CHAPTER V

VEGETATION MONITORING

INTRODUCTION

Vegetation is the only medium for which a significant number of plutonium-specific measurements were made before 1970. For this reason alone, examination of the early vegetation data is important to the historical public exposures studies. In addition, vegetation is one of three general categories of environmental media (air, vegetation, and surface water) that were monitored routinely around the Rocky Flats Plant throughout the 1950s and 1960s. Although gross alpha activity was the focus of the measurement program at the time, the long-term data sets provide opportunities for spatial and temporal trend analysis and for understanding the relative magnitude of particular release events. Plutonium-specific measurements in vegetation, collected after the 1957 fire, from 1969–1972 and after 1979 have helped to verify release events at the site.

Vegetation is the only medium for which a significant number of plutonium-specific measurements were made before 1970.

In Phase I of this project, ChemRisk used environmental measurements of radioactivity in vegetation to develop an upper limit for the release of coarse particles as a result of the 1957 fire. They also compared measured plutonium concentrations on vegetation with calculated deposition patterns for various release scenarios for the 1957 fire to select the most appropriate scenario (ChemRisk 1994a). For Phase II, we have looked at alpha activity in vegetation, collected both onsite and offsite, to establish trends with distance from the site and over time. These trend analyses can help to confirm patterns and relative magnitude of releases from the site. The following sections provide a history of vegetation monitoring for different time periods during the operations at the Rocky Flats Plant (RFP).

SAMPLE COLLECTION AND ANALYTICAL METHODS

The vegetation monitoring program was quite extensive with both onsite and offsite samples collected using a well-laid out grid system. Figure V-1 indicates that most vegetation samples were gathered in 1952 for the preoperational survey (750 samples), in 1957 following the fire in Building 771 (over 200 samples), and in 1969 following the fire in Buildings 776-777 (over 1200 samples). Tables D-3 and D-4 in Appendix D summarize some of the details of the vegetation monitoring program from plant startup through 1990. Both routine and special sampling were carried out on a monthly basis from about March through October during 1952, 1953, and 1954. There were no samples collected in 1955 and 1956. Following the 1957 fire, routine vegetation monitoring was reinstituted.

While many samples were collected, the quality and traceability of the collection and analytical procedures are crucial to the eventual usefulness of the data. Evaluating data quality means examining the collection, handling, and analysis of samples and checking the calculations of the final reported results against the original raw measurement data. As part of our analysis, we reviewed how samples were collected, handled and how the laboratory analyses procedures were controlled and checked before standardized quality control procedures were established in the early 1970s. (See the section in Chapter III, “Bias and Uncertainty in Air Monitoring Data” and the glossary for definitions.) Site survey laboratory logbooks listed the results of the collection and laboratory analysis procedures and results of environmental samples for 1952–1953, 1959–1960, 1962, 1969, 1970, 1971, 1972, 1974, 1975, and 1979 (Dow 1953–1972, Dow 1971–1990). These logbooks provided information on the laboratory procedures, calculations, routine sampling sites and data quality checks that were done throughout these time periods. The 1952–1953 logbook noted that vegetation sample collection began on February 27, 1952.

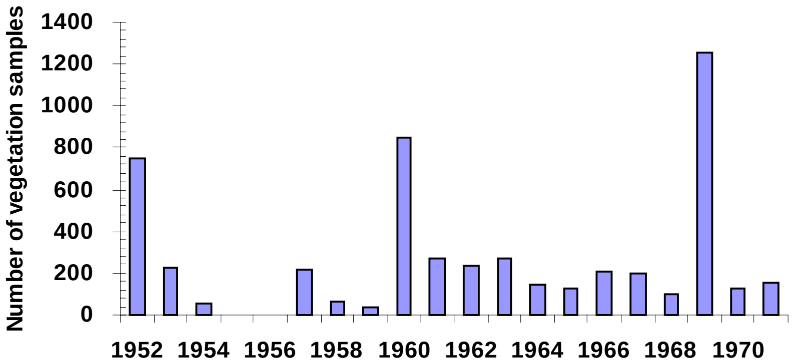

Figure V-1. The number of vegetation samples collected both on and around the RFP from 1952–1972. The largest number of vegetation samples were collected before site operations began (1952) and following two major fires onsite (1957 and 1969). There were no samples gathered in 1955 and 1956.

Although the quality control program was limited during the early years, some instrument and data quality parameters were generally reported (Quimby 1952). For example, it was reported that there were at least 81 vegetation samples and splits for duplicate analyses in 1952 and 1953. Thackeray compared these duplicate analyses and found no indication of laboratory bias and that the "laboratory analyses are well randomized within rather wide limits of error"(Thackeray 1953). Table V-1 gives the yield averages and counter sensitivity for samples collected during this time. The analytical procedure was a standard ether extraction procedure that was widely used at the time and was designed to separate the high energy daughter products naturally present in the environment (Table V-2).

Table V-1. Instrument and Data Quality Parameters for Alpha Analysis in Vegetation (1951–1953)

Parameter	Value
Number of control samples	20
Instrument sensitivity	1 cpm
Yield (std. dev.)	63.2% (2.3%)
Analytical sensitivity	5×10^{-8} μc g^{-1} (50 pCi kg^{-1})
Counter geometry	51%

Potential limitations of the early vegetation data were reported, however. Some of the concerns were 1) the possibility that a contaminated reagent was used for analysis of at least some of the samples before September 1952 and 2) a limited quality control program that included insufficient documentation on the types of vegetation collected and a large number of less-than-detectable values (Thackeray 1953).

Table V-2. Analytical Procedure for Vegetation in 1951–1953[a]

Moisture content

- Eight 50-g samples dried 16 hours at 100°C.
- Weight difference before and after drying less than 10% in all samples.
- Therefore, samples weighed without drying for further analyses

Plutonium-uranium

- 25 g heated in muffle furnace at 600°C to white ash
- Digested with HNO_3 for 8 hours
- Evaporated, residue dissolved in saturated $AlNO_3$
- Two ethyl ether extractions done[b]
- Ether fractions evaporated under infrared lamp

- Aliquot from water layer analyzed for uranium
- Remainder washed with HNO_3 dried onto plate
- Uranium determined chemically
- Plutonium + uranium determined with parallel plate alpha counter

[a] Correlation coefficient computed between the plutonium-uranium determined by total alpha measurement and the uranium shown by chemical method. Coefficient tested for significance with t-test.

[b] Ether extraction was not specific for plutonium and uranium, but was used to separate out high-energy daughter products naturally present in environment (Hammond 1957).

The analytical procedures were basically the same after the startup of routine vegetation monitoring following the September 1957 fire but a tributyl phosphate extraction procedure was used (Geiger 1959). Furthermore, the alpha activity was expressed per unit dry weight of vegetation rather than per wet weight (Dow 1953–1972). Rocky Flats defined gross alpha as alpha emissions from plutonium and uranium only (Ellerbrock 1980).

In the 1950s, most of the vegetation samples were not washed before analysis. In 1961, Hammond (1961) described his experiments to determine the effect of washing vegetation before analysis. Samples were collected biweekly over a 4-month period, for a total of 128 individual samples. Each sample was large enough to provide two unwashed and two washed samples. The results shown in Figure V-2, show that, except for a few samples, washing the vegetation samples before analysis did not have a great effect on the alpha activity levels.

As a result, vegetation measurements are a measure of deposition from airborne plutonium and from plutonium in soil resuspended from the ground. For plutonium analysis, this may not be a problem because there is very limited root uptake of plutonium by vegetation (Little 1980). Others have shown that the deposition of plutonium on vegetation is the major contributor to total plutonium associated with vegetation (Arthur and Alldredge 1982). They estimated that soil attachment to above ground plant parts ranged from 0 to 0.25 g soil per 1 gram of plant.

The samples collected in 1968 and 1969 were the first to be routinely analyzed specifically for plutonium. The plutonium was separated as a nitrate complex from the ashed samples by anion exchange; then counted in low background proportional counters.

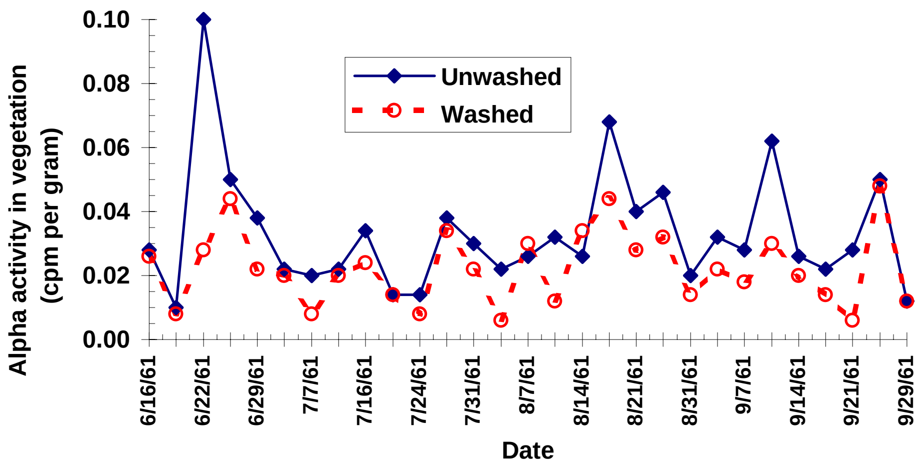

Figure V-2. Effect of washing the vegetation before analysis for alpha activity. These samples were taken near Marshall Lake in 1961 at sampling location V-18.

HISTORICAL PERSPECTIVE ON VEGETATION MONITORING

Preoperational Vegetation Monitoring

A vegetation monnitoring survey was done from July to October 1951, as part of a preoperational background study. Personnel from General Electric at Hanford, Washington collected vegetation samples (of farm crops and types of vegetation prevailing during that period) from 25 locations within a 6-mi (9.7-km) radius of the RFP site (Quimby 1952). The preoperational sampling locations for vegetation were similar to the water sampling locations. (See Figure VI-7, Chapter VI, and Tables D-1 and D-2. Average gross alpha activity (or, plutonium-uranium) in vegetation was 86 pCi kg^{-1} with a standard deviation of 73 pCi kg^{-1}. This average concentration is within a factor of 2 of the minimum detectable concentration (Table V-1). A maximum concentration of 310 pCi kg^{-1} was “definitely related to the uranium content” (Quimby 1952). Data quality was examined with 20 control samples (Table V-1).

Rocky Flats Plant Contractor Vegetation Sampling Program

Initial Vegetation Monitoring–1952 to 1954. From April 1952 through late 1954, Dow Chemical Company sampled vegetation bimonthly at 30 onsite locations along a 500-ft (150-m) grid (referred to as the Austin Co. Grid), at 163 offsite locations along a 2000-ft (610 m) grid, and at 97 remote offsite locations bounded approximately by Denver, Golden, Boulder, and Brighton (Thackeray 1953, Hammond 1969). Maps, reproduced from hand-drawn copies obtained through the Environmental Master File at the RFP, of the Austin Co. and 2000-ft grids are shown in Figures D-1 and D-2 in Appendix D.

Because of difficulties with the program, vegetation samples were not collected during 1955 or 1956.

On September 3, 1952, J. F. Church, representing K. E. Church, withdrew permission to collect samples on their property, resulting in the loss of nine vegetation sampling locations (Hammond 1952). This circumstance and other difficulties with collecting samples may have contributed to the gradual slow-down and termination of the vegetation sampling program after 1954.

Monitoring Associated with the 1957 Fire. Routine vegetation sampling was discontinued after 1954, but it was resumed after the September 1957 fire. In response to the fire, samples were collected at all the locations established in the preoperational 1952–1953 vegetation monitoring program. The samples collected in conjunction with the fire included 222 vegetation samples in 1957 and 132 vegetation samples in 1958. Over 80 of the samples taken in 1957 were analyzed specifically for plutonium, and the data were the earliest plutonium measurements for vegetation.

The Site Survey–Monthly Progress Reports included copies of the actual pulse-height analysis specrtums generated in the analysis of the vegetation samples from 1957, and also specified the types of plants that were collected or the portions of the plants that were analyzed. It appears that the collection and analytical techniques were the same as those used in the earlier years (Hammond 1957, 1958).

Routine Monitoring—1963 to 1970. Routine vegetation sampling data for the years 1963 to 1970 were reported in the Environmental Survey Reports generated by Dow Chemical Company. The routine monitoring consisted of gross alpha analyses of samples collected at 55 to 65 locations on the 2000-ft (610-m) grid and 44 locations off the grid (Hammond 1969). With the exception of handwritten data tabulations for six onsite locations, none of the reports contained onsite vegetation data for this period.

The Environmental Survey Reports presented the average and maximum values for all samples collected within a given distance range from the plant [e.g., samples collected <3 mi (4.8 km), samples collected from 3 to 18 mi (4.8 to 29 km), and samples >18 mi (29 km)].

Monitoring Associated with the 1969 Fire. Special vegetation sampling was conducted following the May 11, 1969 fire. Along with the routine samples, 22 samples were collected from the 11 offsite locations shown in Figure D-3, Appendix D. Both the routine and nonroutine samples collected in 1969 were analyzed for gross alpha and plutonium.

Data collected after the fire are reported as averages within given distances from the plant. It is unclear whether onsite values are included with these data. The only specific reporting of onsite vegetation data related to the 1969 fire that we located, was a hand-drawn map of the onsite sampling grid on which plutonium concentrations for approximately 30 locations have been noted. We have reproduced this map as Figure V-13.

Routine Monitoring—1971 to 1983. After 1970, the routine vegetation sampling data were reported in the site Annual Environmental Monitoring Reports published by Dow. Samples were collected semiannually in 1971 and 1972 and analyzed specifically for plutonium. In 1971, approximately 17% of the vegetation samples analyzed contained less-than-detectable concentrations (MDC ≈ 10 pCi kg^{-1}). The results are reported as the average plutonium concentrations for all samples collected (a) <1 mile of RFP, (b) between 1 and 5 miles from RFP, and (c) >5 miles from the RFP. The reports provide limited information on the types of plants collected (e.g., "plants consumed by grazing animals"). No information is provided on the specific sampling locations.

Routine vegetation monitoring was not done from 1973 through 1978. Beginning in 1979, a new vegetation sampling program was implemented. This program consisted of sampling from two plots near the site and from a control location in Lafayette, Colorado [10 mi (16 km) northeast of the RFP]. The locations of the sample plots were in the buffer zone—one site about 1 mile (1.6 km) northeast of the security fence (near the confluence of North and South Walnut Creeks) and the second site just less than a mile (1 km) southeast of the security fence (just north of Woman Creek). The sampled vegetation analyzed for $^{239,240}Pu$, ^{238}Pu, and ^{241}Am. The 1981, 1982, and 1983 Annual Environmental Reports suggest that vegetation from Plot A (located east southeast of the RFP) may contain more $^{239,240}Pu$ than the Lafayette control. However, perennial grasses only were sampled from the control area while the samples taken at Plot A and Plot B were a mixture of perennial grasses, annual grasses and forbs. For 1980, there were no differences seen in the $^{239,240}Pu$ concentrations in perennial grasses among the three areas (about 20 pC kg^{-1}). The concentration of $^{239,240}Pu$ was higher in the forbs vegetation than in the grasses at the two onsite location, but no forbs were sampled at the control locations for a direct comparison. After 1980, there is no information on the types of vegetation collected. No vegetation samples were collected after 1983.

EVALUATION OF RADIOACTIVITY IN VEGETATION DATA

With the exception of special monitoring conducted in association with the 1957 and 1969 fires, specific plutonium data are not available for vegetation samples before 1970. However, the gross alpha data for samples collected between 1952 and 1970 were useful for assessing spatial and temporal trends, and for helping to verify routine release estimates.

The specific plutonium data generated following the 1957 and 1969 fires can be useful in supporting or verifying the reconstructed source terms for these events. Plutonium contamination of vegetation as a result of the 1957 fire is reported by Hammond (1958).

Our analysis of the vegetation data will be divided into two areas: (1) the temporal trend, that is, the change in activity seen at a particular location over time and (2) the spatial trends, that is, changes in activity measured at various distances from the site at a particular point in time.

Trends in Alpha Activity Over Time

The gross alpha data in vegetation support a distinct pattern with time. Figure V-3 shows the change over time of alpha activity in vegetation samples taken at an onsite location directly east of the 903 Area. The vegetation data clearly reflect the deposition patterns that resulted from key release events onsite, specifically the suspension of plutonium that occurred near the 903 Area. The highest alpha activity levels measured in vegetation from the RFP area were those measured in the late 1960s at this location (up to 30,000 pCi per kg). The detailed vegetation data collected east of the 903 Area are complied in Table D-5 in Appendix D.

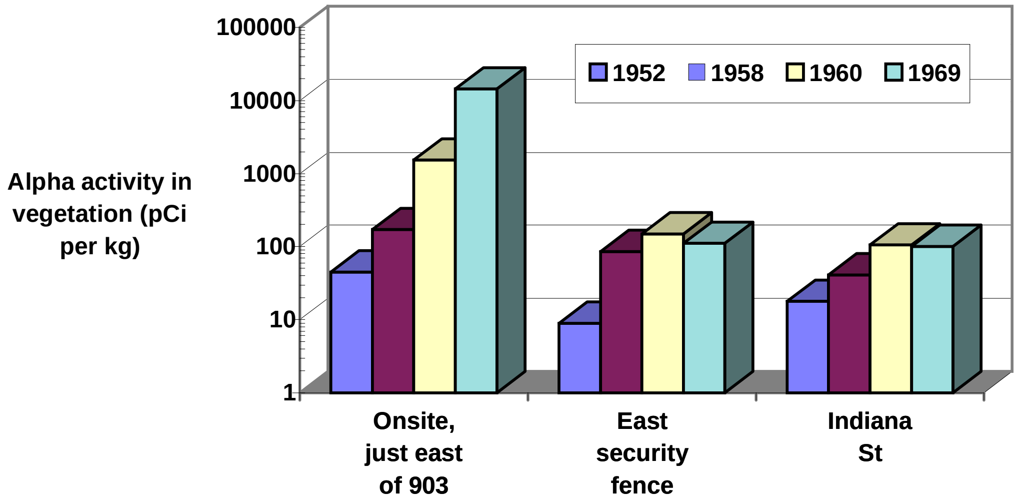

Figure V-3. The change over time of alpha activity in vegetation samples taken at locations east of the 903 Area. The levels measured in 1952 and 1953 were quite low compared to levels seen in the 1960s when drum removal and plowing activities were underway at the 903 Area (see Chapter III, this report and Meyer et al. 1996). The highest levels seen were over 30,000 pCi kg^{-1}.

Comparing the levels of alpha activity in vegetation taken from onsite locations west (upwind) and east of the 903 Area (downwind) shows a gradual increase in activity beginning in the early 1960s (Figure V-4). The highest levels just east of the 903 Area were measured in 1962 (8000 pCi kg^{-1}) and 1969 (14,000 pCi kg^{-1}), respectively.

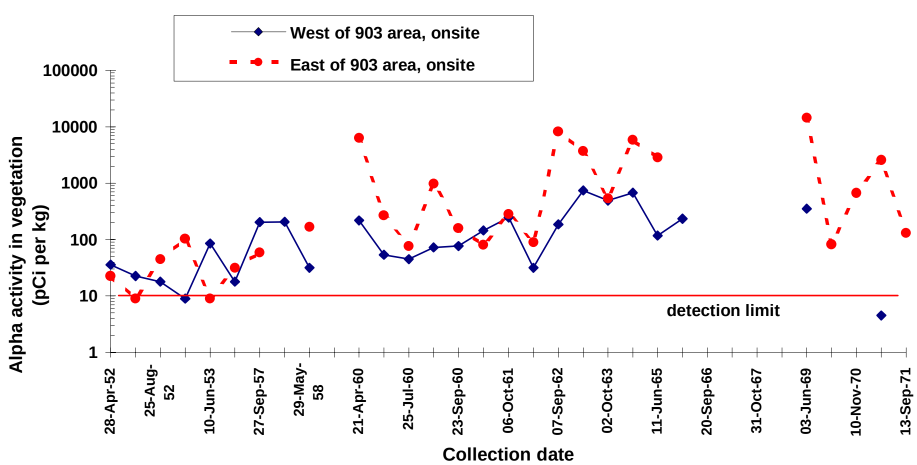

Figure V-4. Comparison of alpha activity in vegetation from west and east of the 903 Area. Gradual increases in alpha levels were seen at both locations but levels to the east of the area were up to 100 times higher than those measured in vegetation from west of the 903 Area.

Looking at results of vegetation monitoring over time can also provide information about the relative magnitude of major release events at the site. Figure V-5 shows a significant increase in alpha activity in vegetation samples taken near Building 771 after the 1957 fire compared to that seen in 1952 and 1953. Levels of alpha activity decreased quite rapidly and then increased again in the early 1960s, perhaps as a result of the increased use of the incinerator in Building 771 at that time. Also, fallout from global weapons testing peaked in 1963 (see Appendix H). It should be noted that the increased levels measured after the 1957 fire (~700 pCi kg^{-1}) are 50 times lower than levels measured in the mid to late 1960s east of the 903 Area.

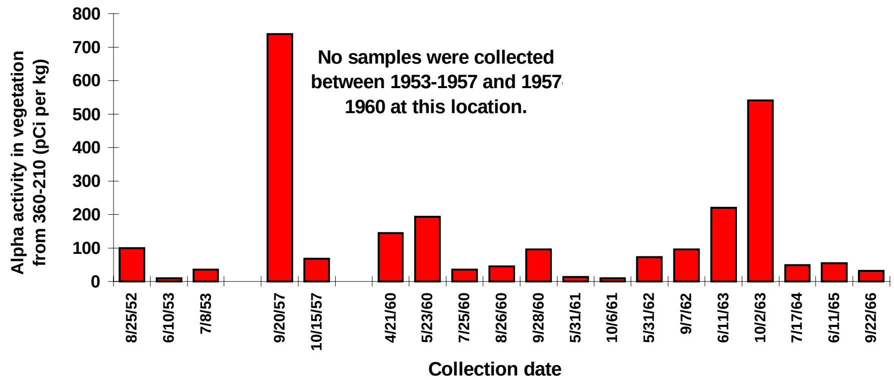

Figure V-5. Levels of alpha activity in vegetation taken at onsite grid location, 360-210 (south of Building 771, where the 1957 fire occurred) from 1952 through 1967. This location had the highest plutonium concentration measured in vegetation following the 1957 fire (See Figure V-12).

Spatial Trends in Radioactivity in Vegetation

As a first step toward assessing the potential usefulness of the gross alpha vegetation data to delineate changes in concentrations with location, onsite and offsite concentrations were compared at two stations downwind of the site (Figure V-6). This comparison was made for the years 1957 to 1965 (excluding 1959, because there were no data) using averages of data from a handwritten tabulation obtained from the Environmental Master File. Data for each of these years were available for only four of the six onsite monitoring locations included in the tabulation. Therefore, these four locations were used in our comparison. The monitoring points (designated as VAG355-185, VAG-355-195, VAG355-205, and VAG355-225) are located along the southern boundary of the RFP production area (see Figure D-1, Appendix D). The two offsite sampling points used in our comparison are located 6 and 12 mi (9.7 and 19 km) southeast (downwind) from the RFP.

As shown in Figure V-6, the onsite alpha levels were about three times higher than those measured offsite for the 1957–1965 period. One of the onsite sampling locations, VAG-355-225, is located very near the 903 Pad. However, when these data points are excluded, the onsite average is only reduced from approximately 300 to 260 pCi kg^{-1}. In addition, the major drum removal and plowing activities at the 903 Area were in the late 1960s, after this time interval.

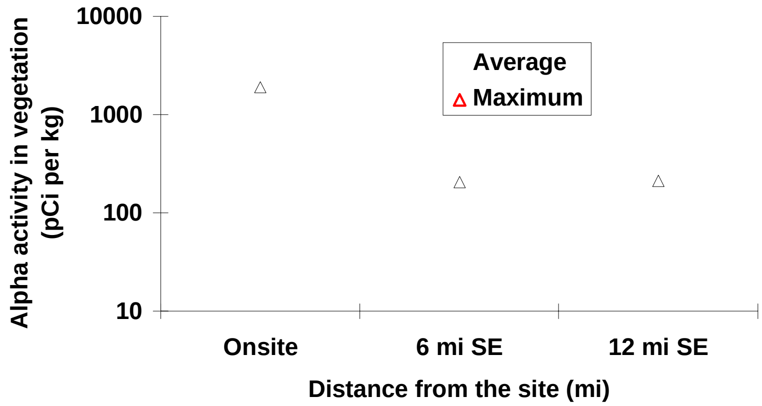

Figure V-6. Comparison of average gross alpha activity measured in vegetation from onsite and two offsite (southeast) locations from 1957 to 1965. The sample sizes averaged 57 for the onsite and 14 for offsite. The onsite average was calculated using four sampling points located along the south boundary of the Rocky Flats Plant production area.

The same pattern of decreasing alpha activity in vegetation with increasing distance is also evident east of the 903 Area (Figure V-7), although the alpha concentrations immediately east of the 903 Area were much higher than the onsite values measured at the south security fence. Figure V-7 shows that the average alpha activity in vegetation east of the 903 Area decreased markedly from 4500 pCi kg^{-1} onsite to approximately 100 pCi kg^{-1} at 2 to 3 mi (1–2 km). This latter concentration is also similar to that measured in vegetation at greater distances from the site (Figure V-6).

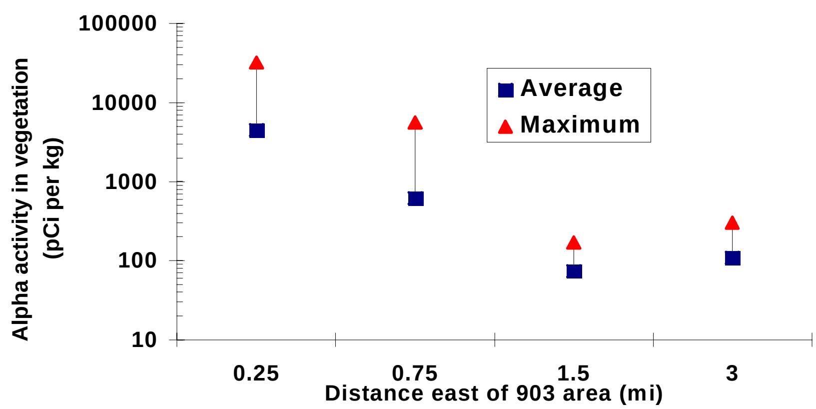

Figure V-7. Comparison of average alpha concentrations measured immediately east of the 903 Area, and at increasing distances from 1952 through 1969.

Grid maps with alpha activity values marked at certain grid points are useful for visualizing both the temporal and spatial distribution of activity during the 1950s and 1960s. For many onsite locations, there is a gradual increase in levels of alpha activity in vegetation through time. Although two of the time periods shown in Figures V-8 and V-9 follow major fires onsite, this trend is seen when other periods, the early 1960s for example, are examined as well. This increased activity is probably related to the general increase of production activity in the 1960s, and to the minimal emission controls on the incinerator in Building 771 which was operating at nearly full capacity during the early to mid-1960s.

Some general findings can be drawn from examining the alpha activity in vegetation from the early years. The levels of alpha activity remained at nearly background levels at locations sampled to the west of the RFP. Furthermore, levels of activity at onsite sampling locations were higher than those observed at vegetation sampling locations offsite. Finally, alpha activity in vegetation decreased fairly rapidly with distance from the security fence to the east.

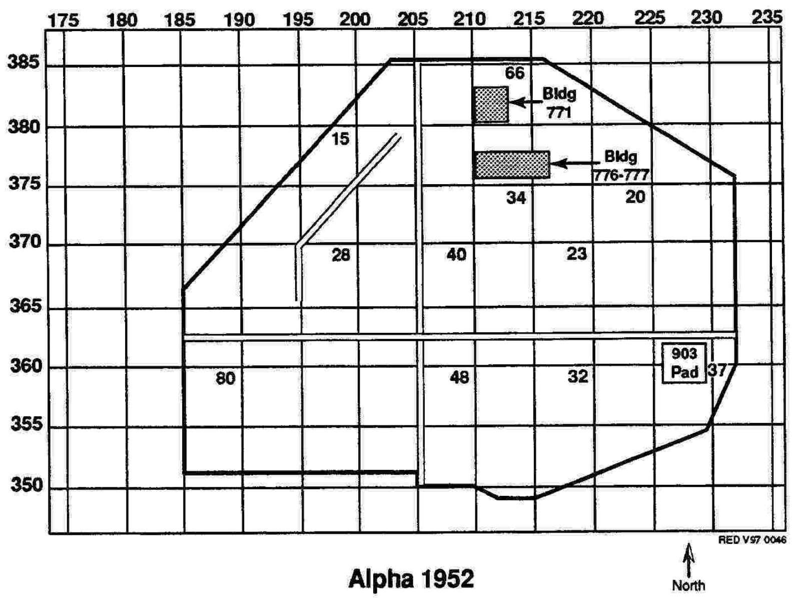

Figure V-8a

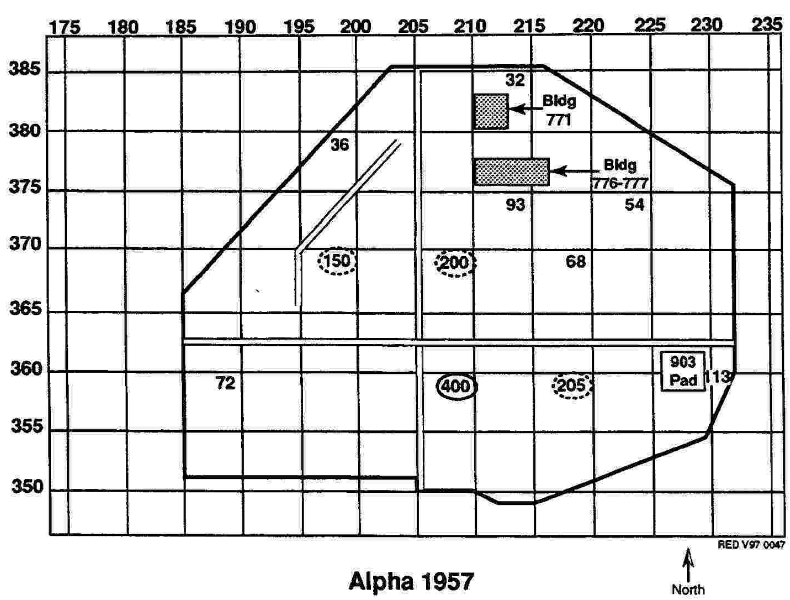

Figure V-8b

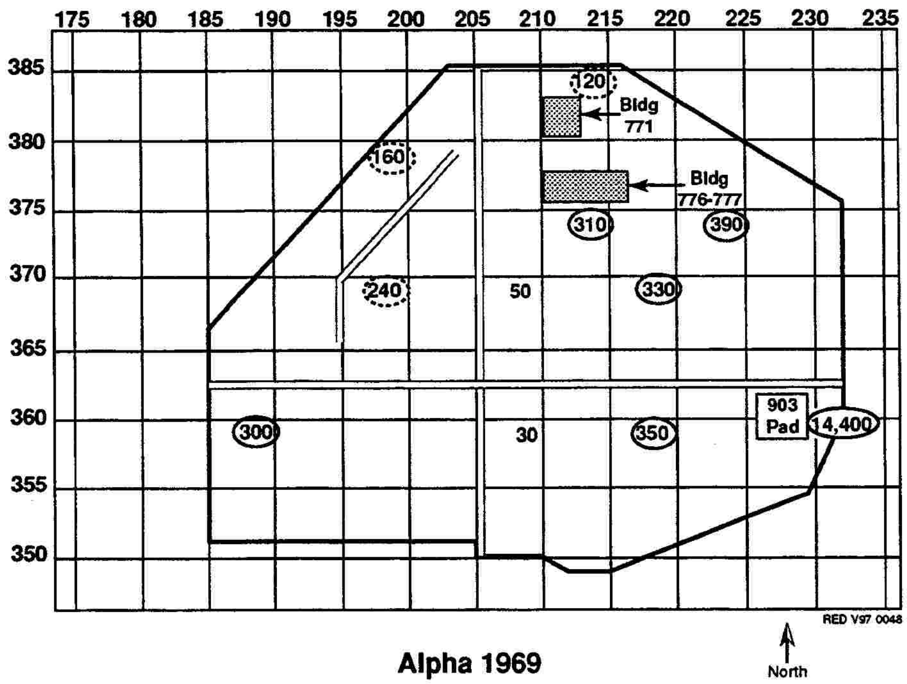

Figure V-8c

Figure V-8. Alpha activity in vegetation samples taken at onsite locations in 1952 (Figure V-8a), in 1957 following the fire in Building 771 (Figure V-8b) and in 1969 following the fire in Building 776-777 (Figure V-8c). The uncircled values reflect the general background alpha activity in vegetation samples in the area. Concentrations of alpha activity in offsite vegetation samples between 1957 and 1965 averaged around 100 pCi per kg^{-1} (See Figures V-5 and V-6). The values circled with a dashed line reflect alpha concentrations in the range of 150–250 pCi kg^{-1}, while the values ringed with closed circles represent the highest values, above 250 pCi kg^{-1} of vegetation. Alpha activity in environmental media is a crude measure of Rocky Flats releases. Plutonium-specific measurements in vegetation following the 1957 are shown in Figure V-11.

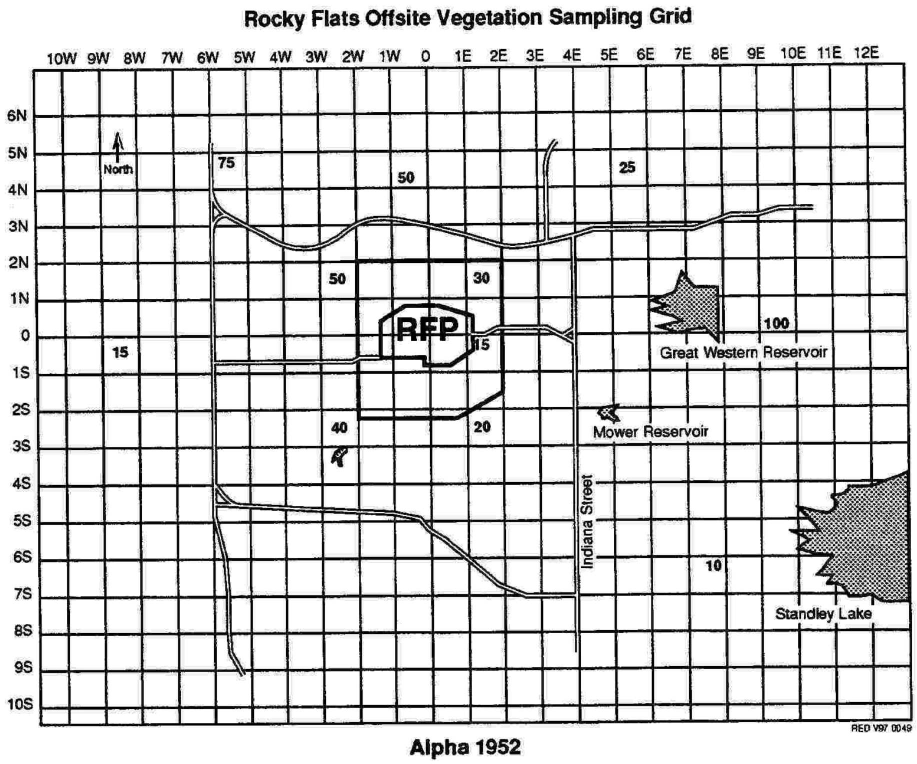

Figure V-9a

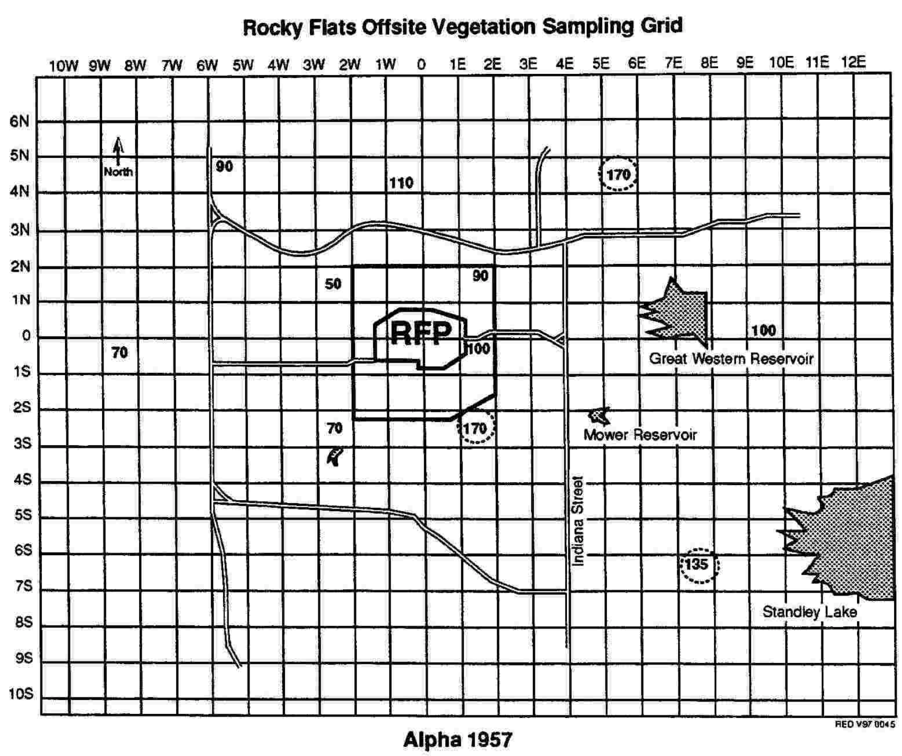

Figure V-9b

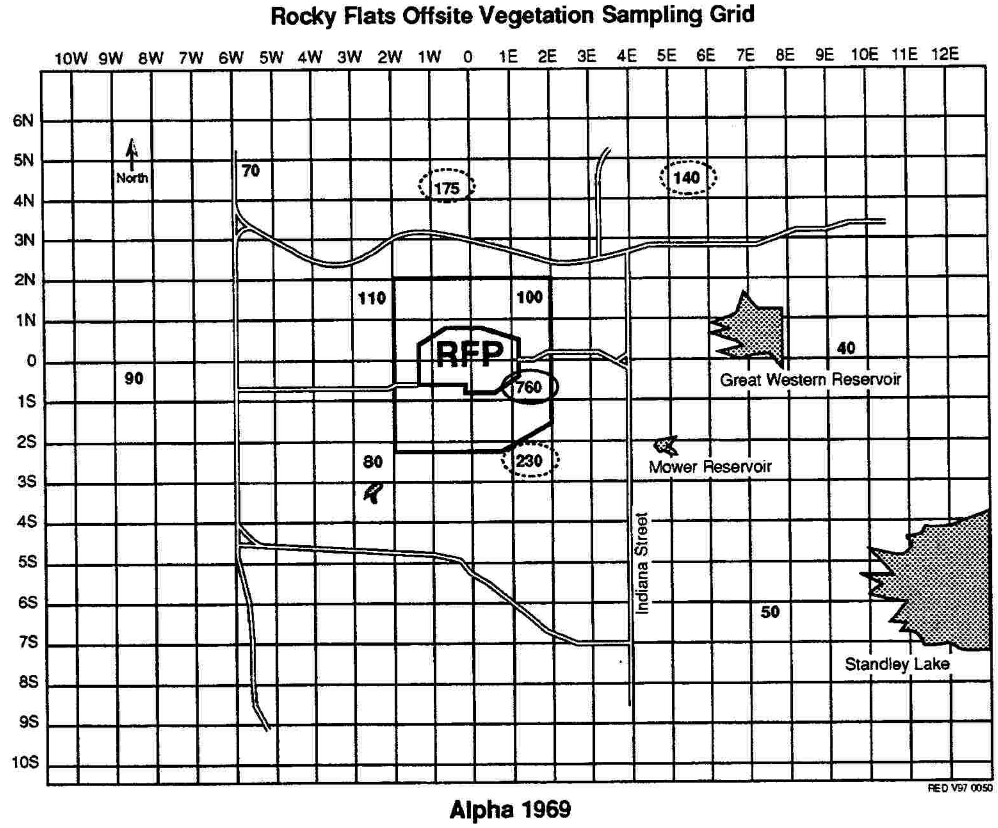

Figure V-9c

Figure V-9. Alpha activity in vegetation samples taken at offsite locations in 1952 (Figure V-9a), in 1957 following the fire in Building 771 (Figure V-9b), and in 1969 following the fire in Building 776-777 (Figure V-9c). The uncircled values reflect the general background alpha activity in vegetation samples in the area. The values circled with a dashed line reflect alpha concentrations in the range of 150 to 250 pCi kg^{-1}. The values ringed with closed circles represent the highest values, above 250 pCi kg^{-1} of vegetation alpha activity, which were found only within the old site boundary, indicated by the heavy outer line around the RFP.

Except for very near the 903 Area, concentrations of alpha activity in vegetation onsite averaged about 3 times higher than offsite (Figures V-5 through V-9). The plutonium-specific measurements made after the September 1957 fire support the same finding (Figure V-10). There is a gradual but significant decrease in concentration with distance from the center of the site. Plutonium concentrations decreased from an average of ~70 pCi kg^{-1} onsite to ~20 pCi kg^{-1} at a distance of 3 mi (4.8 km) from the site, a reduction of about 3 1/2 times. Alpha and plutonium concentrations very near the 903 Area were at least 50 times higher than the onsite average in the late 1960s. A similar steep gradient in concentration with distance is evident from air monitoring data (Chapter III).

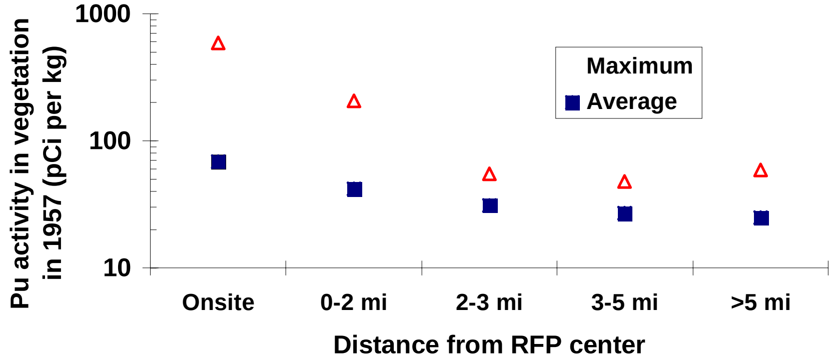

Figure V-10. Comparison of plutonium concentrations in vegetation measured onsite and at increasing distances from the site following the 1957 fire. The data have been grouped by distance from the center of the Rocky Flats Plant.

The onsite plutonium in vegetation data also support other findings that some onsite areas had higher levels of contamination than others. Figure V-11 clearly shows higher plutonium levels in vegetation from locations closest to Building 771 where the 1957 fire occurred. The levels decrease toward the site boundaries to levels comparable to offsite levels (~20 pCi per kg^{-1}).

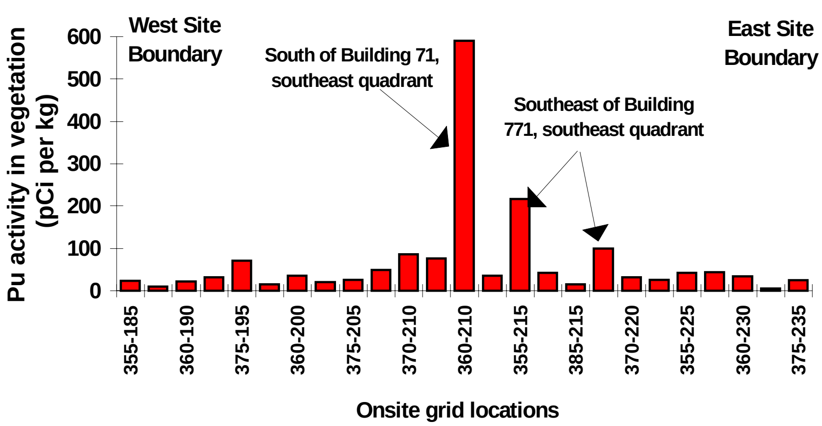

Figure V-11. Plutonium activity in vegetation from onsite locations following the 1957 fire. These locations have been grouped by location from the center of the site outward to the west and east site boundaries. Sample site VAG360-210 is directly south of Building 771 where the fire occurred (see Figure D-1, Appendix D).

It is possible to view the plutonium in vegetation data another way to show a definite spatial distribution by site quadrant. Figure V-12 shows somewhat lower levels measured in the northwest and southwest quadrants with higher levels seen to the east of the site. This pattern adds support to the general deposition patterns seen in soils and reflects the pattern expected from the general meteorology of the area, i.e., winds predominate from the west toward the east and southeast. The plutonium levels measured offsite are at least 10 times lower than the peak values measured onsite. Although these data are useful for discerning spatial trends, the actual number of samples showing increased levels of plutonium was small. The sample number limits the quantitative use of the data.

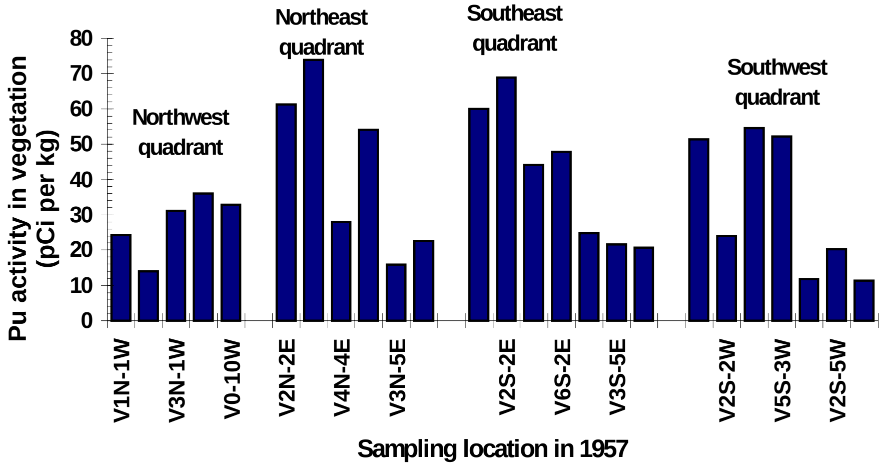

Figure V-12. Levels of plutonium activity in vegetation from offsite locations following the 1957 fire. The data have been grouped by quadrant around the Rocky Flats Plant.

Finally, we can view the spatial distribution of plutonium activity in another way, and visualize the deposition pattern. In Figure V-13, the plutonium concentrations measured in vegetation following the 1957 fire are placed on the onsite grid where the vegetation samples were taken. The highest measured values are circled and illustrate that the higher deposition of materials from the fire occurred to the southeast. The highest levels of plutonium ranged from 200–600 pCi kg^{-1}. If we view the spatial distribution of plutonium levels following the 1969 fire (Figure V-14), we can see that the general deposition pattern is similar to that seen after the 1957 fire, i.e., higher levels were measured southeast of Building 776/777 where the fire took place. The most striking difference, however, is that much higher levels were measured in the vicinity of the 903 Area in 1969 than those measured in 1957. In 1969, the levels ranged up to 32,000 pCi kg^{-1}, with the highest levels seen near the 903 Area.

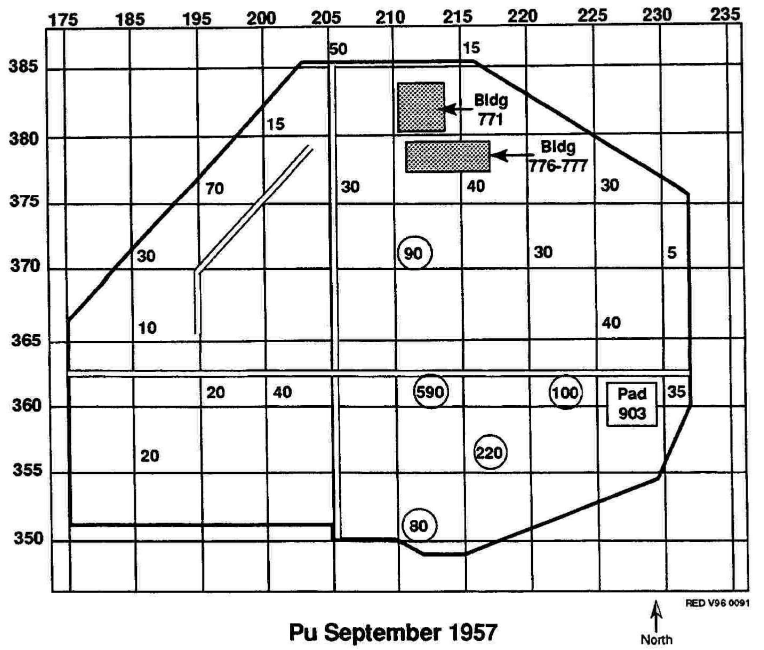

Figure V-13. Map of the onsite vegetation sampling grid (500-ft Austin Co. grid) with plutonium concentrations (pCi per kg) measured in vegetation samples collected after the September 1957 fire in Building 771. The circled values are the highest plutonium concentrations measured following the fire. The heavy line represents the site perimeter fence. Onsite vegetation samples are identified by the grid point coordinates (see [Figure D-1](#)).

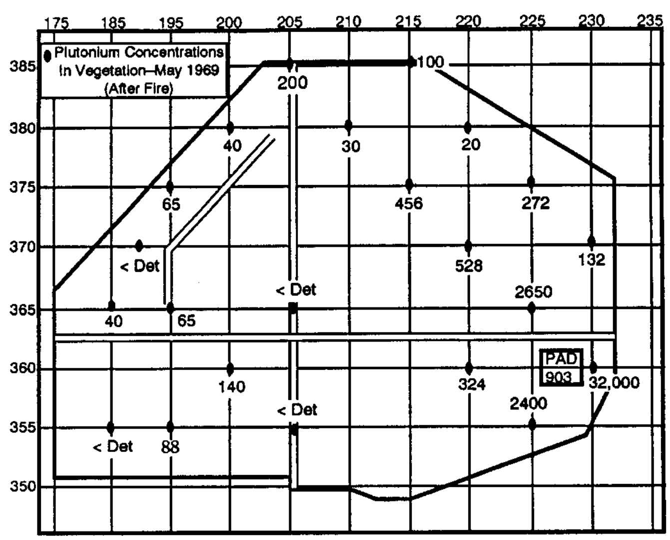

Figure V-14. Map of the onsite vegetation sampling grid (500-ft Austin Co. grid) with plutonium concentrations (pCi per kg) measured in vegetation samples collected after the May 1969 fire in Building 776/777. The plutonium concentrations in vegetation samples were somewhat higher to the southeast of Building 776/777, but the highest levels were associated with the 903 Area.

SUMMARY

Although the historic vegetation sampling data may not meet the quantity and quality standards of today, they have been of considerable value to the historical public exposure studies in several ways. Most importantly, the vegetation monitoring results, considered along with other environmental media, provide an indication of the time history of site releases and information on the spatial distribution of contaminants. The measurements of plutonium in vegetation made after the 1957 fire were evaluated for their applicability to confirming the releases and transport of plutonium following the 1957 fire. The data are difficult to interpret because they are highly variable and depended on localized conditions that were not included in the model (Rood and Grogan 1999). They do provide some general indications of spatial distribution onsite, with highest levels measured just south of Building 771 and decreasing to the west and east of that location. Several key findings from the analysis of the vegetation data are

- Levels of gross alpha in the 1950s and 1960s and plutonium activity following the 1957 fire decreased with increasing distance from the site
- The general trends in the data seem to support the weathering of activity from the plant surface following the 1957 fire
- The general levels of plutonium concentrations in onsite vegetation samples are much higher in 1969 than after in the late 1950s

In summary, although gross alpha activity was measured primarily, the long-term data sets provide opportunities for spatial and temporal trend analysis and for understanding the relative magnitudes of particular release events.

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