

Solstice Creek Field Review: Results and Recommendations

Santa Monica Mountains National Recreation Area

March 6, 2002

Randy Klein, Hydrologist, Redwood National and State Parks
Brannon Ketcham, Hydrologist, Point Reyes National Seashore
Bill Jackson, Water Resource Division, Fort Collins, Colorado
Chad Moore, Earth Scientist, Pinnacles National Monument

INTRODUCTION

On February 5 and 6, 2002, field review and discussions were held regarding the fluvial geomorphic effects of modifying and removing a number of fish migration barriers on the main channel of Solstice Creek near Malibu California. The project area encompasses NPS lands within Santa Monica Mountains National Recreation Area (SAMO) as well as state and Los Angeles County lands and facilities at the downstream end. SAMO staff Gary Busted, Dana Heiberg, and Ray Sauvajot participated in the review, along with the authors of this report. Representatives of several other agencies (Caltrans, California Coastal Conservancy, Los Angeles County Resources Conservation District) were also there to participate in the review.

The reach reviewed extended from the creek's mouth at the Pacific Ocean upstream to a former residence called Tropical Terrace, a channel distance of about 1.8 stream miles. A natural migration barrier (waterfall) at the Tropical Terrace site defines the upper limit of the project area. We visited and evaluated 10 structures within the project reach that would be difficult or impossible for steelhead to negotiate to gain access to upstream spawning areas. The structures consist of: 1) a large, smooth-bottomed culvert beneath the Pacific Coast Highway (PCH) at the creek's mouth; 2) a similar type, but newer culvert on Corral Canyon Road, a county road just upstream of the PCH; 3) an 'Arizona Crossing' (concrete-lined ford) that the NPS plans on replacing with a bridge later this year (described in an environmental assessment (NPS, 2001)); 4) three additional Arizona Crossings farther upstream; and 5) four old stone dams, one of which has failed but still influences the channel. In addition, we reviewed and discussed a proposed streambank erosion control and road buttressing project, and riparian/aquatic habitat considerations.

SOLSTICE CREEK AND WATERSHED DESCRIPTION

Solstice Creek drains about 4.4 mi² of steep terrain in the Santa Monica coastal mountains. It flows through Solstice Canyon to the Pacific Ocean at Dan Blocker State Beach in Malibu. Development in the watershed is concentrated in the lower reaches along the PCH. Much of the watershed above the PCH is only minimally affected by historical development, and now that it lies within the park, will remain so except for a few park facilities (a small visitor center, trails, and a few roads).

Underlying geologic structure (e.g., faults and unit contacts) exerts some control on channel alignment and slope, causing knickpoints at several locations where the channel crosses over relatively hard rock and jogs in channel alignment along faults. A gentler reach bounded by a relatively wide valley bottom is located from about the visitor contact center upstream for about 0.3 miles. Upstream and downstream of this reach, the channel is steeper, more confined, and has coarser bed material.

The creek is fairly steep, with gradients in the lower reaches (downstream of the Tropical Terrace site) ranging from about 2-6% and averaging about 4%. Bed material consists of a wide range of particle sizes, from small sand deposits to large boulder sets. Except for reaches immediately upstream from local grade controls (dams, Arizona Crossings), recent downcutting on the order of about 1-2 feet was apparent. Episodic, large magnitude mud and debris flows that occur in response to wildfire are a dominant geomorphic process in the area. Recently eroded fill terraces adjacent to the channel were observed in several locations along the reach reviewed. Material in these terraces consisted chiefly of poorly sorted deposits ranging from silt to large boulders, indicative of debris flow deposits. Given these naturally occurring, long term geomorphic processes operating in the watershed, the creek bed would be expected to experience alternating cycles of massive sediment transport and deposition followed by periods of fluvial re-working and scour. This is apparently the present mode within Solstice Creek.

Solstice Creek is an ungaged watershed, but flood frequency estimates have been derived for other nearby watersheds by FEMA (1980). The most similar creek described in the FEMA report is Lindero Canyon, also in the Malibu area. Figure 1 shows graphically the flood frequency relations for Lindero Canyon and predictive equations derived from the FEMA estimates for this report. Figure 2 plots the estimates for Solstice Creek along with regression equations derived from the data. Because two flood magnitudes of interest are not given in the FEMA (1980) report (Q_5 and Q_{25}), flood frequency curves for Solstice Creek derived from the regression equations are shown in Figure 2.

Figure 1. Flood frequency relationships for Lindero Canyon (from FEMA, 1980)

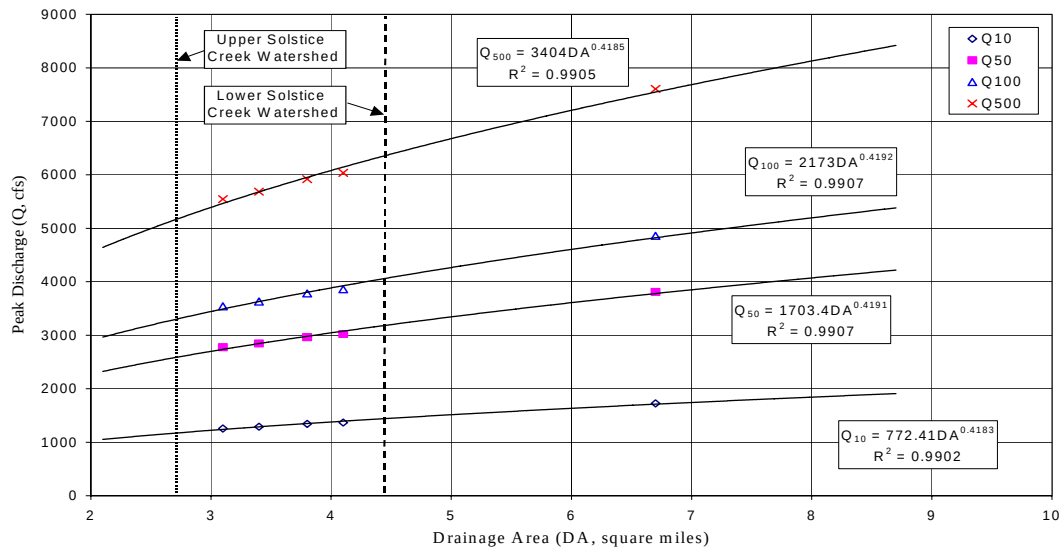


Figure 2. Solstice Creek flood frequency relations (adapted from FEMA (1980)).

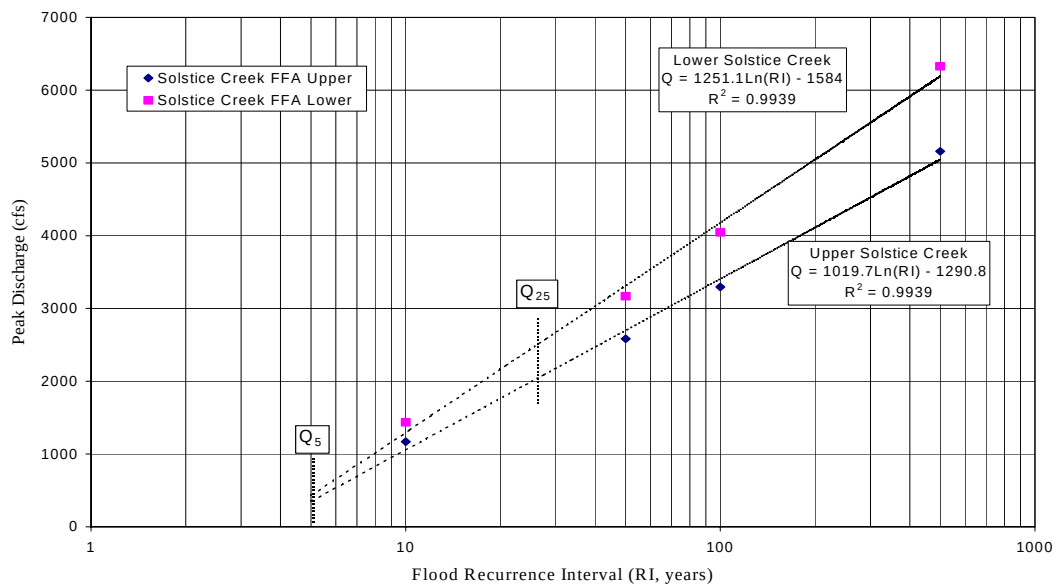


Table 1 lists estimates of peak discharge derived for Solstice Creek at the upper and lower ends of the project reach derived from Figures 1 and 2. Given the localized method used, these estimates of flood magnitudes are probably more reliable than some other methods (e.g., regional regression models). They agree reasonably well with the estimates shown on Figure 4 of the environmental assessment for the lowest Arizona crossing (NPS, 2001; p. 13).

Table 1. Flood frequency estimates for two locations in Solstice Creek (adapted from FEMA, 1980).							
Location	Drainage Area (sq. mi.)	Q ₅	Q ₁₀	Q ₂₅	Q ₅₀	Q ₁₀₀	Q ₅₀₀
Upper watershed (above Tropical Terrace)	2.7	350	1170	2000	2583	3295	5158
Lower watershed (at Pacific Ocean)	4.4	430	1435	2440	3169	4044	6328

FISH HABITAT CONDITIONS

Geomorphic trends and conditions at any given time dictate the quantity and quality of fish habitat. During the field review, it was noted that some important habitat components (deep pools and spawnable riffles) seemed to be in short supply compared to what might be expected in a healthy salmonid stream. Based on field observation, the most viable rearing habitat is located in the vicinity of the railroad bridge. A habitat survey conducted within the project reach in 1999 (Spina and Johnson, 1999) concluded that habitat would support steelhead spawning and rearing were fish to regain access to Solstice Creek.

Pools, pocketwater, and riffles are the dominant habitat types (see Table 2). Spina and Johnson (1999) report the mean residual depth within the pools as 1.9 feet and that pool depth generally decreases in a downstream direction. Of note, the pool depth data are influenced by plunge pools below dam spillways, which compose some of the deepest pools at present. All other habitat units are much shallower on average, but complexity in the form of boulders and cobble provides adequate structure and cover.

Table 2. Habitat type information for Solstice Creek (adapted from Spina and Johnson, 1999)

Habitat Type	N ^a	N%	Length (ft)	% Length	Surface Area (ft ²)	% Surface Area
Pool	52	34%	1989	23%	17634	30%
Pocket water	23	15%	2492	29%	15328	26%
Riffle	33	22%	1772	21%	13037	22%
Step run	20	13%	1433	17%	7336	13%
Glide	17	11%	773	9%	4598	8%
Cascade	6	4%	181	2%	702	1%

^a Number of habitat units

The only record of steelhead trout (*Oncorhynchus mykiss*) in the Solstice Creek watershed is anecdotal, with the last observations in the 1940s (Spina and Johnson 1999). Accounting for the lack of rainbow trout (land locked steelhead) in the system was somewhat perplexing until we discussed the dominant geomorphic action shaping the watershed, namely episodic, large magnitude mud and debris flows that occur in response to wildfire. Steelhead, as opposed to rainbow trout, may persist in these more dynamic watersheds as there is always a population in the ocean that may return to repopulate the stream following potentially catastrophic events.

Spina and Johnson (1999) describe the presence of gravel or cobble located at the tail of pools or head of riffles that would provide spawning habitat for steelhead trout. Very few patches of spawning-sized gravel exceeding a few square feet in surface area were observed during the 2002 field reconnaissance. It may be that the recent scour observed post-dated the survey, causing changes in habitat since 1999. It may also be that steelhead strains within this area may be able to spawn successfully in the small patches of gravel characteristic of Solstice Creek.

Recommendations: Spina and Johnson (1999) included a recommendation for water quality monitoring and assessment to confirm conditions are appropriate, especially during summer low flows. Additional monitoring that would contribute to determining fish habitat suitability and aquatic health would be stream bioassessment using methods described in the California Salmonid Stream Habitat Restoration Manual (DFG, 1998). In addition to documenting stream health, the broader inventory of aquatic species would contribute to the Natural Resources Challenge initiative. Future surveys would help document project success and could either repeat the techniques used in the 1999 NMFS report (but report more detailed information), or could be performed using the California Salmonid Stream Habitat Restoration Manual (DFG, 1998) methods. Cooperative monitoring could be pursued with the California Department of Fish and Game and/or National Marine Fisheries Service to evaluate both the watershed and the habitat response to barrier removal and other habitat improvement projects.

Other fish habitat considerations: The Solstice Canyon road runs alongside the entire 1.8-mile long project reach. The current EA (NPS, 2001) describes upgrading work proposed for the current road up to the education kiosk. The road between the kiosk and the Keller House will also be re-paved following road narrowing from 12 feet to 10 feet. Through most of this reach, the road is within 300 feet of the stream. In many cases, the road prism impinges on the stream channel and significantly reduces the width of the riparian zone. Reduction of the paved surface should, to the extent feasible, be designed to widen the adjacent riparian area by pulling back road fill from the channel. It will likely be necessary to armor the new fillslope toe, as it is located at the outside of a bend.

An erosional inventory of roads within Solstice Canyon and a plan for preventing future road failures should be developed in conjunction with or soon following habitat restoration. Designs to maximize habitat protection should be identified in order to prevent the need for installation of revetments (such as that proposed for the Big Bend road stabilization site) or the sort of rock/cement blankets we observed at the lowest part of the stream between Corral Canyon Road and Highway 1. This would enable a more proactive (and ultimately cheaper) approach to habitat protection than reactively treating road failures once they become a problem and attempting to mitigate the adverse effects of the road work.

The former pond between Dam 4 and Arizona Crossing 3 is another area where riparian restoration could benefit the stream corridor. Failure of this dam has resulted in incision through silt to gravel sized particles formerly stored in the pond. Riprap was imported and installed along a 300-foot section of stream to stabilize the eroding banks. This is one of the few areas where there is appreciable valley width, allowing for establishment of a wider and more stable riparian zone if the rip-rap were to be removed along with excavating some or all of the fill from the floodplain.

BARRIER OBSERVATIONS AND ALTERNATIVES

General Discussion

The 10 barriers vary in fundamental ways, consequently different approaches to their removal or modification will be required. In some cases, the structure will remain in place, but will need to be retrofit to allow fish passage (PCH and Corral Canyon Road culverts). In other cases (e.g., Arizona crossings), structures will be removed and the stream allowed to return to natural a geomorphic condition. In the case of the four dams, removal of these structures will need to consider what to do with the sediment stored behind these structures and how to deal with newly re-exposed streambanks adjacent to the structures. Additionally, because the taller two dams store significant volumes of sediment, a decision must be made whether to: 1) excavate the sediment prior to dam removal, 2) remove the dams in one season and release all sediment to downstream reaches, or 3) progressively lower the dams over a multi-year period so that sediment is metered out to downstream reaches. Common to both the Arizona crossings and the dams, because they both involve lowering of the local base level, subsequent upstream incision may affect streambanks as well as other structures to be retained (e.g., the railroad flatcar bridge upstream from the three lower dams).

To fully evaluate present conditions and anticipate channel responses to barrier removal, some additional data gathering and analyses are necessary. In addition, monitoring the response to restoration work would be beneficial. Data that would be helpful to project planning, design, and evaluation (including possible sources) would include:

- Structure designs ('as built') and maintenance records (Keller family, LA County, Caltrans).

- The fire, flood and sedimentation histories for Solstice Creek (including quantitative, photographic, and anecdotal information) (technical reports (USGS, Calif. DWR, nearby universities), conversations with ‘old timers’, written and photographic historical documents and collections from local restaurants (e.g., Paradise Cove) historical societies, universities, etc.).
- Aerial photo series of the watershed through time (Caltrans, State Lands Commission, US Army Corps of Engineers, US Coast and Geodetic Survey, USGS, WAC Corp, County Public Works Dept., etc.).
- Particle size information from the largest sediment storage units (above the two tallest dams) so that the local and downstream effects of dam removal options can be better evaluated (new data collection).
- Channel longitudinal profile and cross section surveys to characterize stream geomorphology, quantify stored sediment upstream from the dams, and for post-project monitoring (new data collection).
- Photopoints (repeated photographs taken from the same location and of the same subject) at planned worksites and anticipated response reaches (new photos).

The project will require completion of cultural compliance surveys. Many of the information sources identified above will be of assistance for both cultural compliance and geomorphic planning. Staff may be able to cooperate with the Cultural Resources Division in the acquisition and analysis of this historic information on the area.

Migration Barrier Treatments

Following are observations of individual barriers (from downstream to upstream), brief descriptions of alternatives, and miscellaneous considerations.

Pacific Coast Highway Culvert (Caltrans)

Observations: This is an arch culvert with a flat, sloping concrete bottom and concrete aprons at both ends. The culvert bottom slopes at about 2% while the upstream apron slopes at about 8%. The culvert is approximately 18 feet wide and 15 feet tall at the center. Depending on beach elevations, a vertical drop of up to about 4-6 feet may sometimes exist at the downstream end. The drop was about 2 feet during the field review.

Alternatives: Install baffles onto existing bottom or replace bottom with fabricated step-pool structures. Baffles are cheapest alternative, but would reduce flow capacity and may not provide fish access during most flow conditions. Step-pool alternative would be more expensive, but would better guarantee fish access. The vertical drop at the downstream end of the culvert may also present a migration barrier. One or two weirs could be considered immediately downstream of the culvert to accommodate channel bed scour should the baffling alternative be chosen. These structures would have to be linked structurally to the culvert to prevent alteration or settling associated with winter wave action on the unconsolidated sand and boulder beach deposits. Either alternative should be designed to accommodate varying channel bed elevations.

Other Considerations: Erosion of the PCH fillslope immediately south of the culvert exit should be treated. Design of barrier modifications should avoid features that might affect channel location across beach so that adjacent properties are not affected. Guidelines for Salmonid Passage at Stream Crossings (NMFS 2001) should be consulted for sources related to determining feasible treatments for fish passage at this site.

Corral Canyon Road (Los Angeles County)

Observations: This is a box culvert with a flat, sloping concrete bottom and a concrete apron at the downstream end. The culvert bottom slopes at about 6%. The culvert is approximately 18 feet wide and 9 feet tall. Boulder and concrete ‘berms’ appear to have been added to the inside bottom margins of the culvert after initial construction, possibly for the purpose of confining flows to increase depth for fish. These diminish culvert capacity by a small amount and don’t appear to improve migration conditions appreciably. Due to recent downstream channel bed scour, a vertical drop of about 2-3 feet existed at the downstream end at the time of this field review.

Alternatives: Install baffles onto existing bottom or replace bottom with fabricated step-pool structures. Baffles are cheapest alternative, but would reduce flow capacity and may not provide fish access during most flow conditions. However, removal of the boulder berms might offset capacity reduction from baffles, resulting in no change to existing capacity. Step-pool alternative would be more expensive, but would better guarantee fish access. The vertical drop at the downstream end of the culvert may also present a migration barrier. One or two weirs could be considered immediately downstream of the culvert to accommodate channel bed scour should the baffling alternative be chosen. Either alternative should be designed to accommodate varying channel bed elevations.

Other Considerations: Guidelines for Salmonid Passage at Stream Crossings (NMFS 2001) should be consulted for sources related to determining feasible treatments for fish passage at this site.

Downstream-most Arizona Crossing (No. 1) Removal and Bank Revetment (NPS)

Observations: This is a concrete ford that will be removed and replaced with a bridge in 2002 by the park (NPS, 2001). There appear to be two separate concrete pours beneath the ford, one stacked on top of the other. This may have resulted from a retrofit to lessen the dip in the road at the ford at some time in the past, or a repair project in response to channel downcutting downstream that might have undermined the structure. In any case, there is presently about a 5-foot drop from the ford to the creek bed downstream. The channel upstream has aggraded in response to the ford, and downcutting following removal of the ford is anticipated.

Alternatives: The primary alternatives have already been discussed in the environmental assessment (NPS, 2001).

Other Considerations: Current designs include the excavation of stored sediment upstream of the structure and placement of boulders for grade control and fish habitat back into the excavated channel. Depending on the volume and size distribution of stored sediment, these measures may not be necessary. There are likely numerous boulders in the existing material that would remain in the reach as finer sediments are flushed out, and these would evolve naturally into boulder sets similar to those that exist in adjacent reaches. In addition, spawning-sized gravel, which, as mentioned above, seems to be in short supply in Solstice Creek, would be removed from the creek if sediments are excavated. If left in the stream system, these gravels would contribute to downstream spawning habitat in the creek.

Because this project will be implemented this year, a monitoring project should be initiated to provide insights for treating the other barriers. Monitoring should include before-and-after photopoints and channel bed longitudinal profile and cross section surveys. Aquatic habitat information should also be collected for the length of the surveyed profile. Comparison of habitat response before and after treatment will also provide for means of determining potential change at other proposed treatment locations.

Bridge construction drawings (labeled 'Sheet 23 of 39') indicate that the abutments and rock slope protection (RSP, or 'riprap') are design to be somewhat askew relative to the primary streamflow direction. This might cause unwanted channel adjustments as well as localized scour that could undermine the bridge abutments and adjoining RSP. To avoid this, the abutments should be re-oriented to be parallel to the general streamflow direction through the crossing. The footings for the abutments should also be set deep enough to accommodate several or more feet of reach-wide bed scour (beyond that which has recently occurred, as discussed above) below the existing downstream channel bed elevation.

Big-Bend Road Protection Revetment (NPS)

Although not a barrier removal project, plans have been developed to install bank revetment along the outside of a major bend in the stream a short distance upstream of the lowest Arizona crossing. We dubbed this the 'Big Bend' site, and reviewed the site with plan drawings in hand. The purpose is to curb bank erosion so that further undermining of the NPS access road (Solstice Canyon Road) is halted. As shown in the drawing (labeled 'Figure 1 Site Plan'), the revetment impinges on the active channel, especially toward the downstream end. It is recommended that the plans be revised slightly to move the revetment outward from the channel by zero feet at the upstream end to about 10 feet at the downstream end. In addition, adding 'spurs' to the revetment should be considered to encourage pool development along the outside of the bend. Spurs should be constructed integral to the revetment itself and the

revetment should be designed to accommodate local scour around the spurs. The intent of the spurs are to increase the geomorphic roughness of the revetment to prevent continued flow pressure against this structure.

Education Kiosk Construction Area (NPS)

Adjacent to the parking lot, at the proposed education kiosk area and parking lot, concern was raised over the geomorphic control of the channel at the Graduate student research facility. Clarification as to whether the buildings would be constructed at the same place was never confirmed. One issue not raised at the time is that of streamside conservation areas. The NMFS Steelhead 4(d) rule requires a functional riparian corridor be established. Regulations established under the Essential Fish Habitat protection measures will likely be worded in a similar manner. This wording is intended to allow for flexibility, but a general rule of thumb for streamside protection is at least 100 feet. It is likely that this new construction would trigger this streamside protection ordinance.

Regardless, the NPS should consider removal of some riprap from this tight area, as it is causing an artificial increase in velocity, and discharging it onto an unprotected bank on the right side of the valley.

Dam No. 1 (NPS)

Observations: This dam is constructed of stone and concrete. It has about a 9-foot drop from spillway to water surface in the plunge pool below, and the pool itself is about 3 feet deep. The structure has incurred moderate damage, with scour having occurred around the right edge of the spillway and additional scour at the base of the dam. The height of the dam indicates that it has the largest volume of stored sediment of any of the barriers. Bank erosion along the right bank upstream of the dam indicates that the channel appears to have shifted toward the right in recent years. Moreover, the hummocky ground conditions upstream from the dam suggest fairly dramatic channel shifts might have occurred in this reach, a hypothetical that could be investigated by reviewing historical air photos.

Alternatives: This dam could be either: 1) completely removed all at once with stored sediment allowed to be transported downstream relatively rapidly, 2) completely removed all at once with stored sediment excavated out beforehand, or 3) removed in phases so that stored sediment is metered out to downstream reaches. Except for the phased approach, considerations are similar to those discussed above for the downstream-most Arizona crossing. Depending on the volume and size distribution of stored sediment, excavation may not be necessary or even preferable. There are likely numerous boulders in the existing material that would remain in the reach as finer sediments are flushed out, and these would evolve naturally into boulder sets similar to those that exist in adjacent reaches. In addition, spawning-sized gravel, which, as mentioned above, seems to be in short supply in Solstice Creek, would be removed from the creek if sediments are excavated. If left in the stream system, these gravels would contribute to downstream spawning habitat. However, a phased approach might be seriously considered if the volume likely to erode from single-phase removal would significantly impact downstream reaches. Examination of stored sediment by trenching with a backhoe adjacent to the low flow channel could help to evaluate these alternatives.

Other Considerations: Streambanks adjacent to and presently protected by the dam will be quite vulnerable to scour and slumping after the dam is removed. It is recommended that these be excavated back to a stable angle, re-vegetated with willows, and perhaps armored with local boulders at the base of the bank.

The stream channel alignment has jumped to the right valley wall and is cutting into colluvial deposits. In order to insure that the stream cuts back into previous fluvial deposits, the channel should be realigned into the former ponded area, prior to removal of the dam.

Based upon the Spina Johnson survey, the distance between Dam 1 and Dam 3 is 752 feet, with more than half of that identified as riffle habitat. Treatment in this area will increase gradient, and improve the likelihood of the stream developing either pool, or step-run type habitat through this reach.

Dam No. 2 (NPS)

Observations: This dam is relatively small (about a 3 foot drop at low flow; less at higher flows) and probably not a barrier to upstream adult migration. Scour has occurred around the left side of the structure and has been repaired.

Alternatives: Remove the structure, primarily for aesthetic reasons, and rehabilitate the worksite by grading soil to conform with adjacent natural streambank and terrace topography and re-vegetating.

Dam No. 3 (NPS)

Observations: This appears to be an earthen dam with a stone and concrete apron and spillway that was later retrofitted with a poured concrete spillway on top. The spillway has sidewalls and central piers constructed with slots to accommodate weir boards, probably to impound water during the dry season and allow sluicing of sediments during the high flow season. It has about an 8-foot drop from spillway to water surface in the plunge pool below, and the pool itself is about 2 feet deep. The structure appears in fair shape, but a hole has developed in the stone apron. The height of the dam indicates that it has the second largest volume of stored sediment of any of the barriers.

Alternatives: This dam could be either: 1) completely removed all at once with stored sediment allowed to be transported downstream relatively rapidly, 2) completely removed all at once with stored sediment excavated out beforehand, or 3) removed in phases so that stored sediment is metered out to downstream reaches. Considerations are similar to those discussed above for the Dam No. 1. Depending on the volume and size distribution of stored sediment, excavation may not be necessary or even preferable. There are likely numerous boulders in the existing material that would remain in the reach as finer sediments are flushed out, and these would evolve naturally into boulder sets similar to those that exist in adjacent reaches. In addition, spawning-sized gravel, which, as mentioned above, seems to be in short supply in Solstice Creek, would be removed from the creek if sediments are excavated. If left in the stream system, these gravels would contribute to downstream spawning habitat. However, a phased approach might be seriously considered if the volume likely to erode from single-phase removal would significantly impact downstream reaches. Examination of stored sediment by trenching with a backhoe adjacent to the low flow channel could help to evaluate these alternatives.

Other Considerations: Streambanks adjacent to and presently protected by the dam will be quite vulnerable to scour and slumping after the dam is removed. It is recommended that these be excavated back to a stable angle, re-vegetated with willows, and perhaps armored with local boulders at the base of the bank. In addition, a flatcar bridge located a few hundred feet upstream could be subject to undermining from downcutting in response to dam removal. This bridge is not considered for removal. If the depth of the footings for the bridge can be researched this information would be useful to obtain to evaluate possible undermining. If not, then simply digging a pit with a shovel could likely expose the abutment footings to check how deep they are and allow the possible effects of dam removal to be anticipated or prevented. Any trees removed or in danger of falling after dam removal could be placed within the active channel of the stream to enhance cover so long as they are placed in locations and manners that will not contribute to bank erosion.

Arizona Crossing No. 2 (NPS; Keller House)

Observations: This is a concrete ford that will be removed and replaced with a bridge by the park (date as yet unknown). There is presently about a 3 foot drop from the ford to the water surface in the plunge pool below, and the plunge pool was about 2 feet deep. The streambanks below the ford have eroded outward, forming a wide scour hole. The channel upstream has aggraded in response to the ford, and downcutting following removal of the ford is anticipated.

Alternatives: Only a single alternative is provided for this ford, and that is to simply remove the concrete cap from the present roadway.

Other Considerations: The small volume of stored sediment upstream of this ford makes excavation of sediment unnecessary. Boulders that may be exposed upon removal of the concrete cap may need to be re-arranged so that

flow is not diverted into one or both streambanks. A few alders have grown in the small wedge of aggraded sediment upstream of the ford. These will likely fall into the channel as the bed adjusts to the ford removal. These trees should be considered for removal as part of the project so that they don't present a hazard to the residents or the proposed bridge. Any trees removed from the site should be replaced in the channel downstream of the Keller house walking bridge (less than 500 feet downstream of the road crossing).

Dam No. 4 (NPS)

Observations: This dam was originally fairly tall, but has broken apart. Remnant slabs of concrete remain in the channel and on the banks. A large pool exists just below a 2-foot tall waterfall created by the large concrete slab that remains in the channel. The pool depth is approximately 3 feet and is elevated somewhat by a pile of rocks that has been placed at the downstream riffle crest.

Alternatives: This failed dam does not appear to be a migration barrier, so no action is necessary from a fisheries perspective.

Other Considerations: The presence of concrete detracts from the aesthetics of the site, which would otherwise be a bedrock controlled waterfall-pool complex, a rare feature in lower Solstice Creek. In addition, two other large concrete slabs are perched on steep, erodible banks and are likely to fall into the channel in the future. Therefore, it is recommended that these concrete slabs be removed from the channel and banks and disposed of elsewhere.

Arizona Crossings 3-5 (NPS)

Observations: These are concrete fords that will be removed to eliminate them as barriers. There is presently about a 2-3 foot drop from these fords to the water surface in the plunge pool below at each ford. The channel upstream has aggraded in response to the fords, and minor downcutting following removal of the fords is anticipated.

Alternatives: Only a single alternative is provided for these fords, and that is to simply remove the concrete cap from the present roadway/trail. Two are easily accessed by heavy equipment and the concrete should be hauled away to a disposal site. The third could only be accessed by heavy equipment by rebuilding a failed road down a very steep embankment. Because of the disturbance that would result from heavy equipment access, it is recommended that the concrete be broken up in place using portable equipment (e.g., pneumatic jackhammer, etc.) and re-distributed in the channel to reduce visual impacts and avoid diverting flow into the banks.

Other Considerations: The small volume of stored sediment upstream of these fords makes excavation of sediment unnecessary. Boulders that may be exposed upon removal of the concrete cap may need to be re-arranged so that flow is not diverted into one or both streambanks.

SUMMARY AND CONCLUSIONS

Removal of migration barriers on national parklands within Solstice Creek is an essential first step in restoring steelhead runs. This work should precede modification of the lowest two barriers (PCH and Corral Canyon Road) so that when steelhead are re-introduced, they will have a significant length of the channel accessible for spawning. Because the 1999 habitat survey indicates suitable habitat in the project reach, and because steelhead historically used Solstice Creek, the project appears worthwhile and is consistent with NPS goals.

While some of the barriers clearly can be removed without concern for the stored sediment, the taller ones presently hold back larger volumes of sediment and will need further evaluation. The evaluation should be supported by: 1) stream longitudinal and cross section surveys to quantify the volume of stored sediment and predict the upstream extent of channel incision, and 2) trenching to assess the size distribution of stored sediment to evaluate downstream delivery impacts.

Once the data sources mentioned above have been assembled, a synthesis of the information can be completed that will provide a sound basis for justifying the project and the approaches taken in dealing with the various barriers. Because the barriers will not all be treated at the same time, monitoring channel responses (using the techniques mentioned above) from the first one or two can serve as a tool for making sure the approaches considered for the

remaining sites are still valid or identifying the need for modifications in the approaches (i.e., adaptive management).

In addition, evaluation and development of long-term aquatic habitat and water quality monitoring should be established in conjunction with the initial Arizona crossing removal this summer. Some of the dam structures may qualify as historic. A cultural resources survey on these structures should be completed.

LITERATURE CITED

California Department of Fish and Game (CDFG). 1998. California Salmonid Stream Habitat Restoration Manual. Third Edition, Inland Fisheries Division.

FEMA (Federal Emergency Management Agency). 1980. Flood insurance study: Los Angeles County unincorporated areas.

National Marine Fisheries Service. 2001. Guidelines for Salmonid Passage at Stream Crossings. Southwest Region. Hydraulic Engineering Branch. Santa Rosa, CA. 14p.

National Park Service (NPS). 2001. Environmental assessment for rehabilitating facilities and removing low-water crossing of Solstice Creek in Solstice Canyon, Santa Monica Mountains National Recreation Area, Los Angeles County, California. 55 p with appendices.

Spina, A.P. and K.A. Johnson. 1999. Habitat characteristics of Solstice Creek: implications for steelhead. National Marine Fisheries Service, Habitat Conservation Div. Long Beach, CA. 14 p.