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July 30, 1999

98-RF-02990

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Environmental Systems and Stewardship
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SOURCE EVALUATION REPORT FOR RFCA POINT OF EVALUATION GS10 (JULY 1999) - MW-098-99

This Source Evaluation Report is provided in accordance with the Rocky Flats Cleanup Agreement (RFCA) Attachment 5. Specifically, this source evaluation addresses the June 21, 1999 Rocky Flats Environmental Technology Site (Site) notification of reportable 30-day moving averages for plutonium and americium water-quality results in Walnut Creek. These reportable values were measured at the Point of Evaluation (POE) monitoring location GS10 on Walnut Creek upstream of Pond B-1 (referred to as GS10) and may be summarized as follows:

- Reportable 30-day moving average values for plutonium were measured at the POE monitoring location GS10 for the periods April 7 through April 22, 1999, April 26 through April 28, 1999 and May 22, 1999 to the present.
- Reportable 30-day moving average values for americium were also measured at the POE monitoring location GS10 for the period March 30, 1999 to the present.

This Report describes the extensive evaluation of historical data and assessed Site activities and monitoring data to determine probable cause(s) of reportable 30-day moving averages for plutonium and americium at monitoring location GS10. The data received to date have identified no specific source(s) of contamination. The data indicate that the source of the reportable values to be the result of plutonium and americium released to the environment over the past years of nuclear operations at the Site. As current control measures are already sufficiently protective of water quality at RFCA Points of Compliance in Walnut Creek, the Report contains no specific recommendations for source control due to the reportable values measured at GS10.

As part of our ongoing efforts to close the Site in a safe, cost-effective, and environmentally responsible manner, the Site will: (1) continue progress on the Actinide Migration Evaluations; (2) continue an extensive program of routine monitoring and special analysis; (3) continue usage of the existing detention ponds to protect downstream RFCA Points of Compliance; and (4) continue participation in forums to discuss water issues.

1/47

SW-SW-A-003325

If you have any questions on this transmittal, please contact Keith Motyl at extension 2172, or Bill Burdelik at extension 5126.

Martin Wheeler
Vice-President
Waste Operations Services
Rocky Mountain Remediation Services, L.L.C.

MEJ/wkg

Attachments:
As Stated

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RF/RMRS-99-376.UN

Source Evaluation Report for Point of Evaluation GS10

July 1999

U.S. Department of Energy

Rocky Flats Environmental Technology Site

Golden, Colorado

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1. EXECUTIVE SUMMARY

Rocky Flats Environmental Technology Site personnel have completed a source evaluation related to the cause(s) of elevated 30-day moving averages for plutonium and americium[1] at the Walnut Creek Rocky Flats Cleanup Agreement (RFCA) Point of Evaluation (POE) monitoring location GS10. First reported on June 21, 1999, elevated 30-day moving average values have been estimated at the POE monitoring location above Pond B-1 (referred to as GS10) for the periods March 30, 1999 to the present.[2] RFCA requires a source evaluation for POEs when specific constituents are measured above Action Levels; this Report fulfills that requirement.[3]

This Source Evaluation Report builds on the results of the completed Reports (RMRS, 1997c, 1997d, 1997e, 1998c) for the *Plan for Source Evaluation and Preliminary Proposed Mitigating Actions for Walnut Creek Water-Quality Results* (RMRS, 1997b). Site personnel have evaluated historical data, collected additional water samples for analyses, and assessed Site activities as part of the Walnut Creek 1997-1998 Source Evaluation. Site personnel have concluded that the likely source of the elevated measurements of the 30-day average for plutonium and americium at GS10 is diffuse low-level radionuclide contamination released to the environment from past Site operations. The best evidence indicates that the source area of this contamination is thought to be the sub-drainage that feeds only GS10, and not the other monitored sub-drainages above GS10.

Specifically, this Report concludes the following:

- Recent surface-water sampling results from Source Location monitoring stations have further refined the estimation of relative plutonium load contributions to GS10 from upstream sub-drainage areas;
- Readings from in-situ water-quality monitoring probes indicate no unusual or unexpected conditions for WY99 to date; and
- Recent Site activities suggest that neither D&D, ER, excavation, nor routine operations during the event period caused a release of plutonium or americium that resulted in the elevated activities measured at GS10.

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[1] In this report, 'plutonium' refers to Pu-239,-240 and 'americium' refers to Am-241.

[2] The latest analytical result returned from the labs covers the period through 6/13/99. As of 6/13/99, the 30-day averages were still above 0.15 pCi/L for both Am and Pu.

[3] The RFCA requires reporting "when contaminant concentrations in Segment 5 exceed the Table 1 action levels" and that "source evaluation will be required". Further, RFCA states "if mitigating action is appropriate, the specific actions will be determined on a case-by-case basis, but must be designed such that surface water will meet applicable standards at the POCs" (Points of Compliance).

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- The elevated values seen at GS10 and other monitoring locations in the GS10 drainage are not being seen at the Ponds or downstream POCs.

Based on this evaluation, no localized source(s) of contamination have been identified. This Report contains no specific recommendations for source control due to the reportable values measured at GS10.[4] In addition, no specific remedial actions are required, nor is mitigation needed to protect water quality at any POC identified under RFCA.

As part of our ongoing efforts to close the Site in a safe and environmentally responsible manner, the Site will:

1. Continue progress on the AME as a longer-term technical study to provide more specific understanding and insight about the cause(s) and possible effective mitigation measures to prevent reportable radionuclide water-quality measurements;

2. Continue an extensive program of routine monitoring, analysis, and reporting to improve our understanding of potential diffuse source impacts to surface water;

3. Continue to develop and refine the soil characterization strategy within the Industrial Area Strategy, as needed to protect surface water;

4. Continue to provide progress reporting through Quarterly RFCA Reports, Quarterly State Exchange Meetings, AME reports, and informal status/flash briefs.

2. INTRODUCTION

This Source Evaluation Report is provided in accordance with the *Final Rocky Flats Cleanup Agreement* (RFCA; CDPHE et al., 1996) (Attachment 5, §2.4(B)) under "Action Determinations". The RFCA requires reporting "when contaminant concentrations in Segment 5 exceed the Table 1 action levels" and that "source evaluation will be required". Further, RFCA states "if mitigating action is appropriate, the specific actions will be determined on a case-by-case basis, but must be designed such that surface water will meet applicable standards at the POCs" (Points of Compliance).

Specifically, this source evaluation addresses the June 21, 1999 Rocky Flats Environmental Technology Site (Site) report of elevated 30-day moving averages for plutonium (Pu-239,-240) and americium (Am-241) water-quality results at the Point of Evaluation (POE; Segment 5) monitoring location above Pond B-1 (referred to as GS10) in Walnut Creek. Elevated values for plutonium were measured for the periods April 7 through April 22, 1999, April 26 through April 28, 1999, and May 22, 1999 to the present[5]. Elevated values

[4] Future Site Closure and environmental remediation activities already scheduled for the Site may positively influence water-quality at GS10.

for americium were measured for the periods March 30, 1999 to the present[5]. This Source Evaluation Report builds on the results of the completed Reports (RMRS, 1997c, 1997d, 1997e, 1998c) for the *Source Evaluation and Preliminary Proposed Mitigating Actions for Walnut Creek Water-Quality Results* (RMRS, 1997b). This Plan was delivered to the Colorado Department of Public Health and the Environment (CDPHE), the Environmental Protection Agency (EPA), the City of Broomfield and the City of Westminster, on September 15, 1997.

This Report for Walnut Creek gaging station GS10 covers data received by RMRS through July 14, 1999. The following is included in this Report:

- Results and analysis of ongoing automated surface-water monitoring;
- A brief review of existing soil/sediment data;
- An assessment of Decontamination and Decommissioning (D&D), Environmental Restoration, and Site Closure projects; and
- A summary of current Actinide Migration Evaluation findings.

3. BACKGROUND

3.1. SITE HYDROLOGY

Walnut Creek, the subject of this investigation and one of several Site drainages, flows east beyond the Site's boundary at Indiana Street. Downstream of Indiana Street, flows are diverted around Great Western Reservoir via the Broomfield Diversion Ditch, and back to Walnut Creek. Walnut Creek then flows into Big Dry Creek, and on to the South Platte River.

Walnut Creek Tributaries

Upstream from Indiana Street, Walnut Creek receives flow from the following four tributaries (listed in order from north to south and shown in Figure 3-1):

- McKay Bypass Canal (Coal Creek water conveyance canal);
- No Name Gulch (buffer zone drainage basin east of the Landfill Pond);
- North Walnut Creek (northern Industrial Area (IA) drainage basin); and
- South Walnut Creek (central IA drainage basin).

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[5] The latest analytical result returned from the labs covers the period through 6/13/99. As of 6/13/99, the 30-day average was still above 0.15 pCi/L for both Am and Pu.

No Name Gulch and the McKay Bypass Canal only receive runoff from non-IA drainage basins, typically flow during the spring or following large storm events, and are not controlled by detention ponds. The McKay Bypass is also used by Broomfield to transfer water from Coal Creek to Great Western Reservoir. North and South Walnut Creek, in contrast, both have nearly continuous baseflow, receive runoff from the IA, and are controlled by a system of detention ponds. A discussion follows describing how water runs off the IA, into North and South Walnut Creeks, through the detention pond network, and, ultimately, into Walnut Creek where it flows offsite at Indiana Street.

North and South Walnut Creek Flow Controls

All IA surface-water runoff that flows into North or South Walnut Creek is collected by a system of Site stormwater detention ponds. The ponds serve three main purposes for surface-water management: (1) storm water detention and settling of sediments, (2) water storage for sampling and, if necessary, treatment prior to release, and (3) emergency spill control in those instances where a spill cannot be adequately managed without use of the ponds.

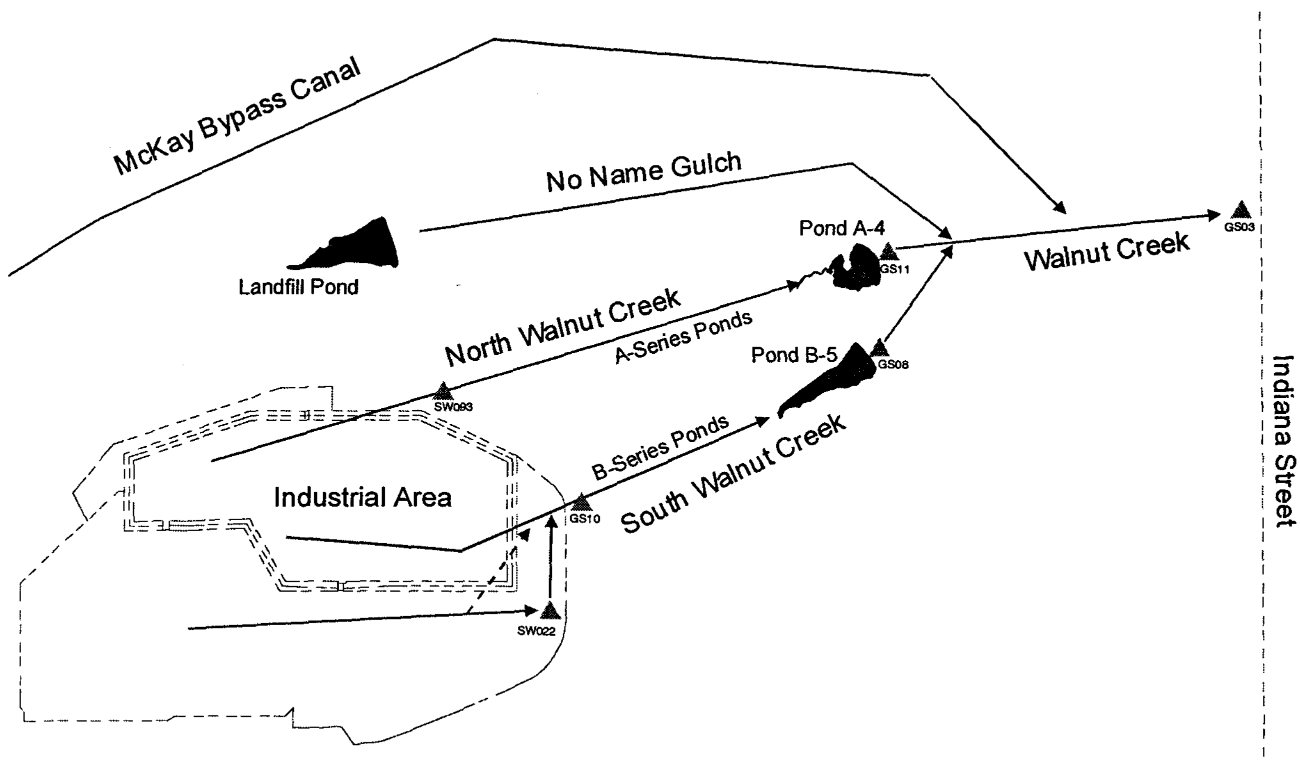

Figure 3-1. Hydrologic Connectivity of Site Drainage and Water Management Features.

South Walnut Creek water is routed through the B-Series ponds. Steps in the water collection and transfer process are briefly outlined as follows:

- Runoff from the south-central IA flows through the Central Avenue Ditch past monitoring location SW022, and then past GS10 (during high runoff periods, some water in the Central Avenue Ditch overflows to a large corrugated metal pipe and flows directly to GS10; shown by dotted line in Figure 3-1);
- Runoff from the central IA flows directly to GS10;
- Runoff from GS10 then flows downstream through conveyance structures, through Pond B-4, and then to Pond B-5 where it is held; and
- Water held in Pond B-5 is discharged periodically in batches to Walnut Creek.

As indicated above, all of the IA runoff that flows into South Walnut Creek is ultimately routed through Pond B-5, detained, and sampled prior to being released to lower Walnut Creek. There is no source of IA runoff that can enter Walnut Creek without first passing through the pond system for discharge from Pond B-5. Downstream from Pond B-5, the only sources of surface-water entering Walnut Creek upstream of the Site boundary are North Walnut Creek (through Pond A-4), No Name Gulch, the McKay Bypass Canal, or overland runoff directly into Walnut Creek.

3.2. GS10 MONITORING RESULTS

As specified in the *Integrated Monitoring Plan* (IMP; Kaiser-Hill, 1998), the Site's Water Operations group evaluates 30-day moving averages[6] for selected radionuclides at gaging station GS10. GS10 receives flow from the central IA and monitors flow to South Walnut Creek via the B-1 Bypass pipeline to Pond B-4 which subsequently flows into Pond B-5. Recent evaluations of water-quality measurements at POE surface-water monitoring location GS10 (located on South Walnut Creek just above Pond B-1 as shown on Figure 3-2) show values above the RFCA POE Action Level Framework value of 0.15 pCi/L for plutonium and americium. Results for recent 30-day moving averages using available data at GS10 are summarized below in Table 3-1 and are shown on Figure 3-3.

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[6] The 30-day moving average activity (pCi/L) for a particular day is calculated as a volume-weighted average for a 'window' of time containing the previous 30-days which had flow. When a negative result is returned from the lab due to blank correction, a value of zero pCi/L is used in the calculations. Therefore, there are 365 x 30-day moving averages for a location that flows all year (366 in a leap year). For days where no activity is available, either due to failed laboratory analysis or non-sufficient quantity for analysis (NSQ), no 30-day average is reported.

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Table 3-1. Recent Water Year 1999 Water-Quality Information from GS10.

Location	Parameter	Date(s) 30-Day Average Above 0.15 pCi/L	Date(s) of Maximum 30-Day Average	Maximum 30-Day Average (pCi/L)	Volume-Weighted Average for WY99 to Date (pCi/L)[a]
GS10	Pu-239,-240	4/7/99 - 4/22/99 4/26/99 – 4/28/99 5/22/99 - [b]	6/8/99	0.363	0.128
GS10	Am-241	3/30/99 - [b]	4/14/99	1.52	0.324

[a] Includes all data that has been received from analytical labs as of 7/14/99.
[b] As of 6/13/99, the GS10 30-day average remains above 0.15 pCi/L.

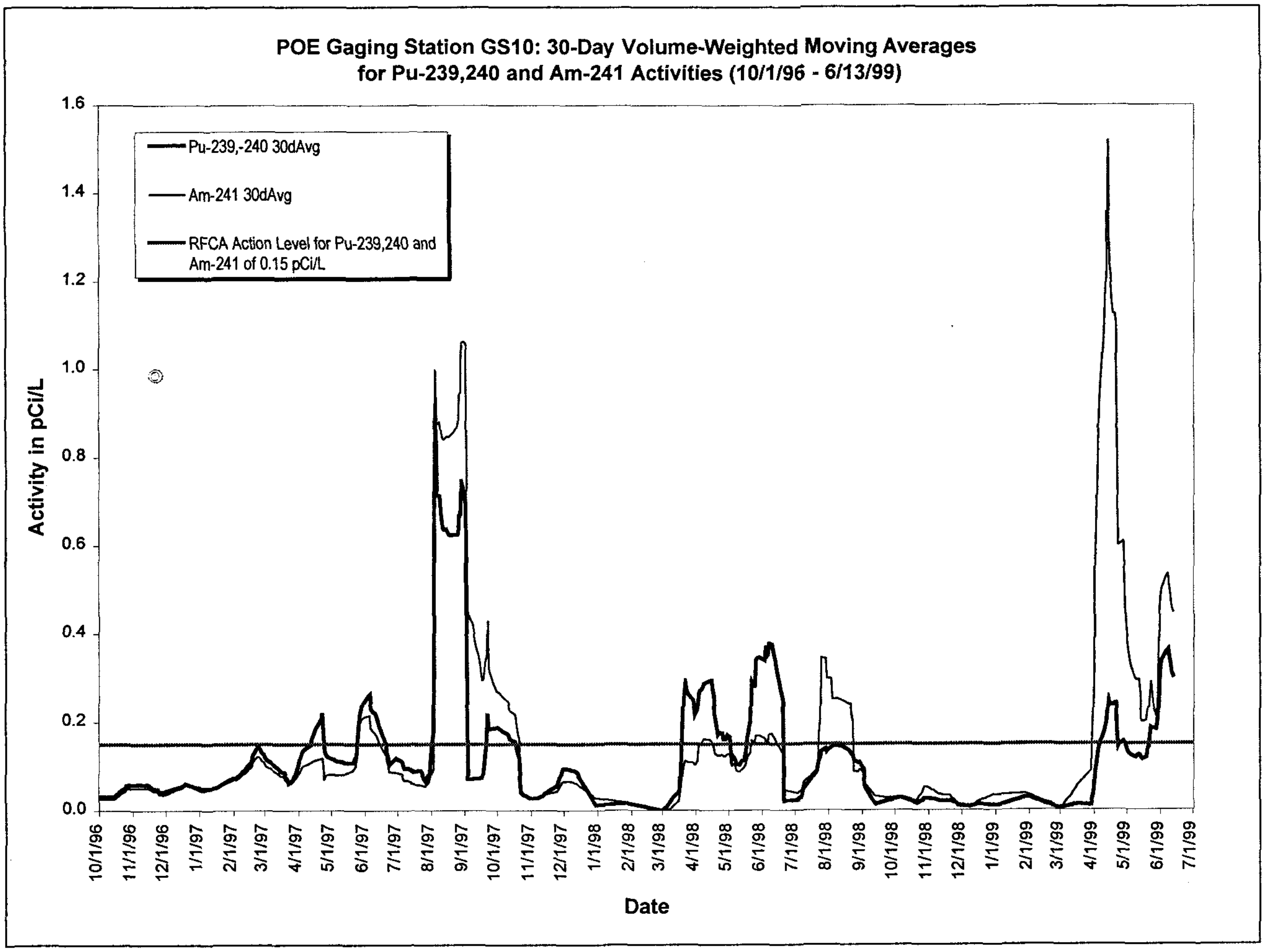

Figure 3-3. Gaging Station GS10 30-Day Averages: October 1, 1996 – June 13, 1999.

The analytical results for the composite samples collected around the period of elevated values have been verified. A review of historical monitoring data shows that these results are not unusual. However, the

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americium levels measured at GS10 are higher than typically measured at other gaging stations given the measured plutonium levels.[7] Storm-event[8] samples collected at GS10 from Water Year[9] 1992 (WY92) through WY96 (under pre-RFCA protocols[10]) had an arithmetic average plutonium activity of 0.23 pCi/L with a maximum of 1.4 pCi/L. For the same period, the arithmetic average americium activity was 0.2 pCi/L with a maximum of 1.0 pCi/L. Additionally, during the period of continuous flow-paced monitoring under RFCA, there were multiple occurrences of 30-day averages above 0.15 pCi/L for both analytes (Figure 3-3). The elevated measurements generally occur during periods of increased stormwater runoff in the spring and summer months (Figure 3-4). Individual composite sample results and detail for GS10 are listed in Table 3-2 and plotted in Figure 3-5 for the period of interest.

Table 3-2. Composite Sample Analytical Results for GS10: March 15 – June 14, 1999.

Composite Sample Period	Pu-239,-240 (pCi/L)		Am-241 (pCi/L)		Composite Sample Volume (Liters)	S. Walnut Cr. Discharge Volume During Sample Period (Mgals)
	Result	Error (±)	Result	Error (±)		
3/15 – 3/30/99	0.005	0.011	0.105	0.029	8.6	0.53
3/30 – 4/15/99	0.315	0.094	1.930	0.329	14.8	2.24
4/15 – 4/22/99	0.201	0.071	0.362	0.110	15.8	2.55
4/22 – 4/24/99	0.046	0.032	0.109	0.057	11.6	2.19
4/24 – 4/29/99	0.177	0.084	0.594	0.145	18.6	3.44
4/29 – 5/1/99	0.130	0.054	0.062	0.041	15.8	5.69
5/1 – 5/10/99	0.021	0.022	0.076	0.046	11.8	2.17
5/10 – 5/24/99	0.543	0.144	0.768	0.178	9.8	1.67
5/24 – 6/10/99	0.073	0.044	0.157	0.070	7.4	1.19
6/10 – 6/14/99	0.189	0.079	0.284	0.090	11.6	0.58

---

[7] Plutonium levels in the environment at RFETS usually are greater than americium levels. Ratios of activities of co-existing radionuclides may provide valuable insight into the origin and age of radionuclide materials -- in effect a radionuclide "signature". Pu-239,-240/Am-241 -- or more simply, Pu/Am -- ratios (Am-241 being a daughter of Pu-241 and found in man-made plutonium) at RFETS typically show values greater than 2.0 and significant and verifiable deviations from these values suggest atypical source(s) "enriched" in americium. In the case of radionuclide data and Pu/Am ratios at GS10, significant deviations from typical Pu/Am ratios > 2, and (fractional) Pu/Am ratios < 1 are associated with recent elevated plutonium and americium WQ data (see Section 4.1.2). In fact, the americium levels at GS10 are often greater than the plutonium levels.

[8] Storm-event samples are generally flow-paced composites consisting of 15 grab samples taken during a direct runoff hydrograph. The grab samples are targeted to be taken on the rising limb. This type of sampling was performed at GS10 from 10/1/92 through 9/30/96.

[9] A Water Year is defined as the period from October 1 through September 30.

[10] Currently under RFCA, samples collected at POEs are continuous flow-paced composites where grab samples are collected during all flow conditions. This type of sampling began at POEs and POCs on 10/1/96.

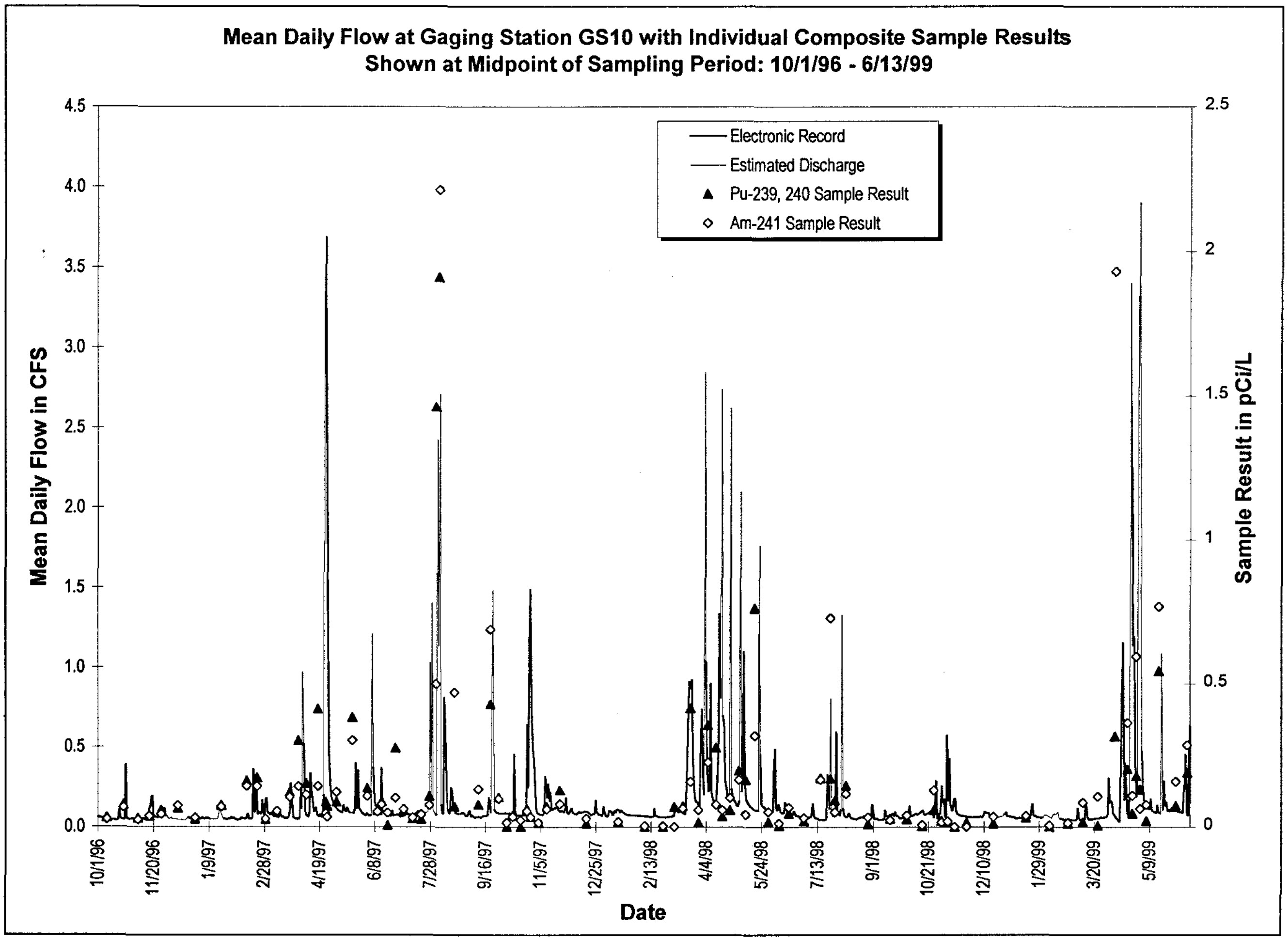

Figure 3-4. Gaging Station GS10 Hydrograph with Individual Sample Results.

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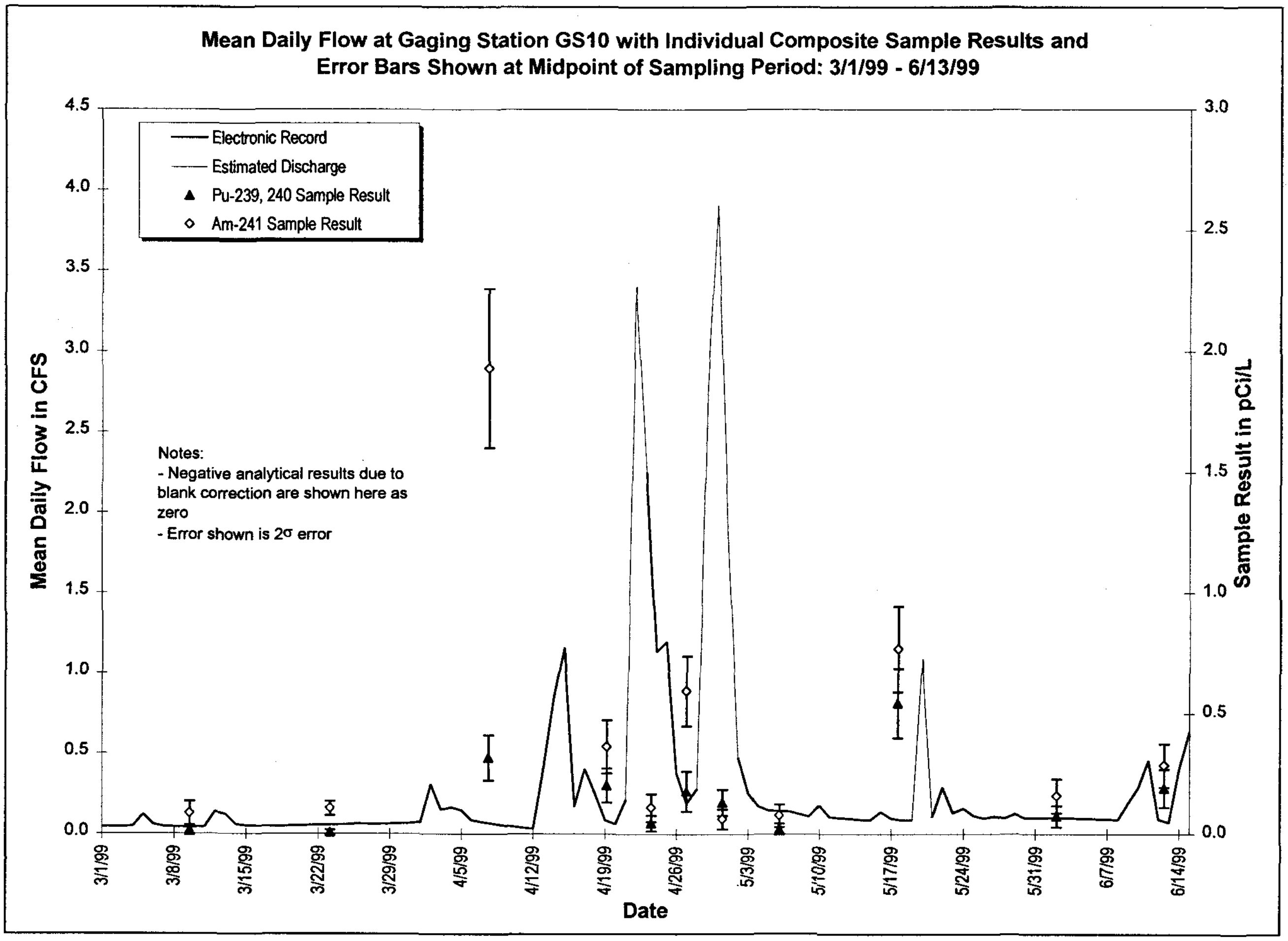

Figure 3-5. Gaging Station GS10 Hydrograph with Individual Sample Results and Error Bars: March 1 Through June 13, 1999.

All water monitored at GS10 during this period flowed to Pond B-5 and was eventually direct discharged to lower Walnut Creek. Pre-discharge samples of the water in Pond B-5 indicated acceptable water quality for all discharges. Analytical results from composite samples collected at gaging station GS08 at the Pond B-5 outfall during the March 22 – April 5, 1999 and April 26 – May 18, 1999 discharges were well below the RFCA standard (Figure 3-6). Results from GS08 for the June 18 -30, 1999 Pond B-5 discharge were not available for this report.

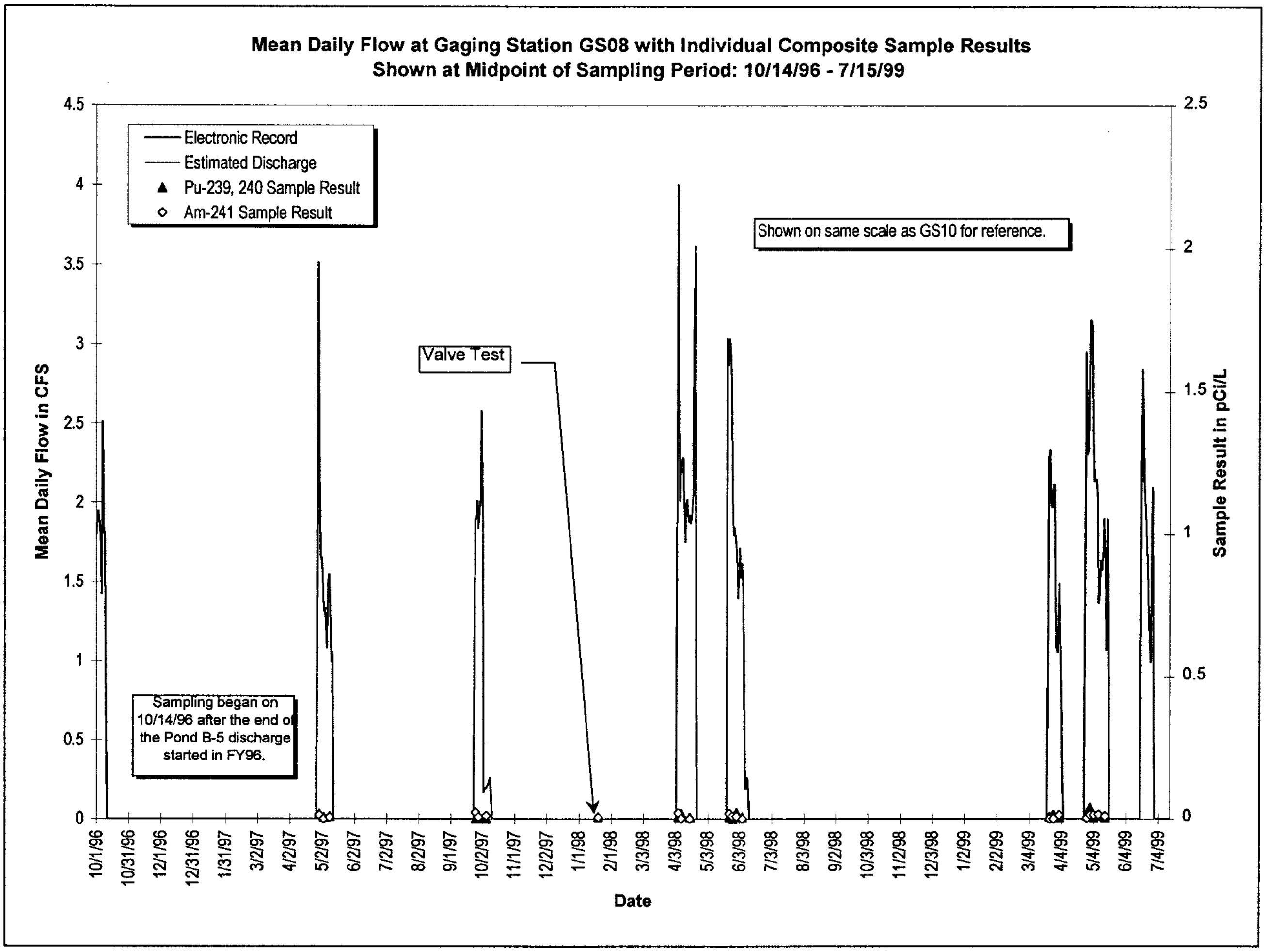

Figure 3-6. Gaging Station GS08 Hydrograph with Individual Sample Results.

All water discharged from Pond B-5 to Walnut Creek subsequently flowed through RFCA POC GS03. Analytical results from composite samples collected at GS03 during the period of interest were also below the RFCA standard (Figure 3-7).

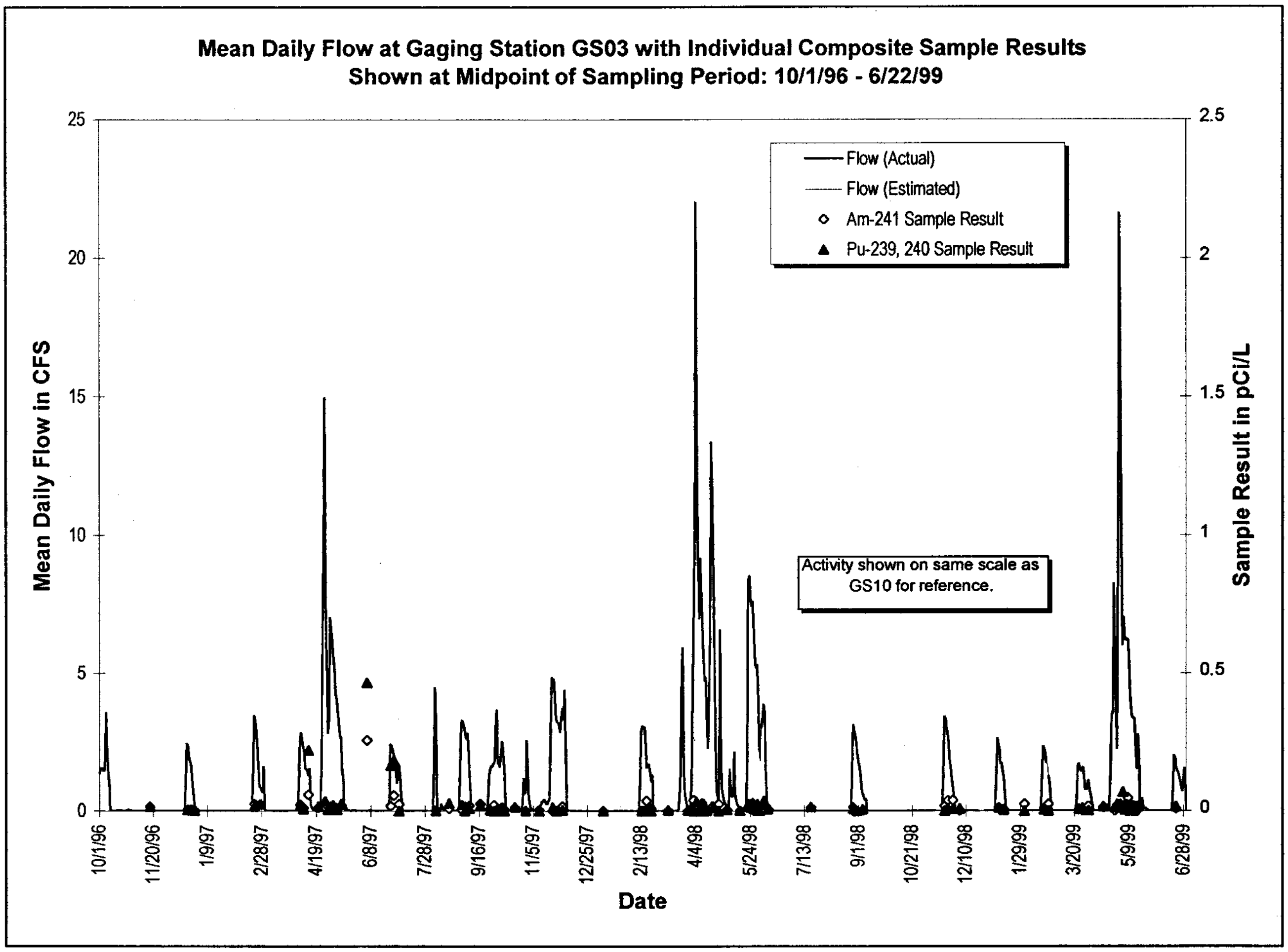

Figure 3-7. Gaging Station GS03 Hydrograph with Individual Sample Results.

4. DATA SUMMARY AND ANALYSIS FOR GS10

4.1. AUTOMATED SURFACE-WATER MONITORING DATA

4.1.1. Data Evaluation

Analytical Data Verification and Validation

All surface water isotopic data are either verified or validated, based on criteria determined by Analytical Services Division (ASD), or the special request of the customer. Approximately 75% of all isotopic data are verified and the remaining 25% are validated. Validation is typically determined randomly for each subcontracted laboratory, based on the specific analysis suites. This random determination may or may not routinely include POE or POC locations. For samples collected at GS10 between 3/15/99 and 6/13/99, all isotopic data were submitted for validation at the request of the Site.

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As of this report, no results from the validation process have been received. However all data packages were reviewed by an ASD staff radiochemist prior to being submitted for validation. The data were all found to be reasonable, with no obvious technical problems apparent in the packages. Validation summaries are expected to be available in the latter part of July 1999 and will be available in future data reports.

Actinide Activities

Starting on March 3, 1998, five upstream monitoring locations have been operating as part of the continuing source evaluation for GS10 in an effort responding to elevated plutonium and americium measurements during WY97. These locations are GS27, GS38, GS39, GS40 and SW022 (Figure 3-2). These stations were installed or upgraded to monitor sub-drainages that are tributary to GS10. These locations are operated to measure plutonium and americium loads from the respective sub-drainages in an attempt to identify any discrete source areas. Summary statistics for sample results from these locations are shown in Table 4-1. The activities for GS27 and SW022 are arithmetic averages since sampling at these locations occurs only during selected storm events. Continuous flow-paced sampling is employed for GS10, GS38, GS39, and GS40, and volume-weighted average activities are given in Table 4-1.

Table 4-1. Summary Statistics for Samples from GS10 and Monitoring Locations Tributary to GS10: March 3, 1998 to Present.

Sampling Location	Number of Samples	Pu-239,-240		Am-241	
		Average Activity (pCi/L)	Maximum Sample Result (pCi/L)	Average Activity (pCi/L)	Maximum Sample Result (pCi/L)
GS10	44	0.163	0.761	0.230	1.93
GS27	22	8.683	64.3	2.381	14.8
GS38	14	0.089	0.193	0.023	0.072
GS39	14	0.164	0.824	0.045	0.16
GS40	15	0.016	0.047	0.026	0.059
SW022	14	1.077	9.49	0.221	1.76

Figure 4-1 shows the average annual activities at GS10 for WY93 - WY99. For WY93 - WY96, arithmetic averages of individual storm-event sample results are plotted. However, due to the continuous flow-paced sampling protocols currently in place under RFCA, the more representative volume-weighted average activities are shown for WY97-WY99. It is important to note that although elevated 30-day averages occurred in recent years, the volume-weighted average is comparable to the activities for other years. This suggests that actinides have been available for transport to GS10 for some time and that the recent elevated measurements at GS10 may be the result of legacy contamination. The recent (WY99) americium activities in excess of plutonium activities are further evaluated in Section 4.1.2.

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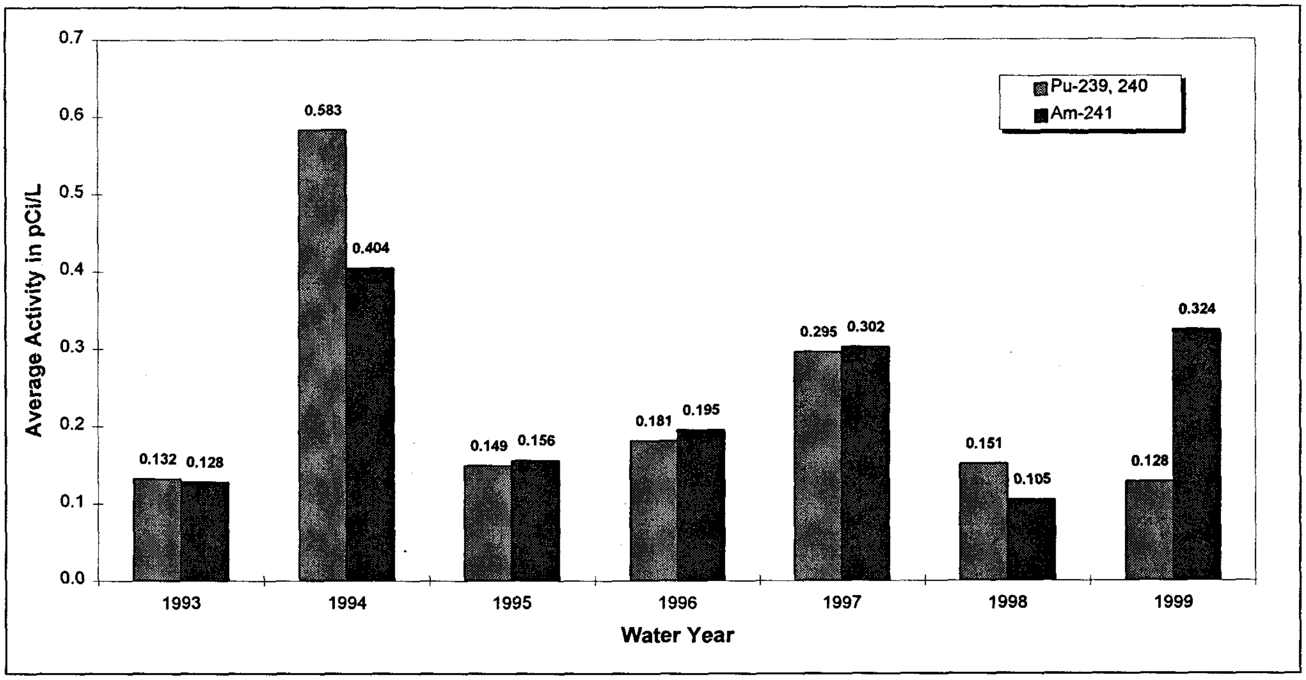

Volume-weighted to date for WY99 is plotted.

Figure 4-1. Average Annual Plutonium and Americium Activities at GS10: Water Years 1993-1999.

4.1.2. Surface-Water Pu/Am Activity Ratio Evaluation

The ratios of plutonium activity to americium activity (Pu/Am ratios) for surface-water samples collected at GS10 are evaluated in this section to better understand the recent americium levels at GS10. Figure 4-2 presents Pu/Am ratios for all surface-water samples collected at the current GS10 monitoring location (3/92 – 6/99)[11,12]. Only samples with both plutonium and americium results greater than or equal to 0.025 pCi/L are included in this evaluation to minimize the effects of analytical error near the detection limit on calculation of the ratios.

Figure 4-2 suggests no long-term trend of increasing or decreasing Pu/Am ratios with time at GS10. Further analysis of data showed no seasonal, monthly, or annual trends in Pu/Am ratios. Likewise, Pu/Am ratios showed no correlation with total suspended solids (TSS). In short, the average Pu/Am ratio at GS10 has been fairly constant for several years, averaging 1.20 for the ratio of Pu/Am. Additionally, 40% of the samples displayed in Figure 4-2 had americium activities in excess of plutonium activities.

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[11] Samples collected at the GS10 location in the late 1980's and early 1990's were assigned the location code SW023.

[12] No samples prior to 3/92 fit the ratio analysis criteria of having both Pu and Am results greater than 0.025 pCi/L. This is likely due to the fact that samples prior to 3/92 were 'fair-weather', single-grab samples. In other words, samples were manually collected, generally during baseflow conditions as opposed to during direct runoff events.

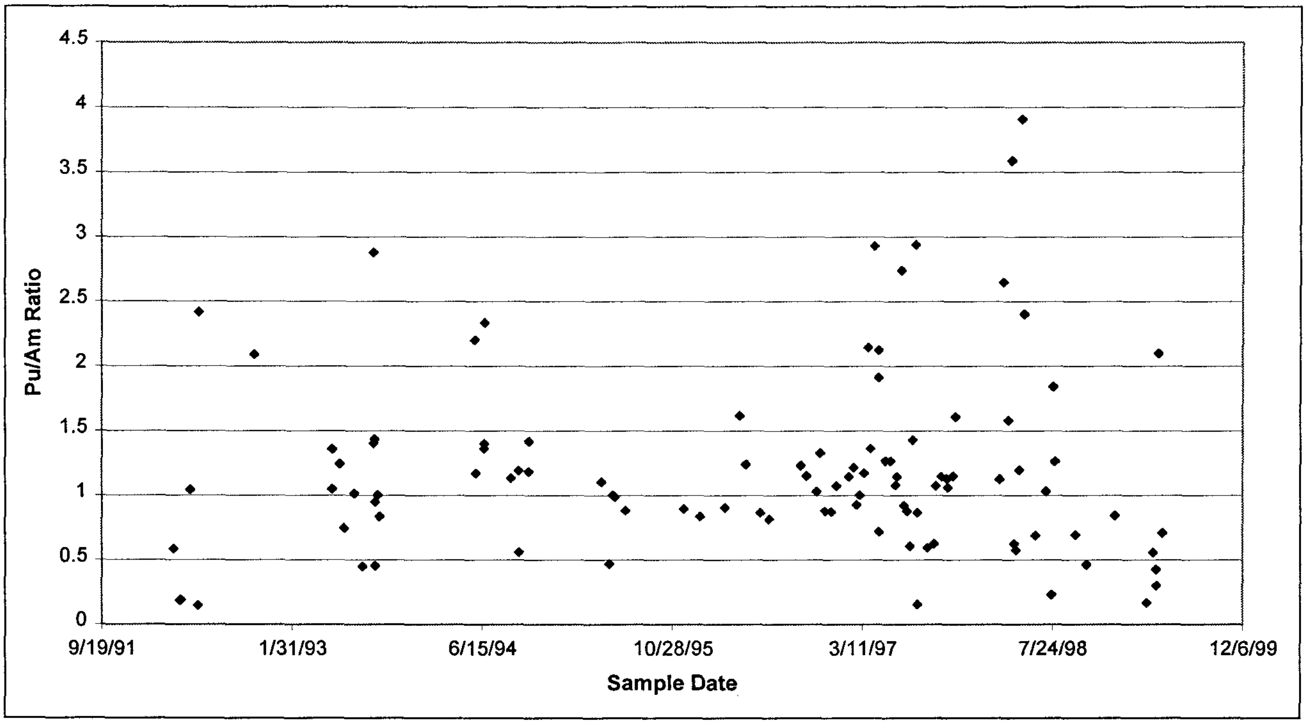

Figure 4-2. Pu/Am Ratios for Surface-Water Samples at GS10

Table 4-2 summarizes average Pu/Am ratios for surface-water samples in various drainages and sub-drainages across the Site. Again, only samples with both plutonium and americium results greater than or equal to 0.025 pCi/L were included to minimize the effects of analytical error near the detection limit. Note that statistical analyses were performed for each drainage without any weighting techniques; consequently, high numbers of samples from a single location may skew averages for the drainage.

Table 4-2. Summary Statistics for Surface-Water Pu/Am Activity Ratios.

Drainage/ Location	Average Pu/Am Ratio	# Samples in Calculation	Standard Deviation
GS10 Monitoring Station	1.20	103	0.72
Monitored GS10 Sub-Drainages (GS27, GS28, GS37, GS38, GS39, GS40, SW022)*	3.62	86	1.74
Site-Wide**	2.19	304	1.69

*GS28 and GS37 are discontinued Performance Monitoring Locations in the Industrial Area, tributary to GS10.
**All available automated surface-water sample data were used to prepare this average.

Results in Table 4-2 indicate that the average Pu/Am ratio from surface-water samples at GS10 is lower than that observed in other drainages and sub-drainages across the Site. However, it should be noted that although the data appeared normally distributed, significant standard deviations were observed.

To further investigate the observed GS10 Pu/Am ratios, results for plutonium were plotted against americium for GS10 and all sample locations within the GS10 drainage. This information is presented in Figure 4-3.

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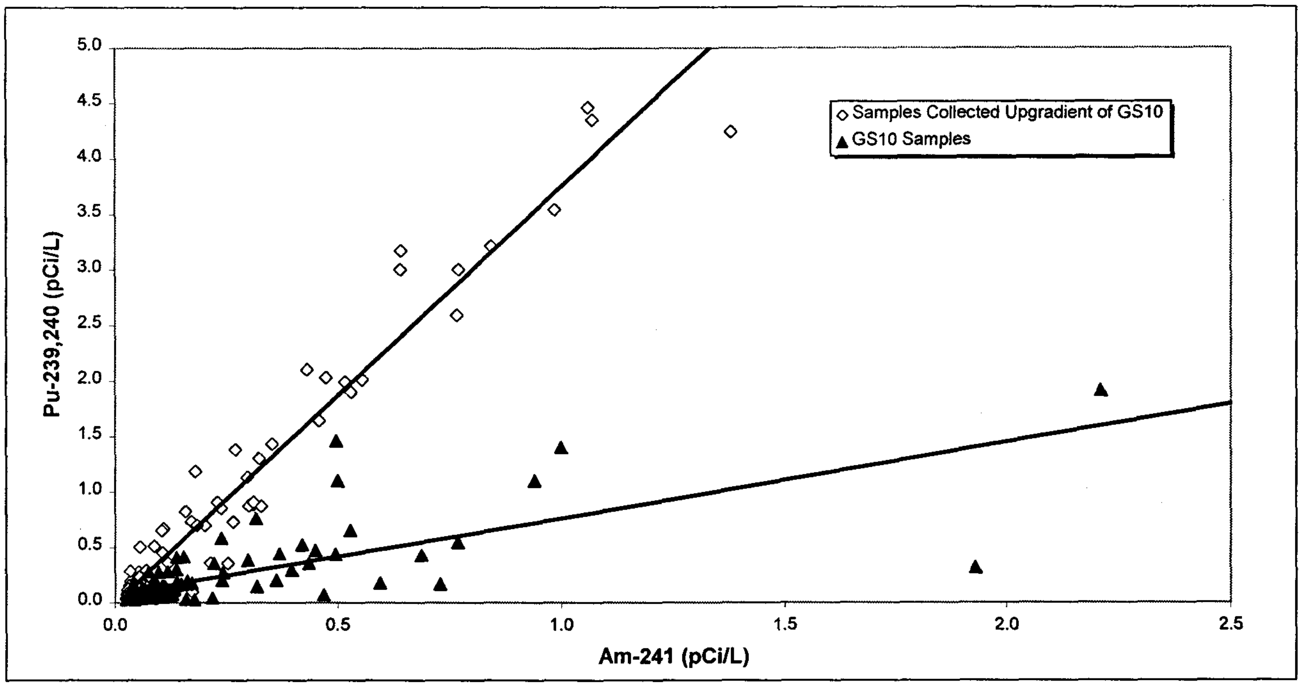

Figure 4-3. Pu vs. Am Results in Surface-Water Collected from GS10 and GS10 Sub-Drainages

Figure 4-3 indicates that the Pu/Am ratios observed at GS10 are markedly distinguishable from those observed in monitored sub-drainages of GS10. This trend suggests that a source of contamination with a low Pu/Am ratio exists within the GS10 drainage, either very close to the GS10 monitoring location or in a sub-drainage not currently monitored by a Source Location monitoring station upstream of GS10.

Similar plots comparing GS10 sample results to those of individual gaging stations within the GS10 drainage were prepared. These plots revealed no likely source area among the monitored sub-drainages. Likewise, plots comparing GS10 sample results to those of Walnut Creek and Woman Creek offered no new insight.

4.1.3. Loading Analysis

Annual GS10 Loads

Annual radionuclide loads for GS10 in micrograms are plotted in Figure 4-4 to show long term loading to GS10. For WY93 - WY96, the arithmetic average activity of individual sample results is multiplied by the associated total annual discharge volume to get pCi, then converted to micrograms[13]. For WY97-WY99, the activity for each flow-paced composite sample is multiplied by the associated discharge volume to get pCi,

[13] Picocuries of plutonium are multiplied by 14.085 to get picograms, and converted for units to get micrograms. Similarly, picocuries of americium are multiplied by 0.3077 to get picograms, and converted for units to get micrograms.

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then converted to micrograms and summed.[14] As stated previously, this suggests that actinides have been available for transport to GS10 for some time and that the recent elevated measurements at GS10 may be the result of legacy contamination.

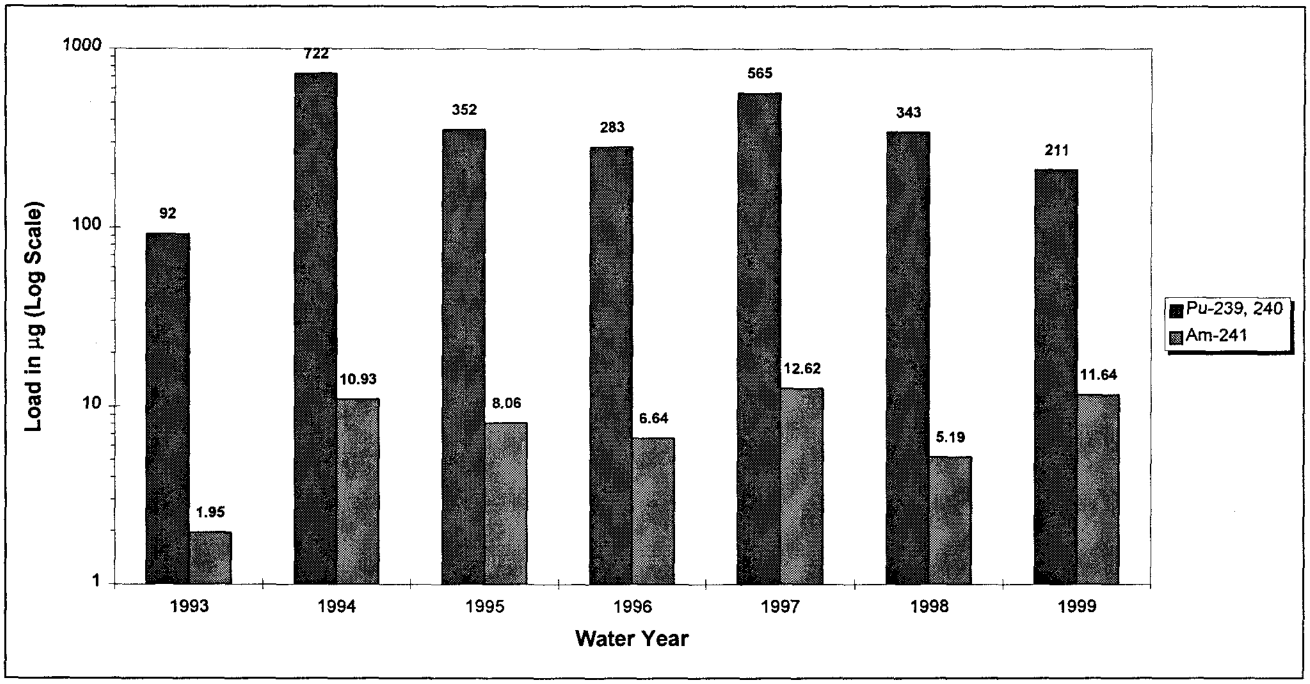

Figure 4-4. Annual Plutonium and Americium Loads at GS10: Water Years 1993-1999.

Relative Sub-Drainage Loads

The loading analysis in this section uses all available data for the period March 3, 1998 through July 14, 1999 from GS10 and the five upstream Source Location monitoring stations (GS27, GS38, GS39, GS40 and SW022). This loading analysis does not address the attenuation of actinides as they are transported from one monitoring location to the next. The analysis assumes that as the period of sampling is increased, the temporal effects of actinide transport will not significantly affect the *relative* loads from the various sub-drainages. The hydrologic connectivity of these locations is shown in Figure 4-5.

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[14] Storm-event samples are generally flow-paced composites consisting of 15 grabs taken during a direct runoff hydrograph and not during baseflow conditions. The grabs are targeted to be taken on the rising limb of a runoff period as flow rates increase to the peak. This is the period during direct runoff when the highest contaminant concentrations are expected to be measured. Under RFCA (starting 10/1/96), samples collected at POEs are continuous flow-paced composites where grab samples are collected during all flow conditions.

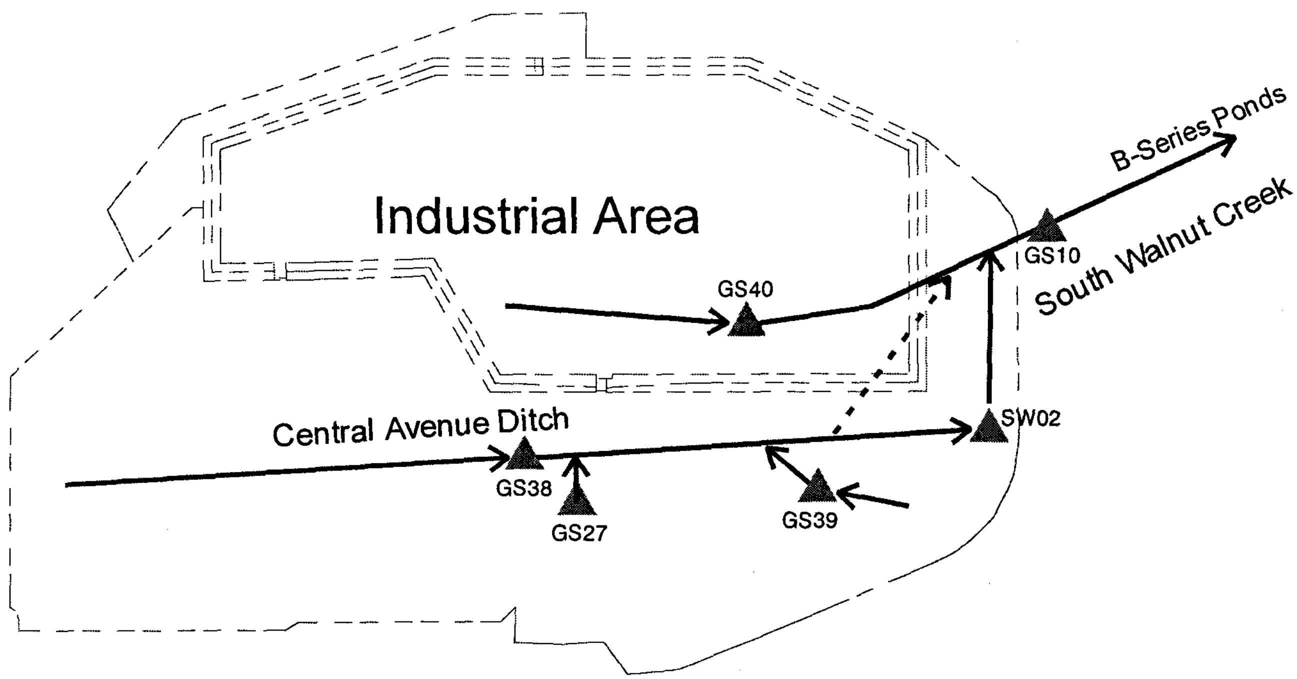

Figure 4-5. Hydrologic Connectivity of Monitoring Locations Tributary to GS10.

<u>SW022 Contribution to GS10</u>

Monitoring location SW022 measures flows at the east end of Central Avenue Ditch, which subsequently flows to South Walnut Creek and then to GS10 (Figure 4-5). The 100, 300, 400, 500, 600, 800, and 900 Areas all contribute runoff to SW022. It is important to note that during high flows, a portion of the flow in the Central Avenue Ditch overflows to a 48 inch pipe which leads directly to South Walnut Creek, bypassing SW022, as indicated by the dotted flow line in Figure 4-5. This 'short-circuiting' of flow causes the calculated load for SW022 to underestimate the contribution from the Central Avenue Ditch sub-drainage area.

Loads for the SW022 sub-drainage tributary to GS10 were calculated by multiplying the arithmetic average activity of the samples collected at SW022 by the corresponding total discharge measured at the gage, and then converting to micrograms. Loads for GS10 were calculated by multiplying the activity for each flow-paced composite sample by the associated discharge volume to get pCi, then converted to micrograms and totaled. The results are given in Table 4-3.

Table 4-3 shows that SW022 contributed approximately 160% of the plutonium load measured at GS10.[15] This apparent loss results from plutonium losses to the streambed between SW022 and GS10 or an overestimation of the SW022 plutonium load. Since SW022 is approximately 1,000 feet upstream of GS10,

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[15] Due to the 'short-circuiting' of Central Avenue Ditch flows directly to GS10, bypassing SW022, and the storm-event sampling, the reliability of this value is unknown. The 'short-circuiting' would cause calculated loads to be underestimated, while the storm-event sampling would cause calculated loads to be overestimated.

half of which is a steep concrete spillway, it is unlikely that much of the load is lost to the streambed. More likely, the storm-event sampling protocols at SW022 result in the preferential collection of samples during high runoff events with relatively high plutonium activities. Therefore, the arithmetic average activity for storm-event samples is likely higher than the actual overall plutonium activity under all flow conditions. Continuous flow-paced sampling facilitates more accurate loading analysis through the collection of representative samples over all flow conditions.

Table 4-3. Comparison of Plutonium and Americium Loads at SW022 with GS10: March 3, 1998 to Date.

Pu-239,-240		
SW022 Load in μg	GS10 Load in μg	SW022 Load as a Percent of GS10 Load
862	531	160%

Am-241		
SW022 Load in μg	GS10 Load in μg	SW022 Load as a Percent of GS10 Load
4	16	24%

Table 4-3 also shows that SW022 contributed 24% of the americium load measured at GS10.[15] This suggests that the majority of the americium load at GS10 originates from areas tributary to GS10 other than the Central Avenue Ditch sub-drainage. Additionally, the americium load attributed to the GS40 sub-drainage is approximately 4% (Table 4-4) of the load at GS10. This information suggests that a source of americium may exist in the sub-drainage area downstream of both SW022 and GS40, specifically the reach of South Walnut Creek near B991 and B995. Previous GS10 source evaluation reports discussed an evaluation of the *Historical Release Report for the Rocky Flats Plant* (HRR; US DOE, 1992) which suggested that past Site operations may have contributed actinides to this area.

GS27, GS38, GS39, and GS40 Contribution to GS10

Monitoring location GS27 measures flows from a small sub-drainage near B884 which subsequently flow to Central Avenue Ditch. Monitoring location GS38 measures flows in Central Avenue Ditch at Eighth Street. The 100, 300, 400, 500, and 600 Areas all contribute runoff to GS38. Monitoring location GS39 measures flows from a sub-drainage including the 903 and 904 Pads and the Contractor Yard. Monitoring location GS40 measures flows in South Walnut Creek just downstream from the 750 Pad. The 700 Area contributes runoff to GS40. The hydrologic connectivity of these locations is shown in Figure 4-5.

Loads for the GS27 sub-drainage were calculated by multiplying the arithmetic average activity of the samples collected at GS27 by the corresponding total discharge measured at the gage, and then converting to micrograms. Loads for GS38, GS39, and GS40 were calculated by multiplying the activity for each flow-paced composite sample by the associated discharge volume, then converted to micrograms and totaled. The results are given in Table 4-4. The results are graphically displayed in Figure 4-6 and Figure 4-7.

Table 4-4. Comparison of Plutonium and Americium Loads at GS27, GS38, GS39, and GS40 with GS10: March 3, 1998 to Date.

Location	Pu-239,-240 Load in µg	Am-241 Load in µg
GS10	531	16

Location	Pu-239,-240		Am-241	
	Load in µg	Load as a Percent of GS10 Load	Load in µg	Load as a Percent of GS10 Load
GS27	46	9%	0.3	2%
GS38	40	8%	0.2	1%
GS39	13	3%	0.1	0.5%
GS40	16	3%	0.6	4%

Figure 4-6 shows that the GS27, GS38, GS39, and GS40 sub-drainages contribute approximately 23% of the plutonium load reaching GS10. However, other sub-drainages not specifically monitored, contribute the remaining 77% of the plutonium load measured at GS10 (414 µg plutonium). These areas include the South Walnut Creek reach between GS40 and GS10 (B991 is in this sub-drainage), a portion of the 500 Area outside the Protected Area (PA), portions of the 800 Area, and the Central Avenue Ditch reach between GS38 and SW022 (Trench T-1 and the Mound Area are in this sub-drainage). The fact that SW022 samples have shown relatively high plutonium activities, coupled with the proximity of the 903 Pad, suggests that the Central Avenue Ditch reach between GS38 and SW022 may contain a significant source of plutonium. Limited soil and sediment data exist for this area.

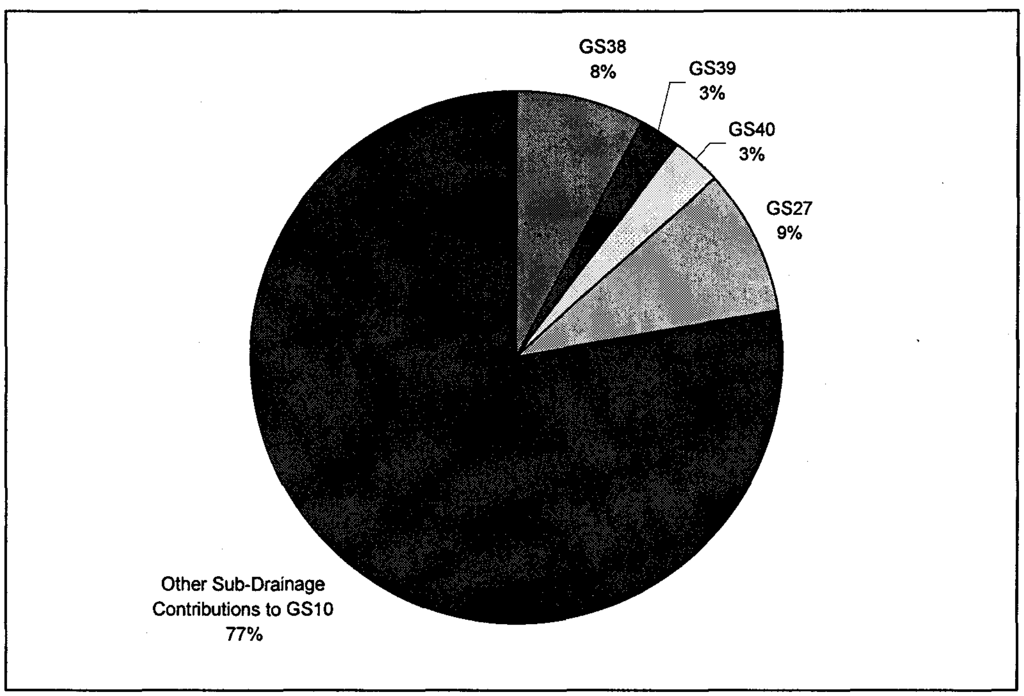

Figure 4-6. Relative Sub-Drainage Plutonium Loads to GS10: March 3, 1998 to Date.

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Figure 4-7 shows that the GS27, GS38, GS39, and GS40 sub-drainages contribute approximately 8% of the americium load reaching GS10. However, other sub-drainages not specifically monitored, contribute the remaining 93% of the americium load measured at GS10 (15 μg americium). These areas include the South Walnut Creek reach between GS40 and GS10, a portion of the 500 Area outside the PA, portions of the 800 Area, and the Central Avenue Ditch reach between GS38 and SW022.

Figure 4-8 incorporates the americium data from SW022 (see Figure 4-5 for hydrologic connectivity) and indicates that the SW022 sub-drainage (with includes GS27, GS38, and GS39) contributes 24% of the americium load to GS10, with an additional 4% being contributed from the GS40 sub-drainage. This further suggests that the South Walnut Creek reach between GS40 and GS10 (B991 is in this sub-drainage) and/or a portion of the 500 Area outside the PA may contain a significant source of americium. Limited soil and sediment data exist for this area.

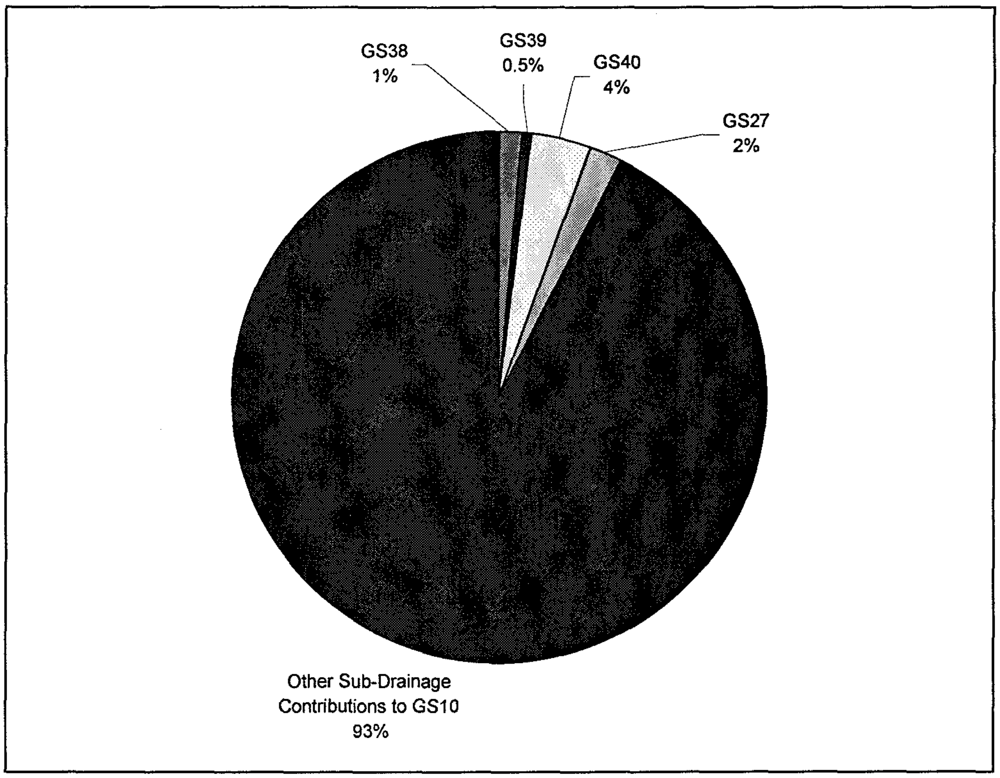

Figure 4-7. Relative Sub-Drainage Americium Loads to GS10: March 3, 1998 to Date.

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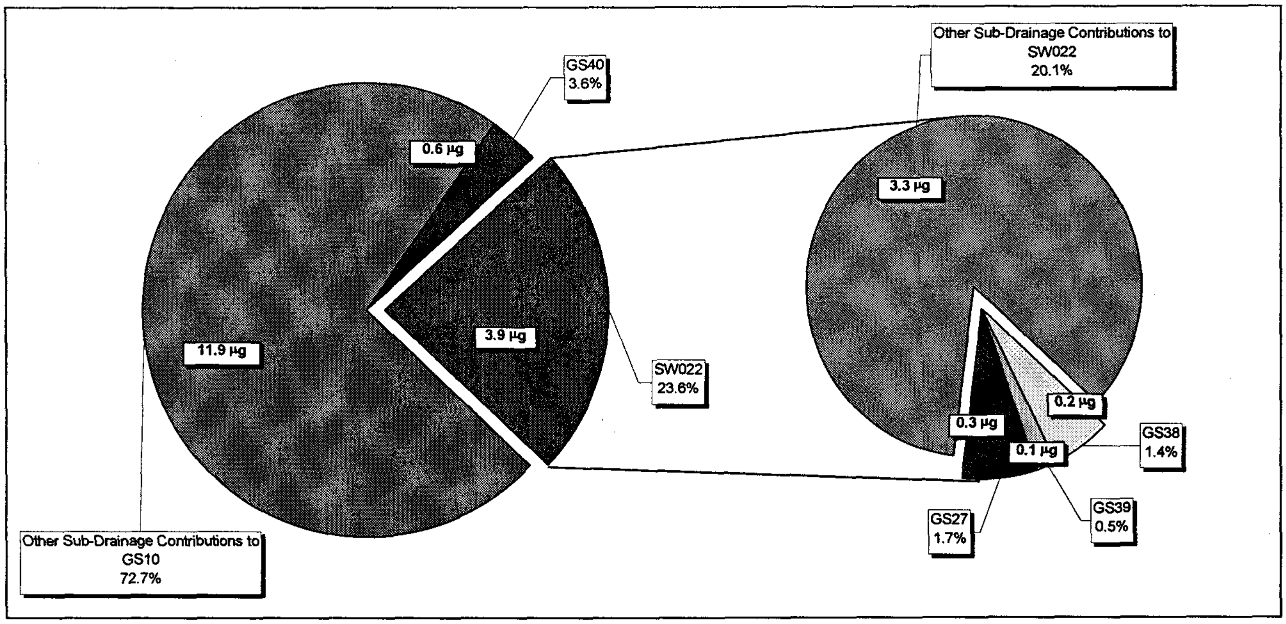

Figure 4-8. Relative Sub-Drainage Americium Loads to GS10 with SW022 Loads Displayed Separately: March 3, 1998 to Date.

4.1.4. Real-Time Water-Quality Parameters

Fifteen-minute readings of temperature, pH, turbidity, specific conductivity, and nitrate are collected by a continuously-deployed, multi-parameter water-quality probe at GS10. Daily averages of readings collected for WY99 to date are presented in Figure 4-9 and Figure 4-10.

As shown in Figure 4-9, mean daily results for pH are steady between 7.3 and 8.0 pH units between October 1, 1998 and July 1, 1999. Daily-average turbidity results indicate numerous sharp peaks of high turbidity. These peaks correspond to runoff events, the frequency and intensity of which generally increase during the spring. Specific conductivity results also exhibit numerous peaks. The high peaks in the winter correspond to snowmelt events. This increased ionic strength can probably be attributed to salting of road surfaces and walkways. The low peaks in the spring also correspond to runoff events, and are likely due to dilution of baseflow by runoff. Finally, nitrate results indicate peaks during runoff events as well. However, nitrate readings are expected to exceed actual nitrate concentrations in the surface water as identified by a study of nitrate ion-specific electrodes performed by the Site (RMRS, 1997a).[16]

[16] Nitrate ion specific electrode (ISE) measurements suffer from limited accuracy and precision in the concentration range observed in Site surface waters. Inaccuracies in nitrate ISE measurements are caused by significant interferences associated with common surface-water constituents including chloride and natural organic matter. Wet chemical field tests have been performed to verify this limitation, and collection and interpretations of nitrate results has been optimized.

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In conclusion, *insitu* water quality monitoring results indicate no unusual or unexpected conditions for WY99 to date. WY99 trends for all parameters are similar to those observed in WY98 and WY97.

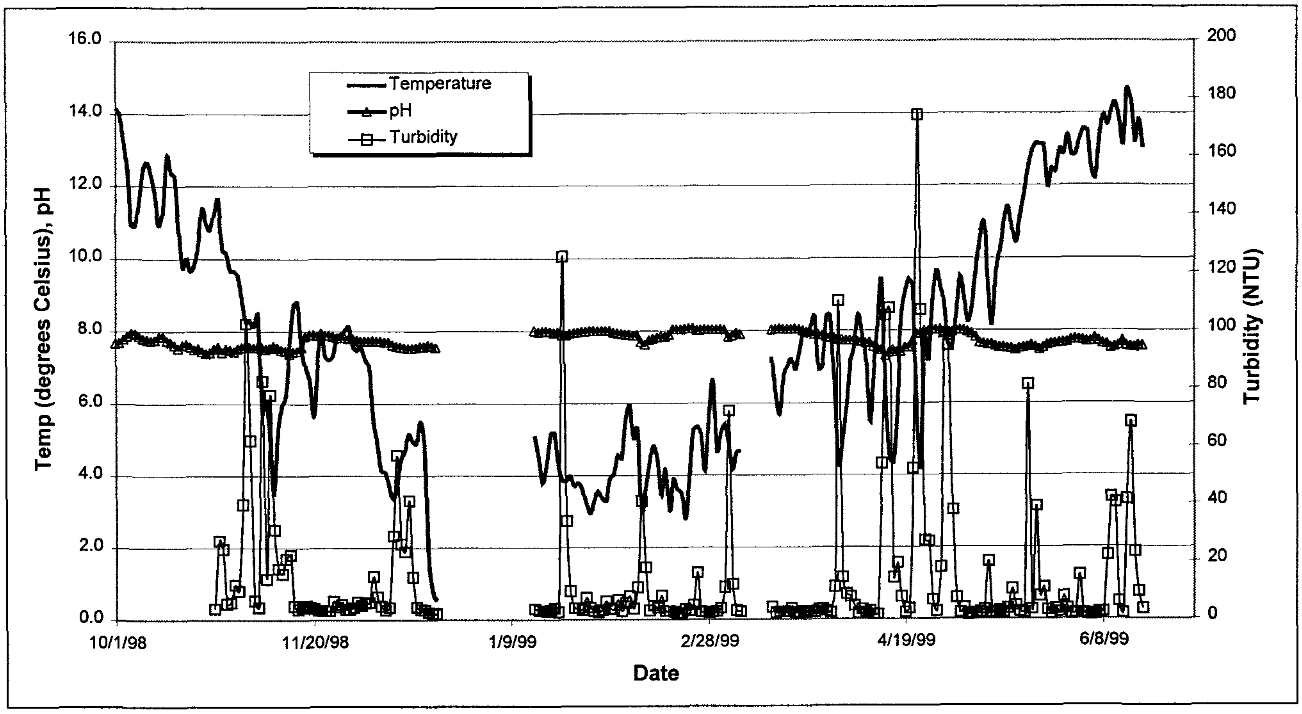

Figure 4-9. Mean Daily Temperature, pH, and Turbidity at GS10 for WY99 to Date.

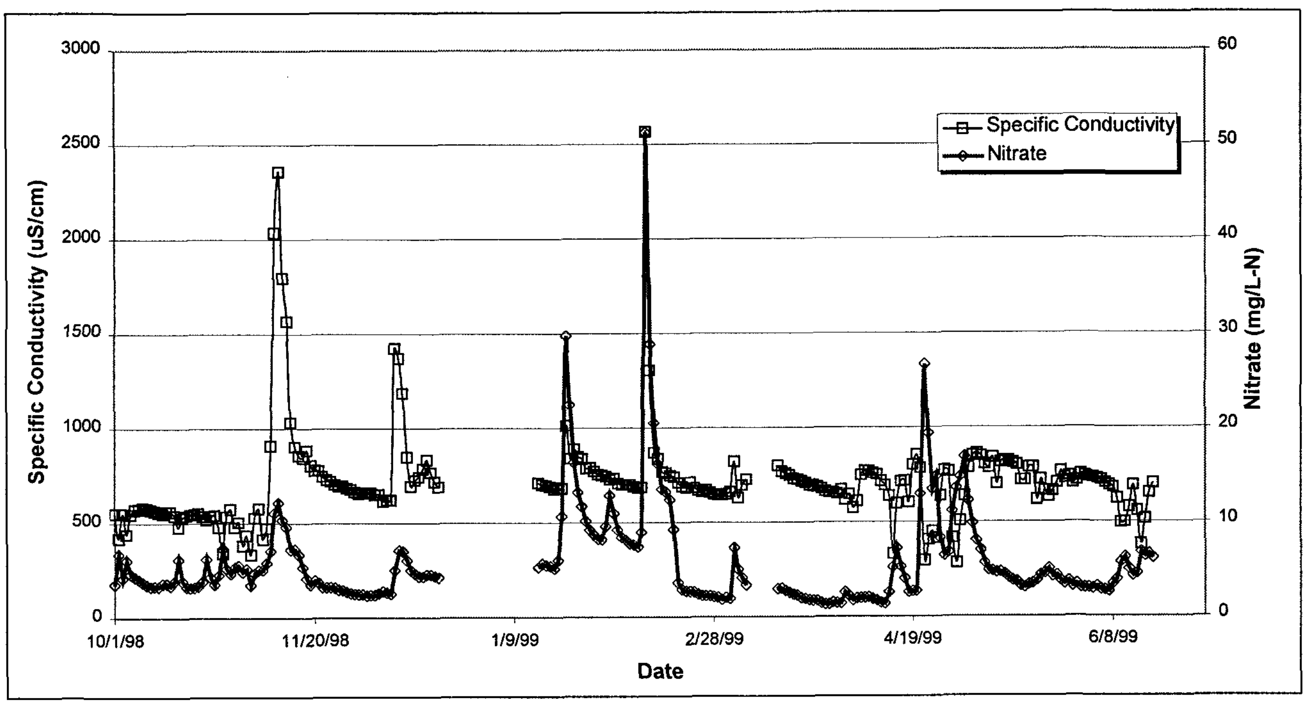

Figure 4-10. Mean Daily Specific Conductivity and Nitrate at GS10 for WY99 to Date.

4.2. SOIL AND SEDIMENT INFORMATION

Site soils have received actinide contamination from various historical releases. Section 4.7 in Progress Report #2 identifies various events from the Site's production era which may have introduced radioisotopes to Site drainages via both airborne and surface-water runoff pathways. As discussed in Section 4 of Progress Report #2, historical reports and a recent review of existing soil/sediment data indicate diffuse low-level plutonium and americium contamination of soils and sediments throughout the GS10 drainage. The GS10 drainage includes various IHSSs and actinide source areas which could provide source terms for elevated levels in surface water. The movement of contaminated soils and sediments in runoff could result in localized deposits or diffuse contamination, depending on natural erosion processes in the GS10 drainage. Airborne contamination has resulted in diffuse contamination, with levels diminishing further from sources such as the 903 Pad.

Soil and sediment activities for samples in the GS10 drainage show a range of 0 to more than 4,000 pCi/g, while most of the results are in the 0.1 to 10 pCi/g range. (see Section 4.6 of Progress Report #2). and present soil and sediment activities in the GS10 drainage. The highest values are associated with soils under the 903 Pad, and therefore do not come in direct contact with runoff. It is generally accepted that plutonium and americium in the Rocky Flats environment are associated with soil particles and actinide transport occurs when those particles move. If actinides were associated with soil solids measurable as TSS, and that TSS were a uniform suspension of all soil fractions (i.e., TSS maintains the same particle size and composition ratios as the surface soils), surface-water activity could be calculated directly from soil activity for a given TSS concentration. Table 4-1 presents the results of such calculations. Specifically, Table 4-1 shows the calculated surface-water sample activities at GS10 which would result from a given basin soil activity, if uniform suspension of surface soils as TSS and complete association of actinides with TSS in solution.

Table 4-1. Hypothetical Calculated Surface-Water Activities for Uniform Soil Suspension and Complete Association of Plutonium or Americium with Suspended Solids at GS10.

	Total Suspended Solids (TSS)	
Basin Soil Activity Ranges (pCi/g)	**250 mg/l (Average)**	**1,500 mg/l (Maximum)**
0.1	0.025 pCi/l	0.15 pCi/l
1 to 10	0.25 to 2.5 pCi/l	1.5 to 15 pCi/l
100	25 pCi/l	150 pCi/l

Based on calculations summarized in Table 4-1, the elevated activities observed at GS10 could be a result of the relatively low-level diffuse contamination within the GS10 drainage area, and not the result of a localized source. The ranges of TSS concentrations and basin soil activities used in the calculations are based on actual, observed values from GS10 surface-water samples and soil samples in the GS10 drainage. Additionally, the apparent relationship between TSS, precipitation, and plutonium activity supports this hypothesis (see previous Reports). It is also possible that soils are eroded, moved by overland flow, and re-deposited in ditches with each passing storm-runoff event. Further, it is possible that occasional movement of 'hot particles' or preferential suspension of plutonium-associated solids is occurring in the drainage. Sections 5.1 and 5.3 of the Final Report provide further insight into the transport and speciation issues influencing surface-water activities

The evaluation in this section specifically addresses soil and sediment Pu/Am activity ratios in an attempt to corroborate the surface-water Pu/Am ratios and understand the recent americium levels at GS10. Historical radionuclide data for soil, surface-soil, and sediment sampling in the GS10 drainage were evaluated as part of this source evaluation and are discussed in this section. Data were retrieved from the Site's Soil Water Database (SWD) for sample locations identified by GIS coverages to be within the GS10 drainage. Only samples with both plutonium and americium results were considered. Further, for all Pu/Am ratio analyses, only samples with both plutonium and americium activities greater than 0.025 pCi/g were included. This limitation was applied to minimize the propagation of the inherent analytical error near the detection limit.

4.2.1. Soil and Sediment Pu/Am Activity Ratio Data Summary

In all, 197 samples were retrieved from the SWD that met the criteria described in Section 4.2. Of these, eight are located in the GS27 sub-drainage, 26 are located in the GS38 sub-drainage, and five are located in the GS40 sub-drainage. The remaining 158 soil samples were from GS10 sub-drainage areas not currently monitored by surface-water stations upstream of GS10. The average Pu/Am ratio for these 197 samples is 3.50. Average Pu/Am ratios by sub-drainage are presented below in Table 4-2.

Table 4-2. Average Pu/Am Activity Ratios for Soil, Surface Soil, and Sediment Samples in the GS10 Drainage.

Sub-Drainage	Average Pu/Am Ratio
GS27 Sub-Drainage	4.6
GS38 Sub-Drainage	3.6
GS40 Sub-Drainage	2.6
Other Sub-Drainage Areas*	3.5

*This refers to soil and sediment samples from sub-drainage areas within the GS10 drainage that are not currently monitored by surface-water stations upgradient of GS10.

4.2.2. Soil and Sediment Pu/Am Activity Ratio Evaluation

Plutonium is plotted against americium by drainage area in Figure 4-13 for all samples that met the criteria described in Section 4.2.

Figure 4-13 reveals no sub-drainages with markedly lower soil/sediment Pu/Am ratios that may be source areas for the low surface-water Pu/Am ratios observed in at GS10. Though the average Pu/Am ratio for samples from the GS40 drainage is somewhat lower than those of the other sub-drainages (see Table 4-2), this average is based on only five results. Further, activities are all fairly low for these samples.

To further investigate the individual sample results with low Pu/Am ratios, sample points within the "other sub-drainages to GS10" series were identified on the GS10 drainage coverage. No apparent trends were revealed. Also, sediment samples were compared to soil and surface soil samples, and no conclusions were reached. Though analysis of the existing soils data was fairly inconclusive, the americium activities at GS10 and the Pu/Am ratio analysis for surface-water samples suggest a source of americium may exist in the drainage.

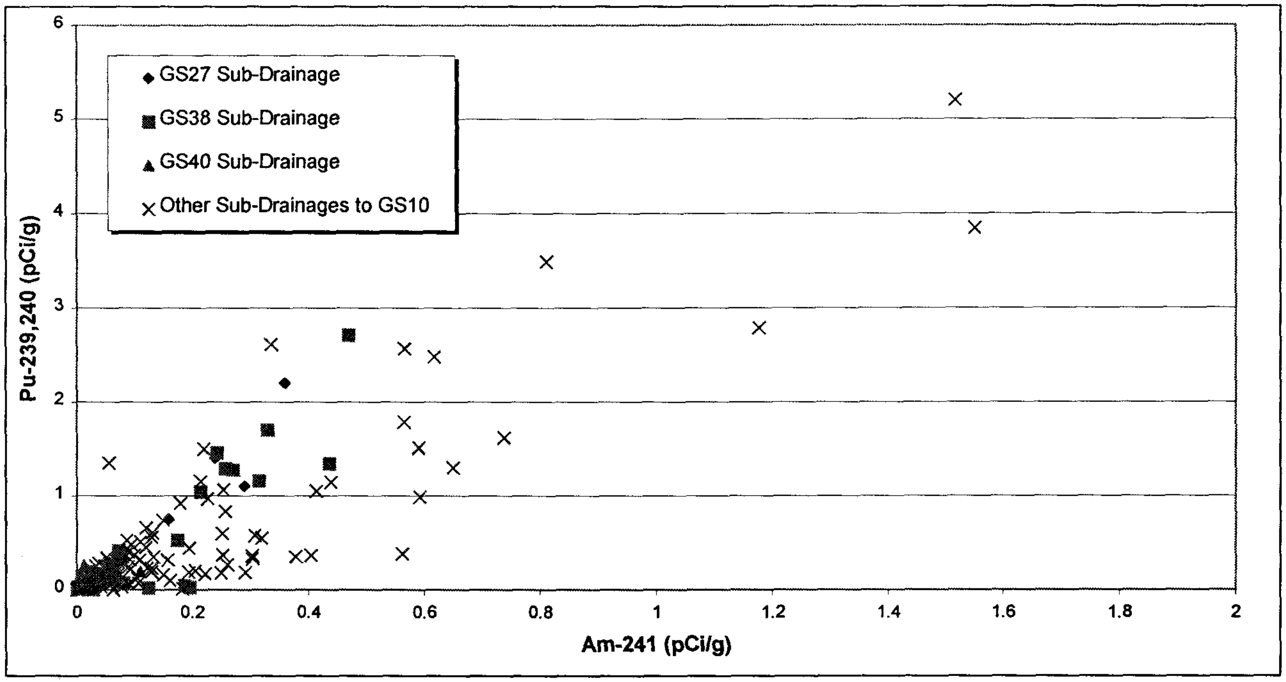

Figure 4-13. Plutonium vs. Americium for Surface-Soil and Sediment Samples Within the GS10 Drainage.

5. ASSESSMENT OF RECENT SITE PROJECTS

Site closure activities, including building D&D work, ER projects, excavation work and routine day-to-day operations are ongoing at multiple locations around the Site. Those activities and projects conducted during the March through June period (FY99) were reviewed and assessed to determine whether or not they represented a plausible source of the americium or plutonium that resulted in the elevated activities observed at monitoring location GS10.

5.1. D&D WORK

D&D project activities occurred throughout the Site during FY99. Several projects in the 400, 700, and 800 Areas could have contributed radiological contamination to the GS10 sub-drainage. For each ongoing D&D project, project documentation was reviewed, project managers were contacted, and Site closure activities were examined in conjunction with water-quality sampling results, to assess whether or not there was a connection between D&D projects and elevated americium and plutonium activity measured in the runoff at downstream monitoring locations. The D&D projects that could have impacted surface water in the GS10 drainage basin are discussed in the following sections.

5.1.1. 400 AREA

Building 444 D&D

Originally constructed in 1953, Building 444 was a production operations facility. The B444 Cluster was primarily used for metals processing. Depleted uranium and beryllium foundry and fabrication activities, for use in nuclear weapons components were the primary focuses of the cluster. Other materials processed included tool steel, specialty alloy stainless steel, graphite, and aluminum. Some less common materials processes were titanium, tantalum, vanadium, gold, silver, copper, and lead. There are no records suggesting that plutonium or enriched uranium were ever processed in the cluster (RMRS, 1998a).

During the March through June 1999 time period, B444 D&D efforts were focused on planning and preparation for classified repack beryllium shop (McMann, 1999). The B444 D&D project manager (Coyne, 1999) stated that the B444 Cluster contains no plutonium and could not have contributed americium or plutonium as observed at monitoring location GS10. Consequently, at this time, there is no reason to suspect that Pu and Am contamination observed at GS10 originated from B444 D&D activities.

5.1.2. 700 AREA

Building 729 D&D

Building 729 was constructed in 1971 as a support facility for B779. B729 contained a filter plenum and an emergency electric power generator. B729 was connected to B779 via a second story bridge.

No known liquid radioactive effluent releases occurred during building strip-out. Airborne activity monitoring was performed during the strip-out of radioactively-contaminated equipment from B729. This included continuous effluent air monitoring on the stack. Final radiological surveys were performed on the building prior to its demolition. The building was radiologically surveyed and determined to be free-releasable prior to demolition. All surveys indicated that the building interior and exterior surfaces were well below the DOE Order 5400.5 release limits for transuranics. Airborne monitoring was performed during building demolition and indicated no radioactive material releases (Grube, 1999). Although Building 729 was demolished during the timeline in question, no unusual events were noted, and work was suspended during periods of high winds. The resulting clean debris was shipped to the Erie landfill for disposal (Zbryk, 1999). Consequently, at this time, there is no reason to suspect that Pu and Am contamination observed at GS10 originated from B729 D&D activities.

Building 776 D&D

During the March through June 1999 time period, all the B776 D&D project activities were limited to glovebox clean-out work. This activity included tool bag out and wipe down of the boxes. These activities were confined inside the building. Further, there have been no liquid discharges or releases from the project that could have contributed to the elevated values at GS10 (Dunn, 1999). Consequently, at this time, there is no reason to suspect that Pu and Am contamination observed at GS10 originated from B776 D&D activities.

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Building 779 D&D

Building 779 was constructed in 1965 and expanded in 1968 (779A) and 1973 (779B). Building 779 was used as a Research and Development center in support of nuclear weapons production. Building 779 contained process equipment that modeled some of the production facility's mission, and laboratory equipment to conduct material and environmental testing. Building 779 was erected over the site of one of the original Solar Evaporation Ponds which was likely to have caused the uranium contamination (11 to 150 dpm/l) that was detected during the construction of the building (RMRS, 1998f).

During the March through June 1999 time frame, the primary B779 D&D activity was internal stripout, which is not expected to have affected Site surface water (Zbryk, 1999). The B779 Final Survey Radiological Engineer stated (Grube, 1999) that it is highly unlikely that any environmental releases occurred as a result of this evolution for the following reasons:

- Continuous effluent air monitoring was in effect, and no known airborne releases occurred.
- No evolutions occurred that would have resulted in any other type of environmental release including liquid effluent.
- No other known activities occurred at the B779 Cluster that would result in any release of transuranics to the environment.

Consequently, at this time, there is no reason to suspect that Pu and Am contamination observed at GS10 originated from B779 D&D activities.

5.1.3. 800 AREA

Building 886 D&D

The B886 Cluster is located in the RFETS Industrial Area (IA) at the east central portion of the Site. Construction of Buildings 886, 875, and 888A was completed in 1964 and commissioned in 1965. Trailer 886A and connecting breezeway were added in 1980. The purpose of the 886 Cluster was to conduct criticality experiments on liquids, powders, and solid forms of fissionable materials (RMRS, 1998e).

There are no Resource Conservation and Recovery Act (RCRA) designated areas within the 886 Cluster. The potential for under-building contamination at B886 is documented in the *HRR*, and the soil surrounding the building is designated as Individual Hazardous Substance Site 164.2, Building 886 Spills. The soil is suspected to be contaminated with uranium. Additionally, given groundwater seepage problems in Buildings 875 and 828, the potential for groundwater contamination from these structures exists.

According to the B886 D&D Project Manager (Sproles, 1999), all B886 plutonium is presently bound in gloveboxes and cannot be released to the environment; and during the March through June 1999 time period, no activities occurred in B886 that would have resulted in any release of plutonium to the environment. Consequently, at this time, there is no reason to suspect that Pu and Am contamination observed at GS10 originated from B886 D&D activities.

5.2. ER PROJECTS

Historically, there have been numerous radioactive releases to the B-series ponds that may have potentially contaminated the soil and sediment in the GS10 basin. Three Site ER projects, currently in various phases of completion, may have affected the migration of these contaminants from their source of origin. These projects include: The East Trenches Groundwater Plume Project (active construction phase), the 903 Drum Storage Area "903 Pad" (sampling and analysis characterization phase), and Trench T-1 (waste shipment project closeout phase).

The East Trenches Plume

The East Trenches Groundwater Plume is located north of Central Avenue, and east of the Perimeter Road. This groundwater plume contains volatile organic compound (VOC) contamination that may originate from the East Trenches and 903 Pad sites and extends northward to where the plume discharges as seeps and subsurface flow into the South Walnut Creek Drainage downstream of the monitoring location GS10.

The East Trench Plume (ETP) project is designed to collect and treat VOC-contaminated groundwater. Though the ETP Proposed Action Memorandum (PAM) (February 4, 1999) states that constituents were below Action Level Framework (ALF) Subsurface Soil Tier II levels, this is no assurance that radiological contamination of surface water is not a concern. There is still no clear relationship between soil contamination levels and observed surface water contamination.

Ongoing excavating activities which began in February 1999 have caused significant soil disturbance to the southeast of GS10. It is reasonable to expect that vehicular traffic and heavy equipment activities mobilized potentially contaminated surface soils. While dust suppression techniques were employed to minimize air suspension of particulates, spring storm events, characterized by heavy rains and high winds, were possible mechanisms for dispersion of contaminants.

During the March through June 1999 time period, no radiological concerns were reported in association with ETP remediation activities (Primrose, 1999).

903 PAD

Releases at the 903 Drum Storage site (IHSS 112) are considered the primary known sources of radiological contamination in the surficial soil in this region of the Site. Drums that contained radiologically contaminated oils and VOCs were stored at this location from the summer of 1958 to January 1967. Approximately three-fourths of the drums contained plutonium-contaminated liquids while most of the remaining drums contained uranium-contaminated liquids. Of the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying concentrations. Also stored in the drums were hydraulic oils, vacuum pump oils, trichloroethane, tetrachloroethene, silicone oils, and acetone still bottoms (RMRS, 1998d). In 1964, leaking drums were noted, and the contents of leaking drums were transferred to new drums, and the area access restricted. When cleanup operations began in 1967, a total of 5,237 drums were at the storage site. Approximately 420 drums leaked to some degree, and 50 of those leaked their entire contents (RMRS, 1998d).

From 1968 through 1970, some of the radiologically-contaminated material was removed, the area graded, and an asphalt cap installed. However, during the drum removal and cleanup, wind and stormwater runoff spread plutonium-contaminated soils to the east and southeast from the 903 PAD area resulting in IHSS 155 (903 Pad Lip). These areas exhibiting elevated plutonium and americium activities east and southeast of the 903 Pad Lip Area are known as the Americium Zone.

During the March through June 1999 time period (Wood, 1999), the 903 Pad characterization efforts involved drilling for the VOC sampling program. Nine boreholes were completed to a depth of approximately 20 feet. Measures to check for the spread on contamination included HIGH Volume air sampling and geoprobe soil borings (3 total). These checks identified no spread of contamination during the drilling program. This supports the program manager's completion records of no reportable releases.

Trench T-1

Trench T-1 is located just northwest of the inner east gate, and about 40 feet south of the southeast corner of the Protected Area fence. Depleted uranium metal chips (lathe and machine turnings) packed in lathe coolant were buried in the west end of Trench T-1 in approximately 125 drums. No documentation existed for contents of the center and east end of the trench (RMRS, 1998b).

Project activities for the March through June 1999 time period that may have impacted surface water quality are summarized below:

- Completed excavation of anomalies identified by electro-magnetic surveys. No additional containers were discovered.
- Continued mounding soil over Trench T-1. Operators are finding many depleted uranium nuggets in the soil stockpile as encountered early in the project. This soil was contaminated with depleted uranium when one of the first drums was breached and the contents spilled into the trench.
- Completed demobilization of the Trench T-1 temporary containment structure. Shipment of the tent structure was completed in April 1999.
- Began site demobilization activities with clean-out of field offices, fencing surrounding the site, miscellaneous tools and equipment.
- Continued site re-vegetation planning.
- Movement of Trench T-1 waste containers to covered storage was initiated. Crates and drums not planned to be shipped to Envirocare or NTS were relocated to Tent 11 on the 904 Pad.

There is no reason, at this time, to suspect that the Trench T-1 project contributed americium or plutonium to South Walnut Creek during the March through June 1999 time period.

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5.3. ROUTINE SITE OPERATIONS

During the period of March 1 through July 1, 1999, 50 incidental waters (IWs) were sampled and dispositioned. All were associated with routine Site activities such as accessing utility pits and building basements. These IWs were assessed using field measurements and chemical analyses for known or suspected contaminants to determine appropriateness for discharge to the environment. Eight (8) IWs were discharged to the GS10 drainage following receipt of analytical results. Isotopic characterization was not part of the assessment of these waters. Measurements for gross alpha and gross beta met IW criteria; however, these measurements are not accurate to the low levels of radionuclides measured at GS10. The remaining IWs required treatment and were routed to various Site treatment facilities (Barker, 1999). At this time, there is no reason to suspect that the small overall quantity of IWs released to the environment contributed to the contamination observed at GS10.

According to Site records, there were no spill events recorded during this time period that may have introduced radioactive contamination to the GS10 drainage. A review of the Shift Superintendent Daily Reports revealed that spills of potentially radiologically contaminated materials were confined to the interior of buildings and adequately contained and cleaned up without threat of discharge to the environment. Additionally, the annual Source Control Reviews, which involve a walk-down of all areas outside buildings within the Industrial Area to identify potential surface-water contamination sources, were completed on June 23, 1999. There were no findings or observations that suggested off-normal conditions that would have resulted in elevated radionuclide measurements at GS10.

5.4. SUMMARY OF RECENT SITE ACTIVITIES IMPACT ON GS10

For the reasons outlined above, there is not reason, at this time, to suspect that recent D&D, ER Projects, excavation, or routine Site operations caused a release of plutonium or americium, resulting in the elevated activities measured at GS10.

6. ACTINIDE MIGRATION EVALUATION

The Site has undertaken a comprehensive multi-year Actinide Migration Evaluation (AME) to improve understanding of the behavior and transport of plutonium, americium, and uranium in the environment. One of the expressed goals of the AME is to quantify the rates of actinide migration via different environmental pathways to explain recent measured quantities of actinides in Site surface-waters and to recommend mitigation activities to minimize impacts to surface-water quality.

6.1. CURRENT (FY99) RESEARCH ACTIVITIES

In FY99, the AME group collected stormwater runoff from GS10 to assess the particle-size distribution of plutonium in suspended solids and to evaluate the characteristics of plutonium-containing particles in surface-water. Approximately 300 liters of water were collected in April for ultrafiltration with various nominal pore-size ultrafilters by Texas A&M researchers. The filtered particles will be analyzed for actinide activity, selected metals, organic carbon, and surface charge. These data should provide clues as to the

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sources of the plutonium-contaminated particles and how their transport might be controlled. A final report is due to the Site in September 1999.

Also in FY99, Colorado School of Mines researchers began investigating the properties of Site soil aggregates and the affect of disaggregation on actinide migration. This investigation will determine the dominant forms of materials that bind smaller, primary soil particles into larger soil particles. Knowledge of the aggregating properties of the Site soils will lend insight to the mechanisms by which plutonium-contaminated soils are moved by natural processes such as freeze-thaw cycling, raindrop impact, erosion and sediment transport.

Colorado School of Mines researchers are also investigating how changes in oxidation/reduction (redox) conditions affect plutonium mobility. This investigation is largely applicable to environments such as wetlands, pond bottom sediments, and saturated sub-surface (shallow/perched groundwater) areas that are contaminated with actinides. Therefore, this study might not be useful for assessing source terms for GS10 plutonium, but it may be helpful for evaluating what happens to the plutonium-contaminated sediments when they are deposited in deep-water or wetland environments that are present in Site detention ponds.

Further, the AME Team has developed calibrated mathematical models to estimate actinide movement via soil erosion (i.e. via water) and by wind re-suspension and air transport. The soil erosion model will be linked to a sediment transport model (Hydrologic Efficiency Code-Version 6T (HEC-6T)) to estimate sediment and associated actinide transport in Site streams. The Water Erosion Prediction Project (WEPP) model is not designed to estimate erosion from industrial surfaces such as those that drain to GS10, but data from GS10 for both suspended solids and plutonium activity will be used in HEC-6T to estimate the potential for transport of plutonium in Site watersheds. The models will be completed by September 30, 1999; and their results may be used to compare actinide loading at GS10 to loading from other Site source terms.

6.2. SUMMARY OF ACTINIDE MIGRATION EVALUATION RESULTS TO-DATE

Soils from the 903 Pad and Lip Area were evaluated using selective chemical extraction methods that test plutonium's association with major, chemically distinguishable soil fractions — namely, exchangeable, carbonate, sesquioxide, organic, and residual fractions. Again, the methodology and protocols are limited to the sample background value of approximately 0.05 pCi(Pu)/g. The following findings are potentially relevant to this source evaluation:

- Activities (pCi (Plutonium and Americium) per gram soil) in the various soil fractions show a nearly three order-of-magnitude range in activity within any particular sample;
- Partition coefficients for soil/sediment-water system (ranging from 10^4 to 10^5 L/kg) suggest that Pu and Am are strongly bound to particulates, and are likely mobilized by physical transport mechanisms, not by dissolution under normal conditions.

More recent significant conclusions from the Actinide Migration Evaluation which are relevant to this source evaluation are as follows:

- Colorado School of Mines researchers released experimental results that indicate plutonium and americium solubility in soils does not increase in strong reducing environments (i.e. low oxygen content). This means that waterlogged soils or wetland environments should not necessarily be regarded as areas with high actinide mobility terms. Rather, these environments could be actinide "sinks," as AME data suggests that actinide solubility actually decreases with decreasing Eh (redox potential).
- Los Alamos National Laboratory researchers determined that the plutonium in the Site environment is predominantly in the +4 oxidation state. Therefore, the plutonium is in the form of PuO_2, which is extremely insoluble and will be transported as a particulate, not a dissolved specie.
- Texas A&M researchers found that plutonium at femptocurie levels (fall out levels) is present almost entirely in colloidal form in Walnut Creek water discharged from the Site.
- Colorado School of Mines researchers determined that Site soil aggregates are predominantly held together with organic materials, not iron and manganese oxide cements. Further work will determine what happens to the plutonium particle-size distribution when the soils are disaggregated by different physical and chemical processes.

6.3. UPCOMING ACTINIDE MIGRATION EVALUATION ACTIVITIES

The near-term scope of work for the AME effort includes several elements applicable to this source investigation:

1. Complete soil aggregation and phase speciation studies to determine chemical speciation of plutonium;
2. Analyze surface-water samples to provide physical and chemical speciation of actinides;
3. Complete redox experiments to assess actinide migration potential in reducing environments;
4. Initiate coordination with Decontamination and Decommissioning (D&D) projects to assist in actinide migration issues surrounding D&D (e.g. actinide leaching from concrete);
5. Complete groundwater geochemical modeling; and
6. Complete erosion, sediment, and air transport modeling.

The surface-water Source Evaluation task team will continue to consult regularly with the Actinide Migration Evaluation Team to remain up-to-date as to the latest findings as well as offer recommendations and insight into possible areas of research.

7. SOURCE EVALUATION SUMMARY

7.1. GS10 SOURCE LOCATION ANALYSIS RESULTS

In the following section, a discussion of source hypotheses for GS10 is presented. Since this report builds on the results of the previously completed reports for the Walnut Creek Source Evaluation, the reader is referred to the following reports for background: Progress Reports #1, #2, #3 (RMRS, 1997c, 1997d, 1997e), and the *Final Report to the Source Evaluation and Preliminary Mitigation Plan for Walnut Creek* (RMRS, 1998c). To date, a singular actinide source of the elevated 30-day averages at GS10 cannot be identified. Information collected to date does not point to any singular conclusion. In fact, it is likely that multiple sources and transport mechanisms are responsible for the elevated radionuclide activities at GS10.

Data from the *insitu* real-time water-quality probe in operation at GS10 for indicators that may point to a cause of the recent elevated actinide measurements at GS10. In conclusion, in-situ water-quality monitoring results indicate no unusual or unexpected conditions for WY99 to date. WY99 trends for all parameters are similar to those observed in WY97 and WY98.

For the reasons outlined in Section 0, no D&D, ER Projects, excavation, nor routine Site operations caused a release of plutonium or americium that resulted in the elevated activities measured at station GS10. Rather, it appears that the elevated activities can be attributed to plutonium and americium source(s) created by historical Site operations, natural actinide transport processes, and atmospheric fallout.

Diffuse or Localized Soil and Sediment Contamination in GS10 Drainage

Site soils have received radionuclide contamination from various historical practices and legacy releases. Section 4.7 in Progress Report #2 identifies various events from the Site's production era which introduced radionuclides to Site drainages via both airborne and surface-water runoff pathways. As discussed in Section 4 of Progress Report #2, historical reports and a recent review of existing soil/sediment data indicate diffuse low-level plutonium and americium contamination of soils and sediments occurs in the GS10 drainage. The GS10 drainage includes various IHSSs and actinide source areas which could provide source terms for elevated levels in surface water. The movement of contaminated soils and sediments in runoff could result in localized deposits or diffuse contamination, depending on natural erosion processes in the GS10 drainage.

AME results to-date suggest that transport of dissolved plutonium and americium is not a significant pathway at the Site, and physical transport of particulate-borne radionuclides is likely primarily responsible for plutonium and americium mobilization. The ramification of these findings as related to specific mechanisms of transport should be further elucidated by additional AME research currently underway. The surface-water Source Evaluation task team continues to consult regularly with the AME Team and remains up-to-date on the latest findings as well as recommended areas of research.

Section 4.2 of Progress Report #2, Section 6.1.2 of the Final Report, and Section 4.1.3 of this report show that the monitored GS10 sub-drainage all contribute actinide load to GS10, further supporting the hypothesis of multiple or diffuse source areas. Data collected from monitoring locations GS27, GS38, GS39, GS40, and

SW022 further determined the proportions of actinide load that each monitored sub-drainage may be contributing to GS10.

The loading evaluation in Section 4.1.3 shows that the GS27, GS38, GS39, and GS40 sub-drainages contribute approximately 23% of the plutonium load reaching GS10. Similarly, the evaluation showed that the GS27, GS38, GS39, and GS40 sub-drainages contribute approximately 8% of the americium load reaching GS10. Other sub-drainages contribute the remaining plutonium and americium load measured at GS10. These other sub-drainages include the South Walnut Creek reach between GS40 and GS10 (B991 is in this sub-drainage), a portion of the 500 Area outside the PA, portions of the 800 Area, and the Central Avenue Ditch reach between GS38 and SW022 (Trench T-1 and the Mound Area are in this sub-drainage). That SW022 has shown relatively high plutonium activities, coupled with the proximity of the 903 Pad[17], indicates that the Central Avenue Ditch reach between GS38 and SW022 may be a significant source of plutonium. However, limited soil and sediment data exist for this area to corroborate this hypothesis.

Figure 4-8 incorporates the americium data from SW022 and indicates that the SW022 sub-drainage (which includes GS27, GS38, and GS39) contributes 24% of the americium load to GS10, with an additional 4% being contributed from the GS40 sub-drainage. This further suggests that the South Walnut Creek reach between GS40 and GS10 (B991 is in this sub-drainage) may contain a significant source of americium. However, limited soil and sediment data exists for this area to corroborate this hypothesis. The *HRR* supports the hypothesis that actinide contamination exists in the drainage immediately upstream of GS10, specifically the sediments in the stream reach between B991 and GS10. The area was identified in the *HRR* due to past radioactive releases to the B-series drainages (as discussed in Section 4.7 of Progress Report #2), and the soil in the area is potentially contaminated with actinides.

Results in Section 4.1.2 also indicate that the average Pu/Am activity ratio from surface-water samples at GS10 is lower than that generally observed in other drainages and sub-drainages across the Site. Results also indicated that the Pu/Am ratios observed at GS10 appear to be distinguishable from those observed in monitored sub-drainages of GS10. These results may suggest that a source of contamination with a low Pu/Am ratio exists within the GS10 drainage, either very close to the GS10 monitoring location or in a sub-drainage not monitored by upstream surface-water monitoring locations. However, the limited soil/sediment data in the 'unmonitored' sub-drainages could not corroborate this hypothesis. Additionally, an evaluation of Pu/Am activity ratios for the existing sediment and soil data in the GS10 drainage did not show the trends noted for surface water or suggest a source of americium enriched soils.

7.2. CONCLUSIONS

This section summarizes the findings of this Source Evaluation, and presents preliminary conclusions based on information presented and analyzed in this report.

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[17] GS39, which directly monitors runoff from the 903 Pad area, shows only moderate actinide transport.

- Surface-water and soil/sediment sampling results suggest that one or more low-level distributed actinide source areas exist within the GS10 drainage. Further, surface-water activities have been of similar magnitudes for the last decade, suggesting source areas that originated as legacy contamination.

- Surface-water sampling results from GS10 show Pu/Am activity ratios that are distinguishable from Pu/Am ratios at other surface-water monitoring location at the Site. This suggests a source relatively 'enriched' in americium may exist in the GS10 drainage.

- Recent surface-water sampling results from Source Location monitoring stations has further refined the estimation of relative plutonium load contributions to GS10 from upstream sub-drainage areas. These load estimations suggest that plutonium source terms may exist in the following sub-drainage areas:
    1. The Central Avenue Ditch reach between surface-water monitoring locations GS38 and SW022;
    2. Portions of the 800 Area;
    3. A portion of the 500 Area outside the PA; and
    4. The South Walnut Creek reach between surface-water monitoring locations GS40 and GS10.

- Recent surface-water sampling results from Source Location monitoring stations have further refined the estimation of relative americium load contributions to GS10 from upstream sub-drainage areas. These load estimations suggest that americium source terms may exist in the following sub-drainage areas:
    1. A portion of the 500 Area outside the PA; and
    2. The South Walnut Creek reach between surface-water monitoring locations GS40 and GS10.

- Evaluation of readings from *insitu* water-quality monitoring probes indicates no unusual or unexpected conditions for WY99 to date. WY99 trends for all parameters are similar to those observed in WY98 and WY97.

- A review of current Site activities indicate that no D&D, ER Projects, excavation, nor routine Site operations caused a release of plutonium or americium that resulted in the elevated activities measured at GS10.

- The elevated values seen at GS10 and other monitoring locations in the GS10 drainage are not being seen at the Ponds or downstream POCs.

7.3. RECOMMENDATIONS

Based on the findings of this Source Evaluation, the following recommendations are offered:

- The Site proposes changing the sampling protocols at SW022 from storm-event to continuous flow-paced to facilitate more accurate loading in the future. Any changes to sampling protocols at SW022 would need to be made with the consensus of the parties involved in the development of the IMP.

- The Site will continue the ongoing RFCA monitoring and source evaluation activities related to GS10 in an effort to further identify the location of sources.

- AME findings as related to specific mechanisms of transport should be further elucidated by additional AME research currently underway. The surface-water Source Evaluation task team will continue to consult regularly with the AME Team to remain up-to-date on the latest findings as well as to recommend possible areas of research.

8. REFERENCES

Barker, S., IWS and IW Program Manager, July 12, 1999, verbal communication.

CDPHE, USDOE, USEPA, 1996. *Final Rocky Flats Cleanup Agreement*, Federal Facility Agreement and Consent Order, CERCLA VIII-96-21 RCRA (3008(h)) VIII-96-01, State of Colorado Docket #96-07-19-01.

Coyne, D., RMRS B444 Project Manager, July 12, 1999, Email communication.

Dunn, R.P., B776 D&D Project Manager, July 14, 1999, Email communication.

Grube, M., B779 Final Survey Radiological Engineer, July 13, 1999, Email communication.

Kaiser-Hill, DOE RFFO, 1998. *Rocky Flats Environmental Technology Site Integrated Monitoring Plan FY98/FY99*, Golden, Colorado, October.

McMann, Doug, July 15, 1999, verbal communication.

Primrose, A., East Trenches Groundwater Plume Project Manager, July 9, 1999, Email communication.

RMRS, 1997a. *Evaluation of the Utility of Nitrate Probes for Real-Time Monitoring at Points of Evaluation and Compliance at the Rocky Flats Environmental Technology Site*, Kaiser-Hill Company, Golden, Colorado.

RMRS, 1997b. *Plan for Source Evaluation and Preliminary Proposed Mitigating Actions for Walnut Creek Water-Quality Results*, Revision 2 RF/RMRS-97-081.UN, Kaiser-Hill Company, Golden, Colorado, September.

RMRS, 1997c. *Progress Report #1 to the Source Evaluation and Preliminary Mitigation Plan for Walnut Creek*, Revision 1 RF/RMRS-97-089.UN, Kaiser-Hill Company, Golden, Colorado, September.

RMRS, 1997d. *Progress Report #2 to the Source Evaluation and Preliminary Mitigation Plan for Walnut Creek*, RF/RMRS-97-115.UN, Kaiser-Hill Company, Golden, Colorado, November.

RMRS, 1997e. *Progress Report #3 to the Source Evaluation and Preliminary Mitigation Plan for Walnut Creek*, Revision 2 RF/RMRS-97-115.UN, Kaiser-Hill Company, Golden, Colorado, December.

RMRS, 1998a. *444 Cluster Closure Project, Project Execution Plan*. Initial Issue: Hazards Reduction - Revision 0, RF/RMRS-98-294, K-H Team, Golden, Colorado, November.

RMRS, 1998b. *Final Proposed Action Memorandum for the Source Removal at Trench 1, IHSS 108.* Revision 5, RF/RMRS-97-011, K-HH Team, Golden, Colorado, August.

RMRS, 1998c. *Final Report to the Source Evaluation and Preliminary Mitigation Actions Plan for Walnut Creek*, RF/RMRS-98-234.UN, Kaiser-Hill Company, Golden, Colorado, April.

RMRS, 1998d. *Final Sampling and Analysis Plan for the Site Characterization of the 903 Drum Storage Area (IHSS 112), 903 Lip Area (IHSS 155), and Americium Zone.* Revision 0, RF/RMRS-97-084, K-H Team, Golden, Colorado, August.

RMRS, 1998e. *Interim Measure/Interim Remedial Action Plan for the 886 Cluster*. Revision 0, RF/RMRS-97-135, K-H Team, Golden, Colorado, July.

RMRS, 1998f. *Project Execution Plan for the 779 Cluster Decommissioning Project*. Revision 1 RF/RMRS-98-206.UN, K-H Team, Golden, Colorado, November.

Sproles, W., B886 D&D Project Manager, July 8, 1999, verbal communication.

U.S. Department of Energy, 1992. *Historical Release Report for the Rocky Flats Plant*, Rocky Flats Environmental Technology Site, Golden, CO, June.

Wood, M., 903 Project, July 16, 1999, verbal communication.

Zbryk, K., Sr. Env. Scientist, July 12, 1999, Email communication.

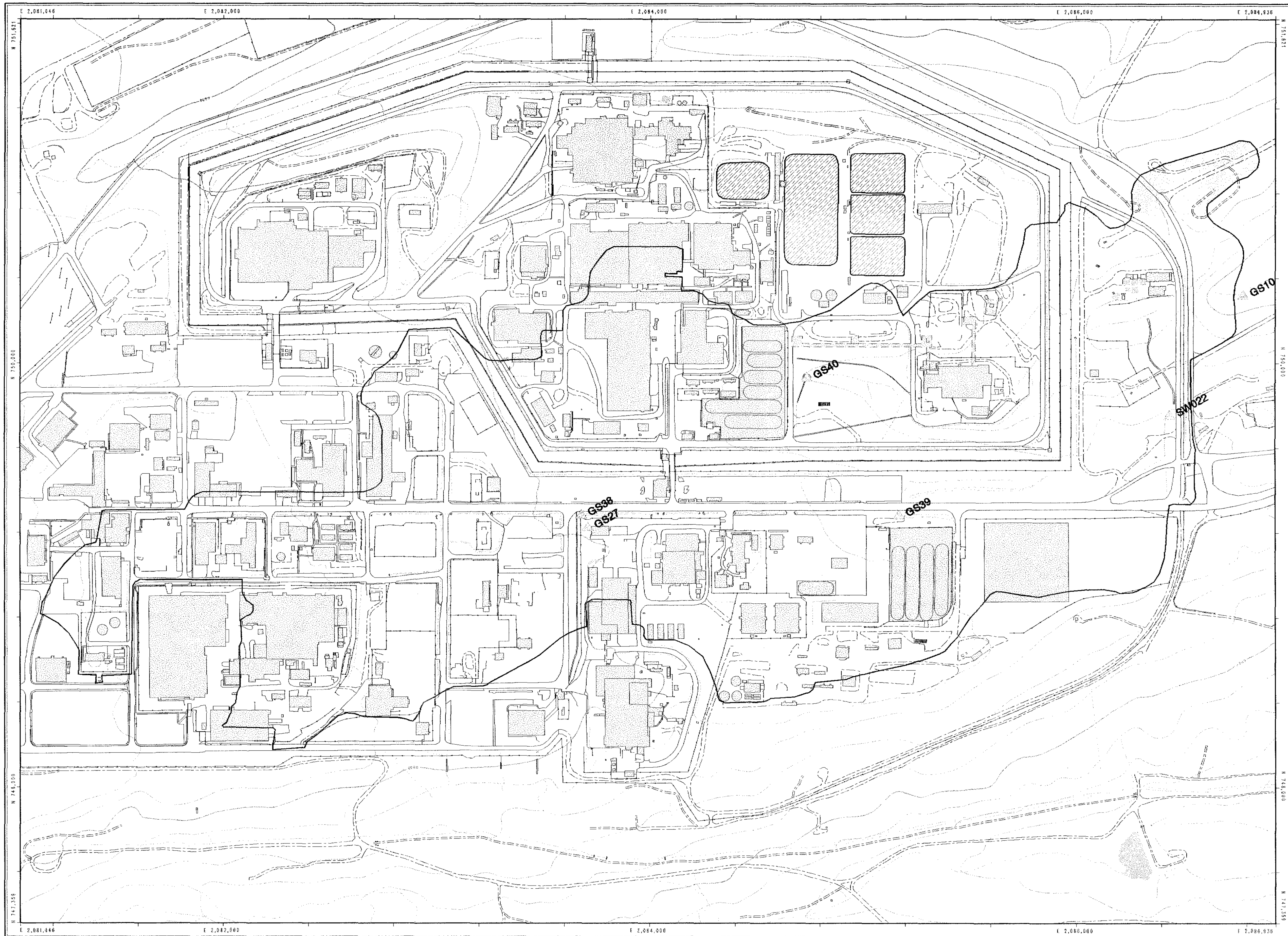

Figure 3-2

Selected Surface Water Monitoring Locations Tributary to GS10

EXPLANATION

Drainage

- GS10 Drainage

Gaging & Sampling Stations

- Surface Water Monitoring Stations

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

Scale = 1 : 5500
1 inch represents approximately 458 feet

150 0 300 600ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
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P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0339 July 22, 1999

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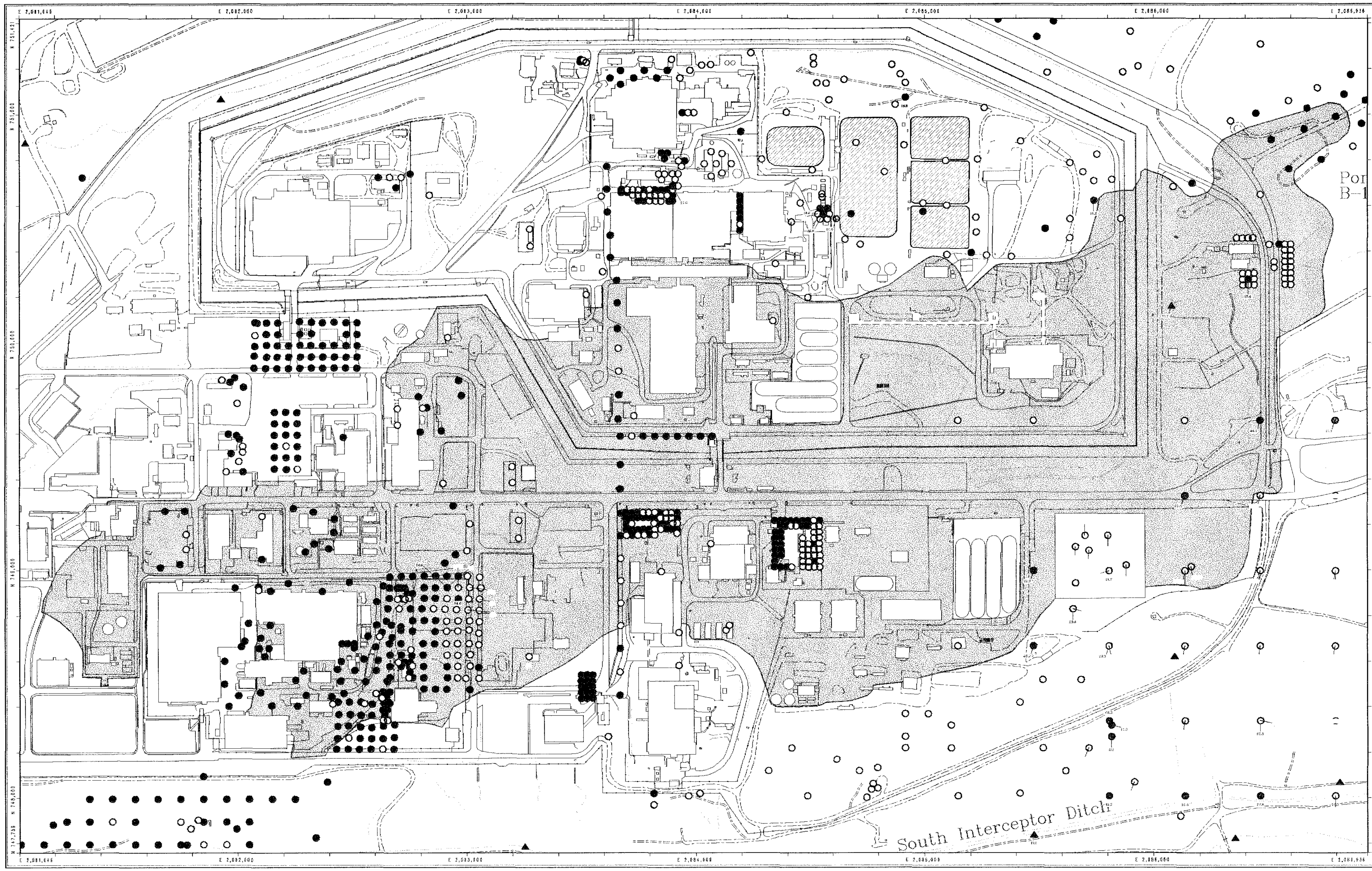

Figure 4-11

Areal Distribution of Pu-239, 240 Activity in Surface Soils

Pu-239,240 Activity in pCi/g

- <= 0.1
- 0.1 - 10
- 10 - 100
- 100 - 1000
- > 1000

(Results are posted for those locations where the results is greater than 7.0)

- GS-10 Drainage Area
- Surface soil location that has been removed (remediated)
- Surface Soil Sampling Location
- Sediment Sampling Location

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

Scale = 1 : 5790
1 inch represents approximately 483 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

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MAP ID: 99-0363 July 21, 1999

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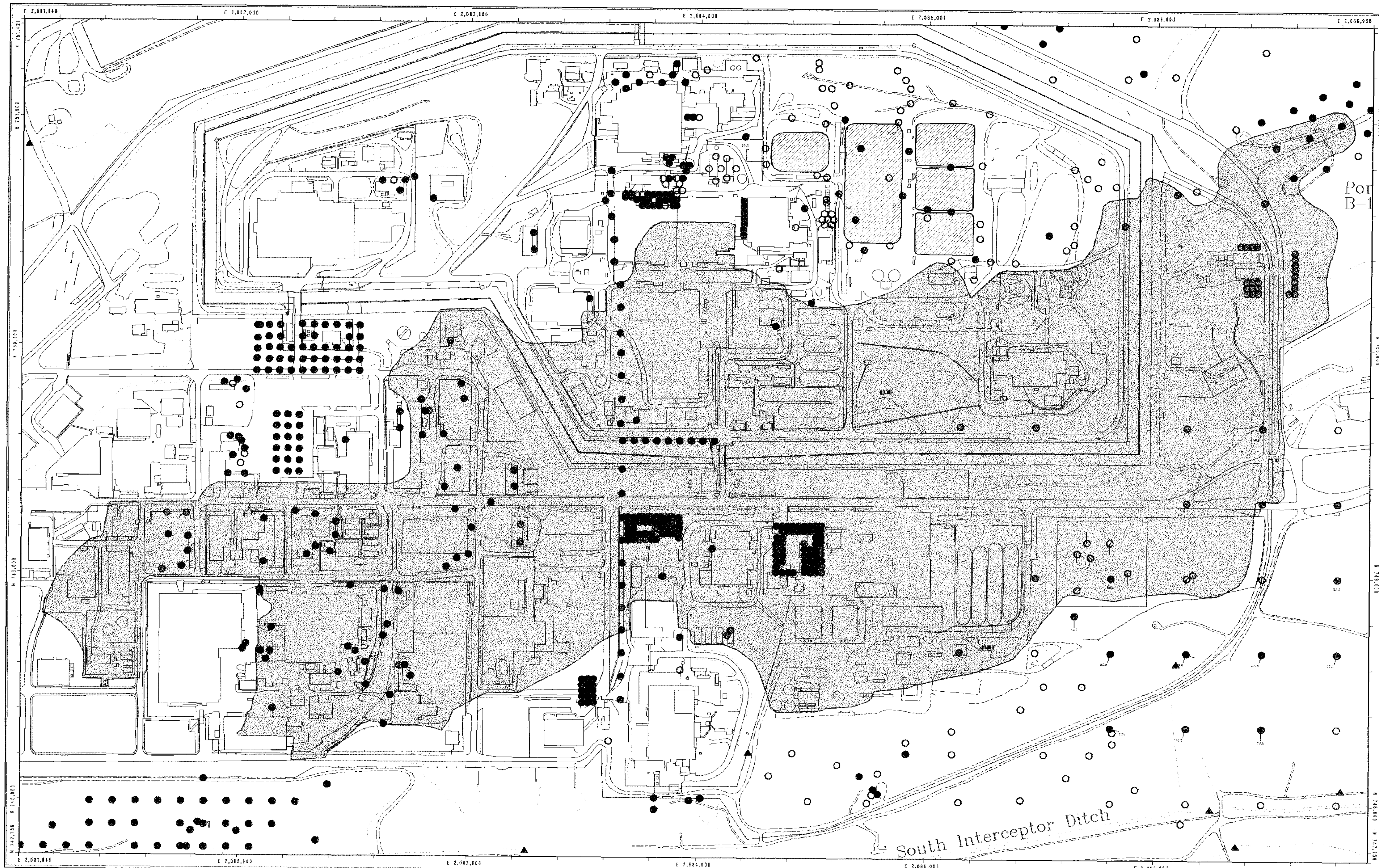

Figure 4-12
Areal Distribution of Am-241 Activity in Surface Soils

Am 241 Activity in pCi/g

- <= 0.1
- 0.1 - 10
- 10 - 100
- 100 - 1000
- > 1000

(Results are posted for those locations where the results is greater than 7.0)

- Surface soil location that has been removed (remediated)
- Surface Soil Sampling Location
- Sediment Sampling Location
- GS-10 Drainage Area

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

Scale = 1 : 5790
1 inch represents approximately 483 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

Rocky Mountain Remediation Services, L.L.C.

MAP ID: 99-0363

July 29, 1999

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