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SITE-WIDE REMEDIAL ALTERNATIVE DEVELOPMENT IN BEAR CREEK VALLEY, OAK RIDGE RESERVATION

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ABSTRACT

This paper presents a case study of an environmental restoration project at a major mixed waste site that poses unique challenges to remediation efforts. Bear Creek Valley is located immediately west of the Y-12 Plant on the Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee. The Y-12 Plant was built in 1943 as part of the Manhattan Project, with its original mission being electromagnetic separation of uranium. Since being completed, the Y-12 Plant has also been used for chemical processing of uranium and lithium compounds as well as precision fabrication of components containing these and other materials. Wastes containing radionuclides, metals, chlorinated solvents, oils, coolants, polychlorinated biphenyls (PCBs), and others were disposed of in large quantities at Bear Creek Valley as a result of manufacturing operations at the Y-12 Plant.

In the late 1980s, Resource Conservation and Recovery Act (RCRA) regulations resulted in capping several source areas to try to limit migration of contaminants. In December 1989, ORR was placed on the National Priority List, making it subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund. Currently, the remedial investigation and the feasibility study for Bear Creek Valley are being prepared.

The Bear Creek Valley feasibility study is using innovative strategies to efficiently and thoroughly consider the information available regarding Bear Creek Valley and process options that could be combined into its remedial alternatives. For example, the feasibility study is simultaneously addressing multiple sites and media within Bear Creek Valley. This is a recent change from the former strategy of considering remedial alternatives for different locations or media at different times. By considering all of the major disposal sites and environmental media in one feasibility study, the

interactions between various locations in Bear Creek Valley are considered. One example would be the way a contaminant source in one area can ultimately contaminate groundwater at another, distant site location. Also, members of the feasibility study team are either actively involved or closely following the progress of several innovative technology demonstrations at ORR. These demonstrations include in situ vitrification of a radioactive waste pit, cryogenic barriers for subsurface containment of contamination, and a new application of jet grouting, multipoint grout injection, for waste stabilization. These demonstrations are being monitored for potential incorporation into feasibility study alternatives.

Other strategies being used for the feasibility study include developing a range of alternatives for each land use decision that could be chosen by regulators using the observational approach to site remediation. Possible land use scenarios for Bear Creek Valley range from industrial waste disposal where protection is only provided for disposal workers and off-site residents, to allowing on-site residents unrestricted groundwater use. The observational approach uses the strategy of managing site uncertainties by developing contingent actions built into remedial alternatives. These contingent actions would be implemented if environmental monitoring or field observation should deem them necessary. Collectively, these unconventional aspects of the Bear Creek Valley feasibility study are designed to make the document more comprehensive in dealing with an extremely complex site.

SITE GEOGRAPHY AND HISTORY

ORR is in East Tennessee, approximately 32 km (20 miles) northwest of the city of Knoxville (Fig. 1). The Y-12 Plant is one of three major U.S. Department of Energy (DOE) facilities at ORR, occupying a section of Bear Creek Valley near the corporate center of Oak Ridge. The Y-12 Plant

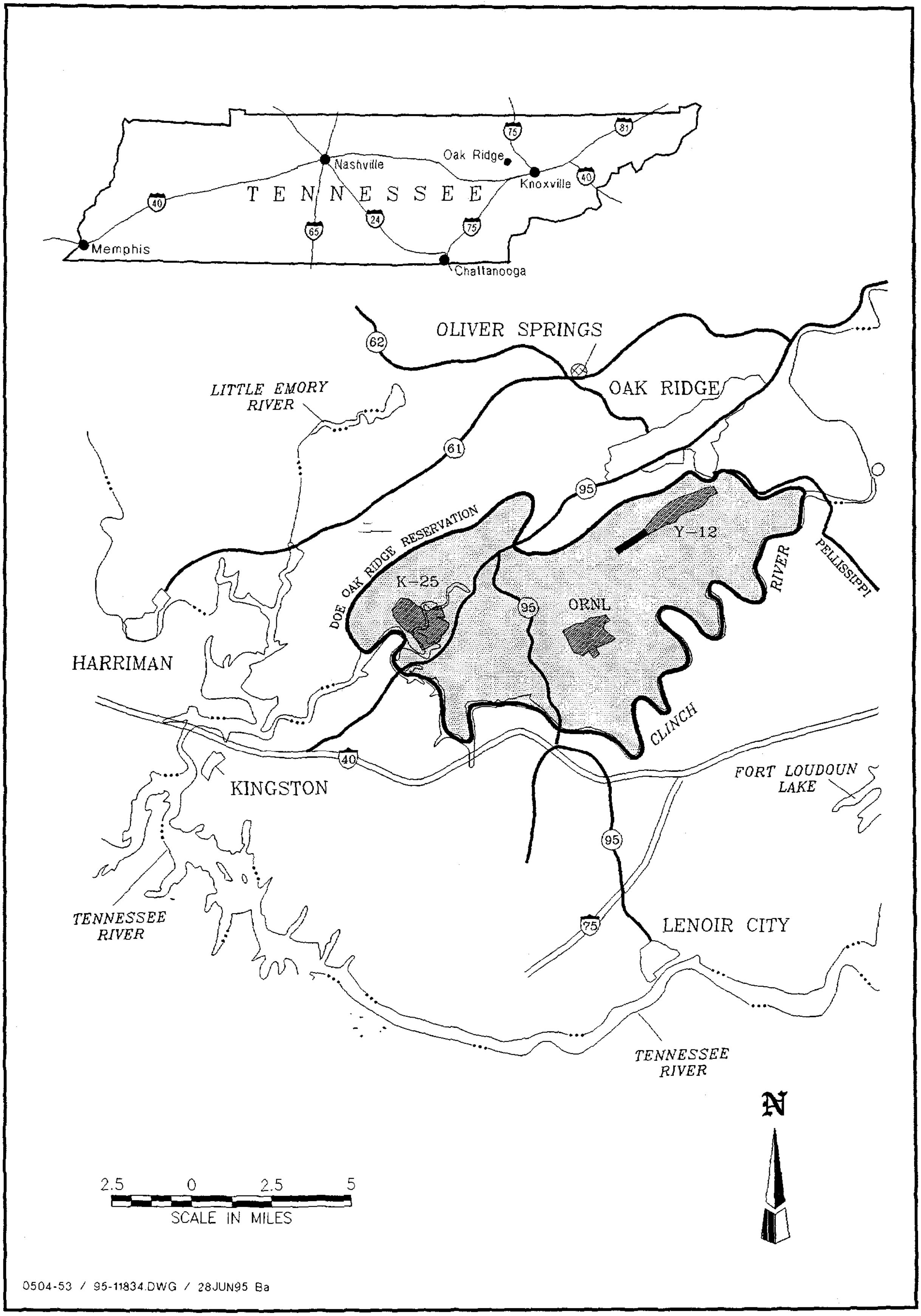

Figure 1. Regional location map.

[approximately 324 ha (800 acres)] is bordered by Pine Ridge to the north and Chestnut Ridge to the south (SAIC 1993).

The headwaters of Bear Creek are at the western edge of the Y-12 Plant, near the former S-3 Ponds site. A series of tributaries feeds Bear Creek primarily from its north side. These tributaries are designated North Tributary 1, North Tributary 2, etc., with numbers increasing from east to west. The Bear Creek Valley-wide operable unit, designated as Bear Creek Valley Operable Unit 1, originates near the western edge of the Y-12 Plant and extends westward down Bear Creek Valley between the south side of Bear Creek Road and the north side of Bear Creek itself. The three disposal areas located over this 3.2-km (2-mile) east to west stretch are the S-3 Ponds, the Oil Landfarm Area, and the Burial Grounds (See Figure 2).

The U.S. Army Corps of Engineers built the Y-12 Plant in 1943. Its original mission was to use electromagnetic separation to isolate ^{235}U from ^{238}U in support of the Manhattan Project (SAIC 1993). Efforts supporting this and other missions during and after World War II generated a variety of radioactive and hazardous wastes disposed of in Bear Creek Valley for the last 52 years. Among the types of wastes disposed of in Bear Creek Valley are uranium turnings and solutions, uranium-contaminated debris, volatile organic compounds (VOCs), PCBs, heavy metals, oils and coolants.

SITE HYDROGEOLOGY AND GEOLOGY

Bear Creek begins at the western edge of the Y-12 Plant near the S-3 Ponds and flows westward down Bear Creek Valley past the disposal areas, before leaving Bear Creek Valley altogether. The creek eventually enters East Fork Poplar Creek. Bear Creek flows along the strike of the Maynardville Limestone formation, which contains extensive karst features capable of rapid groundwater transport. The stream is characterized by both gaining and losing stretches. This means

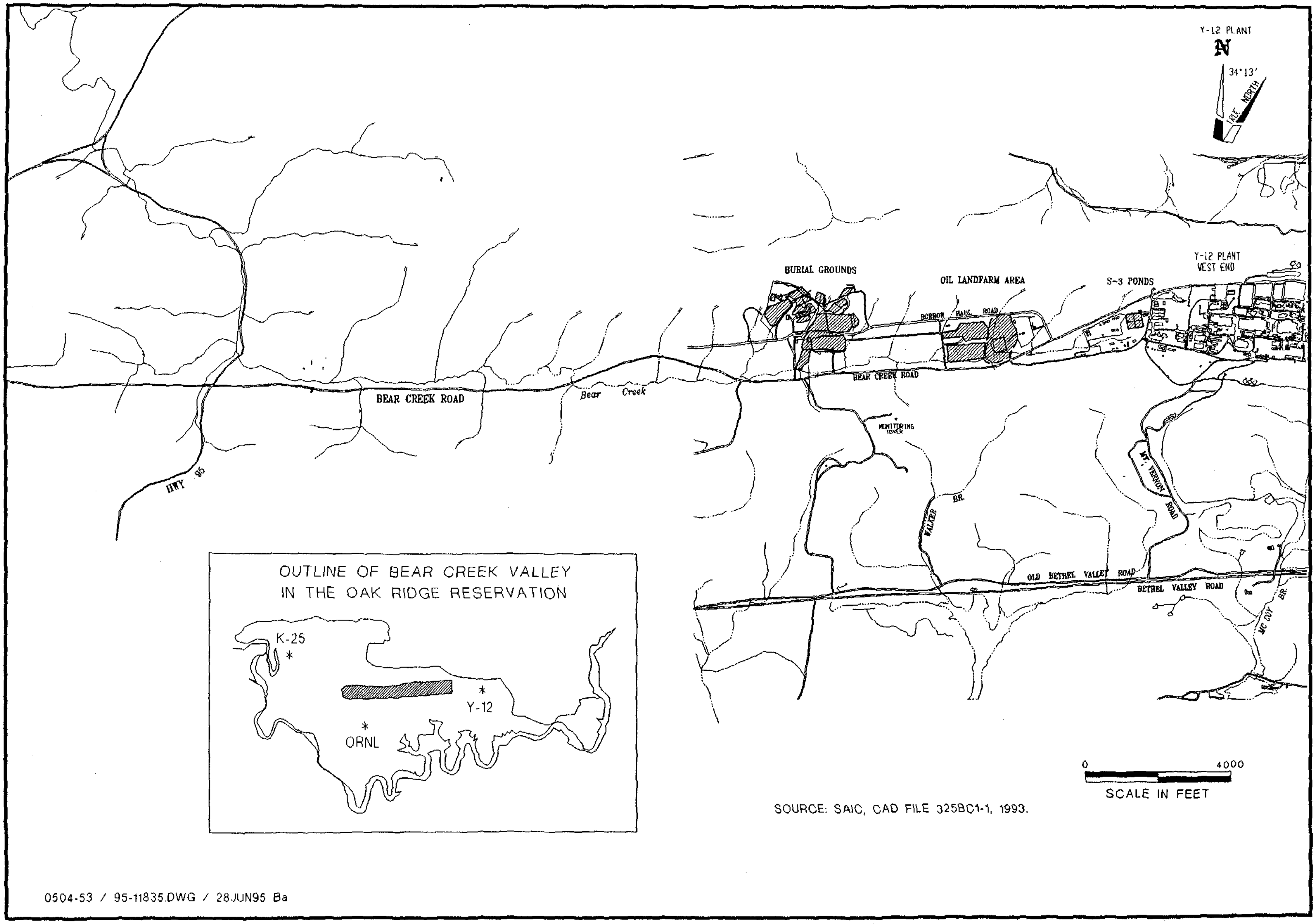

Figure 2. Burial Grounds, Oil Landfarm Area, and S-3 Ponds at the Y-12 Plant.

there are areas where the stream literally disappears from the surface, thus becoming groundwater, and also stretches where groundwater feeds the creek.

Most of the tributaries of Bear Creek flow from near the foot of Pine Ridge on the northern border of Bear Creek Valley in a southerly direction until reaching Bear Creek. These tributaries are small and completely dry certain times of the year.

Besides the Maynardville Limestone, most of the geologic formations in Bear Creek Valley are tight shales with interbedded limestones that have relatively low hydraulic conductivities (Geraghty & Miller 1987). Many of the Bear Creek Valley disposals were made above the Nolichucky Shale—the most relevant of these formations. Due to "tight" formations like the Nolichucky, the migration of contaminants has been surprisingly limited. Perhaps the exceptions to this statement are the uranium and nitrate plumes that have emanated from the S-3 Ponds. These plumes are believed to have migrated more than other liquid wastes in Bear Creek Valley due to both the low pH associated with the plumes and subsequent generally higher metal solubilities, and their proximity to the Maynardville Limestone. With part of the plumes having reached the Maynardville Formation near the S-3 Ponds, an elongated nitrate and uranium plume has spread to the west along the strike of the Maynardville Formation (Radian 1992).

Groundwater is relatively shallow in Bear Creek Valley, and it is probable that the seasonal variation in the water table level allows contact between trench waste and groundwater in most of the disposal areas for at least part of the year. This shallow water table has allowed continuous leaching from waste trenches in many areas that had been capped in past RCRA closures (albeit at slower rates than before) because the caps virtually eliminated vertical infiltration. (Personal Conversation Jim Bailey 1995).

DISPOSAL AREAS

S-3 PONDS

The S-3 Ponds consisted of four square, unlined surface impoundments each approximately 5 m (17 ft) deep and 30 m (100 ft) along each edge. These ponds were built in 1951 and had a total storage capacity of 38 million L (10 million gal) (Energy Systems 1992). Numerous liquid wastes were disposed of in the S-3 Ponds from 1951 until 1983 including uranium nitrate solutions, acids, pickling and plating wastes, technetium, and coolants (SAIC 1993). Annual discharges into the S-3 Ponds were as much as 10.3 million L (2.7 million gal), with significant fractions of these discharges infiltrating into surrounding soils and groundwater (Energy Systems 1987a). Disposals were terminated in 1983, and in situ biodenitrification was initiated.

In 1988, there was a series of chemical additions to the S-3 Ponds in efforts to stimulate more denitrification as well as neutralization of the acidic supernatant. As a result of these activities, the accumulated sludge at the bottom of the Ponds thickened to between 0.6 and 1.5 m (2 and 5 ft) (SAIC 1993). Structural stabilization of the S-3 Ponds was then accomplished by installing crushed stone. The area was then covered by a RCRA cap. Asphalt was applied over the cap to allow the site to be used as a parking lot for the west end of the Y-12 Plant. The Tennessee Department of Environment and Conservation (TDEC) approved final closure of the site in November 1990 (SAIC 1993).

OIL LANDFARM AREA

The Oil Landfarm Area is comprised of three smaller areas, specifically the Boneyard/ Burnyard, Sanitary Landfill-1 and the Oil Landfarm itself. These areas are approximately 2.4 km (1.5 miles) west of the west end of the Y-12 Plant and the S-3 Ponds, and immediately to the north of Bear

Creek (SAIC 1993). North Tributary 3 passes through the west end of the Boneyard/Burnyard while North Tributary 4 forms the western boundary of a small portion of the Oil Landfarm.

The Boneyard/Burnyard was an active disposal site between 1943 and 1970. A variety of wastes were deposited in this area such as magnesium chips that were burned following the ignition of solvents. The metal was placed in burn pans before ignition, and the residues formed during the process were placed in unlined trenches up to 90 m (300 ft) long and 12 m (40 ft) wide and covered with soil (Energy Systems 1991). Other materials disposed of in the Boneyard/Burnyard include pesticides, laboratory chemicals, and solvents and oils used to combust waste following its ignition (SAIC 1993). When the trenches reached capacity, they were covered with soil. Recent site radiation screening "walkovers" as well as remedial investigation data have verified numerous areas of radioactive contamination along the surface of the Boneyard/Burnyard, the majority of which has never been capped (Personal Conversation, Duncan Moss 1995).

The Hazardous Chemical Disposal Area (HCDA) is the one area of the Boneyard/Burnyard that has been capped. It is in the middle of the site and subsequently above the former Boneyard/ Burnyard. This area was used for the neutralization of corrosive gases by bleeding the gas through a reactive slurry and for the release of noncorrosive gases. Laboratory chemicals including picric acid, benzoyl peroxide, ether, acids, bases, and organics were also disposed of in this area by breaking bottles containing the chemicals under a water spray in an open-air concrete tank (Energy Systems 1987b).

Sanitary Landfill-1 was used for the disposal of solid wastes such as plastics, cardboard, paper, rubber, wood, asphalt roofing products, and other materials. Although the waste acceptance criteria for this area prohibited contaminated media from being placed in Sanitary Landfill-1, it is possible that this restriction was not always observed (Energy Systems 1987c). Approximately 81,000 m^3 (105,000 yd^3) of materials were placed in trenches up to 6 m (20 ft) deep and backfilled up to 4.5 m (20 ft) above grade. In 1985, a 0.6 m (2.0 ft) clay cap was installed over Sanitary Landfill-1 with topsoil to promote the growth of erosion-resistant vegetation (Energy Systems 1987b).

The Oil Landfarm itself was established in 1973 with the intention of promoting the natural degradation of organic contaminants such as oils, coolants, PCBs, and VOCs (Energy Systems 1991). Over the next 9 years approximately 3.8 million L (1 million gal) of liquid wastes were disposed of in the Oil Landfarm (Turner et al. 1991). Among these liquid wastes were approximately 57,000 L (15,000 gal) of PCB-contaminated oils skimmed from the surfaces of the Oil Retention Ponds built in the Burial Grounds to reduce migration of waste oils into surrounding tributaries. Besides the organic contaminants mentioned, these liquid wastes contained a number of degradation-resistant contaminants including beryllium, lead, barium, and uranium (SAIC 1993).

Biological degradation was initiated in the Oil Landfarm by adding nutrients and organic wastes to soil during dry months (SAIC 1993). Frequent tilling of the soil ensured an aerobic environment. Infiltration of liquid wastes through the upper soil layers and into the groundwater constantly undermined the land farming efforts. This released contaminants into other environmental media before they could be degraded. A RCRA cap was installed over the Oil Landfarm in 1990 to serve as both an infiltration barrier and a shield to industrial workers.

BURIAL GROUNDS

The Burial Grounds are approximately 3.2 km (2.0 miles) west of the west end of the Y-12 Plant between Bear Creek and Pine Ridge. These grounds are generally considered the most highly contaminated disposal area in Bear Creek Valley. The Burial Grounds are divided into several subregions named Burial Grounds A North and South, A 16, 17, and 18, B, C East and West, D East, West, and South, E, J, and the Walk-In-Pits North and South.

Burial Ground A opened in 1955 for disposing of solid wastes. Unlined trenches were excavated that over the period of operation would range from 4.5 m (15 ft) long by 3 m (10 ft) wide by 6 m (20 ft) deep up to over 240 m (800 ft) long with similar width and depth dimensions (SAIC Appendix B 1993). The solid wastes disposed of in Burial Ground A were extremely diverse, consisting of contaminated paper, wood, metal drums, graphite molds, high-efficiency particulate air filters, and concrete. Trenches were covered by native soils when they reached capacity.

By 1959, liquid wastes in the form of mop waters from floor cleaning activities in the Y-12 Plant were being disposed of in these trenches as well (Turner et al. 1991). During the next 20 years several million gallons of mop waters, oils, and solvents were poured into these trenches. One of the primary methods used to dispose of these liquids was to backfill particular sections of a trench being excavated with riprap and fitting the fill material with perforated standpipes. The liquids could be poured either directly into the standpipes or generally into the riprap with the objective being quick infiltration into the subsurface (Turner et al. 1991).

By 1969, oil began to seep from the west ends of the trenches into North Tributary 7, and shortly thereafter from the east ends of the trenches into North Tributary 6. Oil Retention Ponds 1 and 2 were built to prevent further migration of these oils, with underflow pipes carrying relatively clean water toward the tributaries while oils floating at the surface were impounded. Oil Retention Ponds 1 and 2 were periodically skimmed to remove the oils that were then sent to the Oil Landfarm for biodegradation (Bailey 1979).

In 1989, 2,940 m^3 (3,842 yd^3) of contaminated sludge, sediment, and soils having PCB concentrations above 25 ppm were removed from Oil Retention Ponds 1, 2, and North Tributary 7 and placed in storage. North Tributary 7 was rerouted slightly to the west of its original location and covered with a clay cap, and Burial Ground A North and South including both Oil Retention Ponds was covered by a multilayer RCRA cap (Collins 1990a, 1990b). A leachate collection system was installed along the western edge of Burial Ground A, with the leachate sent to an on-site treatment facility.

Burial Ground A 16 through 18 were used for the disposal of solid wastes similar to those placed in Burial Ground A North and South, although these areas did not receive the liquid wastes such as oils, coolants, and solvents. A portion of Burial Ground A 16 is covered as an overlap from the Burial Ground B, Walk-In-Pits cap. However, the remainder of these areas is not capped.

Burial Ground B was established in 1962 for the disposal of depleted uranium metal and uranium oxides (Turner et al. 1991). The unlined trenches in Burial Ground B were typically 20 to 30 m (65 to 100 ft) long, 3 to 3.6 m (10 to 12 ft) wide and 4.5 to 6 m (15 to 20 ft) deep (SAIC Appendix B 1993). Upon reaching capacity in 1968, Burial Ground D East and West opened for disposal of the same types of uranium wastes, and still later these wastes were placed in Burial Grounds E and J. Although the source areas in Burial Ground D East and West, Burial Ground E, and Burial Ground J have yet to be addressed in terms of a remedial action, Burial Ground B was covered in 1993 as part of a multilayer revetment mat cap that covered this area as well as the Walk-In-Pits.

The Walk-In-Pits opened in 1966 to dispose of uranium metal saw fines and a number of potentially explosive and reactive chemicals (Turner et al. 1991). Picric acid is among the explosive chemicals stored in this area. The area received its name from the fact that ramps were built into the pits to allow careful placement of the wastes, thus improving disposal worker safety.

Burial Ground C began receiving beryllium, beryllium oxide, and thorium, as well as beryllium- and thorium-contaminated wastes in 1962. Materials contaminated with enriched uranium were also placed in Burial Ground D (Turner et al. 1991). Burial Ground C West was covered by a multilayer cap in 1989. An extension of the leachate collection system lining the west edge of Burial Ground A also collects leachate downgradient from Burial Ground C West and sends it to an on-site wastewater treatment facility.

FEASIBILITY STUDY REMEDIAL ALTERNATIVES

The remedial alternatives for Bear Creek Valley were developed to address all major source areas collectively, instead of considering actions in particular parts of Bear Creek Valley at different times. This strategy helps gain an overall picture of the various contaminated media and illustrates how a remedial solution implemented at a particular location can affect other areas and media in Bear Creek Valley. For example, isolating buried waste in certain Burial Ground trenches using a cap and stormflow drains may ultimately help improve the water quality in Bear Creek. However, it is also possible that the isolation will have no bearing upon water quality of Bear Creek. In either case, by examining the relationship between remedial actions designed for various locations and media in the operable unit, a better understanding can be attained of the overall impact an individual process option will have on human health and the environment throughout Bear Creek Valley. In this fashion, the impacts foreseen by choosing each alternative can be analyzed in a more comprehensive manner.

Several alternatives were developed for preliminary screening with objectives spanning a range of land uses in distinct zones. Low-end alternatives maintain the status of existing disposal areas, and call for industrial land use for the remainder of Bear Creek Valley between the western edge of the Y-12 Plant and the western edge of the Burial Grounds. A recreational land use is considered from the western edge of the Burial Grounds to the leading edge of the groundwater contaminant plume, and residential land use is allowed west of the leading edge of the contaminant plume. Conversely, high-end alternatives sought residential land use for all of Bear Creek Valley with groundwater use restrictions until the aquifers are safely remediated below drinking water maximum contaminant levels.

Five of the original 10 remedial alternatives survived preliminary screening to undergo detailed design. The preliminary screening of alternatives was based on effectiveness, implementability, and cost. Although there is still a substantial range in terms of the content and complexity of the remaining alternatives, the two high-end alternatives were screened out. Both of these called for residential land use of the site. Each of the remaining alternatives maintains its own identity in order to evaluate a number of different remedial option strategies. Due to considerable uncertainties associated mainly with source areas and hydrogeology, contingent actions are included under the observational approach in which the effectiveness of base actions are monitored after the chosen alternative is implemented.

The remaining alternatives have retained their numbers assigned during preliminary screening when there were still 10 alternatives; therefore, they are not numbered 1 through 5. Descriptions of the alternatives undergoing detailed design are as follows:

ALTERNATIVE 3

Alternative 3 addresses source areas by combining isolation and excavation with consolidation, while the mass of contaminants in the groundwater is reduced near the sources, and groundwater restoration is achieved west of the Burial Grounds. Isolation techniques to be implemented at the Burial Grounds and the Boneyard/Burnyard include capping disposal sites that have not been capped, surface water controls for run-on and runoff, and the installation of upgradient shallow subsurface stormflow drains. The ecology of Bear Creek would be protected through removal of the contaminated sediment and soil from Bear Creek and its tributaries, collection and ex situ treatment of the water from selected tributaries, and the installation of a combination of active and passive treatment schemes to treat the contaminated groundwater recharging the tributaries. Groundwater would be extracted by a series of wells west of the Burial Grounds and at certain locations near the disposal areas.

The goals of remedial efforts in this alternative are to realize three distinct land uses in different areas of Bear Creek Valley. The S-3 Ponds, Oil Landfarm Area, and the Burial Grounds would remain disposal areas, while the remainder of Bear Creek Valley between the west end of the Y-12 Plant and the west end of the Burial Grounds would be used for DOE-controlled industry. Land west of the west end of the Burial Grounds would be available for residential use.

Alternative 3 has the most comprehensive groundwater extraction scheme of any of the remaining alternatives. Besides having extraction wells in each of the three major source areas, it also has a series of wells throughout the section of the Maynardville Formation groundwater contaminant plume west of the Burial Grounds. These wells are intended to achieve restoration of that portion of the Maynardville Formation as quickly as possible.

Contingent actions in this alternative would include the extension of groundwater extraction wells farther down the Maynardville Formation if migration is still occurring in that direction after the base action has been implemented. Likewise, groundwater monitoring may determine that more extraction wells may need to be placed near any of the three major source areas if the base action design does not perform as expected. Also, it is possible that French drains may need to be installed to protect tributaries or Bear Creek if surface water quality does not improve sufficiently.

ALTERNATIVE 5

Bear Creek Valley source areas are addressed by a combination of in situ treatment, excavation with either on-site consolidation or off-site disposal at an appropriate facility, and isolation achieved by the installation of a multilayer cap. In situ treatment consists of either vitrification or high-pressure grout injection, depending on the waste characteristics of a particular area. Capping and stormflow control activities would be consistent with Alternative 3 apart from the Boneyard/Burnyard. "Hot spots" in the Boneyard/Burnyard would be mechanically excavated and disposed of beneath a new Burial Grounds cap, while the rest of the Boneyard/Burnyard would be capped. Protection of Bear Creek ecology would be identical to the system in Alternative 3 with the exception of in situ wetlands used in specific tributaries rather than tributary collection and wastewater treatment. The goal of the in situ wetlands is to increase surface water detention time and allow natural processes to increase the removal of metals, radionuclides, and organic contaminants from the system. The groundwater extraction scheme is more limited than Alternative 3, with extraction wells only located west of the Burial Grounds and French drains located adjacent to several tributaries as well as part of Bear Creek. The land use objectives are the same as in Alternative 3.

The in situ treatment specified for source areas is the distinguishing aspect of this alternative. A treatability study is in progress that is evaluating the success of injecting grout at high pressures into a heterogeneous debris waste pit, thereby solidifying the waste and dramatically lowering its hydraulic conductivity. If successful, this strategy could be implemented in several Burial Grounds locations. In addition, a paper study could investigate the compatibility of in situ vitrification in trenches filled with uranium turnings. The results of these studies could help determine whether these process options are viable and help determine the appropriate disposal areas in which to use them.

Contingencies for Alternative 5 include more groundwater extraction wells at the leading edge of the Maynardville Formation contaminant plume if continuing migration is detected during monitoring. Also, wells could be placed to help contain the source area plumes if in situ treatment and caps do not limit leachate as expected. Like Alternative 3, tributary protection French drains would be a contingency if the tributary liners prove insufficient. In addition, Burial Ground A North and South have a few possible contingent actions regarding excessive leaching of oils remaining in the trenches, including thermally enhanced soil vapor extraction, in situ biological degradation, and flushing.

ALTERNATIVE 7

The distinct strategy taken in Alternative 7 is to excavate the entire Oil Landfarm Area and release all land between the S-3 Ponds and the Burial Grounds for industrial use. In this respect Alternative 7 is the only one that has only two disposal areas remaining following remedial actions. Contaminated soils, sediments, and debris from the Boneyard/Burnyard, Sanitary Landfill-1, and the Oil Landfarm itself would be excavated and sent to either an on- or off-site disposal facility. An on-site disposal facility would be capable of receiving low-level radioactive waste but not mixed waste. This criteria opens the possibility of having some of the excavated volume sent to both on- and off-site locations. The exact location of the on-site facility is not determined, although a disposal study being written by the Bear Creek Valley Feasibility Study Team is evaluating an area adjacent to other Burial Grounds areas as well as several other ORR locations.

The groundwater extraction scheme proposed for Alternative 7 is substantially different from those in Alternatives 3 and 5. Instead of having a series of extraction wells west of the Burial Grounds western edge with the intention of remediating the Maynardville Formation west of the Burial

Grounds, there are relatively few wells placed at the western edge of the Burial Grounds to prevent further migration of contaminants headed westward down Bear Creek Valley. The portion of the groundwater contaminant plume west of these wells would be able to leave the system without capture and treatment. Natural attenuation, therefore, would be the remedial strategy in that section of Bear Creek Valley.

Since the groundwater extraction scheme in Alternative 7 has no wells west of the western edge of the Burial Grounds, a contingency would be the addition of these wells if monitoring shows that natural attenuation is not meeting maximum contaminant limits in the residential area. Other contingent actions include the extension of the line of extraction wells at the western edge of the Burial Grounds farther north if it is found that groundwater contamination from the Burial Grounds is entering the residential area there at excessive concentrations. As in Alternatives 3 and 5, tributary protection French drains are a contingency if the tributary liners do not provide adequate protection of surface water quality.

ALTERNATIVE 9

Alternative 9 is the first of two low-end alternatives. The capping and stormflow diversion activities are similar to those in previous alternatives; however, groundwater actions and the protection of Bear Creek and its tributaries are completely different. Although there are groundwater extraction wells present in all three of the disposal areas, there are no wells at any location west of the Burial Grounds. In effect, the wells would reduce the mass contribution from points near the source areas to a degree that natural attenuation could be relied on to remediate the Maynardville Formation contaminant plume. Also, the tributary protection trenches and the tributary treatment liners common to Alternatives 3, 5, and 7 are not specified.

This alternative also has a land use objective not seen in the previous alternatives. The land immediately to the west of the Burial Grounds would be used for recreational use with groundwater restrictions, while residential use would be in effect beyond the leading edge of the contaminant plume. Since much of the contamination currently in the Maynardville Limestone formation would be allowed to migrate down Bear Creek Valley, groundwater modeling efforts would be needed to estimate the location in Bear Creek Valley beyond which diffusion will have reduced concentrations to below groundwater maximum contaminant limits. The effects of natural attenuation over time will dictate land use delineation. It is possible, however, that the groundwater contaminant plume in the Maynardville Limestone has already reached equilibrium or is receding. In either case the residential land use scenario would be located no further west than the leading edge of the current plume.

A groundwater contingent action for Alternative 9 would be the addition of wells either immediately west of the Burial Grounds, or near the border between recreational and residential land use, depending upon where maximum contaminant limits are being exceeded. Furthermore, additional action may be necessary to improve surface water quality, either by adding one of the tributary protection systems specified in previous alternatives, or simply by pumping tributary water to the wastewater treatment plant and replacing it with plant effluent.

ALTERNATIVE 10

Alternative 10 is similar to Alternative 9 in terms of its stormflow diversion and capping activities, as well as its surface water strategies.

However, the two alternatives have different groundwater strategies. Alternative 9 has a groundwater extraction scheme proposed in the three major disposal areas and no wells in the Maynardville Limestone for plume containment. Alternative 10 has the opposite groundwater strategy.

Alternative 10 has no groundwater extraction wells in the disposal areas, but has a line of wells at the leading edge of the contaminant plume to prevent further transport of those contaminants that manage to migrate downgradient of the Burial Grounds area. In effect, contaminants from all three disposal areas would be allowed to naturally migrate to the chosen point of containment where they would be captured.

Land use objectives and corresponding borders of Alternative 10 are the same as in Alternative 9. The design of Alternative 10 does not rely so heavily upon modeling since the capture wells at the leading edge of the plume theoretically would prevent further contaminant migration. Therefore, the border can be located near the leading edge of the contaminant plume at the time when the capture wells become operational. The row of extraction wells may be located just east of the residential land use border used in Alternative 9 to maintain consistent land use borders for each of these alternatives.

Alternative 10 has contingent actions such as the addition of groundwater extraction wells closer to the source areas to minimize the contaminant loading entering the Maynardville Formation. In addition, the line of containment wells at the recreation/residential border would have to be extended northward if downstrike contaminant migration in the Nolichucky continues and appears as though it will evade the base action wells. Also, there are surface water contingent actions similar to those in Alternative 9.

CONCLUSION

Bear Creek Valley is an extremely complicated site in terms of not only waste composition in the different disposal areas, but also geology, geochemistry, co-mingled groundwater contaminant plumes, and future migration potential of contaminants. The feasibility study is being written by determining the most likely conditions presently found in Bear Creek Valley, and designing remedial alternatives based upon those assessments. The entire Bear Creek Valley is being addressed by each remedial alternative to ensure that the overall impact of any particular remedial action on the various sites and environmental media is considered.

The uncertainties associated with current site conditions, especially in regard to the source areas, and the effects that the various remedial alternatives would have on these conditions will be managed by contingent actions. These contingencies will be built into the remedial alternatives in case field observation or monitoring of environmental media should dictate that additional or different action is needed to protect human health and the environment in Bear Creek Valley.

The alternatives retained after preliminary screening are being developed with distinct strategies that offer a range of land use objectives for separate areas of Bear Creek Valley. Information concerning cost and effectiveness of several innovative process options is still being gathered from treatability studies. These process options address various environmental media including buried waste trenches, uranium metal trenches, contaminated groundwater, and contaminated soils and sediments. The process options used depend greatly upon the intended disposal options.

Incorporating the results of these studies into effective alternatives will allow regulators and the public to choose from a comprehensive set of alternatives each having its own merit.

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