ENCLOSURE 3

U.S. GEOLOGICAL SURVEY
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Dear Bob:

The August 8-10 meeting in Rockville provided a useful review of the logic tree for the Diablo Canyon long term seismic program, but did not demonstrate that PG&E gives adequate weight to oblique-slip reverse and thrust faulting. Noted below is some of the evidence for these slip orientations on specific faults.

Hosgri fault:

This fault is defined on its shoreward side by one or two eastern, near-vertical, traces that reach the sea floor and on its seaward side by one or more northeast-dipping blind thrust faults that converge eastward and at depth with the steeper, eastern, traces. These relations are partly shown on the maps and sections accompanying the PG&E final report, but are best seen on the interpreted proprietary seismic lines in the supplemental data set. Such geometry appears to be recognized by most interpreters; many of them also recognize an eastward (45-70°) dip below the junction of the thrusts with the eastern trace. Thus the best defined and most consistent elements of the fault system resemble an imbricate thrust fan, and it has been interpreted as such by some analysts.

PG&E derives slip on the Hosgri indirectly from strike-slip observed on the San Simeon fault, 50 km north of the plant site. Geologic and geophysical data along the Hosgri fault offer more direct evidence of a thrust or reverse component of slip. This evidence includes:

- A thick upper Pliocene and Quaternary marine section west of the fault that is juxtaposed against a basement surface, or a thin cover of upper Quaternary sediment on basement, east of the fault.

- Angular unconformities (top Miocene and mid-Pliocene) that are deformed as they approach the fault from the west; southwest dips on the top-Miocene unconformity range up to 40°, those on the mid-Pliocene unconformity up to 20°. These relations show that the fault has had a vertical component of slip during the Pliocene and

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probably well into the Quaternary.

- The wedging-out against the western face of the Hosgri (or over its blind western branches) of unconformity-bounded packets of Pliocene and younger strata . The wedging, together with the deformation described above, indicates a growth fault that has been active since early Pliocene time. Moreover, it demonstrates that the time values assigned to the two unconformities become unreliable near the fault and in the block to the northeast of it; in these regions each unconformity represents a much greater depositional, or time, gap than it does to the west, in the offshore Santa Maria basin.

- A warped and faulted present-day seafloor and a similarly deformed late Wisconsinan (18Ka) surface follow the same trend, and indicate the same sense of vertical slip, as that defined by the late Pliocene and Quaternary structures along the Hosgri.

- The broad Hosgri fault zone now separates a subsiding depositional basin on the southwest from a stable or rising wave-cut platform on the northeast; the present boundary and stratigraphic relations across the fault closely mimic those that prevailed during the earlier history of the Hosgri.

These relations do not rule out a strike-slip component on the Hosgri, but they provide strong evidence that any strike-slip must be accompanied by significant components of vertical and compressive slip. Oblique-slip focal mechanisms from larger earthquakes (M>3) along the Hosgri trend document approximately equal components of strike- and dip-slip.

Geological evidence for extending the San Simeon fault 20 km south of San Simeon Bay, to Point Estero, has not been found, but geologic structures typical of the Hosgri appear to continue northward at least to the latitude of Point Piedras Blancas. If current activity on these two faults is mechanically related, any stepover of fault slip appears more likely to be north of Point Piedras Blancas than to the south, near Point Estero.

But wherever the stepover is, the chief concern for the Diablo Canyon plant is the Hosgri fault, 5 km distant and with abundant evidence of recent dip slip.

Los Osos fault and faults on the south side of the Pismo syncline:

The Los Osos fault on the north side of the syncline and the Olson, San Luis Bay, and Wilmar Avenue faults on its south side have been interpreted by PG&E as near-vertical, block-bounding faults along which the San Luis-Pismo block has been uplifted. This interpretation is difficult to reconcile with:

- surface geologic data from the Los Osos and San Luis Bay faults, which document low or moderate dips inward, toward the synclinal axis.

- subsurface geologic data from the Honolulu-Tidewater drillhole, which shows multiple repetition of Tertiary strata in the lower part of the hole, down to the total depth of about 11,000 ft; dips in the repeated section are low to moderate in sharp contrast to the steeper dips at the surface and in the upper part of the hole.

- surface geologic map relations which require post-Pismo compression, folding, and reverse or thrust faulting.

- earthquake focal mechanisms (in the response to question 43k) near the Los Osos fault, which show evidence of continuing compression across the fault.

The foregoing observations support the hypothesis that the Pismo syncline is still deforming by northeast-southwest compression and that thrust or reverse faults on opposing limbs of the syncline now accommodate the strain formerly manifest in folding. The block uplift and compressional models can be evaluated by compiling structure sections across the Pismo syncline for each model, using available 1:24,000 scale geologic mapping, and dipmeter and lithologic logs from the Honolulu-Tidewater well. At 1:24,000 all surface dips and contacts as well as downhole dipmeter observations can be shown, permitting comparison of the interpreted structure with the data.

LOGIC TREE WEIGHTS:

Despite the above questions, the deterministic magnitude estimate, M=7.2 at 4.5 km, is reasonable for the Hosgri fault; deterministic magnitudes for the faults bordering the Pismo syncline also appear to be reasonable. Probabilistic estimates of magnitudes, and fault slip directions (which may affect the ground motions), are subject to question because of the strong bias toward strike-slip and near-vertical faults in the PG&E report, and because of uncertainty in the direction and amount of net slip. Specifically, for the Hosgri logic tree (figure 3-5, PG&E final report), the following branches are weighted inappropriately:

- Sense of slip: weights for oblique and thrust branches of the logic tree should be greater; oblique slip or thrust is indicated by direct evidence.

- Dip: weight assigned to 90° dip is unrealistic for the fault at seismogenic depths of 4 to 12 km; see PG&E's interpreted seismic profiles, also earthquake focal mechanisms for M>3. Data support dips of 50 to 60°, and lower dips are possible.

- Rupture length: weights assigned to shorter segments, 20 and 45 km, seem much too great if the intent is to quantify the probability for a maximum magnitude earthquake--of chief concern are events that will break multiple fault segments.

- Slip rate: those rates given for oblique slip are inconsistent with the PG&E model, which transfers 1 to 3 mm/yr of strike slip from the San Simeon to the Hosgri.

For the Los Osos fault, similar concerns are:

- Dip: weights are biased toward steep (60°) dip; data from surface geology and the Honolulu-Tidewater well suggest lower values are more likely.

- Rupture length: see comment on this topic for Hosgri fault.

- Maximum displacement: the case (p.3-29, PG&E final report) for a maximum slip per event of 2 m is not convincing; more likely, as other reviewers have noted, this value is closer to an average displacement.

- Average displacement and slip rate: see preceding comment; also, because these values are based on surface measurements on a fault plane dipping 10 to 20°, they represent much greater vertical components at seismogenic depths, if the 60° dip assumed in the PG&E analysis is accepted.

For the San Luis Bay, and other faults along the south limb of the Pismo syncline, a more comprehensive logic tree is needed. If, as PG&E argues, this belt of faulting is an active block boundary, then it warrants more analysis than that presented for the San Luis Bay fault in figure 3-8 of the final report.

These questions will probably not affect the deterministic maximum magnitude by more than 0.2, which is certainly within the uncertainty for magnitude estimates. But a careful weighting of the geologic and geophysical evidence now can provide a broader, more realistic, base for ground motion and probabilistic risk assessments; it may also preclude the need for another LSTP exercise in a few years, when more data on the offshore Santa Maria basin and more records of strong ground motion become public information.

Sincerely yours:

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