barrier. To estimate passage and survival, each year at least 20 adults (downstream of obstruction) and/or 50 juvenile fish

(upstream) should be tagged with passive integrated transponder (PIT) or similar tags using the appropriate method. Adults should be tagged as soon as they arrive to the tributary. Juveniles should be tagged in natal habitats as soon as they are of sufficient size to handle the tag burden. Dual tag reader arrays should be installed above and below the previous obstruction and continuously monitored for the duration of the monitoring period. Spawning ground surveys should be conducted to locate tagged adults. Survival and movement should be estimated using the proper estimator such as multistrata Cormack-Jolly-Seber and multistrata recapture-resight-recovery models (Williams et al 2002, Powell and Gale 2015). Water temperatures should be monitored at the project site throughout the duration of the monitoring effort. Monitoring data should include georeferenced fish capture and relocation (adult carcasses) locations, dates of sampling, site GPS coordinates, adult and juvenile survival and movement estimates, capture/detection histories for tagged fish, and water temperature during the monitoring period. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented and fish passed the obstruction, better information on fish passage (improve the model), better information of adult en route survival and migratory patterns and juvenile survival and movement and timing (improve the model)

Screen/reduce water diversion

MINIMUM EXPECTED

One pre-action and post action survey that documents the existence and addition/modification of screen. If action is reduction in amount of water diverted, measure stream discharge on at least 3 occasions above (0.5 km) and below (0.5 km) the diversion during the time period of the diversion reduction. Up and downstream discharge measurements should be conducted within the same 12h period. Monitoring data should include before and after documentation of screening (if applicable), discharge (if applicable), and dates of measurement. Discharge estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of charter success and partial controllability.

Biological monitoring

One year pre-action and post action surveys that detect entrainment by the diversion if screening was the action. The survey should be sufficient to detect entrainment with a 90% probability both pre- and the post-screening during the juvenile fish rearing and migration period. If reduction in water diversion, no minimum monitoring is required. Monitoring data should include dates of measurement, method for estimating probability of detecting entrainment event during surveys, and discharge during surveys. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented and fish entrainment was prevented, better information on entrainment (improve the model).

MEDIUM EFFORT

Physical feature monitoring

One pre-action and post action survey that documents the existence and addition/ modification of screen if applicable. If action is reduction in amount of water diverted, measure stream discharge continuously above (0.5 km) and below (0.5 km) the diversion during the period of the diversion reduction. Monitoring data should include before and after documentation of screening (if applicable), discharge (if applicable), and dates of measurement. Discharge estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether charter was successfully implemented, better estimates of charter success and partial controllability, estimates of increased water availability due to diversion reduction (model input improvement)

Biological monitoring

One year pre-action and a minimum of 2 years post action surveys that quantifies the number of fish entrained over a 7-day period if screening action. The survey should be sufficient to estimate weekly entrainment rate with 90% precision during the juvenile fish rearing and migration period. If action is reduction in water diversion, no minimum monitoring is required. Monitoring data should include dates of measurement, method for

estimating entrainment rate, and discharge during surveys. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether a charter was successfully implemented and fish entrainment was prevented, better information on entrainment (improve the model), quantitative estimates of entrainment from unscreened diversions (improve the model)

HIGH EFFORT

Physical feature monitoring

No high effort monitoring for this action

Biological monitoring

Two years pre-action and a minimum of 3 years post action surveys that survival in the reach spanning 0.5 km upstream and downstream of the diversion. To estimate survival, each year at least 100 juvenile fish should be tagged in areas > 0.5 km upstream of the diversion with passive integrated transponder (PIT) or similar tags using the appropriate method. Juveniles should be tagged in natal habitats as soon as they are of sufficient size to handle the tag burden. Dual tag reader arrays should be installed at the up and downstream boundaries of the 1km study reach and the diversion, and monitored for the duration of the monitoring period. Survival and movement should be estimated using the proper estimator such as multistrata Cormack-Jolly-Seber and multistrata recapture-resight-recovery models (Williams et al 2002, Powell and Gale 2015). Water temperatures should be monitored at the project site throughout the duration of the monitoring effort. Monitoring data should include georeferenced fish capture locations, dates of sampling, site GPS coordinates, juvenile survival and movement estimates, capture/detection histories for tagged fish, and water temperature during the monitoring period. Estimates must include a quantitative measure of precision such as a variance or standard error.

Information gain: establish whether a charter was successfully implemented and fish entrainment was prevented, better information on entrainment (improve the model), quantitative estimates of the changes in survival associated with screening or reduction in diversion (improve the model)

Literature cited

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