2170/3

December 14, 1984

TO: Steve Wilde

FROM: Ben Everitt

UGMS HAZARDS SECTION

SUBJECT: Report on Spillway Excavation at Smith and Morehouse Dam

I have visited the Smith and Morehouse construction site on October 5, October 30, November 20, and December 5, and gone to the offices of Palmer-Wilding to look at core on November 12 and 28, in an effort to keep appraised of developments since we began to suspect that the right abutment contained landslide debris. Both the supplemental drilling and the excavation of the spillway cut continue to expose evidence that there is more than bedrock in the right abutment. Indeed the entire hillside appears to be a massive complex landslide, possibly extending deeper than our drill holes and farther up the hillside than either the geologic mapping or the aerial photography.

Drill hole 84-3 of the current series (Figure 1) spudded in hard limestone and recovered nearly 100% of core for 90 feet. The interval from 91-94 feet recovered 8 inches of black organic muck containing some spongy peat, confirming the existence of a massive deep landslide in the right abutment and spillway area.

The excavation for the spillway is in hard limestone. The cut is being beveled down by drilling, blasting, and mucking off the rubble in 10 foot layers. Excavation has exposed seams of red-brown to tan moderately well sorted unconsolidated sand, silt, and clay within the rock. On November 20, there was exposed a nearly vertical seam up to 6 inches wide which is continuous for 100 feet between Station 3+00 and 4+00 of the spillway alignment at about elevation 94 (Figure 1). On December 5, the area at Sta. 3+00 was exposed at about elevation 84 and revealed several oblique fracture fillings, one striking N 80° E, dipping 35° N, and another N 70° E, dipping 27° E.

In the vertical seam there is no evidence of horizontal bedding. In places the sediment is graded perpendicular to the dike, coarser in the center and fining to the edges. In others, there are irregular pods of sediment of different texture, some coarser at the edges and others finer. The sediment is in contact with hard gray unweathered limestone in places, and with yellowish weathered or highly fractured rock in other places. The seam becomes narrower toward the northeast (also deeper below original ground surface) and pinches out about 4+00. Toward the southwest it is covered.

The sand is composed of rounded to subrounded clear and pink quartz grains and some purplish quartzite grains indicating that its source is Smith and Morehouse Creek, and that its age is therefore Quaternary. Suspended and scattered in some of the sand bodies are angular chips of the Brazer Limestone up to 1/4" long.

The sand seam at 3+00 and elevation 84 inspected on December 5, dips gently southeast, into the hillside. It is composed of beds of sand, silt, red clay, clayey sand, and limestone breccia oriented parallel to the seam (Figure 2). The footwall of the seam is a hard flat surface of limestone, probably a bedding plane, but not definitely identified as such. The surface is polished in spots and has at least two sets of scratches, one plunging down dip (S 20^{o} E) and the other slightly east of down-dip.

Overlying this slip surface is a 1-2" layer of brecciated gray limestone mixed with a small amount of reddish sand and clay. The breccia crumbles easily into sharp angular fragments; some fracture surfaces bear a thin coating of red clay.

Overlying the breccia is an irregular zone up to 4" thick of finely interbedded fine sand, silt, and red clay. Boundaries between these units are sharp and emphasized by color differences. Unlike the vertical sand seam, sand rather than clay forms the edges. The finely layered sand and clay shows evidence of shearing with compression parallel to the sand seam. The shearing may be due to excavation.

In the vicinity of Station 3+00, I have been able to see exposures of the sand at three different elevations in the spillway cut. Although the strike remained about the same, the dip changed with depth, indicating a set of intersecting fractures which received the sand. The width of the sand seams is very irregular, but seems to decrease with depth. The average grain size decreases with depth, ranging from coarse sand and sandy gravel near the surface to fine sand interbedded with silt and clay at a depth of 20 feet.

These facts suggest that the sand seams were washed in from above rather than injected from below. The fine laminations of sand and clay suggest deposition in open fractures by relatively non-turbulent water. The existence of at least one such open fracture has been confirmed by drill hole 84-4 higher in the right abutment.

The absence of horizontal bedding in the vertical seams and the parallel banding suggests deposition during expansion of the fractures. The preservation of the finely laminated sediments in the sub horizontal seams argues against more than minor amounts of shearing of the seams after deposition.

The one good exposure of sheared sediment occurred only 6" below the excavated cut surface (Figure 2); the observed shearing was probably the result of excavation.

It is not surprising that the earlier core drilling did not reveal the existence of these sand bodies. Fine unconsolidated sand in such narrow seams could easily be washed away during drilling. With Ed Fleming's present careful drilling, we have recovered several samples of probable Quaternary sand from drill holes 84-1 and 84-2; the deepest being at 38 feet.

In 1981 the discovery of sand seams in the limestone knob which formed the right abutment and outlet of the old dam formed the basis for concluding that this feature was a landslide. Subsequently Drill Hole 82-1 confirmed this conclusion when it penetrated glacial till beneath the limestone. At that time there were no clues to suggest that the landsliding extended farther east.

The sand seams discovered during spillway excavation are similar, although larger, than those discovered earlier. In either case it is not entirely clear how such well sorted and finely bedded sand became so thoroughly infiltrated into the fractures in the limestone.

As a result of these recent discoveries, there are three aspects of the safety of the dam which should receive careful consideration.

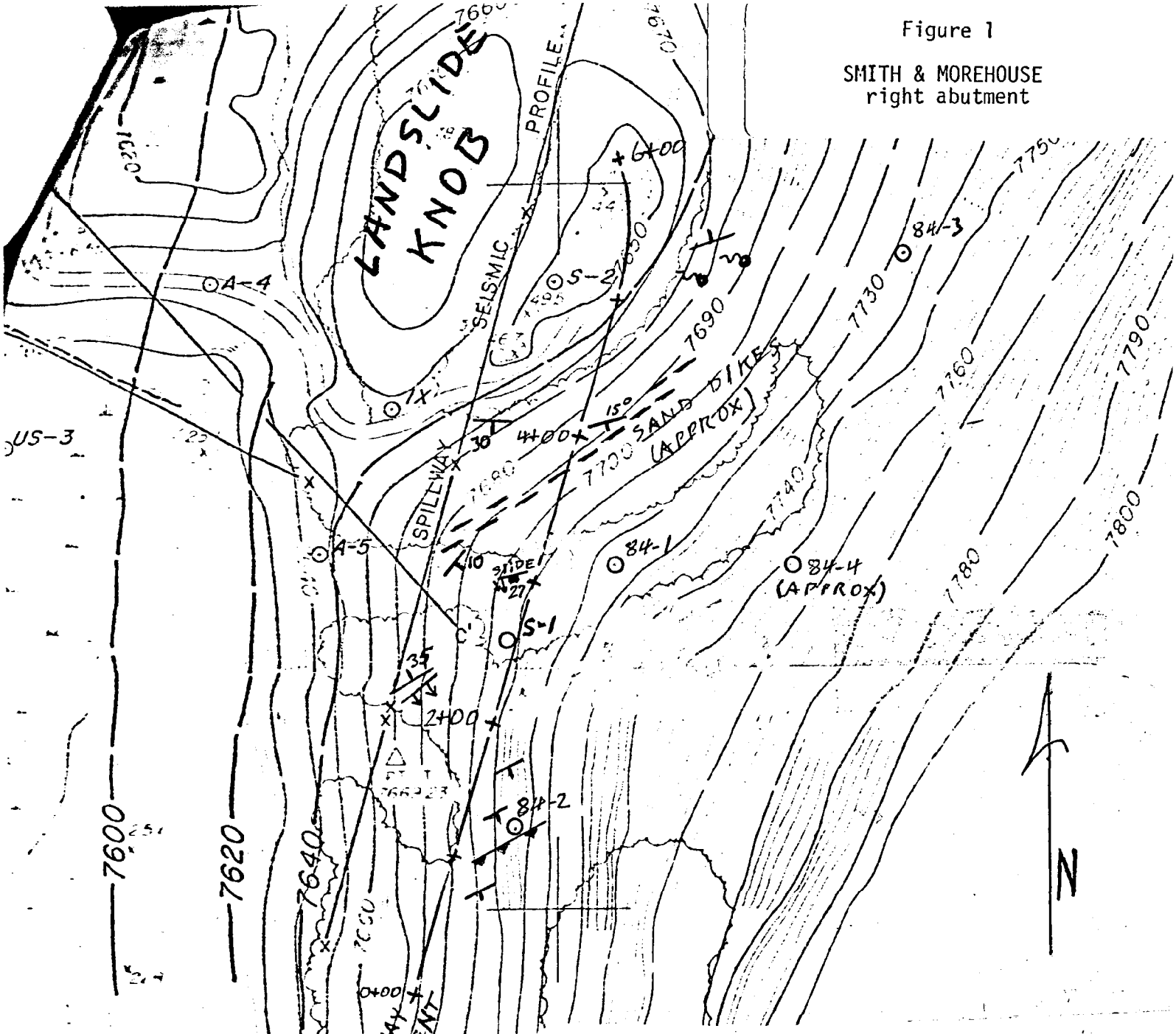
Landslide. - - The stability of the right abutment and spillway. Can we be reasonably sure that it will remain in place during and after construction?

Sand Seams. - - Do the sand seams provide avenues of pipeable material beneath the dam? This question has a bearing on stability and seepage through the abutment. Only a thorough examination of the key trench will answer this question, but it wouldn't hurt to be prepared with some contingency plans if sand seams are found to extend beneath the key trench.

Seepage. - - Although we have already recognized the need to control seepage around the right abutment, this need becomes more important now that we recognize that stability of the abutment is an issue.

Figure 1

SMITH & MOREHOUSE
right abutment



EXPLANATION

Drill Holes, Dashed Where Approx. Located

Seismic Survey Lines W/ Shot Points

20-foot Contours On Bedrock

20-ft. Contours On The Top Of The Lower (Yellow) Till

Base By Aerographics, 1976
Scale: 1" = 100'
Contour Interval: 2 Foot
Geology Compiled By Ben Everitt

THRUST FAULT, TEETH ON UPPER PLATE

FAULT, WITH DIRECTION OF DIP

TR 12/3

FIGURE 2

SKETCH TO SHOW STRUCTURE

IN SAND SEAM, SMITH AND MOREHOUSE SPILLWAY CUT STA. 3+00 @ EL. 84

VERTICAL SECTION