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MEMORANDUM

To: T.C. Greengard
From: B.P. Doty
Date: July 9, 1991

Subject: Hydraulic Feasibility of 881 Hillside French Drain

This memorandum reviews EG&G (1990) and data presented therein in an effort to provide a preliminary evaluation of the hydraulic feasibility of the proposed french drain. This memorandum is based on work performed beginning on July 8, 1991.

REVIEW OF GEOTECHNICAL INVESTIGATION (EG&G, 1990)

Key issues relative to the hydraulic performance of the drain are as follows.

1. The report does not mention saturation or water levels in the soil (colluvium) to be drained.

2. Basal gravels similar to those found in 4-87 do not appear to be present along the proposed drain alignment. Earlier work (Rockwell, 1988) shows continuous gravel from 4-87 to 47-87 (just north of the interceptor ditch) on Plate 5-3.

3. New data on the colluvial hydraulic conductivity are not presented.

4. In general, the bedrock materials encountered appear suitable for construction of the drain (claystone is predominant material).

5. Hydraulic testing does not really address the issue of the conductivity of the material into which the drain will be keyed.

   a. The most shallow tests are generally below the proposed bottom of the drain.

   b. Equipment sensitivity limits the tests to conductivity measurements higher than $1x10^{-6}$ centimeters per second (cm/s).

c. Some of the higher results (e.g., values in excess of $1x10^{-3}$ cm/s in B 3002 90) may result from accidental hydrofracture of the bedrock during the test.

6. The depth of cut shown on Plate 1 of EG&G (1990) never exceeds thirty feet. Engineering-Science (1991) shows the same alignment except west of the Building 881 footing drain discharge, where the alignment is farther south. The Engineering-Science (1991) cuts are never more than twenty-eight feet (Figure 1).

RECOMMENDATIONS

It is recommended that additional review be conducted to determine if gravels are present in the colluvium along the drain alignment and whether the soils are saturated.

It may be advisable to perform simple pumping tests in colluvial wells on the drain alignment (if such exist) in order to confirm the hydraulic conductivity estimates presented in Rockwell (1988), as revised in Attachment D to Rockwell (1989). These values (3) average $1x10^{-4}$ cm/s.

It may be advisable to drill and packer test the materials at the proposed base of excavation along the Engineering-Science (1991) alignment, west of the Building 881 footing drain discharge.

It may be advisable to drill and packer test at other locations along the alignment to show that the materials generally have conductivities of less than $1x10^{-6}$ cm/s, and especially to evaluate whether the higher determinations result from inadvertent hydrofracture.

CONCLUSIONS

In spite of the weaknesses of the geotechnical investigation, the new data do not require changes to the conceptual model of the hillside; it still appears that ground water flows downslope in fairly thin colluvium, perched on top of low permeability bedrock. A french drain should be highly effective in dewatering such a system.

REFERENCES

EG&G, 1990, French Drain Geotechnical Investigation, EG&G Rocky Flats, October 5.

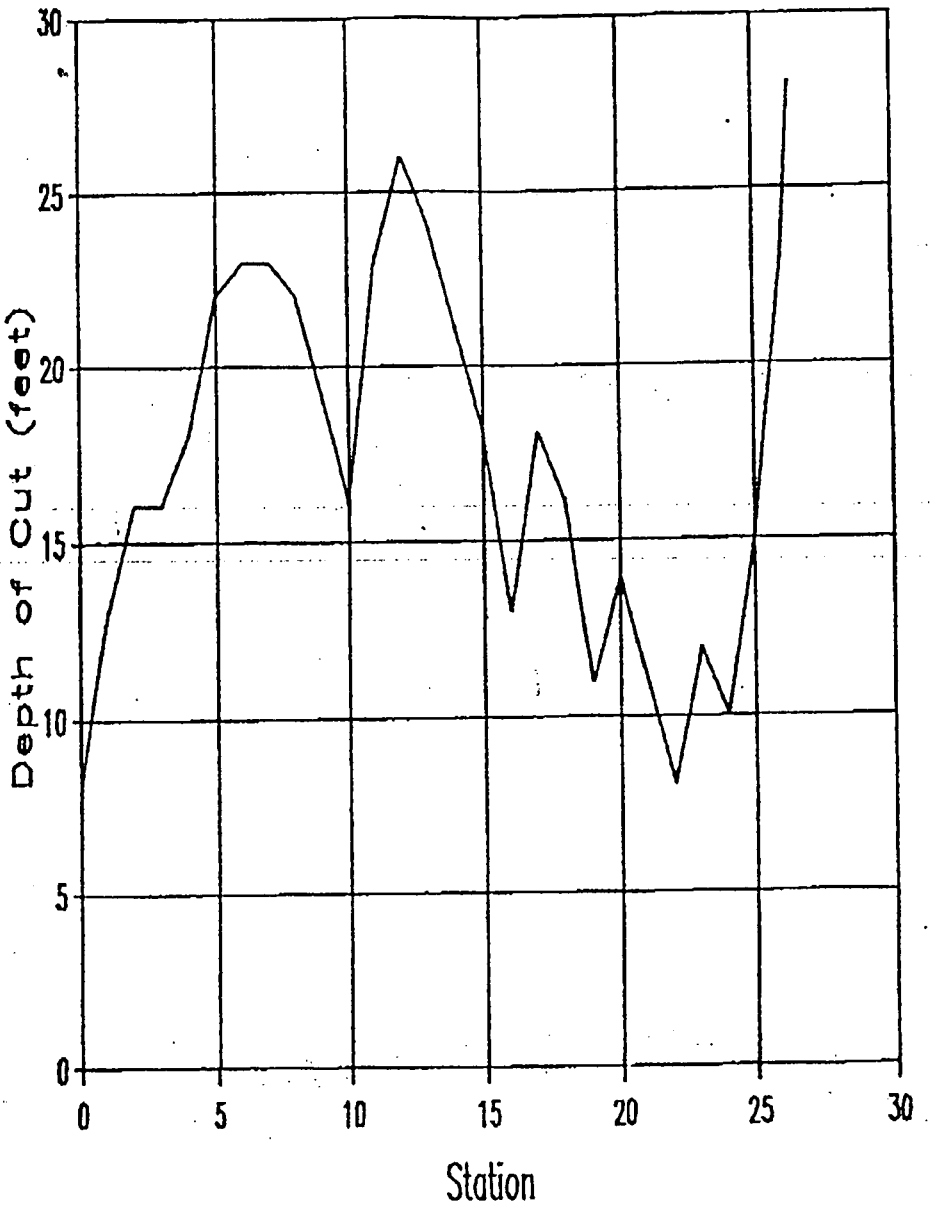
Engineering-Science, 1991, Remedial Action, 881 Hillside, 881 Phase IIB Construction (Collection and Discharge System), Specifications and Drawings, February, revised May.

Rockwell, 1988, Remedial Investigation Report for High Priority Sites (881 Hillside Area), Rockwell International, Rocky Flats Plant, March 1.

Rockwell, 1989, 881 Hillside, Remedial Investigation Report, Responses to EPA Comments, February 24.

FIGURE 1

881 HILLSIDE DRAIN EXCAVATION DEPTHS



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ASSUMING TWO FEET OF EXCAVATION BELOW PVC DRAIN LINE

RESPONSE TO DOE CONCERNS PERTAINING TO THE PROPOSED OU1 INTERIM REMEDIAL ACTION

DOE has expressed concern over the suitability of the proposed OU1 Interim Measures/Interim Remedial Action (IM/IRA) in light of studies performed since issuance of the IM/IRA Plan (DOE, 1990a), specifically the French Drain Geotechnical Investigation (EG&G, 1990). These concerns are documented in a memorandum from EM-45 to David F. Simonson dated July 9, 1991. This document is EG&G's comment-by-comment response to those concerns.

Before addressing each concern, it is useful to review the objective of the IM/IRA and the basis for the selection of the preferred IM/IRA alternative. As noted in the IM/IRA Plan, the overall objective of the IM/IRA is the prevention of release and migration of alluvial ground-water contaminants downgradient of the 881 Hillside Area. The IM/IRA Plan evaluated three alternatives for collection/containment of alluvial ground water: 1) collection using a french drain and a source well; 2) containment using a multi-layered cap and slurry wall; and 3) a source well only. These three alternatives were previously identified in the feasibility study (FS) (Rockwell, 1988) as the most suitable for remediating the 881 Hillside Area. (The FS eliminated further consideration of a well array because of its limited ability to completely cutoff ground-water flow by overlapping cones of depression due to subsurface heterogeneities.) Alternative 2 was not selected because it did not completely contain all the contaminated ground water, and Alternative 3 did not provide assurance that contaminated alluvial ground water would not migrate into the Woman Creek Valley Fill Alluvium.

Even in light of the geotechnical investigation results, it is our opinion that, as originally assessed, the French Drain is the most suitable alternative for meeting the objective of the IM/IRA, i.e., prevention of release and migration of alluvial ground-water contamination downgradient of the 881 Hillside Area. The drain is the most positive method of alluvial ground-water cutoff because it couples an impermeable barrier (the downstream synthetic liner) with ground-water gradient control (the drain itself). It is emphasized that the primary goal of the drain is to prevent contaminant releases to the larger environment. This is felt to be an appropriate aim of the program given the schedule for implementation of the final Remedial Action at the 881 Hillside, which is in part as follows:

Record of Decision	December, 1994
Construction	May, 1996 to November, 1997
Start-up	January, 1998

Using the mean ground-water velocity through colluvium of 150 feet per year quoted in DOE (1990b), known contaminants at the 881 Hillside could move nearly 1,000 feet during the next 6.5 years (well beyond the proposed location of the drain).

With this background, the DOE concerns are subsequently addressed.

Comment 1:

> *Worker Health and Safety - Workers will be required to work in trenches at depths of 50 feet or more to install piping, filters, pumps, etc. Associated safety issues were not addressed. Additionally, construction activities will occur on high-angle slopes (40° or more). The ability of the surface to support equipment at steep angles within acceptable safety limits is questionable. Special construction equipment and techniques will probably be required, resulting in increased costs.*

Response:

> The French Drain Geotechnical Investigation Report does not conclude that excavations in excess of 50 feet will be required. It does state that such excavations would be required to key the French Drain into bedrock exhibiting a hydraulic conductivity of 10^{-6} cm/sec as determined from pump test data. However, because vertical hydraulic conductivities, as measured by back pressure permeability test, are considerable less than 10^{-6} cm/sec, it is concluded that alluvial ground water will not pass under the drain and will be effectively captured by the drain. Therefore, keying the drain into two feet of

bedrock will satisfactorily meet the IM/IRA specification. The detailed design plans show the excavation to be less than 30 feet.

Because of the shallow depth of excavation, special equipment will not be required. For example, it is envisioned that the French Drain will be constructed using standard construction equipment including scrapers, graders, front-end loaders, and backhoes. The French Drain Geotechnical Investigation Report notes that heavy equipment should avoid travel along the uphill crest of the excavation. It is also noted that the construction slope of 40 degrees is recommended to assure worker safety, and as required by OSHA, the excavation will be inspected daily prior to continuance of construction activities. The Environmental Assessment (EA) for the IM/IRA states that, "any accidents which may occur during the construction phase of the proposed action are those typical of small excavation or construction activities. While such an accident might lead to personnel contamination from contaminated ground water or soils, none of the hazardous materials have been identified in concentrations immediately injurious to health. The Job Safety Analysis (JSA) will identify preventive actions and the parties responsible for each basic job. Workers are required to be familiar with the JSA, and a copy of it will be available at the work site."

Comment 2:

Surface Water Contamination/Sediment Loading - Vegetation will be removed from approximately 275,000 square feet of the Hillside. The potential exists for increased erosion and sediment loading of Woman Creek and associated wetlands.

Response:

The EA addresses destruction of grass on the 881 Hillside. This is an unavoidable impact, and steps will be taken to mitigate erosion. For example, the construction specification calls for use of erosion bales to prevent runon, and runoff will be retarded and controlled using benches, berms, and silt fences. There should be no sediment loading to Woman Creek and associated wetlands as the french drain construction will be hydraulically upgradient of the South Interceptor Ditch (SID). The area impacted by the construction will be reseeded immediately upon completion of the project.

Comment 3:

Disposal of Contaminated Soils - The volume of soil requiring testing and possible disposal has increased. If the excavation continues as planned, there may be a need to dispose of 4,000 drums or more of hazardous and possible mixed waste.

Response:

In a letter from EPA to Frazer Lockhart dated June 18, 1991, EPA has stated that if contaminated soil does not pose an unacceptable risk, the soil is not considered to contain a listed hazardous waste, and Part 264 and the land disposal restriction requirements do not apply. Toluene has been determined to be a ubiquitous contaminant in soils along the French Drain alignment. It occurs at concentrations in the "hundreds of ppb". The action level for toluene in the proposed RCRA Corrective Action regulations is 20,000,000 ppb, i.e., this is considered to be a concentration that will not pose unacceptable risk. Therefore, at this time, it appears there will be no unusal use restrictions or disposal requirements pertaining to the excavated contaminated soils.

Comment 4:

Geological Setting (Bedrock/Colluvium Contact) - At the 881 Hillside, up to 50 feet or more of alluvial or colluvial soils overlie bedrock, which generally consists of fractured sandstones and siltstones.

Keying the French Drain into the bedrock may facilitate flow of contaminated water into the bedrock, providing a potential pathway for the subsurface migration of contaminants to downgradient creeks and municipal water supply reservoirs.

Additionally, a paleo-channel (buried ancient stream bed) is thought to exist in the vicinity of the 881 Hillside. It is not known if this feature is present on the Hillside, but if so, the potential exists for ground water flow directions to be considerable different from the direction now inferred.

Response:

Based on data presented in EG&G (1990), the soil along the alignment of the proposed french drain has thicknesses ranging from approximately six feet at B300190 to approximately twenty feet at B301990 (not fifty feet as stated in the comment). The predominant bedrock lithology is claystone (not sandstone or siltstone as stated in the comment). Lenticular, thin (less than five feet thick), very fine-grained, clayey and silty sandstone zones are encased in the claystone. Siltstone horizons (well-indurated, brittle, clayey silts) also occur within the bedrock. It is estimated that approximately seventy-five percent of the bedrock material exposed in the french drain excavation will be claystone.

The uppermost bedrock is extremely resistant to the downward flow of ground water. The twelve laboratory determinations of the vertical hydraulic conductivity of bedrock materials reported in EG&G (1990) range from $2x10^{-6}$ to $6x10^{-9}$ centimeters per second (cm/s); however, most of the values are in the 10^{-8} order of magnitude. The geometric mean of all twelve determinations is $5x10^{-8}$ cm/s, with a standard deviation of 1.5 orders of magnitude. Even more significantly, very different water levels in the soil and bedrock ground-water systems have been observed at the locations of three soil/bedrock well pairs at the 881 Hillside (2-87/3-87BR, 43-87/5-87BR, and 69-86/59-86BR/8-87BR). At these locations, there are downward vertical hydraulic gradients ranging from 0.3 to about 2, indicating that the uppermost bedrock has a very low hydraulic conductivity and is effectively perching the ground-water system in the soil above that in the bedrock (Rockwell, 1988). The uppermost bedrock is expected to continue to behave in this manner after construction of the french drain. In addition, more permeable materials exposed in the french drain excavation will be slush-grouted to seal them and the base of the entire excavation will be covered with a 40-mil PVC impermeable flexible membrane liner. Thus, the construction of the drain is not expected to provide a pathway for downward migration of contaminants.

Paleochannels cut into the top of bedrock that are infilled with Rocky Flats Alluvium have been documented beneath the Rocky Flats Terrace north-east of the 881 Hillside. These paleochannels do not impact the ground-water flow system at the 881 Hillside.

Comment 5:

Slope Stability - Colluvial soil composition and high-angle slopes may result in slope instability, particularly if semi-saturated or saturated conditions occur, perhaps from a summer thunderstorm or other rainfall event. Construction induced slumping could cause the spread of potentially contaminated soils into Woman Creek.

Response:

There is a risk as on any excavation site, that slumping will occur after a heavy rain storm. However, in accordance with the recommendations in the French Drain Geotechnical Investigation Report, the working face of the excavation will be inspected daily to better define areas where stability problems may arise, or areas where steeper slopes might be possible. Because the excavation is entirely above the SID, there will be no transport of contaminated soils into Woman Creek even if there is slumping.

Comment 6:

Integrity of South Interceptor Ditch - The South Interceptor Ditch is a storm diversion along the 881 Hillside above Woman Creek. The realigned French Drain crosses the ditch in several places. Planned construction techniques at these locations may result in the mass movement of potentially contaminated soil into the Woman Creek drainage. These soils could adversely affect aquatic biota and vegetation in and near Woman Creek and could result in violations of the Clean Water Act.

Response:

The realigned French Drain does not cross the SID. Calculations of the lateral extent of the excavation at its deepest point and at its closest proximity to the SID indicate the SID will not be impacted. Furthermore, the construction specification calls for protection of the SID by avoiding excavation, stockpiling of soil, vehicular traffic or other construction activities in the SID.

Comment 7:

Ecological Impacts - Sediment loading affects on wetland biota were discussed previously. Destruction of grass and tree cover on the 881 Hillside would eliminate both the habitat of many birds and small animals and food for larger animals. Trees are not common to the grasslands of RF.

Response:

Some trees will be removed in the process of constructing the French Drain. This will eliminate the habitat associated with the small area of trees at the 881 Hillside. Therefore, in order to mitigate the loss of nesting sites at this area, trees (and grasses) will be replaced. It is recognized that trees are not common in the grassland surrounding Rocky Flats, and there loss may have more ecological impact than if trees were more common. Nevertheless, this is an unavoidable impact but will be expeditiously mitigated.

Comment 8:

Risk Assessment Impacts - Under the IAG Environmental Restoration cleanup process, DOE will have to prepare and Environmental Evaluation (EE) as part of the assessment and remediation for each Operable Unit and roll those into a final risk assessment. These evaluations will begin at the 881 Hillside and Operable Unit 5 (Woman Creek) concurrently with planned French Drain Construction activities. If significant impact to these ecosystems occurs as a result of construction, the actions would need to be reconsidered.

Response:

The greatest potential impact to the environment is sediment loading to Woman Creek and its effect on fish and other aquatic organisms in the creek. However, as previously discussed, there should be no additional sediment loading to Woman Creek because the excavation will occur hydraulically upgradient of the SID. Grass and tree cover will be destroyed, including bird and small mammal habitat and food for larger animals. This will occur in an approximately 5 acre area, and is an unavoidable impact which will be mitigated to the extent possible. This should not be cause for the EE to be redone.

Comment 9:

French Drain Decommissioning - During operation, the French Drain will accumulate and concentrate contaminants in the lining, fill material, and surrounding uphill colluvium. This material may have to be removed at the end of the French Drain life cycle, resulting in a similar effort to the original excavation and similar impacts.

Response:

The operation of the French Drain will not concentrate contaminants in the lining, fill material, and the uphill colluvium, although some adsorption may occur. Although a risk assessment has not been performed which would allow determination of acceptable concentrations of contaminants in these materials, it is our opinion that residual concentrations of contaminants would likely not pose unacceptable risk. This is particularly true if the French Drain is operated until it begins collecting "clean" water which would result in desorption of these contaminants from these materials. Therefore, when the French Drain is decommissioned, it is likely that the exhumed material will not require special handling or disposal.

Comment 10:

French Drain Operational Impacts - Maintenance and operations costs associated with replacement of plumbing and pumps have been addressed. However, costs and environmental impacts of potentially required excavation and reconstruction of sediment-clogged portions of the French Drain have not been considered.

Response:

Maintenance costs for french drains are considerably lower than those associated with well arrays. To further reduce the likelihood of any reconstruction of the French Drain, clean-outs have been provided along the entire length of the drain. Lastly, as a measure of the reliability and low maintenance of french drains, the Building 881 footing drain has been operational for the past 20 years.

Comment 11:

French Drain Case Studies - French Drains do not work well in locations where the hydraulic conductivity of the "aquifer" (colluvium) is close to that of the "aquiclude" (bedrock). They also do not work well in locations where wide variations in hydraulic conductivity exist within the aquifer or aquiclude. Both appear to be the case at the 881 Hillside. A French Drain collection system is installed at Operable Unit 4 (Solar Evaporation Ponds). While there is not a detailed technical evaluation of the success of this system, there are indications that it has not proven effective in capturing all of the contaminant plume.

Response:

It is true that french drains do not create satisfactory cut-offs in layered systems in which the layers are not separable based on hydraulic conductivity; however, the layered system at the 881 Hillside (colluvium over bedrock) is characterized by different hydraulic conductivities. Based on the hydraulic conductivity test results reported in DOE (1990b) for well 2-87 completed in sandy clay similar to the soils found on the drain alignment in EG&G (1990), the hydraulic conductivity of the soil is expected to be $4x10^{-5}$ cm/s. The sixty-seven packer test hydraulic conductivity determinations for the uppermost bedrock reported in EG&G (1990) range from $4x10^{-7}$ to $2x10^{-3}$ cm/s; although the higher values may be a result of shallow rock fracture dilation at low test pressures, and are therefore not true measures of in-situ conditions. The geometric mean of these values is $2x10^{-6}$ cm/s (using all values and assuming values reported as less than a detection limit are equal to the detection limit); the standard deviation is 1.9 orders of magnitude. Even though this mean is higher than the probable true value (skewed by use of the questionable higher values and the use of detection limits as values), the packer tests indicate a hydraulic conductivity contrast between the soil and the bedrock in excess of an order of magnitude.

Although the bedrock consists of three lithologies, these heterogeneities are not expected to adversely impact the functioning of the drain, for the following reasons.

1. The bedrock material is actually fairly uniform. Based on data presented in EG&G (1990), it is estimated that approximately seventy-five percent of the bedrock material exposed in the french drain excavation will be claystone.

2. More permeable materials exposed in the french drain excavation will be slush-grouted to seal them. In addition, the base of the entire excavation will be covered with a 40-mil PVC impermeable flexible membrane liner.

3. The uppermost "heterogeneous" bedrock is effectively perching the ground-water system in the soil above that in the bedrock (based on water levels in soil/bedrock well pairs reported in Rockwell, 1988).

Finally, it is agreed that the french drain near North Walnut Creek downhill from the Solar Ponds is probably not completely effective in capturing all of the contaminant plume. However, it is our belief that this is the result of past operational practices and the design of the drain, rather than a characteristic of french drains in general. In the past during intense precipitation events, the collection sump has overflowed, allowing collected fluids to discharge to the creek and associated alluvium. Also, the Solar Ponds drain is built at least partially in the North Walnut Creek alluvium and does not have a downgradient impermeable barrier. Therefore, during times of low water levels in the alluvium, it is possible for the collected fluids to discharge from the drain into the alluvium as subsurface flow. The 881 Hillside drain has been designed to protect against these possible failure modes (sump pump redundancy and inclusion of a downgradient impermeable barrier).

In conclusion, it appears that the French Drain geotechnical investigation has provided data that support the original basis for selection of the OU1 IM/IRA, and because the French Drain will not cross the SID, there should be minimal environmental impacts. These impacts will be mitigated during and upon completion of the construction. In light of these findings, and in consideration of the funds expended to date on this project and the likely poor reception by the regulatory agencies of "starting over", EG&G believes that the OU1 IM/IRA proceed as scheduled.

REFERENCES

DOE, 1990a, Interim Measures/Interim Remedial Action Plan and Decision Document, 881 Hillside Area, Operable Unit No. 1, U.S. Department of Energy, Rocky Flats Plant, January.

DOE, 1990b, Phase III RI/FS Work Plan, Rocky Flats Plant, 881 Hillside Area, Operable Unit No. 1, U.S. Department of Energy, Rocky Flats Office, January.

EG&G, 1990, French Drain Geotechnical Investigation, EG&G Rocky Flats, October 5.

Rockwell, 1988, Remedial Investigation Report for High Priority Sites (881 Hillside Area), Rockwell International, Rocky Flats Plant, March 1.