Appendix A-1

Gravel Mobility Study Report
Matt Smeltzer

May 13, 2003

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1900 – Pit 3/4/5 July 2, 2003 San Rafael
(FERC #233)

Ms. Kathy Turner
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Re: Comments to R2 Resources February 11, 2003 Gravel Mobility Study Report

Dear Kathy,

The following are my comments to the February 11, 2003 Gravel Mobility Study Report prepared for Pacific Gas and Electric Company (PG&E) by R2 Resource Consultants, Inc. (R2), herein referred to as the Report and cited as R2 Resource Consultants, Inc. (2003). I received the Report at my office on February 21, 2003, and attended via conference call a presentation of its results made by Stuart Beck at the February 28, 2003 PRCT meeting in Redding. In these comments I first acknowledge the effort made by R2 in conducting this well-executed study, and then outline and describe three important inadequacies of the Report. I conclude these comments by discussing the practical implications of the Report's results and conclusions, as modified herein by my comments, for the probable efficacy and design of the various gravel augmentation measures that have been proposed for partially mitigating the Pit 3/4/5 Project's significant impact on bedload sediment supply to the three Pit River bypass reaches.

General Comments

First I would like to acknowledge the considerable effort made by Stuart Beck (R2) and his staff, as assisted by Jeff Cook (Spring Rivers Ecological Sciences). I know firsthand from assisting Stuart and Jeff with part of the field work that this study was a considerable undertaking. Overall, R2 is to be commended for excellent work executing the study plan. Moreover, R2's geomorphology team (Stuart Beck and Sue Madsen) have demonstrated professionalism throughout these hydropower relicensing proceedings. This is particularly exemplified by the way R2 has modified its general process-level narrative description of bedload sediment transport, deposition, and storage dynamics in the Project bypass reaches evidently through insights gained from intensive field observations during this gravel mobility study. Specifically, R2 modified its description from that of a bedload sediment supply-limited bedrock and boulder-bed channel with negligible in-channel bedload sediment storage that is practically insensitive to

changes in supply, to that of a channel with bedload storage concentrated in fixed channel locations, or "gravel patches", the number and size of which fluctuate as a function of local bedload supply: "The number and size of gravel patches might increase following large inputs of gravel and then gradually decrease following gradual transport of gravel through the system" (R2 Resource Consultants, Inc. 2003:xi); "The gravel moves from patch to patch, over a relatively immobile boulder bed." (R2 Resource Consultants, Inc. 2003:4-1). R2's revised narrative description, stated here as an hypothesis, is entirely consistent with the hypotheses underpinning specific gravel supply enhancement measures proposed by USFS in its October 2002 Preliminary 4(e) Conditions, and by FERC in its March 2003 DEIS.

The Report accurately portrays the study objectives we developed jointly in a March 1, 2002 tracer gravel study plan meeting at Pacific Gas and Electric Company's office in San Ramon. Study methods documented in the Report are consistent with my field notes gathered while assisting various parts of the field work, including site selection, and tracer gravel and scour chain installation. All of the installation methods are acceptable by current standards of geomorphic practice and appropriate for the specific channel bed conditions in the Project bypass reaches. The study's greatest limitations are the relatively low number and density of study samples and the non-quantitative methods of assessing tracer gravel mobility and movement. However, I believe the level of effort was appropriate considering both the physical difficulty of the work and the number of other outstanding biological study questions during the 2002 field season. That being said, I believe that reporting and interpretation of the limited number of results data should emphasize that the individual results data are essentially qualitative results of separate individual mobility experiments and not a statistically or otherwise appropriate basis for predicting general mobility of gravel patches in the Project bypass reaches.

Herein lies one of the important inadequacies of the Report. While I acknowledge the difficulty and limited marginal utility of quantitatively vs. qualitatively measuring tracer gravel mobility (i.e., dispersal) and further acknowledge that the Report's narrative descriptions of tracer gravel dispersal are reasonably consistent with my personal post-flow field observations, photographs, and notes, I disagree with the Report's summary conclusions. In my view, the study results show that the mobility of individual in-channel gravel patches ranges widely from none or negligible dispersal to significant or complete dispersal (e.g., more than several meters). The large majority of study results showed none or negligible dispersal. I do not believe that the study results support the Report's over-generalized summary conclusions: "Gravels residing in patches within the current low-flow channel are mobilized at flows between base flow and 1,200 cfs in all three reaches of the Pit River," and "Gravels residing in patches within the current low-flow channel are mobilized at flows between 1,200 cfs and 1,800 cfs in all three reaches of the Pit River." (R2 Resource Consultants, Inc. 2003:5-1)

I produce three tables below to illustrate that the Report's general conclusions are not supported by its results. The tables include verbatim the Report's 1,200 cfs and 1,800 cfs post-flow field observations of in-channel tracer gravel dispersal and scour monitor results. I then summarize the Report's verbatim results for clarity in the two right-most columns of these tables for the 1,200 and 1,800 test flow observations, respectively.

In the Pit 3 Project bypass reach, the sample patch of fine gravel (Sample 3I2; d_{50}=6.5 mm) showed significant or complete downstream dispersal and redeposition more than about 5 meters downstream. The sample of medium-sized gravel (Sample 3I1; d_{50}=29-42 mm) showed moderate dispersal from 2 to 6 meters in multiple directions. The coarse gravel sample (Sample 3I3; d_{50}=75 mm) showed minimal or negligible dispersal of the finer (less than 10 mm) gravel fraction. Of these three samples, only the fine gravel patch showed significant downstream dispersal or sediment transport in the downstream direction. The patches of medium and coarse gravel, more typical of gravel patches in the Pit 3 reach, showed negligible to moderate dispersal, characterized by transport from the 18-inch diameter sample patch to closely neighboring patches in multiple directions, primarily downstream and toward the adjacent channel bank. Part of this dispersal could be viewed as mixing within the larger spatial confines of the bar-scale or pocket-scale hydraulic eddy (tens to hundreds of square feet in area) that typically surrounds or encompasses the individual 18-inch diameter sample patch (1.8 square feet in area) and its several closely neighboring patches. In this case, the larger bar-scale or pocket-scale hydraulic eddy is a more appropriate sample size than the individual gravel patch, and gravel mixing within the eddy area would therefore be considered quantitatively negligible in terms of actual downstream sediment transport because there was no dispersal to a separate downstream gravel deposition site.

Table 1. Summary of Pit 3 Bypass Reach Post-flow In-Channel Tracer Gravel Observations.

Sample ID	d_{50} (mm)	Results (R2 Resource Consultants, Inc. 2003)	Smeltzer Comments Post-1,200-cfs	Smeltzer Comments Post-1,800-cfs
3I1	29 42 15	"…exhibited moderate scatter – mostly downstream (2+ meters), but also some scatter upstream toward the sheltering *Carex* following the 1,200 cfs test flow release. Tracer gravels were transported even further downstream (6 meters) following the 1,800 cfs flow release." (at p. 3-8)	Moderate 2 meters multiple directions 29 mm	Moderate 6 meters multiple directions 42 mm
3I2	6.5 6.5 5.7	"…was widely scattered following the 1,200 cfs test flow release. Colored tracer gravel was visible in a downstream plume that stretched approximately 5 meters long and was up to 3 meters wide. The original location of the tracers was indiscernible; most of the gravel that had been deposited in that location had been displaced and was not replenished during the 1,200 cfs test flow release, i.e., the original location was mostly devoid of gravel following the test flows (this phenomenon was not typical of other gravelly locations following the test flows). Sample 3I2 was largely scattered downstream towards Sample 3I1 following the 1,800 cfs test flow release. It was difficult to relocate the sample because so much gravel had moved." (at p. 3-9)	Significant 5 meters downstream 6.5 mm	Significant 5+ meters downstream 6.5 mm

3I3	75 ** 75	"Little scatter was apparent at Sample 3I3 following the 1,200 cfs test flow release, but some of the smaller grains (approximately <10 mm) were scattered downstream and toward river left (looking downstream) as far as 1.5 meters. This sample was not re-sieved or reinstalled prior to the 1,800 cfs test flow release because minimal disturbance was observed following the 1,200 cfs test flow release. Gravels from sample 3I3 moved downstream following the 1,800 cfs test flow release, depositing behind large boulders in a fan shape towards the middle of the side channel. There was net deposition over the location of the original sample." (at p. 3-9)	Minimal/Negligible 1.5 meters downstream <10 mm	Minimal/Negligible 1.5 meters? multiple directions <10 mm?

In-channel gravel movement was negligible at all three sample sites in the Pit 4 Project bypass reach during both the 1,800 cfs and 1,200 cfs test flows (Table 2). Post-flow observations at the 4I1 and 4I3 samples included "minor" and "limited" dispersal. My personal post-flow observations at these sites indicated practically no tracer gravel dispersal and net gravel deposition on the sample surface. The finer fraction of the 4I2 sample was "scattered broadly within the pocket" at both the 1,200 cfs and 1,800 cfs test flows, but this dispersal from the 1.8-square-foot sample was entirely contained within the larger pocket-scale eddy, and is therefore considered negligible in terms of downstream sediment transport because there was no dispersal to a separate downstream gravel deposition site.

Table 2. Summary of Pit 4 Bypass Reach Post-flow In-Channel Tracer Gravel Observations.

Sample ID	d_{50} (mm)	Results (R2 Resource Consultants, Inc. 2003)	Smeltzer Comments Post-1,200-cfs	Smeltzer Comments Post-1,800-cfs
4I1	19 14 13	"There was some scatter of Sample 4I1 following the 1,200 cfs flow release, but it was minor. There appeared to have been some displacement of gravels downstream and toward the center of the channel, but most of the colored gravels remained in the original sample location. There was no evidence of angler/wading disturbance. There was some deposition of sediment on top of the original sample. Gravels in 4I1 appeared to have barely moved following the 1,800 cfs flow release. There was some deposition of finer sediment on top of the original sample." (at p. 3-25)	None/Negligible	None/Negligible
4I2	18 18 11	"Sample 4I2 was located in a pocket surrounded by boulders. Gravels from Sample 4I2 were scattered broadly within the pocket in all four horizontal directions following the 1,200 cfs test flow release. There is no evidence of angler/wading disturbance. Similar observations were made following the 1,800 cfs test flow release." (at p. 3-26)	None/Negligible *Pocket comprises the appropriate sample area.*	None/Negligible *Pocket comprises the appropriate sample area.*
4I3	8 13 18	"Gravel displacement from Sample 4I3 was limited following the 1,200 cfs test flow release. There was no evidence of angler/wading disturbance. Gravel displacement was also limited following the 1,800 cfs test flow release. Some deposition of gravel on this sample was observed." (at p. 3-26)	None/Negligible	None/Negligible

In-channel gravel movement was none or negligible at ten of the eleven in-channel tracer gravel and scour monitor sample sites in the Pit 5 Project bypass reach (Table 3). Some of the smaller particles in Sample 5I1 were scattered in multiple directions within the larger hydraulic eddy during the 1,200 cfs test flow, and several small particles moved downstream during the 1,800 cfs test flow. Similar dispersal occurred at the 5I3 sample site. In both of these cases, gravel dispersal is measurable but considered negligible in terms of downstream sediment transport because there was very little if any dispersal to a separate downstream gravel deposition site. There was no gravel movement measured at any of the eight scour monitor sample locations. Sample 5I2 was the only in-channel gravel sample to show moderate dispersal. However, particles transported from Sample 5I2 were redeposited less than 1-2 meters downstream. Dispersal from Sample 5I2 could therefore also be considered negligible in terms of downstream sediment transport because there was no dispersal to a separate downstream gravel deposition site.

Table 3. Summary of Pit 5 Bypass Reach Post-flow In-Channel Tracer Gravel and Scour Monitor Observations.

Sample ID	d_{50} (mm)	Results (R2 Resource Consultants, Inc. 2003)	Smeltzer Comments Post-1,200-cfs	Smeltzer Comments Post-1,800-cfs
5I1	29 26 18	"Much of Sample 5I1 was still in the original location of the sample following the 1,200 cfs test flow release, but some gravel was scattered toward river left (looking downstream) and river left upstream due to flow vectors around the boulders at this location. There was no evidence of angler/wading disturbance (i.e., no obvious scuffing or visible foot prints in the site). Some of the gravel from Sample 5I1 was scattered towards river left and some of the smaller particles were scattered downstream following the 1,800 cfs test flow release. Some gravel had also deposited on Sample 5I1." (at p. 3-51)	Minimal/Negligible <1 meter? multiple directions <29 mm?	Minimal/Negligible <1 meter? multiple directions <26 mm?
5I2	17 14 10	"Gravel from Sample 5I2 was scattered downstream following the 1,200 cfs test flow release. A couple of the larger particles still resided in the same area as the original sample, but the rest of the gravel from the original sample was diffusely-scattered in the downstream direction. Deposition of gravel was observed over Sample 5I2 following the 1,800 cfs test flow release. A large piece of gravel from the sample was observed downstream from the original sample location." (at p. 3-52)	Moderate 1-2 meters? downstream <17 mm	Moderate 1-2 meters? downstream 14 mm
5I3	16 10 8	"Much of Sample 5I3 was still located in the same area as the original sample following the 1,200 cfs test flow release. The rest of the sample was scattered in the downstream and river left direction. There was no evidence of angler/wading disturbance around this sample. Pea gravel was found deposited over Sample 5I3 following the 1,800 cfs test flow release." (at p. 3-52)	Minimal/Negligible <1 meter? multiple directions <16 mm?	None
5KC1	64	"No scour was measured…" (at p. 3-55)	na	None/Negligible
5KC2	64	"No scour was measured…" (at p. 3-55)	na	None/Negligible
5KC3	64	"No scour was measured…" (at p. 3-55)	na	None/Negligible

5BB1	31	"…could not be relocated." (at p. 3-55)	na	None/Negligible [1]
5BB2	31	"No scour was measured…" (at p. 3-55)	na	None/Negligible
5BB3	31	"No scour was measured…" (at p. 3-55)	na	None/Negligible
5BB4	31	"No scour was measured…" (at p. 3-55)	na	None/Negligible
5BB5	31	"…could not be relocated." (at p. 3-55)	na	None/Negligible [1]

[1] Scour was almost definitely none/negligible at this scour monitor location because none of the scour monitors on the cross-section detected scour and there was no change in the cross-sectional channel bed profile. The missing monitors were most likely removed by anglers/waders not displaced by scour (Stuart Beck, pers. comm., February 28, 2003).

In summary, closer examination of the study results in the Report reveals that gravel movement was none or negligible in terms of downstream sediment transport at 14 of the 17 in-channel tracer gravel and scour monitor sample sites. These results do not support the Report's over-generalized conclusions: "Gravels residing in patches within the current low-flow channel are mobilized at flows between base flow and 1,200 cfs in all three reaches of the Pit River;" and "Gravels residing in patches within the current low-flow channel are mobilized at flows between 1,200 cfs and 1,800 cfs in all three reaches of the Pit River." (R2 Resource Consultants, Inc. 2003:5-1)

A second important inadequacy of the Report is that it does not outline or discuss the practical implications of its results and conclusions for the probable efficacy or design of the various gravel augmentation measures that have been recommended by USFS, Department of Interior, CDFG, California Trout, Trout Unlimited, and FERC. For example, the probable efficacy of the proposed gravel augmentation measures may be called into question if the Report's results directly or indirectly suggest that gravel placed on the channel bed would be transported through the bypass reach(es) in a relatively short period of time, thereby yielding little or short-term benefit to aquatic habitat per unit program cost. Unfortunately, the conclusions stated in the Report could indirectly suggest this although the results of the same study, correctly interpreted, do not support this hypothesis. Furthermore, the results of this study, correctly interpreted, reveal that results of analytical incipient motion and potential bedload sediment transport calculations contained in R2's original geomorphology report (R2 Resource Consultants Inc. 2001) are not consistent with actual sediment transport dynamics observed in the field during the gravel mobility study. For example, (R2 Resource Consultants Inc. 2001:5-17) reported that analytically estimated maximum diameter particle size moved in the Pit 3 reach at the average annual without-Project baseflow (1,791 cfs) was between 70 and 131 mm. However, at 1,800 cfs the gravel mobility study measured moderate dispersal of particles up to 42 mm diameter at one of the three sample sites, and dispersal of particles less than about 10 mm diameter at the other two sites (Table 1). For the Pit 4 reach, the analytically estimated maximum diameter particle size moved at the average annual without-Project baseflow (1,919 cfs) was between 18 and 120 mm (R2 Resource Consultants Inc. 2001:5-28), but at 1,800 cfs the gravel mobility study showed none/negligible gravel movement for median sample diameters ranging from 13 to 18 mm at all sample sites (Table 2). Analytically estimated potential bedload transport in tons/year for the regulated hydrology in the Pit 3 and Pit 4 bypass reaches are similarly overestimated in the original geomorphology report. The estimated potential bedload transport for current operations were 48,000 to 57,000 tons/year in the Pit 3 bypass reach and 138,000 to 1.5 million tons/year in the Pit 4 reach (R2 Resource Consultants Inc. 2001:5-18; 5-20). Referring to these results, R2 hypothesized that: "under the current operating regime the Pit 3 Reach can easily transport the estimated annual 950 tons of bedload input downstream of the

Lake Britton Dam." (R2 Resource Consultants Inc. 2001:5-20); and "under the current operating regime the Pit 4 Reach can easily transport the estimated annual 523 tons of bedload input downstream of the Pit 4 Dam." (R2 Resource Consultants Inc. 2001:5-29). These hypothesis statements should not be misconstrued in such a way as to minimize the expectations for success of the various recommended gravel augmentation programs, in which, e.g., FERC has proposed placement immediately below the Pit 3 and Pit 4 dams of as little as two to five (2-5) tons/year. The gravel mobility study results in the Report, correctly interpreted, show that the analytical sediment transport estimates contained in R2 (2001) are overestimates and cannot be relied upon in any way to predict the probable efficacy of proposed and recommended gravel augmentation programs. The Report's results simply confirm the logic embodied in all of the various recommended gravel augmentation programs: (1) there is a reasonable expectation that gravel placed directly in the channel below the Project dams will reside in the channel for a long enough period to benefit aquatic habitat; and (2) the methods and amounts of gravel placement should be modified as necessary according to field monitoring of the resulting changes in in-channel sediment storage immediately downstream from the placement site(s).

A third important inadequacy of the Report is that the study plan was not amended to take advantage of the unscheduled spill flows in the Pit 4 reach during the 2002 field season (up to and exceeding 4,000 cfs). Measuring dispersal following the unscheduled spills would have been particularly useful because the 1,800 cfs test flow produced moderate or significant gravel dispersal at only three of the 17 sample sites. Moreover, the study plan was not amended to assess dispersal at the sample sites in spring 2003 in the event that reservoir spill(s) occur as a result of normal winter precipitation.

Summary

It has been pleasurable and rewarding working with Stuart Beck and Sue Madsen during these proceedings. This gravel mobility study was well-executed and the Report accurately documents the study's methods and results. The most important inadequacy of the Report is that the results do not support its summary conclusions. Closer examination of the Report's study results reveals that gravel movement was none or negligible at 14 of the 17 in-channel tracer gravel and scour monitor sample sites. These results do not support the Report's over-generalized conclusions: "Gravels residing in patches within the current low-flow channel are mobilized at flows between base flow and 1,200 cfs in all three reaches of the Pit River;" and "Gravels residing in patches within the current low-flow channel are mobilized at flows between 1,200 cfs and 1,800 cfs in all three reaches of the Pit River." (R2 Resource Consultants, Inc. 2003:5-1) Furthermore, the results contained in the Report, correctly interpreted, reveal that analytical estimates of maximum mobilized particle size and potential bedload sediment transport contained in the original geomorphology report (R2 Resource Consultants, Inc. 2001) were overestimates that should not be used as references for evaluating the probable efficacy or design of the various gravel augmentation measures that have been proposed for partially mitigating the Pit 3/4/5 Project's significant impact on bedload sediment supply to the three bypass reaches. Correctly interpreted, the Report's results simply confirm the logic embodied in all of the various recommended gravel augmentation programs: (1) there is a reasonable expectation that gravel placed directly in the channel below the Project dams will reside in the channel for a sufficient period to benefit aquatic habitat; and (2) the methods and amounts of gravel placement should be

modified as necessary according to field monitoring of in-channel sediment storage immediately downstream from the placement site(s).

Please consider these comments in your continuing evaluation of the various measures proposed to mitigate for the significant Project impact on bedload sediment supply to the Project bypass reaches, and contact me directly if you have questions or would like to discuss sediment management issues further.

Sincerely,

Matt Smeltzer
Senior Engineer/Geomorphologist

References

R2 Resource Consultants, Inc. 2001. Geomorphology of the Pit River in the vicinity of the Pacific Gas and Electric Company's Pit 3, 4, and 5 Project. Prepared by R2 Resource Consultants, Redmond, Washington, for Pacific Gas and Electric Company Technical and Ecological Services, April 9, 2001.

R2 Resource Consultants, Inc. 2003. Gravel mobility in the Pit River in the vicinity of the Pacific Gas and Electric Company's Pit 3, 4, and 5 Project. Prepared by R2 Resource Consultants for Pacific Gas and Electric Company Technical and Ecological Services, February 11, 2003.

Qualifications

Matt Smeltzer is a Senior Engineer and Geomorphologist for Stetson Engineers in San Rafael, California, and is Project Manager under contract to the US Forest Service to provide technical assistance in conjunction with the FERC hydropower relicensing proceedings for Pacific Gas and Electric Company's Pit 3/4/5 project (FERC #233). Mr. Smeltzer assisted the Forest Service in analyzing geomorphologic processes and issues on the Pit River bypass reaches and in preparing comments to initial Geomorphology reports in 2001 and 2002. Mr. Smeltzer also assisted in the design of the gravel mobility study plan in 2002, assisted R2 in selection of study sites and installation of tracer gravels and scour monitors, and conducted independent field surveys of tracer gravel movement during and following both demonstration flows in 2002.

Mr. Smeltzer obtained a Bachelors of Science in Civil and Environmental Engineering with high honors from the University of Michigan, Ann Arbor in 1995, and a Master of Landscape Architecture in Environmental Planning from the University of California, Berkeley in 1998 where he conducted thesis research on instream flow management and sediment transport in the Owens River Gorge as a Graduate Research Fellow at the White Mountain Research Station in Bishop, California, with G. Mathias Kondolf as major Professor. As a Senior Engineer and Geomorphologist for Stetson Engineers since 1999, Mr. Smeltzer provides technical assistance with geomorphology, hydrology, and engineering issues to the US Forest Service in connection with FERC hydropower relicensing proceedings on the Pit River and Upper Stanislaus River in California, Clackamas/Oak Grove Fork in Oregon, and the Baker/Skagit Rivers in Washington. Mr. Smeltzer has concurrently maintained a Research Fellowship at UC San Diego and part-time Research Scientist and Lecturer appointments at UC Berkeley, where he frequently lectures, leads the Graduate Environmental Planning Studio, and periodically publishes peer-reviewed articles on stream restoration and management topics emphasizing appropriate applications of geomorphic analysis in regulated river management. Mr. Smeltzer's previous experience includes geomorphic and spawning gravel assessments of Mill Creek for the US Fish and Wildlife Service and Deer Creek for the Nature Conservancy, and detailed assessments of Butte Creek, Uvas Creek, Carmel River, and the Owens River. Mr. Smeltzer is a co-author with Matt Kondolf and others of the CALFED Fluvial Geomorphology White Paper, which included an inventory and assessment of spawning gravel augmentation project implementation and performance throughout the Sacramento-San Joaquin River watersheds, and more recently an Instream Gravel Mining Issues White Paper for the State of Washington, and a river and sediment management planning guidance document for the Guatemalan government.