ENVIRONMENTAL RESPONSE TO REMEDIAL ACTIONS AT THE WELDON SPRING SITE – AN ENVIRONMENTAL SUCCESS STORY

J. A. Meier, T. D. Welton
Jacobs Engineering Group-Weldon Spring Site
7295 Hwy 94 South, St. Charles, MO 63304

ABSTRACT
Environmental remediation activities have been ongoing at the Weldon Spring Site for over a decade, beginning with small interim response actions and culminating in completion of surface cleanup as represented by closure of the 17 hectare (42-acre) on-site disposal cell. As remedial actions have incrementally been accomplished, the occurrence of site-related contaminants in on and off-site environmental media have effectively been reduced. The DOE-WSSRAP has demonstrated success through the effective reduction or elimination of site related water and airborne contaminants along multiple migration pathways. This paper briefly describes the remedial measures affected at Weldon Spring, and quantifies the environmental responses to those remedial measures.

INTRODUCTION – WELDON SPRING PROJECT OVERVIEW

The Weldon Spring Site Remedial Action Project has been an active DOE remediation site since 1986. The DOE has undertaken to clean up the chemical and radiological contamination at the site's various operable units in a manner that met both the intent and substance of the CERCLA and NEPA requirements. The site has a process history that spans over half a century and completion of this remediation phase marks an ending to the long and challenging task of securing the site's contaminants in a manner that was protective during cleanup and will remain protective of human health to the distant future.

The history of the site is multifaceted. Prior to WWII, the area of St. Charles County, Missouri occupied by the site was rural, small family farm land with small communities dotting the landscape. The Army selected approximately 6880 hectares (17000 acres) to develop what was to become the largest explosives production plant in the United States. Within this 6880 hectares (17000 acres) reservation, approximately 688 hectares (1700 acres) in the center were used for actual production facilities, the remaining being used for product packaging and storage, operations management centers, and security buffer area. The plant operated from 1941 to 1945 on 18 production lines, producing as product both trinitrotoluene and dinitrotoluene explosives. Of the 688 hectares (1700 acres) used for ordnance production, approximately 90 hectares (220 acres) was transferred in 1956 to the Atomic Energy Commission for construction of the Weldon Spring Uranium Feed Materials Plant (WSUFMP). The WSUFMP operated from 1957 to 1966, when operations ceased. The plant sat idle from 1966 to 1986, when the DOE began official clean up operations.

From project inception in 1986 to well into the early '90's, the DOE and it's contractors engaged in characterization of the various contaminant sources and migration pathways. Understanding fate and transport was fundamental to not only the clean-up strategy, but also to understanding the need for and providing interim public health and safety mitigation measures.

The contaminant sources on the WSSRAP site included the following, as depicted on Figure 1: the chemical plant buildings and internal process operations equipment, external process piping, sludge settling (raffinate) pits, waste dumps around the site, contaminated soils and sediments, and remnant features from the former explosives production operations of the 1940's, including wooden piping, foundations and contaminated soil. Each of these contaminant sources presented the potential for migration of contaminants to one or multiple environmental pathways, and each required focused attention to ensure adequate remediation.

The first major contaminant removal effort involved removal of external process piping to eliminate uncontrolled asbestos fiber release and the potential for free liquid release from residual product within the pipes. Following external piping removal, the process buildings, with all their associated excess chemical product inventory, had to be stabilized in preparation for building dismantlement. Over 10,000 separate containers of abandoned process chemicals had to be characterized and consolidated for proper storage and disposal. These consolidated chemicals were stored on-site in a renovated building converted for use as the project's RCRA waste storage facility. Following stabilization of the buildings' internal waste materials, the buildings and other ancillary facilities were painstakingly removed to gain access to subsurface soil contaminants. Contaminated soils were removed and stored in engineered piles for later placement into the permanent disposal facility. Contaminated sediments from down-gradient lakes and streams were removed and retrieved for onsite storage. On-site waste dumps created and used during plant operations were significant sources of surface water contamination at the site's stormwater outfalls until removal of the dump areas in the early '90s.

The remediation of contaminated environmental media and contaminant source areas began slowly in the early years of the project. Momentum increased as cleanup actions taken under Interim Response Actions, as the formal CERCLA RI/FS process progressed and matured to final remedial decisions under the Weldon Spring Chemical Plant Operable Unit. The following sections provide details as to the types and quantities of original contaminants, the consequential levels of environmental contaminants and the impact of clean up and removal actions on those environmental contaminants.

ENVIRONMENTAL RESPONSE TO CLEANUP ACTIVITIES

Soil Contaminants:

Soils at the chemical plant site became contaminated over the course of the various operations from the 1940s to the 1960s. Soils beneath waste pits, process buildings, dumps, contaminated water discharge routes, and many miscellaneous mechanisms became contaminated above levels of acceptable risk. Cleanup standards were established in the Record of Decision for the Chemical Plant and the DOE developed a remedial design and clean up confirmation plan according to the characterization data relative to those ROD requirements. Soil remediation was accomplished over the period from 1995 to 2000. The soil contaminants uranium-238 and thorium 230 were selected as representative contaminants for this analysis. Table I exhibits the pre-remediation and post-remediation soil contaminant concentrations.

Table I. Soil Contaminant Concentrations Before and After Remedial Actions

Soil	Uranium (pCi/g)			Thorium (pCi/g)		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum
Pre-remediation	43	590	0.2	44 pCi/g	1230	0.1
Post-remediation	2.9	11	0.1	1.56 pCi/g	23	0.1

Ref. WSSRAP Project Analytical Database.

Surface Water

It was determined, from the pathway analysis conducted at the beginning of the project, that off-site residents and recreational users could come into contact or ingest surface water or sediment originating from the site. Surface water was influenced by two general mechanisms: storm water flowing from the site may contact site-source contaminants and be carried off-site, and contaminants remaining in sediment on site and in down steam channels may become resuspended. It was determined that radium, thorium, nitrate, As, Cr, Pb, Tl, Li, and 2,4-DNT were soil contaminants and possible contaminants of surface water. Uranium was the most evident contaminant in storm water. Off-site surface water in the vicinity of the quarry affected by quarry wastes was exclusively the Femme Osage Slough, which receives ground water that was contaminated by materials in the quarry. Since the quarry was excavated as a basin with internal drainage, all surface water within the quarry proper was captured in the quarry pond and no surface runoff had occurred.

Surface water from the north and west of the chemical plant site flows through several lakes in the August A. Busch Wildlife Area on it's way to the Mississippi River. Surface water from the south of the site flows to the Missouri River by way of the "Southeast Drainage". Following cessation of operations at the WSUFMP in the '60s, water in the raffinate pits was contained and did not surface discharge, therefore did not directly contribute to surface water contamination in local streams. Some leakage from the pits did contribute to groundwater contamination that surfaced at nearby springs. Water in the contaminated Frog Pond and Ash Pond basins did flow to the surface. Surface water originally entered the Ash Pond but was diverted around the pond in late 1988 and early 1989 to reduce the exposure to contaminants in the pond. A similar action was taken for Frog Pond although it was much less contaminated.

Interim actions completed early in the project to prevent imminent contamination of storm water were:

- Asbestos was removed from overhead piping and placed in short term storage until long-term storage areas were developed.
- PCBs were flushed from electrical equipment and placed into containers for disposal. PCB oils and contaminated equipment were transported off-site to permitted facilities.
- Chemicals from various buildings were containerized and stored in building 434.

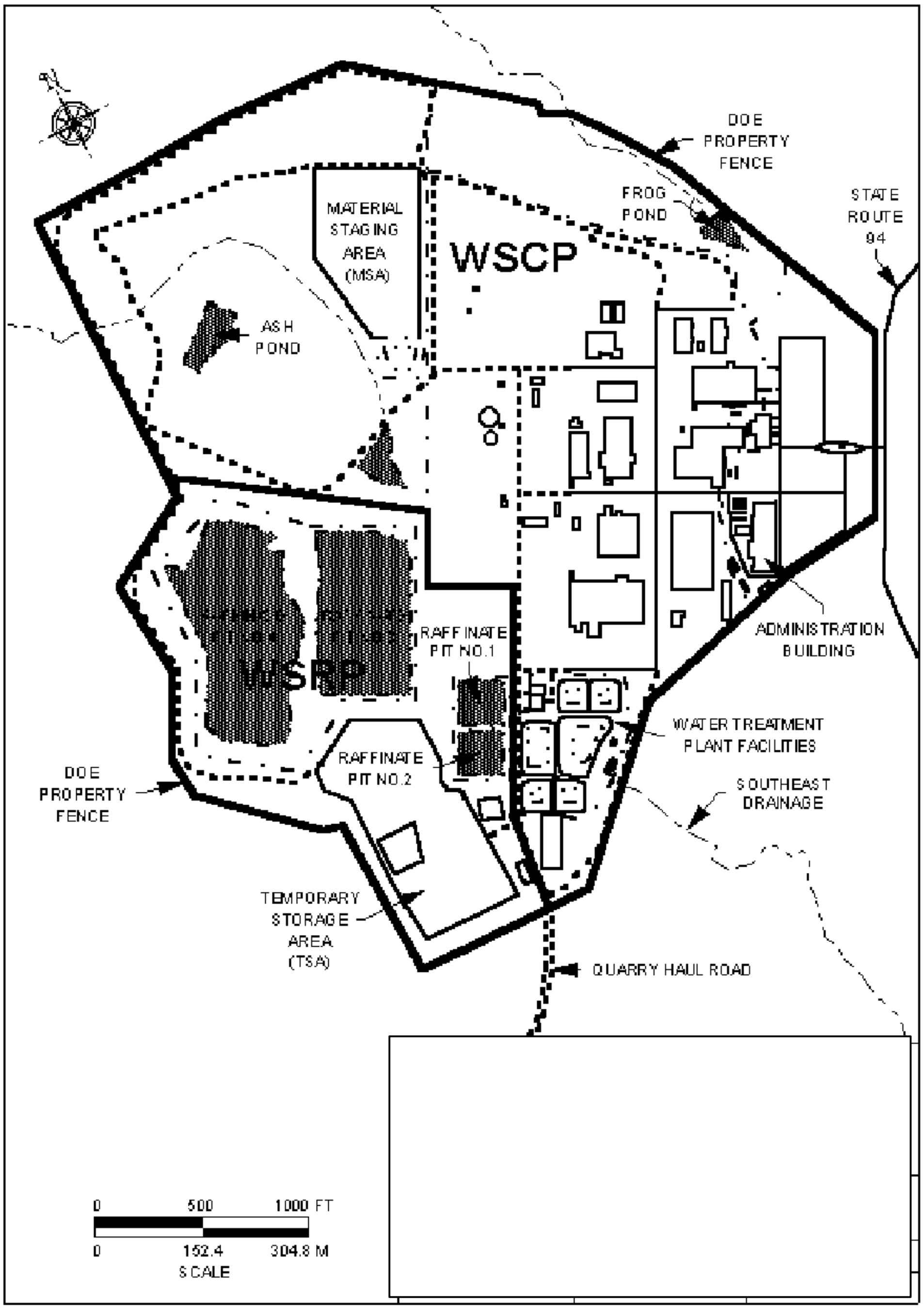

Fig. 1. Original Plant Layout and Waste Sources.

- Berms were raised on raffinate pit 3 to prevent water from overtopping the berms.
- Building, sump, tank, and other contained water at the site was pretreated by means of a mobile water treatment plant early in the process.

Annual average uranium levels at the primary NPDES outfalls (NP-0002, NP-0003 and NP-0005) in 1987, before any remedial actions were taken were 210 pCi/l, 2240 pCi/l and 780 pCi/l respectively. Remedial actions taken after that time reduced the concentrations overall but in some instances annual averages increased during years when some actions were taken. For most of the project, stormwater flowed from the site at three major NPDES permitted discharge location; NP-0002, NP-0003, and NP-0005. Monitoring was conducted both upstream and downstream of the outfalls to give indications of elevated levels and was useful in investigation of elevated level sources. Figure 2 shows the historical annual uranium concentrations for all outfalls.

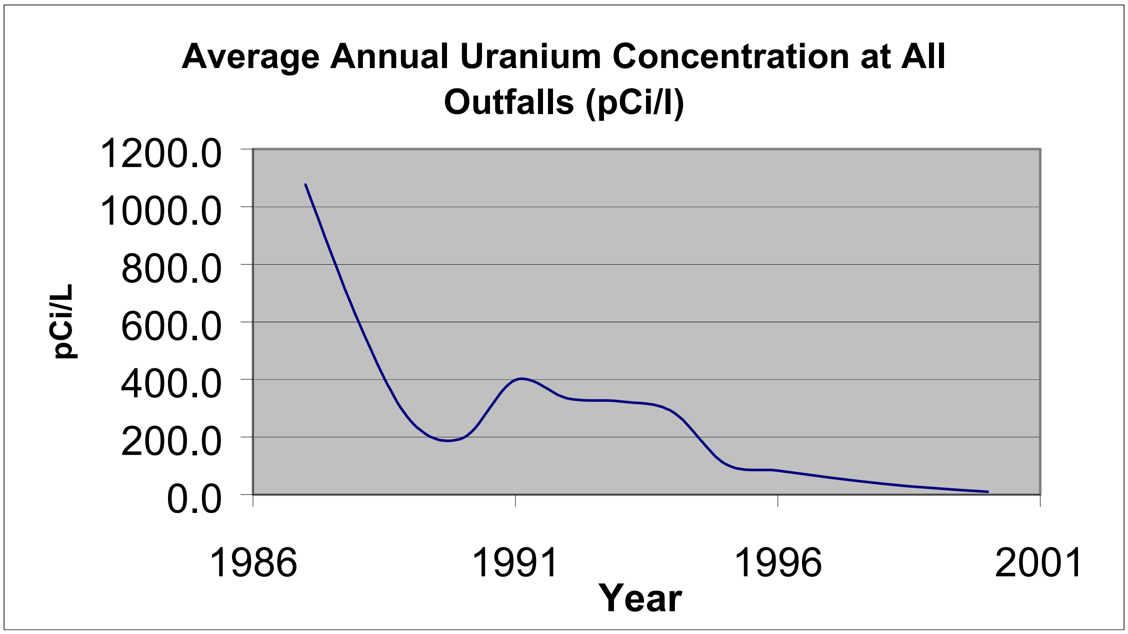

Fig. 2 – Average Annual Uranium Concentration at Outfalls

Outfall NP-0002 is downstream of the Frog Pond area and received runoff from the pond area and a large number of the uranium processing buildings. Actions were taken, such as capturing dust control water runoff, to reduce the concentration of uranium in the runoff. After this increase, uranium concentration declined at the outfall through completion of soil remediation. From an annual average high of 230 pCi/l in 1993 uranium has decreased to an annual average for 2001 of 5.6 pCi/l.

Outfall NP-0003 is downstream of the Ash Pond area and received runoff from the pond area and some of the uranium processing buildings. Ash Pond was a highly contaminated area and early in the project, storm water runoff entered it from the site. The annual average concentration was reduced from a high of 2240 pCi/l to 280 pCi/l in 1989 after runoff was diverted around the pond. After the diversion, uranium concentrations at outfall #3 were predominantly dependent on precipitation patterns. Dry summers tended to produce lower concentrations because there would be little runoff from Ash Pond. Winters, with its freezing and thawing and saturated soil conditions saw increased flow and elevated uranium levels from Ash Pond. During 1994 the south dump area was capped which reduced the annual average after that time. Also, pond water was actively managed after the pond became a storage area for contaminated soil from the site.

Ash Pond was completely remediated during 1999 and the uranium average concentration decreased to 12 pCi/l for 2001.

Outfall NP-0005 received runoff from process buildings and paved areas. Outfall NP 0001, which also discharged to the NP-0005 watershed, discharged flow from the abandoned process sewer that drained decant water from the raffinate pits during operation. Surface water from the part of the NP-0005 watershed entered the pipe to outfall NP-0001 at a ditch along the army road.. As part of the interim response actions for the site cleanup, the process sewer and the sanitary sewer were intercepted at manholes upstream and the manholes were converted to pump stations to divert the water in the sewers to the site water treatment plant for treatment. In addition to contaminated water diversion, an area of contaminated soil received a soil cover that resulted in a reduction of the uranium annual average at outfall NP-0005. Ultimately, through the execution of the source removal activities, soil and facility removal permanently eliminated these sources. The annual average uranium concentration at outfall NP-0005 declined from a high of 780 pCi/l to 7 pCi/l in 2001.

To reduce contaminated runoff during remediation, steady efforts were made to capture and test stormwater runoff, to evaluate the need for treatment. Raffinate pit, quarry water and other contaminated waters were treated in the site and quarry water treatment plants. The bulk of the treated water was held in effluent ponds and sampled for compliance and was not released until compliance was demonstrated. On some occasions process monitoring was used to demonstrate probable compliance and the treated water was directly discharged. After the raffinate pits and the quarry water were completely treated, the site and quarry water treatment plants were demolished for disposition in the storage cell. smaller mobile water treatment plants were used.

The decrease in uranium contamination in surface water discharged at the perimeter outfalls was quickly reflected in reduced levels at the downstream Busch Conservation Area Lakes and at the monitoring location at Dardenne Creek (see Figure 3). The highest average at the outlet of Lake 36 (downstream of outfall NP-0002) was 36 pCi/l which occurred in 1994. With the completion of remediation the level declined to 5.2 pCi/l for 2001. The highest average for Lake 35, which is downstream of Lake 36, was 17 pCi/l also in 1994. This declined to 4.3 pCi/l in 2001. The highest level for the outlet of Lake 34, which is downstream of Burgermeister Spring (but not directly in a site surface watershed), was 25 pCi/l in 1987 and this has declined to 6.3 pCi/l for 2001. The average uranium levels at Dardenne Creek have remained fairly steady over the years at 2 pCi/l with 5 pCi/l being the maximum in 1994. The level declined to 1.4 pCi/l for calendar year 2001. After the site is stabilized, levels at all locations are expected to decline to background levels of less than or equal to 2.0 pCi/l.

Historically, airborne releases and atmospheric migration of radioactive contaminants resulted from disturbance of waste materials in both quarry and chemical plant areas. To protect the public and the environment, an intensive program of air monitoring was conducted during the remedial action to assess airborne concentrations of radionuclides in the work zones and at various perimeter and off-site locations. This program included radon monitoring (alpha track and electret), external gamma radiation monitoring (TLDs), radioactive particulate monitoring (both high and low volume), ambient dust monitoring and airborne asbestos monitoring. With completion of the remediation of contaminated materials and the final disposition of these materials in the permanent disposal cell, the potential for airborne release of radionuclides has been eliminated, and monitoring for radioactive airborne contaminants has ceased.

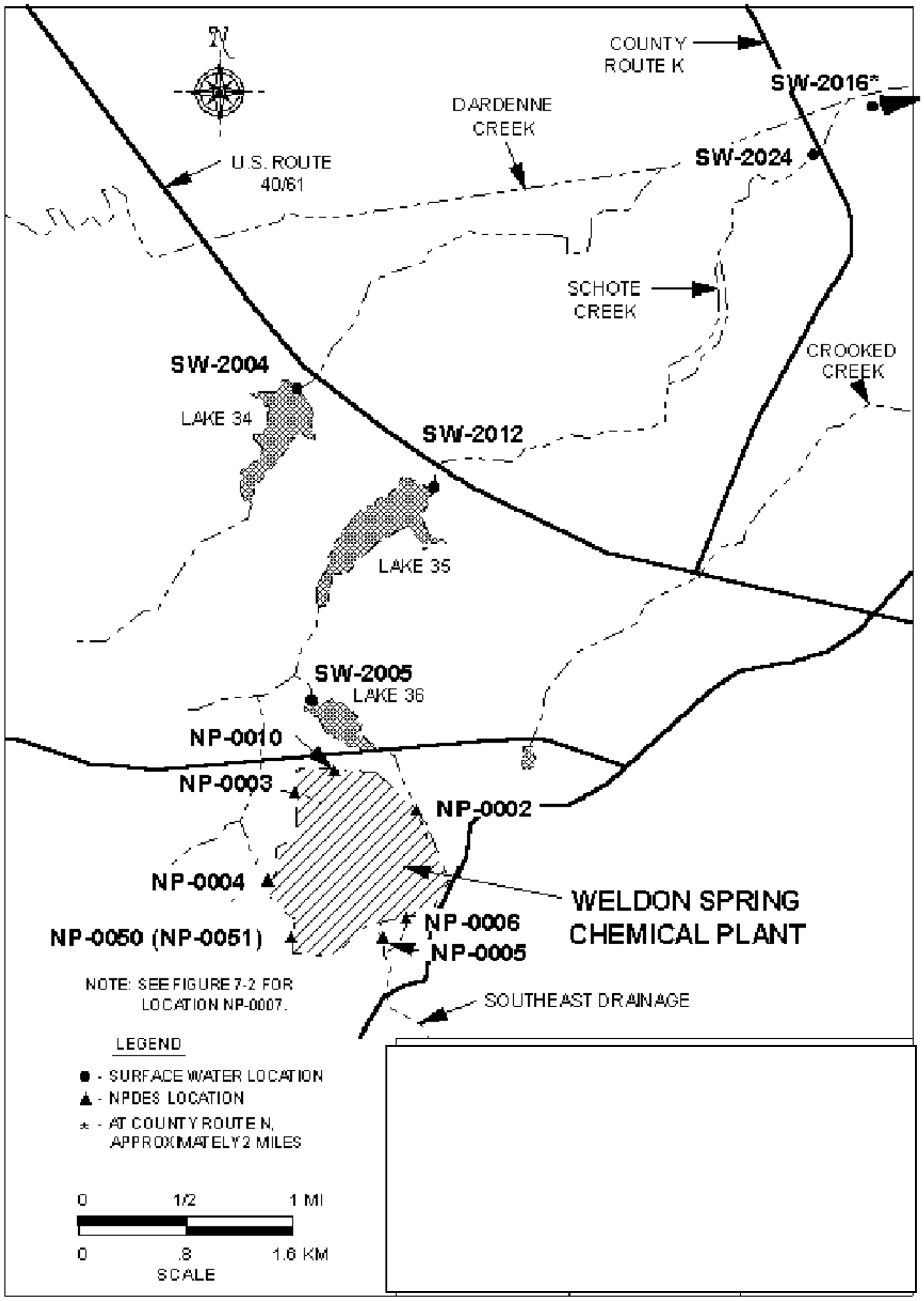

Fig. 3. Surface Water Monitoring Locations for the WSSRAP

Air Quality

To effectively monitor the diffuse sources present at WSSRAP, four air monitoring programs were utilized: site specific monitoring, perimeter monitoring, critical receptor monitoring and a monitoring program specifically designated to assess radiological impacts at the Francis Howell High School. These four programs were designed to meet the requirements for airborne effluent monitoring and environmental surveillance as specified in the Regulatory Guide and Department of Energy orders 5400.1 and 5400.5. Investigation levels were established for airborne particulate, radon and total dust concentrations.

The facilities of Francis Howell High School are within 1000 feet of the site and the school is attended by over 2000 students, teachers, administrators, and other full time school employees. In 1988, the project committed to the high school that remedial operations at the site would not result in an increase in ambient radioactive particulate levels at the school. The monitoring network was installed to demonstrate our performance against that commitment and the regulatory air quality requirements.

The project was subject to several applicable radiological public guidelines, including:

- NESHAP standard of 10 mrem (0.1 mSv) effective dose equivalent annually due to airborne emissions other than radon at off-site receptor locations.
- DOE limit of 100 mrem (1 mSv) total effective dose equivalent for all exposure pathways on an annual basis(excluding background).

The U.S. Environmental Protection Agency National Emission Standards for Hazardous Air Pollutants (NESHAPs) establishes criteria for release of airborne radioactive particulates. Airborne radionuclide concentrations were monitored at designated critical receptor locations and a dose was calculated for each receptor. Critical receptor locations are areas where members of the public abide or reside and there is a potential exposure to airborne radioactive particulate contaminants. Air monitoring was conducted beginning during CY 1987 but monitoring to meet the requirements of NESHAPs did not start until CY1990. The WSS chose to meet the NESHAPs emission monitoring and dose assessment requirements by measuring airborne radionuclide concentrations at designated critical receptor locations rather than through the use of computer modeling. Airborne radioactive contaminant levels at the critical receptors were compared to the levels at a background station.

The effective dose equivalent never exceeded 10 mrem at any of the critical receptors and has, in fact, remained below 1 mrem over the entire course of the project.

Airborne emissions were minimized through the disciplined application of designed engineering controls and effective field implementation, along with active monitoring and response systems. Dust control water from either water trucks or hoses was used during building demolition, foundation removal, soil remediation, cell construction and any other time dust could be perceived as a problem. Dust control water was also used at the quarry and the borrow areas.

Water was applied in a manner to minimize runoff. During building cleanup, prior to demolition, fans and HEPA air filters were used to place a negative pressure in buildings to allow filtering of contaminants from the air inside the buildings.

Asbestos materials were bagged and temporarily stored in SeaLand-type box containers until they were placed in the disposal cell. Radon gas was monitored during remediation and was also monitored on top of the cell until the radon barrier was placed and proven effective. A meteorological station has been located at the site since 1994 to provide data for atmospheric dispersion and diffusion modeling, ecological studies, construction management activities, environmental safety and health activities, evaluation of placement of perimeter air monitors, correlation of above normal perimeter air monitoring results with meteorological conditions, and assessment of soil conditions for earth moving work.

While radioactive airborne contaminant concentrations statistically exceeded background levels at the site perimeter during periods of the project when active waste handling was on-going, levels off-site never exceeded public dose limits for air particulates or radon gas. Most significant, however, was that for the entire period of remedial actions, continuous monitoring at the Francis Howell High School demonstrated that measured levels of radioactive air particulates never statistically exceeded background.

The air monitoring program at the site perimeter and at critical receptors was completed in calendar year 2000, when all waste handling was complete and the project demonstrated 90 days of background levels of the air quality constituents of concern.

Groundwater Contaminants

The local geology beneath the WSSRAP project area is primarily composed of fractured, flat-lying sedimentary rock units, including primarily limestone, but also , dolomite, sandstone and shale units. The contamination is confined to the upper-most aquifer with no deep migration of concern. As is to be expected, groundwater contaminants respond more slowly to surface remedies: The final decisions on how to manage the existing groundwater contamination have yet to be agreed upon between the DOE and state and federal regulators; however, we have seen some recognizable trends beginning in some contaminant types, and the DOE is confident that the source removal already achieved, along with time and natural processes, will continue to have beneficial effects on the groundwater quality beneath the site. Contaminants in the groundwater related to project operations include, primarily:

Chemical Plant Groundwater

Nitroaromatics:

Nitroaromatic compounds in soils across the site were a remnant of Army Ordnance operations at the facility during the 1940's. Pockets of contamination associated with those former operations have been located both through characterization activities and through circumstantial discovery during other remedial actions and subsequent soil regrading activities. Contaminated soils have been cleaned up and confirmed over the course of the overall remedial action at the site and groundwater concentrations are beginning to show a response to these efforts. Nitroaromatic groundwater contaminants are showing generally stationary to downward trends in 7 contaminated wells. One of the six nitroaromatic contaminants, 1,3,5-TNB, was observed as an upward trend in one well. While some areas of the groundwater remain stable in terms of their nitroaromatic contaminant levels, there are no current plans for active remediation, and long-term monitoring is believed to be best approach, based on their associated risk.

Nitrate:

Since removal of the high nitrate wastes in the raffinate pits, nitrate has shown a downward trend in 6 of 15 affected wells, a stationary trend in 5 wells and a slightly upward trend in 2 wells, probably affected by the disturbance of nitrate contaminated soils and an exposure of those soils to increased precipitation during the remedial activities. With backfill of the raffinate pit excavations eliminating ponding effects and continued exposure of the surface soils to the vegetated surface cover material, the DOE expects the remedial actions will ultimately result in a downward trend in all affected wells.

Trichloroethylene:

TCE was discovered in the groundwater at the Chemical Plant site in 1996. While the exact source of the TCE has not been located by characterization data, many deteriorated drums that were labeled to have contained TCE were discovered during remediation of raffinate pits, immediately adjacent to the TCE plume. Disturbance of the pit materials during remediation may have caused a transient spike of TCE into the local groundwater system. The area of the plume south of the raffinate pits area has been monitored since 1996 and levels of TCE are declining, with 5 of 6 wells showing a downward trend and one well remaining stationary in concentration. The project is currently planning a pilot scale test of the feasibility of insitu treatment for TCE in this shallow aquifer.

Quarry Groundwater

The effects of source removal are beginning to be witnessed in the vicinity of the quarry. Radioactively and chemically contaminated wastes in the quarry were removed during the early and mid-90s. Groundwater monitoring since that time has shown downward trends for 2,4-DNT in two of the 4 contaminated wells. While the behavior of uranium is not quite as responsive, two of the 16 wells in the quarry vicinity are beginning to demonstrate downward trends, with the other 14 wells remaining stationary in concentration. The DOE is in its second year of a two year study of the effectiveness of a capture and treat system for uranium in the contaminated zone. Site specific geochemistry is being evaluated as to its propensity to release insitu uranium contamination for removal and treatment. The final analysis of the removal effectiveness will occur in mid-2002.

Burgermeister Spring:

The Burgermeister Spring is the primary resurgence point for groundwater captured by the immature karst system in the vicinity of the site. This karst systems has been well documented by contaminant characterization efforts and dye-tracing experiments since early in the project history. This spring flows on average approximately 3 liters/sec with a peak flow of over 1000 liters/sec. Studies of the drainage basin contributing to Burgermeister Spring show that the area of the Weldon Spring Site contributes a relatively small fraction of the volume of flow. The spring exhibits site related contaminants, including uranium and nitrate. Efforts toward reducing the surface discharge of uranium in stormwater over the history of the remedial activities has been reflected in the reduced contaminant levels evident at Burgermeister Spring. Figure 4 represents the behavior of the uranium contamination at the spring.

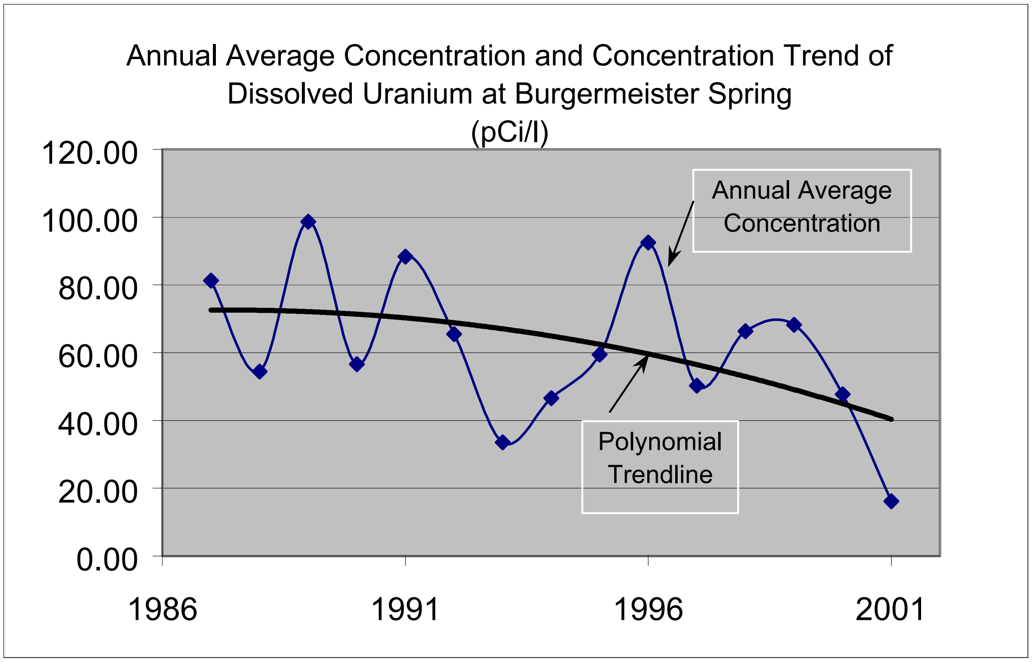

Fig. 4. Annual Average Uranium Concentrations at Burgermeister Spring.

CONCLUSION

The WSSRAP has completed the construction and closure of the on-site disposal cell. All contaminant sources have been removed and final site restoration is underway. Long-term monitoring will ultimately document the success of the remedial actions at the Weldon Spring Site and will verify the effectiveness and integrity of the disposal facility. The data highlighted in this report demonstrate that these remedial actions have had immediate lasting benefit in the reduction of contaminant emissions from the site in both water and air pathways. The remediation of the soil contaminants will have a lasting benefit in reducing the risk to future visitors and residents in the area. The affects of source removal on site related contaminants in the groundwater system are beginning to become evident and the DOE is confident that further improvements will be demonstrated as the groundwater system dynamics allow for natural processes to reflect the removal of contaminated sources.

REFERENCES:

1. MK Ferguson Co. and Jacobs Engineering Group, Weldon Spring Site Environmental Report for Calendar Year 2000., DOE/OR/21548-886, Contract No. DE-AC05-86OR21548, July, 2001, Rev. 0.