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THE PUDDLE REPORT

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PONDING IN OPEN PITS AT AREA G AFTER THE SEPTEMBER 10 - 11, 1973 RAINS

Margaret Anne Rogers

Sumner Barr

Bill Purtymun

Linda Trocki

CONFIDENTIAL

Ponding of water occurs in some of the LASL contaminated disposal areas if a substantial amount of precipitation falls in a short enough time. The risks due to ponding are unknown; consequently ponding should be minimized whenever and wherever possible. The presence of water in LASL disposal pits, therefore, warrants study.

There are varying opinions on the significance of ponded water in contaminated disposal areas. There seems to be little solid fact to support any particular opinion, however. This report does not propose to answer the question of significance, but describes an incidence of ponding at Area G which cannot be considered atypical.

Without the August 30 rain, August 1973 would have been the second dryest August on record. Two and two-tenths inches of precipitation (at the Administration Building) places August 1973 in the lowest quarter of the record. Between August 28 and 30 approximately 1 inch of rain fell in Area G. Most of this rain was on the 30th, and all of it was absorbed into the tuff and did not pond. With an estimated evaporation rate of 1/3" - 1/2" per day for standing water, it probably took 4-5 days for this rain to evaporate out of the tuff. Evaporate is used in this context to mean the apparent disappearance of ground moisture. (See Table I)

On September 9, 23, 25, and 26 there was a trace of rain in Area G. The term trace means that there is not enough precipitation for raindrops to coalesce on the ground surface. The significant September rains were midnight - 9:30 a.m. September 10 (Rain 1) and 6:30 p.m. September 10 - 4:00 a.m. September 11 (Rain 2).

Rain 1 produced .72 inches of precipitation in Area G. Clearing began about 11:00 a.m. By 11:30 a.m. paved roads were dry. The unpaved access road to Area G at 2:00 p.m. showed no signs of drying. It was slick and even "soupy" in in places. The hazardous road condition seemed to be the result of slow penetration of moisture. Only the upper 1 inch of road surface appeared to be wet. Ponding occurred in Pit #8 only. (See photographs for September 10, 1973)

From midnight - 6:30 p.m. September 10, the evaporation estimate is .20 inches. (See page 2 Office Memorandum H8-73-218) This leaves .52 inches of Rain 1 retained by the ground when Rain 2 began. In the next 9 1/2 hours 1.5 inches of rain fell at Area G.

At 10:00 a.m. on the 11th there was low overcast in Area G. The condition of the access road was much improved. The road surface while wet was no longer slick. Besides Pit #8, ponding now had occurred in the Decontamination Pit and Pits #12, #17, and #7. No water ponded in Pit #16 or Pit #21. (See photographs for 10:00 a.m. September 11,

1973) By 11:00 a.m. sun was breaking thru over Area G.

The evaporation estimate for the period 6:30 p.m. September 10 - 10:00 a.m. September 11 is .07 inches. This leaves a total of 1.95 inches of rain retained by the ground at 10:00 a.m. on the 11th. (See photographs 10:00 a.m., 9-11-73)

Water remained ponded in Pit #12 and the Decontamination Pit until the morning of the 12th, in Pit #17 and Pit #7 until the morning of the 13th, and in Pit #8 until the morning of the 14th. (See photographs)

The bottom surface of the Decontamination Pit appeared dry the afternoon of the 14th. It was the morning of the 19th before the bottom surface of Pits #17, #12, #8, and #7 appeared dry. (See photographs)

Moisture penetration in the soil and in the tuff excavated from Pit #7 was determined by color change. Shallow trenches were dug with a rock hammer, crowbar, and railroad pick. When the soil color or the crushed tuff color changed from dark to lighter, this depth was recorded as the depth of moisture penetration. The four trenches dug in the soil near the pinon tree north of Pit #8 on the mornings of September 11, 12, and 13 and the afternoon of September 14 (6, 31, 54, and 82 hours after Rain 2) showed moisture penetration depths of 6", 5 1/2", 6 1/2", and 3 1/2" respectively. (See photographs)

In order to approximate moisture penetration of a covered pit, four trenches were also dug in the top of the tuff excavated from Pit #7. Moisture penetration 31, 54, 82, and 151 hours after Rain 2 was 15", 12", 17 1/2" and $>$16", respectively. (See photograph)

Bill Purtymun and Linda Trocki began drilling holes in the bottom of Pit #7 the morning of the 17th. They reported a moisture break (in solid tuff) at a depth of two to three feet. Again determination was made by color change.

Pit #7 was completed August 3, 1973. It is 30 feet (maximum) deep by 50 feet wide by 600 feet long with its axis east-west parallel to topographic contour lines. The bottom, toes, and walls of the pit are cut in Unit 2b of the Tshirege member of the Bandelier Tuff. The pit's north wall is approximately 5 feet higher than its south wall. Natural drainage would be from north to south at right angles to the pit's axis. The pit's east toe has a conspicous southerly slope; this is not true of the pit's west toe. (See colored photographs) There was no evidence of drainage into the pit from the east toe after either Rain 1 or Rain 2. However, after Rain 2 strong runnels in the west toe and a delta at the base of the west toe showed a considerable amount of water and sediment had run into the pit from the west. (Compare

photographs of Pit #7 at 2:00 p.m., 9-10-73 with 10:00 a.m., 9-11-73) Very little water ran over and down the walls of the pit. Mud streaks on the walls show where water did run. Most of the mud streaks do not reach the bottom of the pit. (See colored photographs)

As a result of Rain 1, 1800 ft^3 (13,465 gal.) of rain fell in Pit #7. All of it was absorbed by the tuff which is highly porous. (See photograph of Pit #7 2:00 p.m., 9-10-73) It can be estimated that 500 ft^3 (3740 gal.) of absorbed moisture evaporated before Rain 2 began at 6:30 p.m. Therefore, 1300 ft^3 (9725 gal.) of Rain 1 was retained by the tuff. This water retention estimate is low. (See discussion by Sumner Barr) Rain 2 dumped 3750 ft^3 (28,052 gal.) of water into the pit. Evaporation during Rain 2 was 150 ft^3 (1122 gal.). The estimate of the amount of water which fell and remained in the pit as of 4:00 a.m. September 11 (the time when Rain 2 ended) is 4900 ft^3 (36,654 gal.) Water ponded along the south wall for a distance of 116 feet after Rain 2. (See photograph of Pit #7, 10:00 a.m., 9-11-73) Water marks on the south wall and the bottom show ponding of approximately 982 ft^3 (7346 gal.) of water. (See method for estimating puddle volume in Pit #7) It cannot be calculated how much of this ponded water was water which ran into the pit. It was calculated that 4900 ft^3 (36,654 gal.) fell and remained in the pit of which

3600 ft^3 (26,930 gal.) was available for ponding. (There was no ponding after Rain 1) Therefore, a minimum of 2618 ft^3 (19,584 gal.) of Rain 2 was absorbed by the tuff. [3750 ft^3 - (150 ft^3 + 982 ft^3)] The estimate of total water absorption by the tuff in Pit #7 from Rains 1 and 2 is 3917 ft^3 (29,301 gal.). From 4:00 a.m. September 11 until 8:00 a.m. September 13, when the Pit #7 puddle disappeared, evaporation can account for 363 ft^3 (2715 gal.) of puddle loss. The other 618 ft^3 (4623 gal.) of puddle must be accounted for by penetration. (See Table 2)

The temptation is to extend the calculation of evaporation rates and evaporation volume to the time when the bottom surface of Pit #7 appears dry. At this time, the morning of the 19th, there was still moisture in the pit. Desiccation cracks had begun to form some time earlier. As drying continued, curling occurred at crack edges producing "mud curls". The morning of the 19th the upper surface of the "mud curls" and of the area between "mud curls" (site of original desiccation cracks) was dry. If "mud curls" were turned over, they were wet on the bottom as was the area beneath them. Therefore, the figure of 12,075 ft^3 (90,327 gal) evaporation for the period 8:00 a.m. September 13 - 10:00 a.m. September 19, more than twice the amount of water which originally fell in the pit, well demonstrates the limitations of the evaporation estimates based on the Thornthwaite-Holzman formula used by Sumner Barr. (See Sumner Barr's discussion) The formula can be used to calculate evaporation of ponded moisture, but cannot reasonably be used to calculate evaporation (over a period of days) of penetrated moisture.

Bill Purtymun and Linda Trocki drilled 4 holes in Pit #7. The last hole was completed September 20th. Samples of cuttings were taken at five foot intervals for all holes. Each five foot cutting sample is an averaged sample for that five foot interval. The samples were analyzed for moisture content. (See Office Memorandum H8-73-M296)

The relationship of the Pit #7 holes to the Pit #7 pond was: Holes #1, #2, and #3 not covered by pond; Hole #4 located where pond was 9½ inches deep. Even though the 0' - 5' cutting sample from Hole #4 was taken 9 days after Rain 2 and 7 days after the pond disappeared, moisture content is in sharp contrast to the cutting samples from the 0' - 5' intervals in the other holes. There can be little doubt the high percent moisture by weight for the 0' - 5' interval in Hole #4 is related to the ponding.

The location of the Pit #7 pond is related to difference in elevation of the pit bottom. Whether it is also related to joint pattern cannot be determined. Joints cannot be traced from one wall to the other with any degree of certainty because powdered rock debris covers the pit bottom. (See Map of Pit #7 from 1 + 00 to 4 + 00, Area G)

In the open pits of Area G there appears to be a relationship between ponding and amount of precipitation and between ponding and elevation of each pit. After Rain 1 the only pit which held water was not the lowest pit; however, after Rain 2 all pits held water except the highest pit and the third highest pit. The

missing ponding factor (or factors) has not yet been determined. Possibilities for the missing factor(s) are: fracture pattern, fracture fillings, powdered rock debris on pit bottom, and type of waste in pit.

At the times of Rains 1 and 2 grading to prevent water from running into the open pits was not done. It has been done now. While this report does not try to determine the significance of ponding, it does seem wise to maintain grading and thus minimize a possible problem.

From looking at the Pit #7 pond, it appears more water is absorbed than is evaporated. There is no way with present data to say how long this water is retained by the tuff --- does it continue to migrate downward (or laterally) or after a certain period (of absence of new precipitation) does it migrate upward?

This report should be the first of several which address these questions.