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DCN: 90-227-005-04-03

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Review of Hargis and Associates, Inc. (1989):

Summary of Interim Remedial Investigations, January 1987 to April 1989, U.S. Air Force Plant 4, Fort Worth, Texas

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August 1990

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1.0 INTRODUCTION

Hargis and Associates, Inc., 1989 (Hargis), under contract to General Dynamics, produced a summary report that describes the interim remedial investigations performed at Air Force Plant 4 (Plant 4) between January 1987 and April 1989. The focus of the report is characterization of ground-water conditions in the Paluxy Formation on the west side of the facility; and in the Upper Zone and Paluxy Formation on the east side of Plant 4 and the adjoining area of Carswell AFB.

Radian Corporation (Radian) was tasked to review the Hargis report under Modification 0004 to the IRP Phase II Stage 2 Statement of Work for Carswell AFB, with special attention to findings from the eastern part of the study area (including the Carswell AFB flightline area). Of major interest are documented ground-water contaminant plumes in the Upper Zone deposits of the flightline area (Radian, 1986; 1988) that are suspected of being sourced wholly or in part on Plant 4 property. As they may have implications on future activities at Carswell AFB, this report presents Radian's assessment of interpretations and conclusions in the Hargis report related to:

- Hydrogeologic characteristics and occurrence of Upper Zone deposits;
- Nature and extent of Upper Zone ground-water contamination;
- Potential contaminant sources; and
- Potential pathways for contaminant migration.

According to the Hargis report, the basis for their interpretation of Upper Zone conditions on the east side of Plant 4 is data from 67 soil borings, 31 Upper Zone monitor wells, and several rounds of ground-water sampling and analysis performed since 1987. Selected data from the Carswell AFB IRP Phase II Stage 2 report (Radian, 1988) are also referenced.

2.0 HYDROGEOLOGIC CHARACTERISTICS AND OCCURRENCE OF UPPER ZONE DEPOSITS

Hargis defines the Upper Zone geologically as the unconsolidated alluvium and fluvial terrace deposits present in the study area. Hydrogeologically, the Upper Zone is defined to include these sediments and underlying weathered sections of the Cretaceous Goodland Limestone. This is an appropriate distinction since the formations are geologically unconformable. According to Hargis, ground water in the Goodland Formation is hydraulically connected with that in the unconsolidated Quaternary sediments in those areas where the sediments are saturated.

The base of the Upper Zone rests on the irregularly eroded bedrock surface of the Cretaceous Walnut Formation throughout most of the eastern portion of the study area. Where present, the Walnut Formation constitutes an aquitard between ground water in the Upper Zone and in the Paluxy Formation, according to Hargis, based on the observation that "the aquitard is dry and the upper Paluxy Formation is not fully saturated" (p. 21). No data are provided to evaluate the degree to which the Walnut Formation inhibits vertical movement of ground water.

2.1 Lithology

The lithologic descriptions of the Upper Zone deposits presented in the text are consistent with the borehole and monitor well logs provided in Appendices A and B. The Upper Zone sediments include clays, silts, sands and gravels, as is typical for alluvial deposits. The commonly encountered fining upward (decreasing grain size) sequence of sediments and the occurrence of basal gravel deposits in buried channels is documented in the field record.

The nature and distribution of lithologies portrayed in the Hargis report is generally consistent with findings from IRP Phase II investigations in the flightline area of Carswell AFB (Radian, 1986; 1988), and from the IRP Phase II Stage 1 study at Plant 4 (Radian, 1986a). However, the method used for obtaining lithologic samples is not specified. The drilling method indicated on the logs is mainly "flight auger," with a few borings drilled by "mud rotary." If lithologic descriptions and identifications of lithologic contacts were derived from cuttings only rather than undisturbed core samples, this should be indicated.

2.2 Areal and Vertical Extent

Upper Zone alluvial deposits reportedly occur throughout most of the area of investigation. In the eastern part of Plant 4, they vary in thickness up to 61 feet (HM-90), based on Hargis' borehole logs (Appendices A and B). Basal sand and gravel deposits are prominent in two subsurface troughs interpreted as erosional channels on the bedrock surface. This interpretation is supported by the correlation of contour maps depicting basal gravel thickness (Figure 3) and elevations of the base of the Upper Zone (Figure 4). A single channel, originating near the southern end of the Plant 4 assembly building bifurcates in the vicinity of the east parking lot. One branch of the channel trends northeastward to the northern end of the Carswell AFB flightline where lack of data prevent further extrapolation. The second branch of the channel trends southeasterly, beneath the Carswell AFB runways, toward the southern end of the flightline area. The second channel is in direct line with monitor wells installed by Radian just east of the Carswell AFB flightline. The channel (and coarse basal fill deposits) can be extended continuously onto Carswell AFB by incorporating the lithologic data obtained by Radian from past flightline drilling operations. The continuity of this channel and the highly permeable nature of the basal channel fill deposits suggest it may be a preferential pathway for migration of contaminants in ground water beneath Plant 4 onto Carswell AFB (see Section 5). The Hargis report also recognized that the thick basal gravel deposits may act as conduits for rapid transmission of large volumes of contaminated ground water (p. 19).

2.3 Ground-Water Occurrence and Flow Directions

The Hargis text (p. 19) indicates that ground-water flow in the Upper Zone of the east area was assessed on the basis of data collected in April 1989. However, no tabular summary or specifics (such as actual date(s) of measurement at individual wells) of this water level survey are provided. It is therefore not known whether the data are synoptic and thereby appropriate for evaluation of the potentiometric surface configuration and ground-water flow patterns or not. Because the ground water in the Upper Zone is unconfined, infiltration of precipitation (and irrigation) is a major source of recharge. Depending on the length of time over which the water level measurements were taken, the weather conditions (or watering patterns) during that period, and site-specific variations in infiltration rates and the permeability of soils or other surface materials, water levels may not reflect equilibrium (static) conditions in the aquifer. This uncertainty is exacerbated by the "Note" on Figure 9 indicating that the water level contours portrayed were "based on measurements April 1989 or most recent data." Pending satisfactory resolution of these uncertainties, all of the Hargis interpretations of ground-water occurrence, potentiometric surface configurations, and ground-water flow directions require substantiation on the basis of a fully documented, synoptic water level survey.

The potentiometric surface interpreted by Hargis (Figure 9) is erratic in the vicinity of the assembly building suggesting either numerous points of recharge or contouring of non-representative data (see preceding discussion). Aside from precipitation, potential sources of recharge identified by Hargis include broken water mains, sewer lines, and storm sewers. The relatively high hydraulic gradients in this area are consistent with Hargis' conclusion that bedrock topography influences ground-water flow direction and rate in the Upper Zone, since the bedrock surface is steeply dipping in this area (Figures 4 and 5). East of the assembly building, the water table exhibits less variability and the hydraulic gradient is lower, consistent with the locally flatter bedrock topography.

Notwithstanding the uncertainties surrounding the representativeness of the water level data, the ground-water flow directions shown on Figure 9 appear reasonable insofar as they tend to follow the bedrock topography, especially the eroded bedrock channels and permeable channel fill deposits of the Upper Zone. Also as shown on Figure 9, Hargis interpreted the existence of a northeasterly-trending ground-water divide beneath the Plant 4 assembly building. In the position indicated, such a ground-water divide could potentially inhibit or prevent ground water on the west side of the assembly building from migrating eastward, toward Carswell AFB. However, even if the posted water levels are taken at face value, the potentiometric surface in this area can be alternately contoured as shown in Figure 9-A. In that situation, ground water west of the assembly building could flow eastward beneath the Plant 4 engineering office building. As shown by Hargis on Figure 16, a plume of trichloroethylene (TCE) centered on monitor well HM-29 could potentially migrate eastward along this flow path.

2.4 Hydraulic Properties

The Hargis report indicates that no aquifer tests were performed on any Upper Zone monitor wells during the period of interim remedial investigations (January 1987 - April 1989). However, aquifer (slug) tests were performed by Radian in the adjacent flightline area of Carswell AFB during IRP Stage 2 studies in April, 1988. The calculated conductivities for the Upper Zone were in the range of 10^{-3} to 10^{-4} cm/sec.

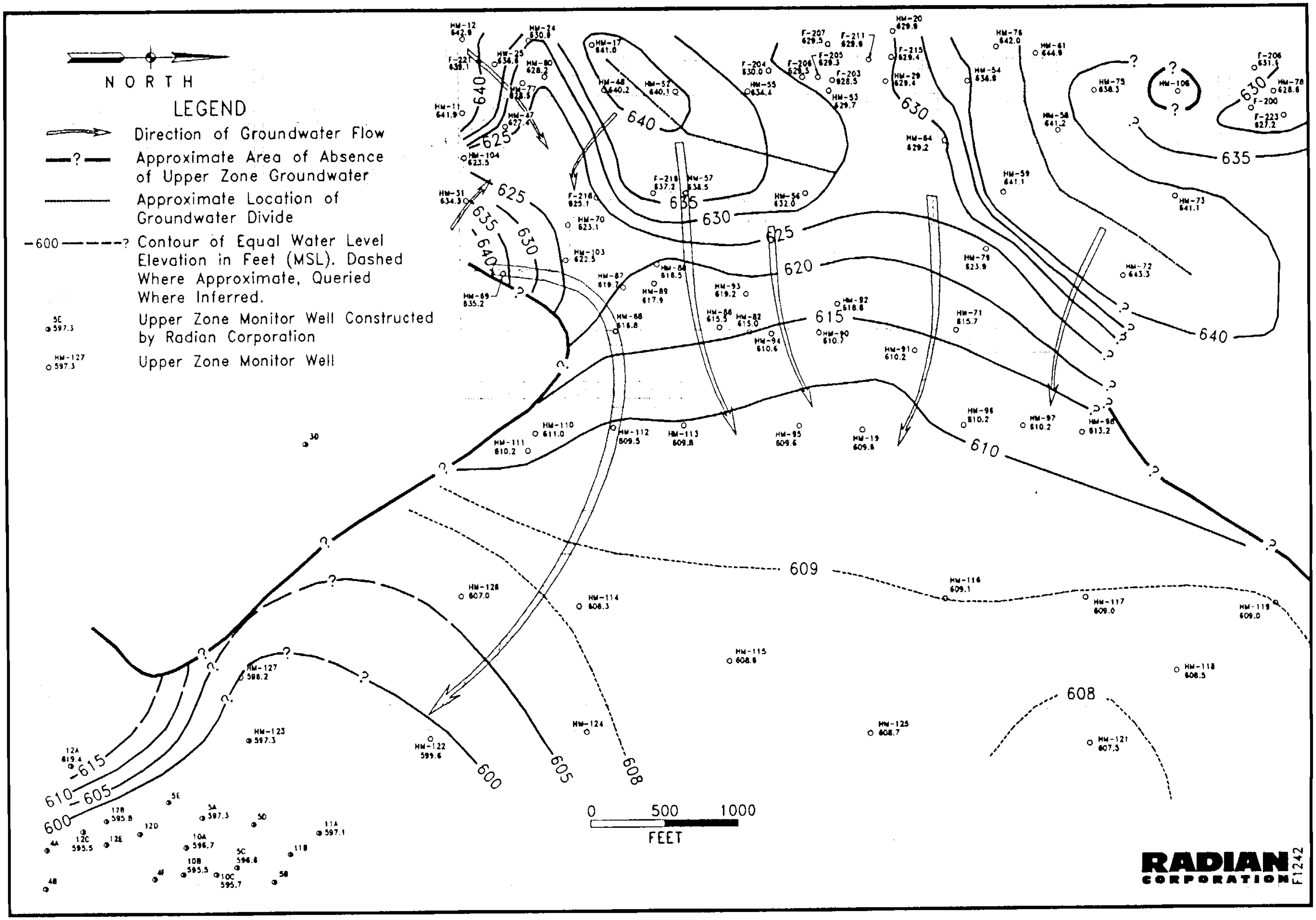

Figure 9-A. Alternate Contouring of Water Level Data Posted on Figure 9 (Hargis, 1989)

3.0 NATURE AND EXTENT OF UPPER ZONE GROUND-WATER CONTAMINATION

Chromium, trans-1,2-dichloroethylene, and trichloroethylene were the most commonly detected contaminants in the Upper Zone ground water of Plant 4 (Hargis, 1989). Isoconcentration contour maps were generated by Hargis showing the distribution of these contaminants (Figures 14, 15, and 16, respectively). However, the analytical results represent ground-water samples that were collected at different times using different techniques. Samples were collected by Hargis in December, 1988 (i.e., grab samples from RSB borings) and April, 1989 (i.e., monitor well samples from HM wells). Radian collected ground-water samples from the Carswell AFB flightline monitor wells in April 1988. Using such "mixed" data to draw conclusions concerning the concentration distribution and extent of ground-water contaminants is not technically valid. Also, since the solvent contaminants tend to be "sinkers" it is important to identify the screened intervals of all monitor wells so the probability of their intercepting these contaminants can be evaluated. No data were included to make this determination as only a generic Upper Zone monitor well construction diagram was provided (Appendix F). Each of the three major contaminants is discussed in the following subsections.

3.1 Chromium

Figure 14 shows the estimated areal extent and concentration distribution of chromium contamination in Upper Zone ground water as interpreted by Hargis. The contoured chromium concentrations are from samples collected during two separate events approximately one year apart (April 1988 versus April 1989), with all 1988 data from wells on Carswell AFB. As previously noted, any interpretations based on data from two such temporally distinct events are highly speculative.

The plume configuration shown on Figure 14 of Hargis suggests chromium is migrating from the east parking lot area of Plant 4 to the northeast and southeast along the two eroded bedrock channels (previously discussed). The highest concentrations occur just east of the parking lot, decreasing with distance along the channels.

Chromium was also detected in Upper Zone ground-water samples collected by Radian from monitor wells located just east of the Carswell AFB flightline. Hargis suggests (p. 25) that the chromium detected in the Carswell wells is from a different source than the chromium in ground water beneath Plant 4 based on "the distribution and concentration of total chromium in water samples collected from these (Carswell AFB) wells," and contours the Carswell data separately. However, the distribution of data points is extremely sparse east of runway 130. Because of this, chromium data could be contoured alternately. By extrapolating the 0.05 ppm isoconcentration contour to encompass sampling points on the Carswell AFB flightline (monitor wells 5C, 5D, 10A, 10B and 10C), the existence of a continuous plume, extending from a source(s) on Plant 4, beneath the runways, to the Carswell AFB flightline area could be interpreted (Figure 14-A). The orientation and configuration of this projected plume also corresponds closely to the southeasterly-trending bedrock channel that may be a preferential pathway for contaminant migration (see discussion at Section 5).

Finally, the chromium results used in the Hargis report (including those taken from Radian, 1988) are for total chromium (i.e., results from unfiltered samples). Assuming all samples were acidified in the field per standard EPA sample preservation protocol for metals analysis, some contribution to the reported total chromium may be attributable to leaching of suspended sediments in the water samples. Variable amounts and compositions of suspended materials could thereby potentially affect the analytical results without reflecting actual variations in ground-water chemistry (i.e., dissolved chromium).

3.2 Trans-1,2-Dichloroethylene

Figure 15 of the Hargis report shows the interpreted areal extent and concentration distribution of trans-1,2-dichloroethylene (DCE) in the

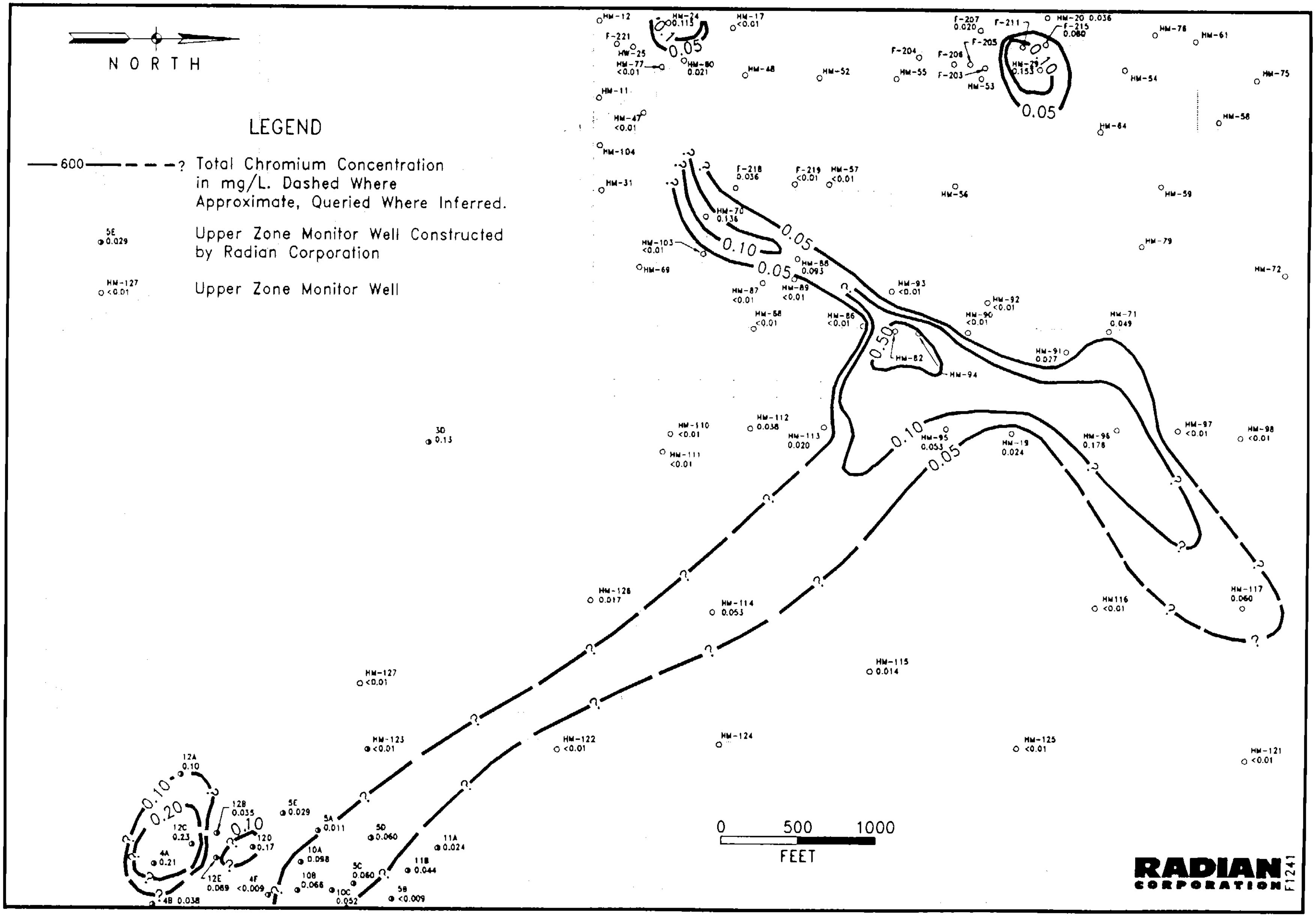

Figure 14-A. Alternate Contouring of Total Chromium Data Posted on Figure 14 (Hargis, 1989)

Upper Zone ground water beneath Plant 4. Trans-1,2-DCE, apparently sourced beneath the southern end of the Plant 4 Assembly Building where a maximum concentration of 6,700 μg/L was reported (HM-94), is migrating in a plume from the east parking lot area toward Carswell AFB.

Figure 15 is based on analysis of ground-water samples collected by Hargis in April 1989 (HM wells) and by Radian in April 1988 (Carswell AFB flightline wells). The same problems discussed regarding the interpretation of chromium results from two temporally distinct sampling events apply to the trans-1,2-DCE data. Also, because trans-1,2-DCE is an intermediate transformation product of trichloroethylene, interpretations involving multiple and/or primary versus secondary sources are necessarily complicated (see Section 3.3).

Although not discussed in the text, on-site headspace analyses of ground-water grab samples collected from boreholes drilled on Carswell AFB in December 1988 were performed by Microseeps, Ltd. Trans-1,2-DCE was among the volatile organic compounds reported (Appendix D). Notably, only one sample (RSB-40A) had a reported trans-1,2-DCE concentration above 25 ppb (μg/L). Because these samples were collected as grab samples from boreholes rather than from properly developed wells, their representativeness is questionable. Many of the reported concentrations are inconsistent with the plume configuration portrayed on Figure 15. For instance, in the area beneath the southern part of the Carswell AFB runways, borehole water samples located in areas of high trans-1,2-DCE concentrations (based on the 1989 monitor well data) commonly contained lower than expected trans-1,2-DCE levels* (e.g., RSB-34:6.5 ppb and RSB-41:20.5 ppb within 500 ppb contour; RSB-39:4 ppb, RSB-43:1 ppb, RSB-51:2 ppb and RSB-59:14 ppb between the 100 ppb and 500 ppb contours).

That trans-1,2-DCE concentrations in the grab samples from 1988 do not correlate well with the 1989 monitor well data contoured in Figure 15 may result from the grab samples being non-representative of ground-water quality.

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*Trans-1,2-DCE concentrations are averages of values reported in Appendix D.

Alternatively, it may reflect real, measurable changes in Upper Zone ground-water chemistry between the two sampling events. In fact, the grab sample results are more consistent with the lack of trans-1,2-DCE detects in the Radian analytical results from the Carswell AFB flightline wells (also sampled in 1988) than the more recent Hargis data. The Radian non-detects may be the result of more than just high dilution factors, as suggested by Hargis (p. 26).

Noting the two high concentration nodes depicted on Figure 15, re-examination of the monitor well data suggests that a third node may exist within the area of the 500 ppb closed contour beneath Carswell AFB Taxiway 197. These trans-1,2-DCE concentration highs may reflect discrete pulses of solvent, released episodically and moving along the same path as the larger, more continuous dissolved contaminant plume.

3.3 Trichloroethylene

Trichloroethylene (TCE) data cited by Hargis are from samples collected by Radian in April, 1988 (Carswell AFB flightline wells); and by Hargis in December, 1988 (RSB grab samples) and April, 1989 (HM monitor wells). Figure 16 shows Hargis' interpretation of the TCE plume in the Upper Zone ground water based on analytical data from all three sampling events. It is noteworthy that the TCE concentrations from RSB borehole water samples were included in construction of Figure 16, but parallel data for trans-1,2-DCE were not included in Figure 15 which depicts the trans-1,2-DCE plume in Upper Zone ground water. In addition to the lengthy time interval over which the samples were collected and analyzed, the TCE concentrations detected in the RSB grab samples may not be representative of actual concentrations in the ground water. Although plotted with the monitor well data on Figure 16, the RSB samples were not collected using standard procedures for sampling ground water from wells. Hargis states in their report:

> "An initial 'timed sampling' experiment,...determined that VOC concentration levels in the bore hole increased with time and bail out after drilling. Therefore a minimum one

hour waiting period was used before bailing out the borehole and sampling."

Whether a minimum one hour waiting time is sufficient to ensure representative volatile organics concentrations in the ground water is questionable. Drilling may temporarily affect local ground-water conditions. Development, which is required for monitor wells, was not performed on the boreholes to compensate for any such effects. Comparison of the analytical data from the RSB boreholes and the HM wells in close proximity to them indicates that the TCE concentrations from the boreholes are generally lower (by as much as 30 percent) that the concentrations reported for the HM wells. However, because the samples were collected and analyzed at different times (approximately four months apart) differences in concentrations related to sampling technique cannot be distinguished from temporal effects and quantified. Grab sample volatile organics data from boreholes should have been critically evaluated for representativeness and based on that determination, consistently included or eliminated from consideration when assessing ground-water conditions.

The Hargis report indicates that TCE is migrating from the east parking lot area of Plant 4 eastward toward Carswell AFB. The highest concentrations (up to 25,000 μg/L, April, 1989) occur along the trend of the bedrock channel beneath the east parking lot. Monitor wells sampled by Radian east of the flightline on Carswell AFB contained TCE in concentrations up to 6,400 μg/L (monitor well 10B, April, 1988).

Hargis concludes that TCE detected in ground-water samples from Carswell AFB monitor wells located hydraulically upgradient of well 10B "may have originated from Plant 4," (p. 27) but that the "higher TCE concentrations detected in monitor well 10B indicate that another source of TCE may be present in the southwest of the runways on Carswell AFB" (p. 27-28). Hargis supports this position by speculating that the ratios of TCE to trans-1,2-DCE and the presence or absence of detectable concentrations of vinyl chloride suggest a different source for the TCE in Carswell AFB wells than that originating on Plant 4 (p. 28-29).

Based on Radian's review of the available data, it appears certain that the TCE observed in the Carswell AFB flightline monitor wells is at least partly derived from a source(s) at Plant 4 and in wells located upgradient of well 10B, the detected TCE is probably entirely from Plant 4. Radian knows of no evidence supporting Hargis' speculation on the existence of "another source of TCE...southwest of the runways..." Except for Landfill No. 3, all potential sources of environmental contamination in the flightline area are located east of taxiway 197. Landfill No. 3, located beneath the north-south runway has been shown to pose no environmental or human health hazard (Radian, 1988; 1989).

When evaluating the possibility that another source of TCE on Carswell AFB may be contributing to the apparently elevated concentration detected at monitor well 10B, several points not discussed in the Hargis report need to be considered. First, well 10B is located immediately adjacent to and downgradient of Site 10, a former waste burial area on Carswell AFB. Reportedly, drums of waste solvents were disposed of at this site in the past but no records documenting waste volumes are available (CH2M Hill 1984; Radian 1986, 1988). Considering the wells proximity to the disposal area and the correlation between reported waste types and observed ground-water contaminants, it is likely that some component of the TCE in monitor well 10B is attributable to this site. However, the magnitude of the potential contribution from this approximately 2,000 square foot site is expected to be minor when compared to that from the plume underlying the upgradient areas of Carswell AFB and Plant 4. Also, based on the April 1988 data, "background" TCE values relative to well 10B are approximately 3,000 $\mu g/L$. Assuming worst case conditions, if the balance of TCE detected in 10B is entirely from Site 10, a maximum contribution of less than 3,500 $\mu g/L$ is indicated. In this scenario, roughly half of the TCE observed in the Carswell AFB flightline wells located downgradient of well 10B could be attributable to Site 10, with the remainder associated with the source(s) on Plant 4.

Secondly, it is important to note that the concentrations of TCE detected in samples collected from monitor well 10B have varied significantly with time. Two rounds of samples collected in February and March, 1985 had averaged duplicate TCE concentrations of 4,470 μg/L and 4,780 μg/L, respectively (Radian, 1986). However, the two samples collected in March and April, 1988 contained TCE at 11,000 μg/L and 6,400 μg/L, respectively (Radian, 1988). These values represent an almost 42 percent decrease in the detected concentrations over a one month period. This is especially noteworthy when considering the implications of contouring the 1989 TCE data from the Hargis wells with those from samples collected at Carswell AFB one year earlier.

The distribution of high TCE concentrations on Plant 4 is similar to that of trans-1,2-DCE (compare Figures 15 and 16). As discussed in Section 3.2, this pattern is suggestive of pulsed solvent release and migration of coherent solvent masses within the larger dissolved contaminant plume. This scenario could account for the apparently elevated TCE concentration in the April 1988 ground-water sample from monitor well 10B without necessarily requiring any release of TCE from Site 10.

Finally, Radian questions the use of TCE transformation product ratios as discriminators of contaminant sources. While the basic approach is intuitively sound, factors governing the transformation process are extremely varied and complex. Natural factors influencing the fate of TCE over time include:

- The state in which TCE initially enters the ground-water environment (i.e., DNAPL versus dissolved);
- Advection;
- Dispersion;
- Sorption;
- Evaporation; and

- Biodegradation (TCE may transform into any one of three DCE isomers, subsequently into vinyl chloride; and ultimately into CO_2 and Cl^-).

The approach of using transformation product ratios is further complicated by the fact that the three biodegradation pathways have widely varying rates (half-lives of tens of days to two-to-three years), most of the factors are site-specific and must be determined by direct field measurement and multiple sources of any or all of the transformation products may be involved. Also, as suggested by Hargis, high detection limits for trans-1,2-DCE could account for the lack of reported detections in Carswell AFB ground-water samples. A similar situation could be responsible for the lack of detects of vinyl chloride in Hargis' well samples as detection limits for this analyte ranged up to 250 μg/L (Appendix G). Radian concludes that the data used by Hargis are insufficient in detail and quantity to warrant using this technique to distinguish sources.

4.0 POTENTIAL CONTAMINANT SOURCES

The Hargis report identifies several potential on-site (Plant 4) sources of the Upper Zone ground-water contamination beneath Plant 4 and speculates on the existence of additional sources on Carswell AFB. As discussed in Section 3, the main contaminants of concern in the east area of Plant 4 and the adjacent flightline area of Carswell AFB are:

- Chromium;
- Trans-1,2-DCE; and
- TCE.

Hargis' identification of potential sources for each of these contaminants is discussed below.

4.1 Chromium

Referencing CH2M Hill's 1984 Phase I report, Hargis identifies two former chrome pits located in the south area of Plant 4 as likely sources of the chromium contamination detected in Upper Zone ground-water samples on the east side. This appears to be a reasonable conclusion, based on the locations of the pits and ground-water flow directions interpreted by Hargis (Figure 9). However, the maximum chromium concentrations shown on Figure 14 are located almost one-half mile northeast of the former pits. This could indicate the existence of another chromium source in closer proximity to the high ground-water concentration area, or that any ongoing releases from the chrome pits are much smaller than in the past. Also, Hargis does not address potential source(s) for the chromium high centered on HM-29. This area is located on the west side of their interpreted ground-water divide (Figure 9) and therefore should not be affected by contaminants migrating from the pits.

The suggestion that chromium detected in samples from monitor wells in the Carswell AFB flightline area is from an alternate source is not supported by defensible data. See the discussion in Section 3.1.

4.2 Trans-1,2-DCE

Hargis identifies the southern end of the Assembly Building, and specifically the wastewater collection basins as potential sources of the trans-1,2-DCE detected on the east side of Plant 4. One of the two high concentration nodes is located immediately adjacent to and downgradient of the basins, supporting this interpretation. The second high concentration area may have resulted from earlier, episodic releases from the same source. No other source is suggested for the relatively high concentrations (840 μg/L and 470 μg/L) detected in monitor wells HM-123 and HM-122, respectively. These wells are located on Carswell AFB, just east of taxiway 197 and are upgradient of all known or suspected waste disposal areas on Carswell AFB.

4.3 TCE

The southern part of the main Assembly Building and Parts Plant, and the wastewater collection basins are identified by Hargis as potential sources of the TCE detected in the Upper Zone ground water beneath Plant 4 and the Carswell AFB flightline area upgradient of monitor well 10B. This appears reasonable based on the April 1989 TCE results from the HM-series wells. Hargis also suggests that another source of TCE contamination in the flight-line area of Carswell AFB may exist, but provides no discussion of potential candidate sites. Based on previous IRP studies of Carswell AFB, Site 10, a waste burial area where drummed solvents were reportedly disposed in the past, has the highest potential to be a contributing source, if an additional source exists (see discussion at Section 3.3).

5.0 POTENTIAL PATHWAYS FOR CONTAMINANT MIGRATION

Radian concurs with the conclusion of the Hargis report that the sand and gravel-filled channels in the eroded bedrock surface are important pathways for contaminant migration in the Upper Zone ground water. Due to the relatively high density of the solvent compounds, they are expected to sink through the saturated zone and to migrate rapidly through these permeable basal deposits. By incorporating the lithologic data from the Carswell AFB flightline wells installed by Radian, the southeastern channel can be extended continuously onto Carswell AFB. Without any apparent flow restrictions or diversions suggested by the borehole data, it is likely that the contaminants detected in the flightline area of Carswell AFB are at least in part continuous with the plumes sourced on Plant 4.

6.0 CONCLUSIONS

The Hargis report provides a synthesis of a broad range of information pertaining to ground-water conditions at Plant 4 and the Carswell AFB flightline area. Interpretations of subsurface geologic conditions (i.e., lithology and extent of Upper Zone deposits) are generally supported by direct evidence (i.e., borehole/monitor well logs). However, many of the interpretations presented in the report are, in Radian's assessment, not adequately supported by the available data. Due to the limited amounts, variable types and incomplete documentation of data generated in multiple studies, interpretations concerning contaminant distribution, ground-water occurrence, potentiometric surface configuration and ground-water flow directions in the Upper Zone cannot be independently verified. While all of the interpretations made by Hargis are feasible, the general sparsity of defensible data does not support conclusive determinations. However, based on Radian's independent assessment, available data strongly suggest at least part of the contamination detected in samples from the Carswell AFB flightline area is sourced at Plant 4. Determination of the relative contributions from Plant 4 and Carswell AFB, if any, will require additional monitor well installation and ground-water sampling and analysis.

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