

OU5 WIND RESUSPENSION POTENTIAL STUDY

February 1995

EG&G Rocky Flats, Inc.
Golden, Colorado 80402-0464

Prepared by:

Advanced Sciences, Inc.
405 Urban Street, Suite 401
Lakewood, Colorado 80228

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Introduction

The amended field sampling plan, Technical Memorandum No. 15 (TM15), for the Woman Creek Priority Drainage, Operable Unit No. 5 (OU5) RCRA Facility Investigation/Remedial Investigation (RFI/RI) Work Plan (DOE 1994) described four air quality investigations: the Radioactive Ambient Air Monitoring Program (RAAMP), special OU5 ambient air samplers, a wind resuspension potential study, and an examination of the volatilization of soil gases. The RAAMP and OU5 samplers have continued operation as part of the routine air quality monitoring programs at the Rocky Flats Environmental Technology Site (RFETS). The amended RFI/RI Work Plan recommended the investigation into the volatilization of gases from OU5 only if inhalation of volatile chemical species was decided to be an exposure pathway of concern. At this writing, the inhalation of volatile organic compounds by workers or future residents outdoors has not been designated a complete exposure pathway.

This report discusses the supplemental field investigation into the wind resuspension potentials of the soils in OU5 that was conducted as part of the Addendum to Final Phase I RFI/RI Work Plan. It presents the objectives, methods, and results of the study.

Wind Resuspension Potential Study Objectives

Air dispersion modeling provides the primary basis for assessing the inhalation risks posed by windblown contaminated dust to current and future residents and future outdoor workers. Perhaps the most critical input parameters to air dispersion models are those associated with the source terms. In the situation of OU5, the important source input factors are the contaminant levels in the surface soils and the wind resuspension potentials of those soils. The original investigations of the OU5 RFI/RI Work Plan focused on the contaminant levels in the surface soils and those findings are discussed extensively in TM15. The objective of the additional air quality study was to assess the wind resuspension potential of the Individual Hazardous Substance Sites (IHSSs) in OU5.

In 1993, EG&G conducted a field investigation throughout Operable Unit No. 3 (OU3) to determine the wind resuspension potentials of the soils in the areas east of Indiana Street (EG&G 1994). The OU3 study utilized a portable wind tunnel. That study yielded important information about the wind erosion potential of the OU3 areas, possibly the most valuable of which was the calculation of specific threshold friction velocities and threshold wind speeds of the sites that were examined. Friction velocity, which is a measure of the wind shear at the erodible surface, characterizes the capacity of the wind to cause surface particle movement. Threshold friction velocity is the minimum velocity that results in particle movement. Threshold wind speed is equivalent wind speed at an elevation above the ground surface, for example, 10 meters which is the standard height of a reference anemometer. The purpose of this wind resuspension potential study in the Woman Creek Drainage was to estimate the threshold friction velocities of the OU5 sites and compare these to the OU3 wind tunnel study results. If the OU5 investigation results compare favorably with the threshold friction velocity values determined in the OU3 wind tunnel study, then the OU3 data can be utilized reliably for the OU5 RFI/RI air dispersion modeling and, henceforth, the Human Health Risk Assessment (HHRA).

Wind Resuspension Potential Study Methodology

The investigation of the wind erosion potential of contaminated soils in areas of interest in OU5, including IHSS 115, IHSS 133, the Surface Disturbance South of IHSS 133, IHSS 209, and the Surface Disturbance West of IHSS 209, was proposed as a phased approach. The first phase involved a limited field investigation of the site and comparisons of these results with those of the more intensive wind tunnel study that was performed at OU3. If the first phase results were inconclusive, then a second phase was recommended. The second phase would be the replication at OU5 of the intensive field studies that were conducted in 1993 at OU3.

The wind resuspension potential study relied on the rapid assessment methodology described by Cowherd et al. (1985). The field examinations consisted of observations about sites selected as representative of the areas of interest. The soil type was characterized along with the soil moisture and presence or absence of soil crusting. The extents of bare soil, vegetative cover, and other nonerrodible elements (gravels and cobbles larger than 1 cm diameter) were estimated. Finally, a soil sieving procedure was conducted with 4 mm, 2 mm, 1 mm, 0.5 mm, and 0.25 mm sieves to estimate the aggregate size mode of the surface soil. From the estimate of the aggregate size mode, the threshold friction velocity of the soil was determined from a figure in the reference document. A correction factor was calculated to account for the increase in threshold friction velocity due to the nonerrodible elements.

In working with the rapid assessment method, several limitations and difficulties with the procedures and calculations were encountered. The reference document (Cowherd et al. 1985) cautions that the procedures provide only a "first-cut, order-of-magnitude" estimate of exposure in limited applications. Nevertheless, the Cowherd method is endorsed as affording a degree of accuracy consistent with simplified quantitative estimation procedures (EPA 1988). Approaches such as the Soil Conservation Service method (Woodruff and Siddoway 1965) to estimate wind erosion apply to annual losses from crop land and cannot be applied to generate short-term estimates. The Cowherd method was selected because of the current land use of RFETS, the nature of the soils and vegetative cover in OU5, and the episodic high-wind events characteristic of the region.

Certain assumptions incorporated into the rapid assessment method somewhat limited the interpretations of the OU5 study. Most apparent was the utilization of only a few sieve sizes to estimate the mode of the aggregate size. Soil elements larger than 1 cm and smaller than 0.25 mm were not included in the sieve analysis. At some locations, these fractions, more frequently the larger end of the scale, composed the most volumetric fraction. Standard soil sieving techniques quantify the fractions by weighings. The Cowherd rapid assessment method calls for visual estimates of the relative sizes of the catches. Investigators for this study improved the technique by volumetrically measuring the individual fractions to estimate the mode. In addition, it was difficult to estimate how much of the nonerrodible elements were embedded in the ground surface. When in doubt, 50 percent seemed like a reasonable estimate. A serious limitation in the view of the investigators was the poor quantitative accounting for the mitigating effects of partial vegetative cover. Correction factors for nonerrodible elements could not be assigned values above 10 due to limitations in the graph accompanying the reference document.

Wind Resuspension Potential Study Results and Discussion

Field work was performed from January 20 to January 27, 1995. Weather conditions during the month prior to the field study were unusually dry. All soils were dry during the study period. Ambient temperatures were unseasonably warm, in the 40 °F and 50 °F ranges. Daytime winds during the study period were light from the southeast and east.

The 1993 OU3 wind tunnel study examined four terrestrial sites. These same four terrestrial sites were investigated as part of this wind resuspension potential study (Figure 1). Sites T-1, T-2, and T-3 of the OU3 wind tunnel study were chosen for that study as representative of the soil and vegetation conditions on areas directly east of the Rocky Flats Plant. Conditions were somewhat different at each site. At T-1, the soil was a clayey silt with some fine gravels, and vegetative cover was fair to good. Location T-3 was three-fourths of a mile or more east of T-1. Here the soil was a silty, sandy gravel. Although the vegetative cover was far less than at T-1, the other nonerodible elements provided a comparable overall coverage. Location T-2 displayed a silty sand with fair vegetative cover. The fourth terrestrial location, T-4, was about two miles southeast of the other three OU3 wind tunnel study sites. It had been selected because it was characteristically different from the other three sites. The soil was a silty sand, and although the aggregate size mode was comparable to two of the other OU3 sites, the vegetative and other nonerodible cover at this fourth location was minimal.

Ten locations, in two groups of five each, were chosen as representative of soil and vegetation conditions within IHSS 115 (Figure 2). Surface slopes throughout the landfill are fairly steep, 15 percent to 40 percent and facing south. Locations 115AQ1 through 115AQ5 were situated west to east along the top of the landfill slope. Soils were gravelly sands with larger aggregate size modes and noticeable bare soil. The extent of nonerodible elements, both gravels-cobbles and vegetation, was variable. Location 115AQ5 was somewhat down the slope and displayed a smaller aggregate size mode and more vegetative cover. The remaining locations in IHSS 115, 115AQ6 through 115AQ10, were situated east to west along the lower elevations of the landfill. They were characterized generally by smaller aggregate size modes and very good vegetative cover.

Within IHSS 133, five locations were examined as representative of conditions in that area of interest (Figure 3). Area slopes were gentle, approximately five percent with a south orientation. Soils were gravelly sands and sandy silts with smaller aggregate size modes. Vegetative cover was excellent, usually complete.

At this writing, the three surface disturbance areas on the south side of Woman Creek are not considered areas of contaminant concern and have not been included as radiological sources in the air dispersion modeling for the OU5 RFI/RI. Fewer locations within these three areas were examined in this wind resuspension potential study.

The Surface Disturbance South of IHSS 133 is located on a flat hilltop on the south side of Woman Creek. Within this area, two locations, identified as SASH-AQ16 and SASH-AQ17, were investigated (Figure 4). Soils were gravelly sands indicative of a hilltop situation. The aggregate size modes were smaller. Vegetative cover was very good.

IHSS 209 is a large, basically level, surface disturbance area on another hilltop on the south side of Woman Creek. Three locations, identified as 209AQ18 through 209AQ20, within IHSS 209 were examined (Figure 5). The soils on this hilltop were generally sandy gravels exhibiting larger aggregate modes. Vegetative cover was only fair, but other nonerrodible elements added conspicuous protection from wind erosion.

The Surface Disturbance West of IHSS 209 is a moderately sloping hillside, north-facing, on the south side of Woman Creek. Two locations, W209AQ21 and W209AQ22, were examined in this homogeneous area (Figure 5). Gravelly and clayey sands characterized the slope. Aggregate size modes were smaller. Vegetative cover was uniformly very good.

The results of the OU5 wind resuspension potential study are summarized in Table 1. The rapid assessment method produced values for threshold friction velocities at the four OU3 wind tunnel study sites that were within the same order of magnitude, but higher by several factors, as the results of the OU3 wind tunnel study (Table 2). The results of the rapid assessment method were more conservative (higher) than those of the wind tunnel study. Field observations of the vegetative and soil conditions at both the OU3 wind tunnel study sites and throughout OU5 found that the two areas generally were comparable. Soil particle aggregate size modes were typically larger throughout OU5. The vegetative cover was generally more extensive in OU5 than in OU3, excepting the top of the landfill slope and IHSS 209.

The threshold friction velocities calculated for the OU5 locations were consistently higher, sometimes by an order of magnitude, than the values reported in the OU3 wind tunnel study. Consequently, the threshold wind speed values from the OU3 study can be applied to the air dispersion modeling for the OU5 RFI/RI and HHRA with the confidence that conservative, health-protecting assumptions are being exercised.

The rapid assessment method yielded values that are conservative estimates of the threshold friction velocities and threshold wind speeds around OU5. With the availability of the results of the wind tunnel study at OU3, where field conditions are generally comparable to OU5, more accurate values are not required at this time for air dispersion modeling purposes.

Table 1. OUS Wind Resuspension Potential Study Results

| Location | Aggregate size mode estimate (mm) | Threshold friction velocity, u^*_t -uncorrected (cm/s) (Fig 3-4) (1) | Bare soil (m^2)(2) | Vegetation coverage (m^2)(2,3) | Other nonerodible coverage (m^2)(2,3) | Vertical fraction embedded | Equivalent frontal area of nonerod. elements (m^2) [Coverage*(1-amb.frac.)] | Lc [Eq.front.area/Area of bare soil] | Correction ratio (Fig.3-5)(1,4) | Threshold friction velocity, u^*_t -corrected (cm/s) [u^*_t *(Ratio)] | Equivalent 10-m wind speed (mi/hr) (5) |
|------------|-----------------------------------|--|------------------------|------------------------------------|---|----------------------------|---|--------------------------------------|---------------------------------|--|--|
| 115AQ1 | 4 | 115 | 0.3 | 0.35 | 0.65 | 0.35 | 0.4225 | 1.4 | 10 | 1150 | 418 |
| 115AQ2 | 3 | 100 | 0.6 | 0.15 | 0.25 | 0.5 | 0.125 | 0.2 | 10 | 1000 | 364 |
| 115AQ3 | 4 | 115 | 0.4 | 0.35 | 0.25 | 0.5 | 0.125 | 0.3 | 10 | 1150 | 418 |
| 115AQ4 | 4 | 115 | 0.2 | 0.05 | 0.8 | 0.5 | 0.4 | 2.0 | 10 | 1150 | 418 |
| 115AQ5 | 1.5 | 75 | 0.15 | 0.8 | 0.25 | 0.5 | 0.125 | 0.8 | 10 | 750 | 273 |
| 115AQ6 | 0.5 | 50 | 0.1 | 0.9 | 0.1 | 0.75 | 0.025 | 0.3 | 10 | 500 | 182 |
| 115AQ7 | 0.75 | 58 | 0.55 | 0.4 | 0.15 | 0.5 | 0.075 | 0.1 | 7 | 406 | 148 |
| 115AQ8 | 4 | 115 | 0.1 | 0.9 | 0.65 | 0.5 | 0.325 | 3.3 | 10 | 1150 | 418 |
| 115AQ9 | 1.5 | 75 | 0.05 | 0.95 | 0.15 | 0.5 | 0.075 | 1.5 | 10 | 750 | 273 |
| 115AQ10 | 0.75 | 58 | 0.05 | 0.95 | 0.03 | 0.5 | 0.015 | 0.3 | 10 | 580 | 211 |
| 133AQ11 | 3 | 100 | 0.05 | 0.95 | 0.25 | 0.75 | 0.0625 | 1.3 | 10 | 1000 | 364 |
| 133AQ12 | 1.5 | 75 | 0 | 1 | 0.05 | 0.5 | 0.025 | #DIV/0! | infinite | infinite | infinite |
| 133AQ13 | 1 | 65 | 0.25 | 0.75 | 0.1 | 0.5 | 0.05 | 0.2 | 10 | 650 | 236 |
| 133AQ14 | 4 | 115 | 0 | 1 | 0.7 | 0.5 | 0.35 | #DIV/0! | infinite | infinite | infinite |
| 133AQ15 | 0.75 | 58 | 0 | 1 | 0.3 | 0.8 | 0.06 | #DIV/0! | infinite | infinite | infinite |
| SASH-AQ16 | 0.75 | 58 | 0.2 | 0.8 | 0.3 | 0.5 | 0.15 | 0.8 | 10 | 580 | 211 |
| SASH-AQ17 | 0.3 | 40 | 0.03 | 0.97 | 0.3 | 0.5 | 0.15 | 5.0 | 10 | 400 | 145 |
| 209AQ18 | 4 | 115 | 0.25 | 0.4 | 0.4 | 0.5 | 0.2 | 0.8 | 10 | 1150 | 418 |
| 209AQ19 | 4 | 115 | 0.2 | 0.3 | 0.5 | 0.5 | 0.25 | 1.3 | 10 | 1150 | 418 |
| 209AQ20 | 4 | 115 | 0.1 | 0.5 | 0.65 | 0.8 | 0.13 | 1.3 | 10 | 1150 | 418 |
| W209AQ21 | 0.5 | 50 | 0.1 | 0.9 | 0.15 | 0.5 | 0.075 | 0.8 | 10 | 500 | 182 |
| W209AQ22 | 0.75 | 58 | 0.1 | 0.9 | 0.025 | 0.5 | 0.0125 | 0.1 | 7 | 406 | 148 |
| OU3T-1AQ23 | 0.3 | 40 | 0.25 | 0.7 | 0.05 | 0.25 | 0.0375 | 0.2 | 10 | 400 | 145 |
| OU3T-2AQ25 | 0.5 | 50 | 0.35 | 0.6 | 0.15 | 0.2 | 0.12 | 0.3 | 10 | 500 | 182 |
| OU3T-3AQ24 | 2 | 88 | 0.05 | 0.25 | 0.7 | 0.5 | 0.35 | 7.0 | 10 | 880 | 320 |
| OU3T-4AQ26 | 0.5 | 50 | 0.85 | 0.1 | 0.1 | 0.5 | 0.05 | 0.1 | 7 | 350 | 127 |

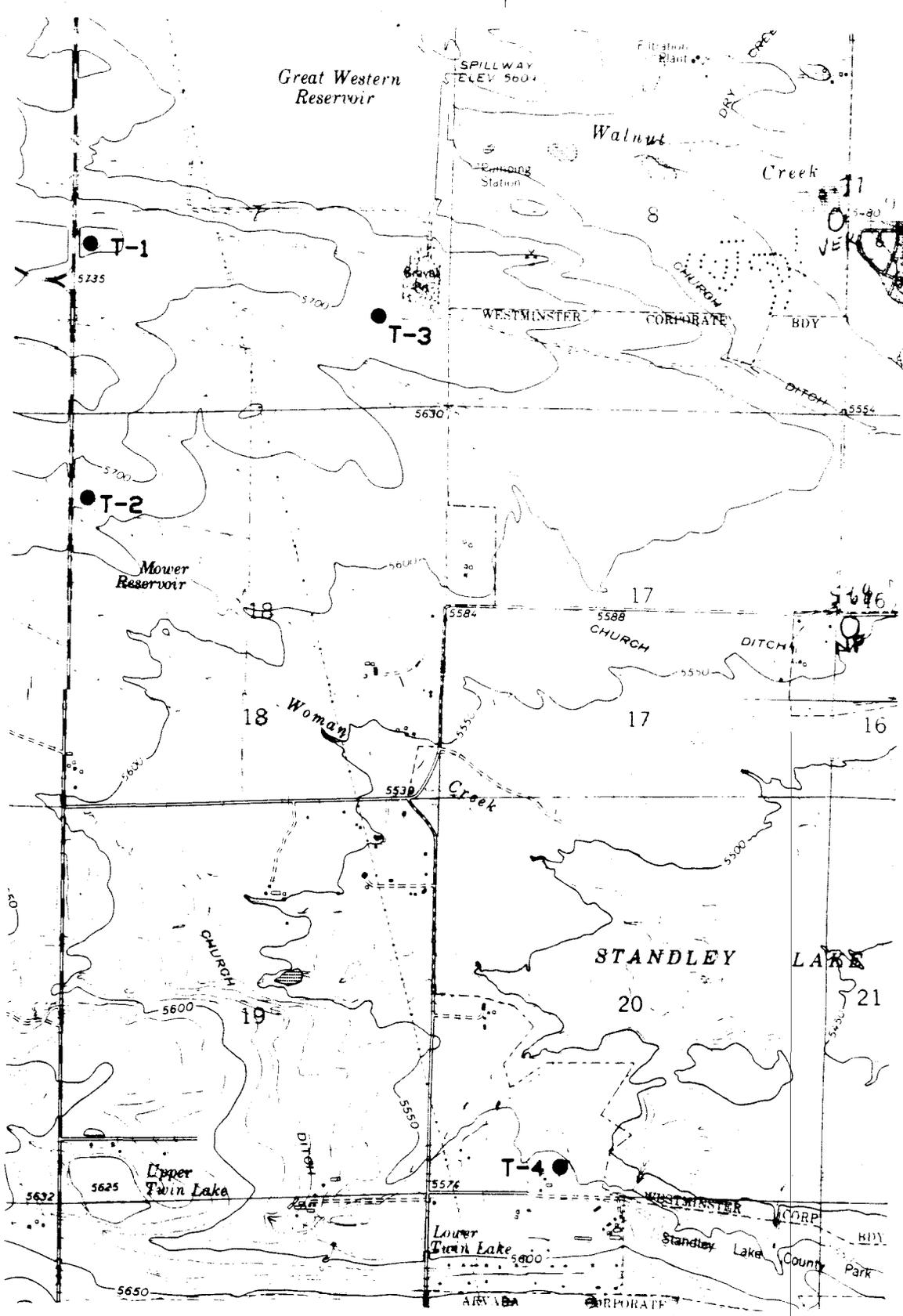
Notes:

- (1) Figure references are from Cowherd et al., 1985.
- (2) Estimates are based on examinations of 1 m^2 of ground at selected locations.
- (3) Sum of vegetation coverage plus other nonerodible elements coverage may be more than (1-Bare soil) due to overlap of vegetation and other nonerodible elements.
- (4) Maximum correction ratio extrapolated from Figure 3-5 is 10, which is used for all Lc values >0.1
- (5) Equivalent 10-m wind speed is calculated from the threshold friction velocity using the logarithmic wind profile distribution, $u(z) = (u^*/0.04)(\ln z/z_0)$, where the roughness height, z_0 , is assumed to be 1.5 cm facility-wide.

**Table 2. Comparison of Results of 1993 Wind Tunnel Study and
1995 Rapid Assessment Method**

| OU3 location | Threshold friction velocity (cm/s) | |
|--------------|------------------------------------|------------------------------|
| | 1993 Wind tunnel study (1) | 1995 Rapid assessment method |
| T-1 | >280 | 400 |
| T-2 | >170 | 500 |
| T-3 | >180 | 880 |
| T-4 | >160 | 350 |

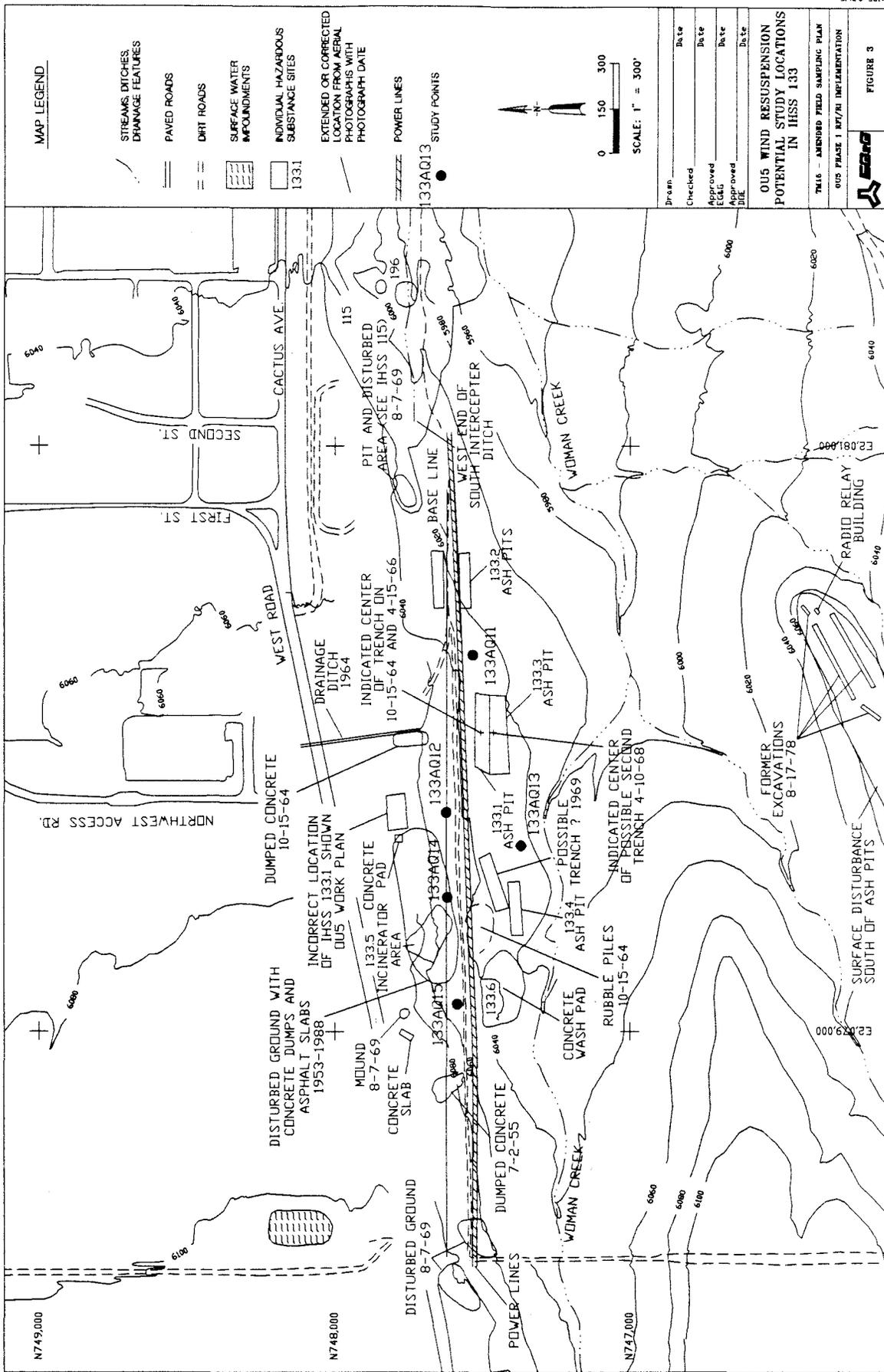
Note: (1) EG&G 1994.



1993 OU3 WIND TUNNEL STUDY
 TERRESTRIAL SAMPLING SITES

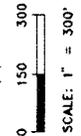


FIGURE 1



MAP LEGEND

- STREAMS, DITCHES
DRAINAGE FEATURES
- PAVED ROADS
- DIRT ROADS
- SURFACE WATER
IMPOUNDMENTS
- INDIVIDUAL HAZARDOUS
SUBSTANCE SITES
- EXTENDED OR CORRECTED
LOCATION FROM AERIAL
PHOTOGRAPHS WITH
PHOTOGRAPH DATE
- POWER LINES
- STUDY POINTS



| | |
|----------|------|
| Drawn | Date |
| Checked | Date |
| Field | Date |
| Approved | Date |
| DIC | Date |

OU5 WIND RESUSPENSION
POTENTIAL STUDY LOCATIONS
IN IHSS 133

FIG. 1 - AMENDED FIELD SAMPLING PLAN
OU5 PHASE I RFI/RI IMPLEMENTATION



FIGURE 3

N749,000

N748,000

N747,000

MAP LEGEND

- STREAMS, DITCHES, DRAINAGE FEATURES
- DIRT ROADS
- SURFACE WATER IMPOUNDMENTS
- INDIVIDUAL HAZARDOUS SUBSTANCE SITES (IHSS)
- STUDY POINTS

SASH-AQ17

209

SCALE: 1" = 200'

0 100 200

Drawn _____ Date _____

Checked _____ Date _____

Approved EGG _____ Date _____

Approved DDE _____ Date _____

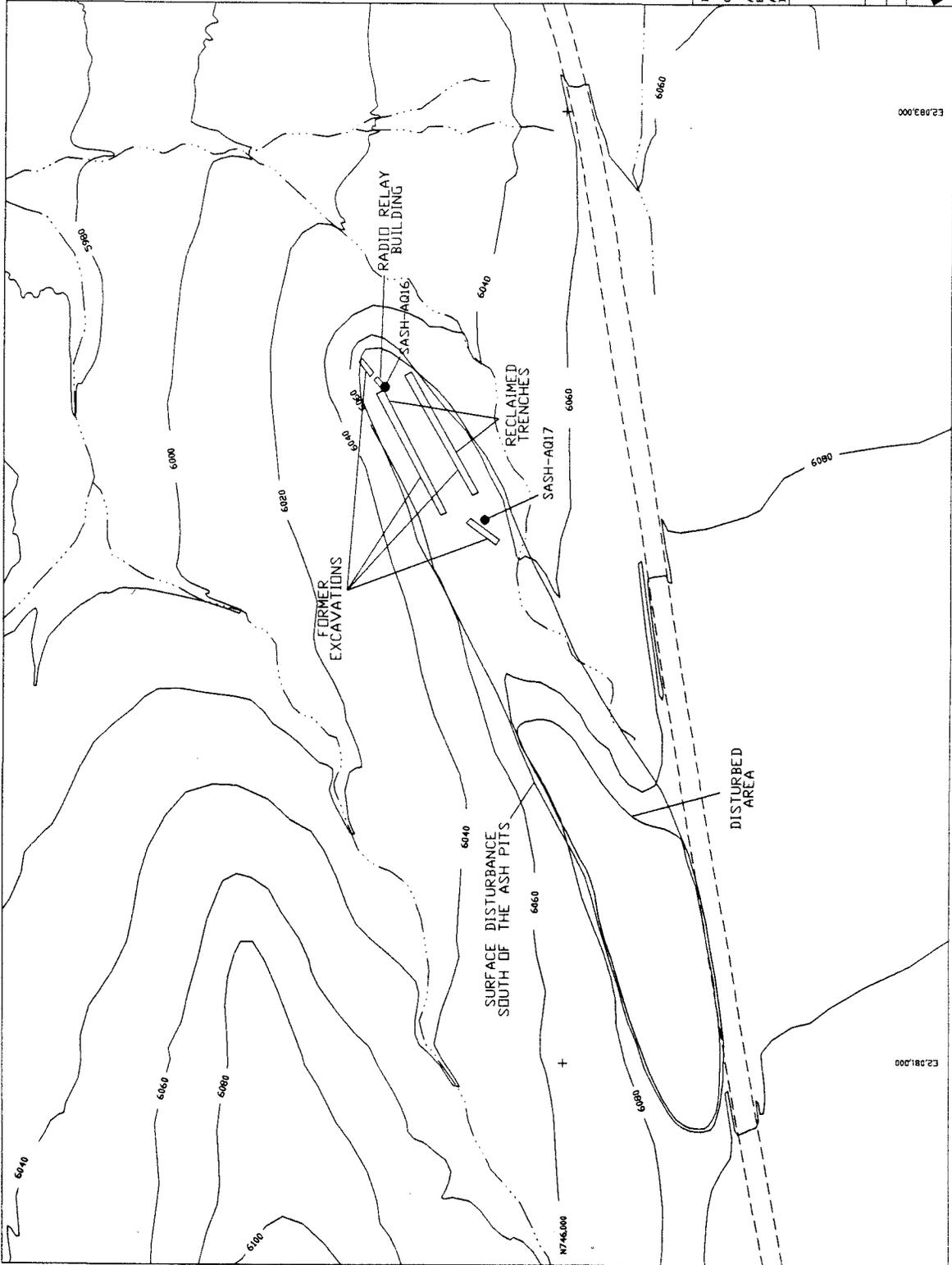
005 WIND RESUSPENSION STUDY LOCATIONS IN SURFACE DISTURBANCE SOUTH OF THE ASH PITS

THIS - AMENDED FIELD SAMPLING PLAN

005 PHASE I REV/RI IMPLEMENTATION

EG&G

FIGURE 4



E2.083.000

E2.081.000

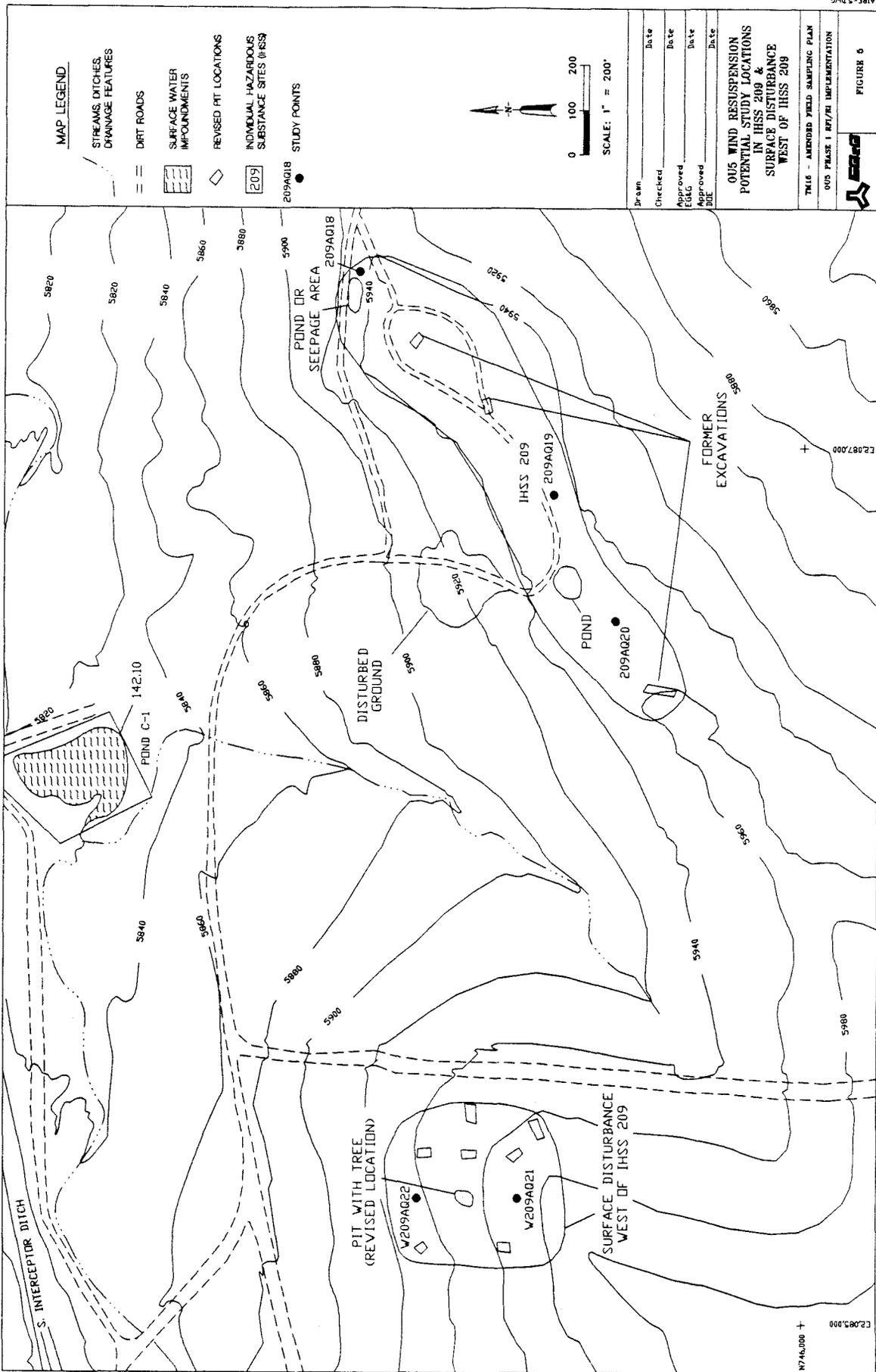


FIGURE 0

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