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Remedial Investigation/Feasibility Study of the Clinch River/Poplar Creek Operable Unit

Volume 4. Appendixes G, H, and I—Information Related to the Feasibility Study and ARARs

Jacobs Engineering Group, Inc.

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Energy Systems Environmental Restoration Program

Remedial Investigation/Feasibility Study of the Clinch River/Poplar Creek Operable Unit

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PREFACE

This Remedial Investigation/Feasibility Study Report of the Clinch River/Poplar Creek Operable Unit on the Oak Ridge Reservation (DOE/OR/01-1393/V1–V5&D3) was prepared in accordance with requirements under the Comprehensive Environmental Response, Compensation, and Liability Act for reporting results of a site characterization for public review. This work was performed under Work Breakdown Structure 1.4.12.3.1.02.41 (Activity Data Sheet 9302, "Clinch River/Poplar Creek Operable Unit"). This document provides the Environmental Restoration Program with information about the Phase 1 and Phase 2 investigations (1988–1995) performed at the operable unit. It includes information on risk assessments that have evaluated impacts to human health and the environment, and it contains information about the development of the feasibility study. Information provided in the document forms the basis for the Record of Decision in the Clinch River/Poplar Creek Operable Unit.

CONTENTS

TABLES

ABBREVIATIONS

AEA	Atomic Energy Act
AES	Automated Estimating System
ALARA	as low as reasonably achievable
APC	Air Pollution Control
ARARs	applicable or relevant and appropriate requirements
AWQC	ambient water quality criteria
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
CRM	Clinch River mile
CWA	Clean Water Act of 1972
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EFPC	East Fork Poplar Creek
EPA	U.S. Environmental Protection Agency
FDA	Food and Drug Administration
FFA	Federal Facilities Agreement
IAG	Interagency Agreement
LDR	land disposal restrictions
LLW	low-level radioactive waste
MCL	maximum contaminant level
MSD	marginal sediment disturbance
NA	Natural Area
NCP	National Contingency Plan
NERP	National Environmental Research Park
NPDS	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPRM	Notice of Proposed Rulemaking
NRC	Nuclear Regulatory Commission
NSSD	no significant sediment disturbance
NWP	Nationwide Permit
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PCB	polychlorinated biphenyl
PCM	Poplar Creek mile
PMSD	potential major sediment disturbance
RCRA	Resource Conservation and Recovery Act
RGO	remedial goal options
RHA	Rivers and Harbors Act
RHS	radioactive hazardous substances
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
TBC	to be considered
TCA	*Tennessee Code Annotated*

TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
USACE	U.S. Army Corps of Engineers
USC	*United States Code*
WAC	waste acceptance criteria
WBS	Work Breakdown Structure
WM	Waste Management
WQC	water quality criteria/criterion

EXECUTIVE SUMMARY

This report presents the findings of an investigation into contamination of the Clinch River and Poplar Creek near the U.S. Department of Energy's (DOE's) Oak Ridge Reservation (ORR) in eastern Tennessee. For more than 50 years, various hazardous and radioactive substances have been released to the environment as a result of operations and waste management activities at the ORR. In 1989, the ORR was placed on the National Priorities List (NPL), established and maintained under the federal Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Under CERCLA, NPL sites must be investigated to determine the nature and extent of contamination at the site, assess the risk to human health and the environment posed by the site, and, if necessary, identify feasible remedial alternatives that could be used to clean the site and reduce risk. To facilitate the overall environmental restoration effort at the ORR, CERCLA activities are being implemented individually as distinct operable units (OUs). This document is the combined Remedial Investigation and Feasibility Study Report for the Clinch River/Poplar Creek OU.

This report is organized into five volumes, the first of which presents the main text. Chapter 1 describes the regulatory setting, and Chapter 2 broadly portrays the environmental setting. Chapter 3 depicts the operational and release history of the site and characterizes in detail the nature and extent of contamination. Chapter 4 briefly identifies other regulatory requirements that are applicable or appropriate to the site. Chapters 5 and 6 assess the risk to human health and the environment, respectively. Chapter 7 explains the purpose and organization of the feasibility study. Chapter 8 defines remedial action objectives for the site; identifies pathways and contaminants of concern; and screens general response actions, potential remedial technologies, and process options. Chapter 9 develops remedial alternatives based on the remedial action objectives, the screened technologies, and representative process options. Chapter 10 analyzes, evaluates, and compares the remedial alternatives. Chapter 11 lists the references cited in the main text.

Volumes 2–5 consist of appendices that contain supporting data and information. Volume 2 characterizes the biota on the ORR (Appendix A) and summarizes data related to contaminant concentrations in water (Appendix B), in sediment (Appendix C), and in biota (Appendix D). Volume 3 presents information related to the human health risk assessment (Appendix E) and the ecological risk assessments (Appendix F). Volume 4 focuses on the feasibility study, detailing the selection of remedial process options (Appendix G) and providing the basis for the cost estimates for each remedial alternative (Appendix H). Volume 4 (Appendix I) additionally presents the applicable or relevant and appropriate requirements (ARARs), which help define the extent of the remedial response. Volume 5 is a compilation of data from individual studies that were conducted as part of the overall remedial investigation. As such, the volume addresses the quality assurance objectives for measuring the data (Appendix J) and presents selected historical data (Appendix K), data from several discrete water characterization studies (Appendix L), data supporting the sediment characterization (Appendix M), and data related to several biota characterization studies (Appendix N).

BACKGROUND

The ORR is a 34,600-acre tract of land in Anderson and Roane counties, Tennessee. It is administered by DOE, and it houses three main facilities: the Oak Ridge Y-12 Plant, the K-25 Site (formerly known as the Oak Ridge Gaseous Diffusion Plant), and Oak Ridge National Laboratory (ORNL). Each facility was created in the early 1940s as part of the U.S. government's war effort. The K-25 Site was used for the large-scale production of enriched uranium until its shutdown in 1985. The Y-12 Plant had several missions, but it primarily manufactured nuclear weapons components; production there ended in 1992. ORNL was initially a pilot-scale plant for the production of plutonium, but its post-war mission has centered on nuclear reactor research and the production of radionuclides for use in medicine and science. In addition to these operations, each plant has housed large support operations, including maintenance shops; waste treatment, storage, and disposal areas; steam plants; storm and sewer drains; and infrastructure.

The Clinch River/Poplar Creek OU is located adjacent to the ORR and consists of the Clinch River and several tributary embayments in Melton Hill and Watts Bar reservoirs. Both reservoirs are large multipurpose impoundments created and maintained by the Tennessee Valley Authority. The OU extends from the upstream boundary of the ORR at Clinch River mile (CRM) 49 in Melton Hill Reservoir, downstream to the mouth of the Clinch River in Watts Bar Reservoir at Kingston. It also includes several embayments that extend up tributary streams, including the McCoy Branch embayment of Melton Hill Reservoir and the Poplar Creek embayment [up to Poplar Creek mile (PCM) 5.5] of Watts Bar Reservoir. Originally, the OU included all of Watts Bar Reservoir downstream of the confluence of the Clinch and Tennessee rivers, but this area was segregated into a new OU (the lower Watts Bar Reservoir OU) in 1994, and a CERCLA Record of Decision was reached in 1995. No action-based remedial alternatives were implemented in lower Watts Bar Reservoir. The OU is currently being monitored to ensure that exposure to contaminants remains low.

REMEDIAL INVESTIGATION

The remedial investigation had two primary objectives: (1) to characterize the nature and extent of contamination, and (2) to assess the baseline risk to human health and the environment. Under CERCLA, if site risks are too high, remedial action is generally warranted. This investigation was implemented in a phased approach. First, existing environmental data were used to develop a preliminary site model, which considered the known or suspected contaminant sources, the physical characteristics of the site, and the environmental fate of various contaminants. An initial round (Phase 1) of limited sampling of water, sediment, and fish was then conducted (in 1989) to confirm these historical data and to refine the site model. A much more extensive sampling effort (Phase 2) was conducted in 1994 to more definitively meet the objectives.

Nature and Extent of Contamination

Several contaminant sources were included in the site model. The waters of Poplar Creek were known to receive effluent from the Y-12 Plant (and the City of Oak Ridge) via East Fork Poplar Creek (EFPC), which enters the Poplar Creek at PCM 5.5. Large quantities of elemental mercury were released from the Y-12 Plant in the late 1950s, and small quantities currently continue to escape from contaminated buildings, equipment, and soils. Increased levels of mercury, therefore, were predicted in water, sediment, and biota of Poplar Creek downstream of EFPC. (Contamination at the Y-12 Plant and contamination in the EFPC floodplain have been addressed separately in efforts at other ORR OUs). Other contaminants known to have been released from the Y-12 Plant include uranium, polychlorinated biphenyls (PCBs), and several metals. Poplar Creek also has historically received a variety of effluents from the K-25 Site, through which the creek flows. Numerous metals, uranium, PCBs, laboratory chemicals, and organic solvents are thought to have been released from the site. In addition, the downstream reaches of Poplar Creek formerly received coal ash from the K-770 steam plant at the K-25 Site, and sediment at this location was expected to contain elevated levels of several metals, particularly arsenic.

The contaminants of potential concern in the Clinch River below Melton Hill Dam are primarily man-made radionuclides, by-products of nuclear fission. Contaminants were released to the Clinch River via White Oak Creek, which enters at CRM 20.8. Studies in the 1960s demonstrated that water-soluble radionuclides were rapidly and greatly diluted upon entering the Clinch River and were quickly transported downstream, with little loss of contaminant mass (i.e., they remained in solution). However, those contaminants that adsorbed to particulate matter became bound to particles of suspended sediment and accumulated in areas of sediment deposition. Earlier studies indicated that the principal radionuclide of potential concern in Clinch River sediment at the beginning of this investigation was ^{137}Cs, which is strongly particle-associated and has a relatively long (30-year) half-life. Because peak releases of ^{137}Cs from ORNL occurred at the same time as peak releases of mercury from the Y-12 Plant, peak concentrations of each were known to co-occur in the lower Clinch River, buried under several inches of cleaner sediment. Although one would have expected sediment in the Clinch River below White Oak Creek to contain the highest levels of ^{137}Cs and other radionuclides, there was actually very little sediment in this portion of the river, most having been scoured and transported downstream by the periodic high-volume releases of water from Melton Hill Dam, located approximately 2 miles upstream.

Current contaminant releases from ORNL are much lower than those of the 1950s and 1960s and are largely due to leaching or runoff from waste disposal areas. Most of these areas are no longer in use and are themselves the focus of environmental restoration efforts at ORNL.

Fly ash from the Y-12 steam plant was formerly disposed of in a settling pond located near the headwaters of McCoy Branch on Chestnut Ridge. As a result, several contaminants associated with coal ash, particularly arsenic, were known to be present at elevated levels in surface water and sediment in the McCoy Branch embayment of Melton Hill Reservoir. Because the embayment is bisected by a road built on fill material, conditions were expected to be worse in the upper embayment, whose water had limited mixing (via a culvert) with waters of the lower embayment and the main reservoir.

In addition to these ORR-specific concerns, it was known that fish collected on and near the reservation contained more PCBs than fish found at most upstream reference areas. PCBs had been used at each of the three facilities. The ORR as a whole has likely been a source of PCBs to the environment. However, PCBs have been widely used in transformers and in industrial operations, and numerous potential sources exist throughout eastern Tennessee. The identification of sources is difficult because PCBs bioaccumulate in fish and other organisms to much greater levels than in water or sediment, where they are largely undetected. The extent to which the ORR had contributed to the problem was unclear.

The knowledge of these site conditions was used to guide the remedial investigation. Much of the sampling focused on Poplar Creek, where the combination of multiple sources and site conditions (e.g., areas of significant sedimentation, less water volume than in the Clinch River) were expected to result in some of the highest levels of contamination. Sampling in the Clinch River focused on fish and sediment, media in which contaminants tend to accumulate. Sediment sampling was limited in the Clinch River between Melton Hill Dam and Poplar Creek because sediment was scarce there.

The results of the site characterization phase of the remedial investigation were consistent with the site model. The nature and extent of contamination were evaluated by identifying those study reaches in which levels of any contaminant in water, sediment, or biota were elevated in comparison with levels in upstream reference reaches. The nature and extent of contamination are described as follows.

- **Arsenic in surface water and sediment of upper McCoy Branch Embayment.** Average concentrations of arsenic (4.1 μg/L) in surface water exceeded the state of Tennessee's recreation-based Ambient Water Quality Criterion. This criterion is designed to protect persons who regularly consume fish taken from a particular body of water. In sediment, elevated levels of arsenic, vanadium, and boron were found throughout McCoy Branch Embayment, but concentrations were highest in the upper embayment.

- **Radionuclide levels in water, sediment, and biota of the Clinch River downstream of White Oak Creek.** Average gross alpha and gross beta levels and mean activities of ^{90}Sr and ^{3}H in surface water were a factor of ten higher than reference values. These data were extremely variable, probably as a result of the extreme variability in flow below Melton Hill Dam. A conservative evaluation of the radionuclide concentrations indicated that, even immediately below White Oak Creek, the state's Ambient Water Quality Criterion for protection of domestic supplies was not exceeded.

  Levels of ^{137}Cs were elevated in Clinch River sediment below the mouth of White Oak Creek. This radionuclide has a strong affinity for particles, particularly the clay minerals that make up a significant portion of Clinch River sediment. However, the discharge of water from Melton Hill Dam resulted in the scouring of most of the sediment from this portion of the river, creating larger inventories of ^{137}Cs in the lower Clinch River, where sedimentation is greater.

  Bluegill sunfish and largemouth bass collected in 1989 from the Clinch River near the mouth of White Oak Creek contained ^{137}Cs at levels 100 times that of fish from upstream reference areas. Catfish were found to have levels approximately ten times that of reference areas. Although elevated, these levels were not thought to pose a significant risk to persons or wildlife consuming these fish, and thus radionuclide analysis was discontinued after the initial round of sampling. However, the species-specific baseline human health risk assessment has identified ^{137}Cs as a contaminant of concern in largemouth bass. Additional bass and sunfish will be collected to determine whether concentrations have dropped since the Phase 1 data were collected.

- **Mercury in surface water, sediment, and biota of Poplar Creek downstream of East Fork Poplar Creek.** Average mercury concentrations in surface water, sediment, and biota were significantly elevated in Poplar Creek downstream of EFPC in comparison with average values upstream of EFPC. Elevated concentrations (up to 0.19 μg/L) measured in Poplar Creek surface water below EFPC and in the Clinch River downstream of Poplar Creek exceed the state's Criterion Continuous Concentration (CCC) (0.012 μg/L). This criterion is designed to protect aquatic life from chronic exposure to mercury. Although also elevated above reference values, mean mercury levels in fish did not exceed the Federal Drug Administration's action level (1.0 mg/kg) in any species sampled. Several individual largemouth bass, however, had mercury levels that exceeded this value. Increased body burdens of mercury were also found in benthic organisms living in Poplar Creek, in heron eggs and chicks from a rookery near Poplar Creek, and in laboratory mink fed a diet high in fish from Poplar Creek. A decreasing gradient of biological effects, as measured by a suite of physiological and physical indices, was found to extend from upper Poplar Creek downstream through the Clinch River. This gradient in effects can be roughly correlated with a decreasing gradient in fish body burdens of mercury and PCBs in the downstream direction.

- **Metals and radionuclides in the sediment of Poplar Creek.** In addition to mercury, contaminants in Poplar Creek sediment that were elevated above reference levels were silver, arsenic, boron, cadmium, copper, chromium, nickel, vanadium, ^{238}U, ^{235}U, ^{234}U, ^{99}Tc, ^{137}Cs, and ^{60}Co. PCBs (Aroclor 1254), rarely detected in sediment anywhere in the system, were detected in Poplar Creek. As with mercury, concentrations of copper, cadmium, and chromium increased immediately below EFPC and likely represented releases from the Y-12 Plant. Concentrations of silver, nickel, ^{99}Tc, and the uranium isotopes were elevated below K-25 discharge points, and copper and chromium concentrations in this area were substantially increased above the already elevated levels found below EFPC. Increased levels of arsenic, vanadium, and boron were found in lower Poplar Creek and were associated with an area where the disposal of coal ash from the K-770 steam plant historically took place. The increased levels of ^{137}Cs and ^{60}Co were restricted to the last mile of Poplar Creek and are thought to be caused by backflow from the Clinch River, which regularly takes place as a result of reservoir operations.

- **PCBs in fish of Poplar Creek and the Clinch River.** Mean PCB levels in largemouth bass were highest in Poplar Creek. Although no bass were available from the reference reach of Poplar Creek, concentrations were still greater than at most other study and reference sites.

  Mean concentrations of PCBs in catfish were highest in Phase 1 samples collected from the White Oak Creek Embayment (now part of a separate OU) and in fish from the Clinch River immediately downstream. Levels were significantly increased over those in Melton Hill and Norris Reservoir catfish. Mean concentrations in catfish from Poplar Creek below the confluence with EFPC were greater than those in catfish from above the confluence. Mean total PCB concentrations in largemouth bass did not exceed the FDA action level (2.0 mg/kg) at any location. The mean concentration in catfish did not exceed this action level at any location (except at the White Oak Creek Embayment). However, individual fish from the Clinch River and Poplar Creek had concentrations that exceeded this level.

  The PCBs detected in fish flesh were almost exclusively Aroclor 1254 and Aroclor 1260. An analysis of individual PCB congeners in catfish did not reveal any patterns that could explain additional sources of PCB contamination.

Risk Assessment

The data used to characterize the nature and extent of contamination were also used to meet the second objective of the remedial investigation, risk assessment. The baseline risk assessment contained in this report consists of a human health risk assessment and an ecological risk assessment.

Risk to human health was evaluated for seven exposure scenarios, each of which contained one or more pathways through which exposure actually occurs. The seven scenarios were (1) the use of surface water as an untreated drinking water source, (2) the consumption of fish, (3) the use of the reservoir shoreline during winter drawdown, (4) swimming, (5) the hunting and consumption of waterfowl that frequent the ORR, (6) the dredging and subsequent land disposal of sediment, and (7) the use of surface water for irrigation. In each scenario, risk from carcinogens was assessed by assuming a 30-year exposure duration, and risk from noncarcinogens was assessed by assuming a 6-year exposure period. Under CERCLA, media whose pathways result in either a cumulative excess cancer risk of 1.0E−04 or a Hazard Quotient of 1.0 (a measure of noncarcinogenic exposure) generally warrant remedial action at the site.

The human health risk assessment evaluated the risk from each contaminant for which sufficient data existed to obtain a representative concentration. Therefore, the human health risk assessment identified certain analytes whose presence did not appear to be the result of the ORR operations. Because these contaminants might have contributed significantly to overall risk, they generally were included in the risk assessment.

Thirty-five potential contaminants of concern were identified in Clinch River and Poplar Creek water, sediment, and fish. The majority of contaminants were found in deep sediment, and the greatest risks were identified through the agricultural pathways. Of the contaminants identified, only 2 in water, 7 in fish, and 19 in sediment were clearly site-related.

Eight contaminants of concern, all noncarcinogens, were identified in surface water in the OU. Five were identified in the drinking water scenario; the non-site-related analyte manganese drove the risk in all reaches except in upper McCoy Branch, where arsenic contributed most of the risk. Seven contaminants of concern were identified in the irrigation scenario, and two were identified in the swimming scenario (Poplar Creek only). The two contaminants identified in the swimming scenario (Di-n-octylphthalate and Aroclor 1254, also identified in the irrigation scenario) were detected infrequently and therefore might not be contaminants of concern. In general, the number of contaminants of concern in each scenario was greatest in Poplar Creek and least in McCoy Branch.

Seven contaminants of concern were identified in the shoreline-use scenario, which was based on contaminant concentrations in near-shore sediment only. Melton Hill Reservoir is managed in such a way that no prolonged drawdown occurs; therefore, assessment of this scenario was not conducted for the area. Noncarcinogenic risk was common throughout near-shore areas along both the Clinch River and Poplar Creek, and it was driven almost exclusively by manganese via inhalation of resuspended sediment. A significant (<1.0E−04) excess cancer risk existed in one subreach of Poplar Creek, primarily because of chromium exposure via the inhalation pathway.

Eleven contaminants of concern were found in fish. Most of the contaminants were organic compounds (PCBs and pesticide residues) and were found in catfish and largemouth bass from both the Clinch River and Poplar Creek. The excess cancer risk from the consumption of catfish exceeded 1.0E−03 in all study reaches, primarily as a result of Aroclor 1260. The excess cancer risk from the ingestion of largemouth bass was generally equal to or less than one half of that from the ingestion of catfish. Arsenic and Aroclor 1260 were the primary contributors to carcinogenic risk from the ingestion of largemouth bass. Several radionuclides were also identified as carcinogenic contaminants of concern, but they generally contributed only a small portion of the total risk. The exception was ^{137}Cs, which contributed a significant portion of the risk associated with the ingestion of largemouth bass from the Clinch River immediately below the mouth of White Oak Creek. Contaminants of concern that were important noncarcinogens included mercury, Aroclor 1254, and chlordane in one or more species in Poplar Creek and the Clinch River.

In the dredging scenario, 31 contaminants of concern were identified in sediment. This scenario assessed the risk from contaminant exposure that would occur if dredge spoil were placed on land where it was accessible to humans. Several direct exposure pathways were evaluated, as were several agricultural scenarios in which contaminant concentrations in produce, milk, and beef were modeled from sediment contaminant concentrations.

Of the direct pathways, external exposure to gamma-emitting radionuclides in spoil from throughout most of the Clinch River (including Melton Hill Reservoir) and at the mouth of Poplar Creek would result in an excess cancer risk greater than 1.0E−04. At all locations downstream of White Oak Creek, the primary contributor to risk via external exposure was ^{137}Cs. In Melton Hill Reservoir, the risk was primarily due to ^{60}Co from a non-DOE source (now closed) on Braden Branch. In all reaches for which data were available, manganese in spoil posed the greatest risk to adults and children via the inhalation of resuspended sediment. Barium similarly posed ubiquitous risk but generally only to children. In addition to this noncarcinogenic risk, the inhalation of resuspended spoil from lower Poplar Creek would result in an excess cancer risk of 2.1E−04, primarily due to arsenic and chromium. Finally, the incidental ingestion of arsenic and mercury in spoil from lower Poplar Creek would be potentially harmful to children.

In the three agricultural pathways evaluated under the dredging scenario, the milk and meat ingestion pathways showed the most carcinogenic potential. Evaluation of the majority of the reaches for which data were available indicated that the ingestion of milk and beef produced with vegetation grown on dredge spoil would result in an excess cancer risk greater than 1.0E−04 and that many reaches had risk values an order of magnitude greater. The contaminants responsible for the majority of this risk were members of a class of ubiquitous contaminants known as polycyclic aromatic hydrocarbons. In particular, benzo(a)pyrene and dibenz(a,h)anthracene drove this risk. In addition, in those reaches where it was detected, Aroclor 1260 contributed significantly to the risk. By contrast, the excess cancer risk in vegetables was generally lower, exceeding the 1.0 E−04 threshold in only two locations; in these locations the risk was driven by different analytes than in the other two pathways. In Poplar Creek adjacent to the K-25 Site, ^{99}Tc was the primary contributor to risk, although nine other analytes at this location were also of concern. At one location in the Clinch River, the organic analyte N-nitroso-di-n-propylamine was identified as a contaminant of concern but was detected in only one of three samples from that reach.

Evaluation of every subreach for which there were data indicated that one or more of the agricultural pathways posed an unacceptable risk under the dredging scenario. Fourteen noncarcinogenic contaminants of concern were identified. Risk in the milk and meat pathways was frequently driven by mercury and Aroclor 1254. Risk in the vegetable ingestion pathway was frequently driven by manganese, except in the Poplar Creek subreaches, where mercury was the concern.

The ecological baseline risk assessment estimated the ecological risk due to contaminants in the Clinch River/Poplar Creek OU. Seven assessment endpoints were evaluated during the assessment: (1) reduced species richness or abundance or the increased frequency of gross pathologies in fish; (2) reduced species richness or abundance of benthic macroinvertebrate communities; (3) reduced abundance or production of piscivorous wildlife populations; (4) reduced abundance or production of flying insectivorous wildlife populations; (5) reduced production in terrestrial plant communities; (6) reduced abundance or production of terrestrial wildlife populations; and (7) reduced viability of any individuals of a threatened or endangered species. For each endpoint, the reduction in the parameter was required to be 20% or more and to be the result of toxicity.

Three lines of evidence were used in the ecological risk assessment. First, the site and media-specific contaminant data used in the site characterization were evaluated against a series of benchmark values (e.g., the no-observed-effects level) to determine whether concentrations were great enough to cause adverse effects. Second, site-specific toxicity data were used to determine whether these levels were actually causing a toxic effect at a particular site. Finally, site-specific biological survey data (species richness and abundance) were used to help assess whether any toxicity was actually having an impact at the population or community level. When all lines of evidence were not available for each of the endpoints, risk assessment was usually based on contaminant data alone. The assessment for the fish endpoint used data on fish pathologies and fecundity as a fourth line of evidence.

The fish community in Poplar Creek was found to be at significant risk from episodically high concentrations of several metals (copper, mercury, nickel, and silver). Toxicity to fish was assessed by using several test protocols and organisms. Poplar Creek water was toxic to Japanese medaka and redbreast sunfish embryos, but not to fathead minnows or *Ceriodaphnia*. The fish community of Poplar Creek exhibited decreased species richness and abundance in comparison with a reference site with similar habitat (Bull Run Creek embayment of Melton Hill Reservoir). The results of the ecological risk assessment for fish indicated that, while individual fish were probably suffering some physiological impacts immediately below WOC, the fish community was not being significantly impacted in the Clinch River. In McCoy Branch, adverse impacts could not be ruled out, but data were unavailable for some of the lines of evidence (data on fish community, pathology, and fecundity).

The benthic macroinvertebrate community of Poplar Creek was identified as being at significant risk from several metals (arsenic, mercury, nickel, and silver) and PCBs in surface sediment. The benthic community contained fewer species and had less abundance of organisms than the communities at other sites. The toxicity data did not reveal consistently toxic effects, but in at least one test from each site a toxic response was observed in test organisms of at least one species. The benthic communities of the Clinch River and the McCoy Branch embayment were found not to be significantly impacted by contaminants.

Risks to piscivorous wildlife were assessed by using two avian species (great blue heron and osprey) and two mammalian species (mink and river otter). Two lines of evidence, biomonitoring data and contaminant data in whole fish, were available for assessing risk to heron and osprey. Partly because of their wide foraging behavior, osprey were found to be not at risk from contaminants even though mercury levels in Poplar Creek fish exceeded benchmark values. Although the data indicated that individual heron feeding exclusively in certain portions of Poplar Creek might be at risk, the local populations of the avian species were not expected to be impacted. This conclusion was supported by surveys of the reproductive success of osprey and great blue heron in Poplar Creek: the surveys found high reproduction and no increase in deformities. Mink were not identified as being at risk from contaminants in either Poplar Creek or the Clinch River. However, individual river otter feeding in Poplar Creek near the mouth of EFPC would be expected to have a significant risk of impaired reproduction. Although river otter do not currently exist within the OU, they have recently been reintroduced into east Tennessee, and the natural expansion of their range is expected to lead to their re-establishment on the ORR. Because the otter is a state threatened species, impacts to individual otter would be considered significant.

The risk to insectivorous wildlife was assessed by using one avian species, the rough-winged swallow, and two mammalian species, the gray and little brown bats. In each case, only one line of evidence (contaminant concentrations in benthic insects) was available for the assessment. These data indicate that a colony of rough-winged swallows feeding in Poplar Creek near the mouth of EFPC could suffer impaired reproductive potential as a result of mercury exposure, but the magnitude of the effects could not be evaluated. Populations of neither species of bat were found to be at risk. Although mercury concentrations in Poplar Creek were high enough to put individual bats at risk if they were to forage exclusively within this area, the foraging range of bats is great enough that this possibility is unlikely.

The ecological risk assessment for terrestrial wildlife was based on a dredging scenario much like that used in the human health risk assessment. The assessment examined risk both to the plant community that would develop on dredge spoil and to a herbivorous mammal (eastern cottontail) foraging there. A single line of evidence (contaminant concentrations in sediment) was available for use in the assessment. In the sediment of one or more study reaches, 12 metals were found at concentrations that exceeded benchmarks indicative of plant toxicity. The greatest number of metals were found in lower Poplar Creek, which contained arsenic, boron, cadmium, chromium, mercury, nickel, selenium, uranium, and vanadium. Benchmark numbers for plants were not available for a large number (i.e., 37) of the organic compounds; therefore, these analytes could not be evaluated. Populations of cottontails foraging on future spoil from lower Poplar Creek or from the Clinch River immediately downstream of Poplar Creek would be at significant risk of impaired reproduction due to levels of mercury and cadmium. A number of other analytes from these (and most other) reaches might pose a risk to individual cottontails foraging on future spoil; however, population-level effects from these contaminants would not be expected.

Ecological risk from radiation exposure was assessed separately. Risks to many of the same endpoint species were assessed, including a benthic organism (a mayfly), epibenthic (bottom-dwelling) fish, piscivorous wildlife (great blue heron), and a terrestrial herbivore (eastern cottontail). The assessment used the contaminant data for radionuclides to calculate the total radiation dose to these organisms. The DOE limit of 1.0 rad/day was used to assess acceptable exposures for most organisms; the International Atomic Energy Agency's recommended limit of 0.1 rad/day for terrestrial organisms was used to assess exposure for cottontail rabbits. None of the calculated doses approached the appropriate benchmarks above; thus, the radiological contaminants in the various environmental media of the OU did not pose a significant ecological risk.

Based on the findings of the site characterization and risk assessments, a number of pathway and media-specific remedial goal options (RGOs) were developed for individual analytes, which represent concentrations corresponding to an ARAR or to an acceptable human health or ecological risk level. RGOs were developed only for those reaches containing one or more environmental media that exceeded one of the criteria and thus indicated the potential need for remedial action in that reach. In almost every reach studied, RGOs were developed for one or more analytes for each of the three media evaluated.

FEASIBILITY STUDY

On the basis of the remedial investigation, a feasibility study was conducted to identify remedial alternatives that would be effective in reducing contaminant concentrations or reducing or eliminating exposure and that could be feasibly implemented. The overall approach taken in the feasibility study was to focus on remedies for site-related contaminants as identified in the site characterization. Therefore, remedies were not evaluated for those reaches in which risk was primarily the result of non-site-related contaminants (e.g., manganese-driven risks in surface sediment or in water). In addition, no remedies were evaluated for surface water contaminants. Remediation of surface water is best effected at the source of the contamination, which in each case is primarily in upstream OUs. Moreover, remediation of the large volumes of flowing water is not practical. The use of institutional controls is the only remedy considered for limiting human exposure to fish. Therefore, active remedies evaluated in the feasibility study focus on site-related contaminants of concern in sediment.

Four alternatives are evaluated in the feasibility study. Alternative 1, the no-action alternative, is required by CERCLA to be evaluated. As the name implies, this alternative would be easily implemented at no cost. However, the risk assessments indicate that the no-action alternative would not be protective of human health or the environment.

Alternative 2 consists of the use of institutional controls and advisories to reduce exposure to contaminants in fish and sediment. Although not empowered under CERCLA, the state of Tennessee, the Tennessee Valley Authority, and the U.S. Army Corps of Engineers each have separate regulatory authority to regulate activities that could result in the disturbance of sediment in the Clinch River and Poplar Creek. Each of these agencies is party to an interagency agreement with DOE that requires the multiagency review, on a case-by-case basis, of all permit applications that propose activities with the potential to disturb sediment. The state of Tennessee currently issues fish consumption advisories warning the public to avoid or limit consumption of certain species of fish in which contaminant levels are unacceptably high. The present worth cost of implementing alternative 2 for 30 years, including future monitoring and administrative costs, is estimated to be $3.6M.

Alternative 3 incorporates the institutional controls described in alternative 2 and in addition proposes the combined containment and removal of contaminated sediment from Poplar Creek. The presence of several contaminants in the sediment of Poplar Creek posed a risk to human health or benthic organisms. Seven separate locations in Poplar Creek would be remediated, through the use of a combination of sediment containment technologies in the near-shore areas (bottom elevation >733 ft msl) and sediment removal technologies in deep water areas (bottom elevation <733 ft msl). A total area of 388,800 ft^2 is proposed for containment, and a total of 179,250 yd^3 for removal (the top 3 ft of sediment), at a total present worth cost of $109.6M. Removal of the deep sediment would also address the potential for future risks to human health and the environment in the dredging scenario.

Alternative 4 also incorporates the institutional controls of alternative 2, but in addition it proposes the removal of contaminated sediment from Poplar Creek. Removal of those sediments in Poplar Creek that pose a human health or ecological risk would require the removal and safe disposal of approximately 226,500 yd^3 of sediment, at a total present worth cost of approximately $123.5M. Because benthic habitat extends bank-to-bank, addressing the existing ecological risk by removing sediment would also address both the existing human health risk in the near-shore scenario and the potential for future human health risk and ecological risk in the dredging scenario.

Appendix G

SELECTION OF PROCESS OPTIONS

G1. SELECTION OF REPRESENTATIVE PROCESS OPTIONS

This chapter describes technologies and process options retained from the first screening step, technical applicability, for further evaluation in terms of their implementability, effectiveness, and cost. One (or more) representative process option is selected and carried forward for further evaluation to represent the other process options in the technology group. This limits the number of options used in alternative development, but it allows flexibility to reevaluate other options at the proposed plan, the Record of Decision, or the remedial design stages. Options that are extremely difficult to implement, offer no significantly improved protection, or are very expensive will not be used for remedial alternative development.

Fish consumption and exposures to shallow (upper 15 cm exposed at winter pool) sediments are the main threats to human health identified that could reasonably occur. Exposure to deep (covered year round under water) sediments is an unlikely scenario. Deep sediment action technologies may become necessary if, for example, pathways of concern (linked to deep sediments) emerge that elevate human health or ecological risks to unacceptable levels. For this reason, applicable technologies and process options will be discussed with regard to effectiveness, implementability, and cost when possible with respect to deep sediments and retained as contingent options. However, selection of representative process options will not be determined on the basis of deep sediment criteria at this time.

A summary of the technologies retained from the first screening in Figure 8.1, Section 8.2 for site applicability are presented in Table G.1. Each process option is briefly described as to its site, contaminant, and remedial effectiveness, implementability, and cost. Representative process options for various technologies are indicated by bold type. The remaining process options are shown in shaded boxes. Following Table G.1 is a detailed discussion of technical aspects of site-applicable retained options, including effectiveness, implementability, cost, and selection of representative technologies.

G1.1 NO ACTION

This general response action does not initiate remedial action and assumes that present security measures that limit access are not maintained. Short- or long-term monitoring is also excluded. Although this scenario may not reflect current conditions, the purpose of the no action alternative is to provide a baseline for comparison with other alternatives, as required by the National Contingency Plan.

G1.2 INSTITUTIONAL CONTROLS AND ADVISORIES

Institutional controls include access and use restrictions and maintenance and monitoring. These actions can be used alone or in combination with other technologies to reduce the risk of exposure to contamination to acceptable levels. The objectives of access and use restrictions are (1) prevent prolonged exposure to contaminants, (2) control future development and disturbance of the Operable Unit (OU), and (3) ensure continued effectiveness of any engineered remedial actions.

Table G.1. Technology and process option screening summary

General response action	Remedial technology	Process options	Effectiveness	Implementability	Cost
No action	None	Not applicable	Will offer no additional protection	None	None
Institutional controls and advisories	Access use and restrictions	Deed restrictions	Effective in restricting activities on property owned by DOE which may be released for unrestricted use	Implementable for DOE-owned property	Negligible costs
		Public advisories	Effective in alerting people to fish consumption limits/prohibitions or water contact	Implementable and currently managed by TDEC	Negligible costs
		Permit program	Effective at restricting sediment-disturbing activities such as dredging	Implementable, in place, and currently administered jointly by COE, TDEC, and TVA	Negligible costs
		Land purchase/ condemnation	Effective in placing contaminated property under DOE control	Not currently necessary; no private properties identified with unacceptable contaminant levels	If necessary, costs could be high
		Physical barriers	Effective in limiting access to affected areas	Not difficult to implement	Medium capital; low O&M
	Maintenance and monitoring	Monitoring	Effective in detecting contaminant input changes to the system, human availability, or bioavailability	Not difficult to implement	Low capital; low O&M
		Surveillance and maintenance	Effective in ensuring other implemented options continue to perform as needed	Not difficult to implement	Low capital; medium O&M
Source containment	Capping (horizontal barriers)	Armorform	Effective initially for shallow sediment capping, but has an uncertain long-term reliability; not effective for deep sediments	Difficult to implement; will require large amounts of construction equipment, site preparation, and erosion/fugitive dust management during site preparation and cap construction phases	High capital; medium O&M

Table G.1 (continued)

General response action	Remedial technology	Process options	Effectiveness	Implementability	Cost
		Geomembrane cap	Effective for shallow sediment capping with good life expectancy, durability, and reliability; not effective for deep sediments	Difficult to implement; will require large amounts of construction equipment, site preparation, and erosion/fugitive dust management during site preparation and cap construction phases	High capital; low O&M
		Clean sediment	Effective for deep sediment capping, but may be subject to same erosion that removed original sediments and biotic intrusion	Difficult to implement; will potentially require periodic replacement of eroded sediments and is also susceptible to biotic intrusion	Medium capital; low O&M
Removal	Excavation	Mechanical	Effectively removes source material from shallow sediment areas; low effectiveness in submerged conditions	Difficult to implement; will require critical timing to execute removal during window of opportunity at winter pool	High capital; low O&M
	Dredging	Mechanical dredges	Effective in removal of source material under submerged conditions; removes material at high densities	Difficult to implement due to potentially increased levels of turbidity	High capital; medium O&M
		Hydraulic dredges	Effective in removal of source material under submerged conditions; removes material at relatively low densities	Difficult to implement; considerable amounts of water will require separation and potentially need treatment before disposal	High capital; medium O&M
		Pneumatic dredges	Effective in removal of source material under submerged conditions; removes material at high densities	Impractical for shallow areas	High capital; medium O&M

Table G.1 (continued)

General response action	Remedial technology	Process options	Effectiveness	Implementability	Cost
Turbidity minimization	Water turbidity minimization	Silt curtains	Effectively contains fugitive sediment; effectiveness may diminish as curtains may respond to fluctuations of moving water	Difficult to install, particularly over large areas; impermeable material reacts to changes in water levels and may break; may require frequent inspections for breaks	Low capital; low O&M
		Silt screens	Effectively contains fugitive sediment; effectiveness depends on filter mesh size and degree of turbidity	Difficult to implement, particularly over large areas; mesh material allows water to pass, but excessive turbidity can clog the material and cause breakage; may require frequent inspections for breaks	Low capital; low O&M
Ex situ treatment	Physicochemical	Chemical extraction/ soil washing	Effective in separating contaminants associated with fine sediment from coarse sediment	Implementability is poor because site sediments are predominantly fine silts and clays; volume reduction minimal	Medium capital; low to medium O&M
		Solidification/ stabilization	Effective in reducing mobility of certain contaminants to acceptable levels	Implementable for certain contaminants (e.g., arsenic); potentially reduces leachability to WAC levels	Medium capital; low O&M
		Chemical-precipitation/ flocculation	Effectively transforms dissolved ions in solution to a solid form causing changes in electrostatic charge and ion flocculation	Difficult to justify new treatment facilities, unless existing on-site facilities cannot treat waste water effluent from drained sediment	Medium capital; low to medium O&M
		Ion exchange	Effective in capturing contaminant ions in water by exchanging them with "donor" ions	Difficult to justify new treatment facilities, unless existing on-site facilities cannot treat waste water effluent from drained sediment	Medium capital; low to medium O&M

Table G.1 (continued)

General response action	Remedial technology	Process options	Effectiveness	Implementability	Cost
	Thermal	Incineration	Effectively removes volatiles (including mercury) from solids at high temperatures	Difficult; air emissions compliance limits off gas contaminants	High capital; high O&M
		Thermal desorption	Effectively removes volatiles (including mercury) from solids at low temperatures		
		Pyrolysis	Effectively removes volatiles (including mercury) from solids at high temperatures	Difficult; air emissions compliance limits off gas contaminants	Medium capital; low O&M
		Infrared thermal	Effectively removes volatiles (including mercury) from solids at low temperatures	Difficult; air emissions compliance limits off gas contaminants	Medium capital; low O&M
	Dewatering	Belt filter press	Effectively dewaters sediment slurry; may require several operating units to dewater large volumes	Implementable, but gravity drainage in sloping dewatering pad is simpler, more cost-effective means to accomplish same task	High capital; medium O&M
		Settling ponds	Effective in dewatering sediment slurry with high water content; not effective for slurry with high solids content	Minimal amounts of water removed during shallow sediment removal render settling ponds impractical; potentially viable in dredging scenario with large quantities of sediment removed at low solids densities	Medium capital; medium O&M
		Fly ash	Effective in absorbing small amounts of free water	Implementable, but increased volumes of treated material raise disposal costs	Low capital; low O&M
		Low temperature thermal heating	Effectivley drives off moisture from soils	Comparatively easy as low temperatures do not breach air emission limits for off gasses	Medium capital; low O&M

Table G.1 (continued)

General response action	Remedial technology	Process options	Effectiveness	Implementability	Cost
		Sloping dewatering pad	Effectively dewaters excavated sediment or sediment slurry with relatively high solids content	Somewhat difficult during site preparation and construction phase, but very low maintenance using gravity drainage and evaporation to dewater sediments	Medium capital; low O&M
Disposal	On-site sediment/ disposal	**Y-12 Plant Landfill V or VII**	Effective, but may have volume limitations and WAC considerations	Implementable, but would have to comply with WAC and TDEC approval	Low capital; low O&M
		Beneficial reuse	Effective for use as backfill at ORR	Implementable, but activity limits must be met and TDEC approval	Low capital; low O&M
	Off-site sediment/ disposal	**Envirocare**	Effective for disposition of dewatered solid low level or Class A mixed waste	Implementable, but difficult due to transport distance	High capital; medium O&M
	Water disposal	**Y-12 Plant West End Treatment Facility**	Effective for treatment and disposal of contaminated water removed from dewatered sediments	Implementable; consultation with wastewater treatment officials needed to schedule wastewater criteria and delivery timetable; potentially more cost-effective than construction of new facilities	High capital; medium O&M
	Waste transportation	**Trucks**	Effective in transporting material in and around on-site areas, but may require precautionary measures to avoid leakage of wet sediment	Implementable; trucks readily available, but precautions regarding leakage are largest concern to assess	Low capital; low O&M
		Rail	Effective for shipments to the western United States	Implementable for shipments of waste material over very long distances (e.g., Envirocare)	Medium capital; low O&M

COE = U.S. Army Corps of Engineers
DOE = U.S. Department of Energy
LLW = low-level radioactive waste
O&M = operation and maintenance
ORNL = Oak Ridge National Laboratory
TDEC = Tennessee Department of Environment and Conservation
TVA = Tennessee Valley Authority
WAC = waste acceptance criteria

G1.2.1 Access and Use Restrictions

- Deed Restrictions—Deed restrictions are legal covenants and notifications placed on property deeds that notify a potential buyer of the limitations on the use of affected property. They are legally binding limitations that can prevent development or other alterations of the property that could increase the health risk of contaminants. Deed restrictions are useful where contaminants lie on Department of Energy (DOE) property at depth and where release of the property can reasonably be expected in the future. For example, use of contaminated sediment or soil for agriculture, landfilling, or other excavation type activities could be prohibited. Irrigation for agriculture may also be excluded or limited depending on water quality.

- Public Advisories—Published and posted fish consumption, water contact, and/or water consumption advisories provide warnings concerning limitations on fish consumption, dermal contact with surface water, and consumption of surface water. Agricultural uses of surface water may be considered for advisory protection for such uses as limits on recommended livestock watering quantities or irrigation of food crops in certain areas. Some advisories are already in place in several waterways in the region, including Clinch River and Poplar Creek for fish consumption limits and/or water contact.

- Permit Programs—U.S. Army Corps of Engineers (USACE), Tennessee Department of Environment and Conservation, and the Tennessee Valley Authority (TVA) must issue a permit before sediment-disturbing activities in the affected area are allowed, whether for maintenance of minimum navigable channel depths, use as aggregate, or for any other similar activity.

- Land Purchase—Land purchase/condemnation is the acquisition of property that is not owned or within the control of DOE and is affected by unacceptable levels of contaminants released by DOE. This option may be considered to place the property under DOE administrative control. In the event that the affected portion of the property presents an unacceptable health hazard and neither purchase nor any other means of risk reduction can be agreed on by the property owner and DOE, then condemnation of some or all of the affected property may become necessary in order to place the property under DOE control and thereby restrict access to it. Currently, no property outside of DOE property has been identified with contaminants with ECR above 1.0×10^{-4} or HI > 1.0 in shallow sediments. No deep sediment contamination has been identified on private property. Deep sediments lie in main channel areas managed by TVA and USACE and would not be available for purchase.

- Physical Barriers—Physical barriers include, but are not limited to, erected fences or similar barricades around the perimeter of a contaminated area that limits access to a site. To maintain and/or enhance effectiveness of the fence, an active, periodic patrol, warning signs, and an active public information program are recommended. Warning signs in fenced areas may offer site-specific information tailored to the area, which contains information in addition to the routine warnings currently in place regarding fish consumption and water contact.

G1.2.1.1 Effectiveness

All of the access and use restrictions can be effective in long-term management of contaminants if sustained and managed properly.

G1.2.1.2 Implementability

All of the access and use restrictions can be implemented with minimal difficulty, except for land purchase/condemnation which is very difficult.

G1.2.1.3 Cost

All access and use restriction process options are comparatively inexpensive relative to active remedial process options outlined in Sections G.1—G.7, except land purchase/condemnation which would vary according to size and land value.

G1.2.1.4 Selection of representative process option(s)

All access and use restriction process options will be carried forward as representative process options, except land purchase/condemnation. Currently, no private property has been identified as having contaminated shallow sediment with unacceptable risk. Redistribution of contaminants may elevate risk on private property to unacceptable levels, at which time land purchase/condemnation may be reevaluated.

G1.2.2 Maintenance and Monitoring

- Monitoring—Long-term monitoring of contaminant levels in water, sediment, and biota is used primarily to identify changes in conditions, evaluate the effectiveness of the chosen remedial action, determine whether adjustments or additional process options are needed, and determine whether existing or future receptors are threatened. Short-term monitoring with frequent sampling may be used to identify changes that arise due to planned sediment-disturbing activities, such as dredging or during implementation of remedial actions where release of potential contaminants from sediment could occur. More frequent monitoring would allow for timely detection of contaminants and subsequent appropriate measures implemented. Examples of OU monitoring include:

- Surface sediment grab samples used in determining the nature and extent of contaminants in sediment. They can serve both as a measure of existing site conditions as it relates to isolating areas targeted for remedial action and as a means of detection in condition changes, such as redistribution of, or, new sources of contaminants.

- Biological samples taken of aquatic, benthic, and piscivorous organisms used to characterize effects from contaminants, which are useful in documenting and evaluating site conditions.

- Surface water samples taken to monitor the water quality at various points along the OU. Monitoring the water can detect new sources or changes in existing sources, which can verify that controls placed on the OU or remedial actions are performing satisfactorily to keep contaminants immobilized.

- Surveillance and Maintenance—Routine surveillance and maintenance would include physical site surveys and maintenance, as needed, to verify and ensure the integrity of any engineered controls or devices (e.g., caps or fences). These process options are used to ensure or verify that the objectives have been and continue to be met. They are all implementable.

G1.2.2.1 Effectiveness

The maintenance and monitoring process options can be effective in long-term management of wastes if instituted and managed properly.

The effectiveness of this response depends on its continued implementation. Access restrictions are subject to change in political jurisdiction, legal interpretations, and regulatory enforcement, and require maintenance of physical barriers.

G1.2.2.2 Implementability

The maintenance and monitoring process options can be implemented with minimal difficulty.

G1.2.2.3 Cost

Maintenance and monitoring process options are comparatively inexpensive.

Cost of maintenance and monitoring activities depends on their scope, frequency, and duration, which in turn, depends on the remedial action alternative selected.

G1.2.2.4 Selection of representative process option(s)

All monitoring and surveillance and maintenance process options are effective, implementable, and cost little. All are carried forward as representative process options for assembly into remedial alternative actions.

G1.3 SOURCE CONTAINMENT

OU-applicable containment technologies include capping. This technology isolates the source of contamination, which remains in place, from human contact or migration to the environment.

G1.3.1 Capping (horizontal barriers)

Capping technology is intended to (1) minimize release of near-shore contaminants by wind or water erosion, (2) isolate shallow sediments from contact by humans or biota, and (3) potentially cover deep sediments should they be uncovered by scouring or similar means. Capping technologies consist of Armorform, geomembrane, and clean sediment covers.

Construction of a cap or cover near or on shore would involve secondary technologies such as clearing, grubbing, erosion control, waste compaction, and regrading before placement of the cap. In general, capping is performed when an extensive quantity of waste materials at a site precludes excavation, costs to remove the material are prohibitive, and/or more extensive remediation is not warranted based on site risks. The main disadvantages of capping are the need for long-term maintenance and uncertain design life. Caps must be periodically inspected for settlement, erosion, and intrusion by animals and deep-rooted vegetation.

Armorform is a double layer woven fabric engineered exclusively to serve as a form for casting concrete erosion control revetments and linings. Armorform is placed on the bottom of a waterway and filled with clean mortar. The permeable panels retain solids and allow excess water to escape as the solids harden into a concrete structure.

Geomembrane cap construction places an impermeable layer of synthetic material which is placed over contaminated sediments. It is covered by a filter fabric, which protects the geomembrane from the layer of riprap that is placed on top of the filter fabric. The entire cap is secured by an anchor trench approximately 0.3 m (1 ft) wide by 0.6 m (2 ft) deep. The trench runs parallel to the waterway and may be backfilled with clean sediment, concrete, or riprap. The riprap offers good protection from wind and water erosion, as well as, increase shoreline stability and also decrease availability of contaminants.

Clean sediment can be used to cap contaminated sediments in the deep channel areas. Isolation of contaminated sediments may be necessary where cleaner overlying sediments are thin or nonexistent. Clean sediment can be dumped in large quantities from barges over areas in deep water or placed by equipment such as a backhoe in confined or shallow areas.

G1.3.1.1 Effectiveness

For shoreline capping, the geomembrane cap is more effective in the long-term because reliability and stability are greater than that of Armorform. Armorform reliability is expected to diminish comparatively quickly as the concrete ages and cracks, weakening the overall stability of the cap. The geomembrane riprap cover withstands most stresses and, if necessary, replacement of any riprap cover can be done more easily and quickly than replacement of concrete casts. For deep sediments, neither Armorform nor geomembrane caps are considered effective in submerged conditions and reliability of these options would be uncertain.

Clean sediment placed over contaminated deep sediment would be effective although protection may be short-lived because any area where contaminants are exposed due to erosion will likely continue eroding any added sediment. Replenishment of clean sediment may be necessary for this option to remain effective. Biotic action may also compromise the integrity of this cap in either deep or shallow areas.

G.1.3.1.2 Implementability

Implementability of either an Armorform or a geomembrane cap will be difficult, but feasible for shallow sediments. Both require extensive amounts of construction from site preparation to cap construction to closure. Implementation of these are not be technically feasible in deep sediments.

Implementability of placing clean sediment over deep sediments is feasible, but area, depth, and water speed in which sediment cover is needed governs the level of difficulty. Implementation would probably be best when water is lower and speeds are slowed. This minimizes the amount of clean sediment drift away from the area intended for coverage.

G1.3.1.3 Cost

Costs for Armorform or geomembrane cap installation will be high. Significant amounts of site preparation and cap construction require heavy equipment to clear brush and river debris. Armorform may be somewhat higher in materials costs due to the specialized nature of the forms and may require more frequent inspections and potentially more maintenance costs. Geomembrane cap material is comparatively cheaper, but requires somewhat more labor to place two layers of geotextile, geomembrane, and carefully placed riprap on top. Inspection frequency would be comparatively less for the geomembrane cap as erosion resistance and stability are considered to be better than Armorform; therefore, inspection costs would be less.

Clean sediment costs are moderately high. Sediment itself is relatively cheap depending on the amount needed. Initial placement costs of the sediment will vary according to the area intended for coverage. Large areas, mainly in the open channel, will be covered comparatively quickly and efficiently from barge dumping as most of the sediment covers the bottom by gravity settling. However, costs will increase due to the amount of sediment being used and the use of multiple barges to carry the material from the clean sediment source to its final destination. Small isolated coverages will require typically less sediment, but generally more labor to place the material. Its use in deep water would be extremely costly and the life expectancy low. Armorform requires a considerable amount of time to install and requires periodic inspections and maintenance to ensure that cap integrity remains intact.

G1.3.1.4 Selection of representative process option(s)

Implementability and cost for Armorform or the geomembrane cap are roughly the same, but uncertain performance of the Armorform makes it less desirable. The geomembrane cap is selected as the representative process option for capping shallow sediments, based on greater reliability and durability at comparable cost.

Placement of clean sediment over deep sediments is not chosen at this time as a representative process option due to uncertain reliability, but is site-applicable and retained as a contingent action mainly for deep sediments.

G1.4 REMOVAL

Removal technologies include mechanical excavation and mechanical, hydraulic, and pneumatic dredging of contaminated sediments. These technologies may be used in combination with a dewatering treatment (Sect. 1.6.4), other ex situ treatments (Sects. 1.6.1–3), and/or disposal technology (Sect. 1.7).

G1.4.1 Excavation

Mechanical excavation as discussed in this document is the physical removal of sediment typically using machinery such as backhoes, trackhoes, front-end loaders, bulldozers, clamshells, and draglines. Some units may be mounted on rubber tires (backhoes) that can be used for fast excavations on stable working surfaces. Other track-mounted units (trackhoes and bulldozers) can be used in areas where slippery traction may hinder mobility of tire-mounted types. A general excavation sequence might be as follows.

1. Construct site access (haul roads, etc.), avoiding any wetlands destruction or threatened or endangered plant or animal species destruction.

2. Prepare the site, including silt fences for run-on diversion and runoff control. Scrape sediment to a predetermined depth using a backhoe, trackhoe, front-end loader, or similar device.

3. Load sediment into lined trucks.

4. Transport material to an appropriate treatment area or disposal facility.

5. Cover open, incomplete excavations with a tarp to inhibit precipitation and potential erosion.

6. Seed and mulch disturbed areas above summer pool is recommended. Replacement of sediment is probably unnecessary.

G1.4.2 Dredging

Dredges remove sediment covered by water by dislodging sediment, lifting the sediment, and either transporting it directly to shore or to a temporary staging point (e.g., a barge) pending transport to shore. Three basic types of dredges are effective at removing contaminated sediments: mechanical, hydraulic, and pneumatic.

Mechanical dredges dislodge the sediment using mechanical equipment and dig the sediment as the means for removal. The principal advantage of this type dredge is that the density of the removed material is at or near the same as its in situ density, which means that less water is carried with the sediment, and that smaller volumes of water potentially require treatment. Types of mechanical dredges include bucket wheel dredges, clamshell dredges, and closed-bucket clamshell dredges.

Hydraulic dredges pump sediment in a slurry formed by suctioning the sediment. Some hydraulic dredges use mechanical agitation to loosen the sediment to a sufficient density so that it can be lifted and pumped. Slurry is typically transported across floating or pontoon-supported pipelines to shore. Examples of hydraulic dredges include plain suction, cutterhead, dustpan, hopper, and mud cat.

Pneumatic dredges operate principally by the motive force supplied by compressed air to dislodge the sediment which then is transported by pump to shore. The pneuma pump and the airlift dredge are types of pneumatic dredges.

G1.4.2.1 Effectiveness

Mechanical excavation is effective at removing shallow sediments during winter pool. Other than at winter pool, mechanical excavation remains effective at removing the sediment, although greater levels of turbidity will be generated and require stricter control over fugitive sediment. Careful handling of the saturated material would be necessary to prevent leaks or spills.

Mechanical and hydraulic dredges are effective in dredging shallow or deep sediments. Each is a proven process option type used at other sites to remove contaminated sediments under various conditions. Pneumatic dredges are not effective in shallow conditions. Efficiency of pneumatic dredges increases with water depth, making pneumatic dredges potentially well-suited for deep sediment removal. Dredging, in general, can be somewhat more advantageous in that sediment can be removed through piping to shore facilities, effectively reducing the amount of potential worker exposure.

G1.4.2.2 Implementability

Implementability of mechanical excavation in shallow sediments during winter pool is good compared to dredging. The added water recovered and the greater level of engineering controls necessary to contain fugitive sediment makes dredging more difficult to implement than excavation.

Some mechanical dredges can recover at or near in situ densities, but a certain amount of water contained in sediment pore space will be recovered along with the contaminated sediment and may be considered a waste stream that requires additional treatment and/or disposal. Hydraulic dredges operate in either shallow or deep sediment, but remove large amounts of water along with the sediment to form the slurry, which only increases the amount of water to potentially treat. Pneumatic dredges do not operate efficiently in shallow conditions and are considered implementable only in deep water where it is reported to remove sediment with a high solids content.

G1.4.2.3 Cost

Costs for removal, in general, will be high for capital expenditure and operations costs for either excavation or dredging. Neither technology has a clear cost advantage.

G1.4.2.4 Selection of representative process option(s)

Mechanical excavation is selected as the representative process option to remove contaminated shallow sediments based on greater ease of implementability and because there is typically less water to potentially recover and treat or dispose than with dredging.

Mechanical, hydraulic, and/or pneumatic dredges are site applicable, but are more difficult to use in removing contaminated shallow sediment. Pneumatic dredges will be retained for deep sediment removal.

G1.5 TURBIDITY MINIMIZATION

During removal or containment, sediments may be resuspended in surface water, transported downstream, and deposited on the sediment surface, where it may be available to biota or humans. Turbidity minimization technologies can mitigate adverse effects of sediment resuspension.

G1.5.1 Water Turbidity Minimization

Turbid water minimization limits the amount of fugitive sediment resulting from other remedial actions. Isolation and capture of this sediment diminishes potential risks that may have otherwise risen due to increases of available contaminants leaving the active work site.

Silt curtains are impervious barriers that extend vertically from the water surface to a specified depth. Flexible nylon-reinforced polyvinyl chloride (or similar) fabric forms the barrier and is maintained in a vertical position by flotation segments at the top and a ballast chain (for weight) along the bottom. Tension cables are built into the curtain just below the flotation segment and repeated at some distance(s) below the flotation segment to reinforce the curtain against currents and other hydrodynamic forces. Anchor lines hold the curtain in place in circular or arc-shaped fashion. Silt curtain effectiveness depends on the degree of suspended silt behind the barrier, curtain configuration, mooring, and especially the hydrodynamics of the system.

Silt screens are synthetic geotextile fabrics that allow water to pass through small openings in the fabric yet retain the silt. Mesh size of the material determines the size of particles that can pass. Typical mesh sizes are 70–100 United States standard sieve. The advantage silt screens have over silt curtains is that they can be extended to the bottom sediment. It is suspended at the top by a line of floats and anchored to the bottom. Excess material is installed and allowed to drape at the bottom.

This will allow the slack to be taken up during water level rises without stressing the fabric. The mesh size selection must be small enough to capture the smallest size target particle, yet not clog and reduce water flow. Clogged screens may not properly respond to fluctuations in flow rate or water level and may break.

G1.5.1.1 Effectiveness

Silt screens and silt curtains are effective in retaining fugitive sediments during operations that disturb sediment (e.g., dredging). These process options are not effective for containment or excavation actions because these are conducted when shallow sediments are subaerially exposed.

G1.5.1.2 Implementability

Silt curtains or screens are moderately difficult to install and inspect and maintain for breaks in the material, which would allow potentially contaminated material to escape.

G1.5.1.3 Cost

Costs for these process options will be relatively high and depend on the area to be effectively isolated, and inspection and repairs.

G1.5.1.4 Selection of representative process option(s)

Since both process options are not effective for other than submerged conditions, dredging was not selected as a representative process option, and mechanical excavation is based on removal of shallow sediments exposed at winter pool water level, these will not be selected as representative process options. Either silt curtains or silt screens or both are considered effective, implementable, and cost-effective when used for dredging or similar submerged sediment-disturbing activities and will be retained on a contingent basis.

G1.6 EX SITU TREATMENT

Treatment is used to reduce volume, mobility, or toxicity of a waste. The treatment technologies remaining after the initial technical applicability screening include physicochemical treatment, thermal treatment, and dewatering.

G1.6.1 Physicochemical

A significant number of technically applicable sediment physicochemical treatment process options exist, including chemical extraction/soil washing, solidification/stabilization, dehalogenation, precipitation/flocculation, and ion exchange.

Chemical extraction/soil washing targets contaminants sorbed onto sediment particles, which tend to associate with fine particles. Soil washing separates these from the coarser particles in an aqueous-based system. The wash water may be augmented with a surfactant, pH adjustment, or chelating agent to help remove organics or heavy metals, including radionuclides. This technology offers potential for leaching out contaminants from coarse-grained sediments. The wash fluids and fine-grained sediments are residuals that may need further treatment and/or disposal. Clean coarse-grained sediments can be returned to the site. Soil washing will not be carried forward because large amounts of fine-grained sediment in the OU will not significantly reduce the amount of waste material to be either additionally treated or disposed of..

Solidification/stabilization can do one or more of the following: improve the handling and physical nature of the sediments, as in free water sorption; decrease the surface area of the waste mass across which transfer or loss of contaminants can occur; and limit the solubility of any hazardous constituents in the waste. Solidification technology adds a reagent to transform the sediments into a solid. Liquid or semi-solid waste tends to become solidified, thus improving the handling and physical nature of the material. Solidification encapsulates the waste into a structurally stable solid. Solidification is achieved by either decreasing the surface area of the waste or surrounding the waste in an impervious capsule. The contaminated sediment is mixed with water and a binding agent and allowed to cure into a solidified mass. Stabilization reduces the mobility of a contaminant by converting COC(s) into less mobile or toxic forms. Wastes that leach heavy metals or other contaminants can be stabilized to immobilize the hazardous contaminants. Although the contaminant is immobilized, the waste may maintain its original physical nature and handling characteristics. Stabilization/solidification can be accomplished by use of cement-based materials, pozzulanic-based materials (silicon dioxide), thermoplastic, and organic polymer materials.

Chemical precipitation/flocculation is a process in which dissolved chemical species such as toxic metals are transformed into a solid phase for removal. This process is primarily used to remove of metals. It decreases solubility of the contaminants either by pH adjustment or by adding chemicals which effectively reduce the electrostatic repulsion inherent in ions, thus causing them to come together due to their net attractive surface charges. The Oak Ridge Reservation (ORR) facilities have the system for treating contaminated water.

Ion exchange is an ex situ volume and toxicity reduction process to remove ionic species, principally inorganics, from aqueous waste streams. Ion exchange is based on use of specifically formulated resins and natural inorganic materials that have an exchangeable ion bound to the resin with a weak ionic bond. If the electrochemical potential of the ion to be recovered (contaminant) is greater than that of the exchangeable ion, the exchange ion goes into solution and the contaminant ion binds to the resin.

G1.6.1.1 Effectiveness

Chemical extraction/soil washing is effective if there is a high amount of coarse-grained material. Large amounts of coarse material will be removed and render a small amount of fine silt and clay with most or all of the contamination.

Solidification/stabilization will effectively reduce the mobility of inorganic contaminants and improve disposal options.

Water may be treated with ion exchange or chemical precipitation/flocculation effectively. Inorganics are the main contaminants in sediment that elevate risk to unacceptable levels. Any leachable portion of these that emanate from dewatering sediment may alter the water quality sufficiently to preclude discharge to the reservoir. Treatment with an ion exchanger for these contaminants may be necessary before other potential treatment steps (for water-borne contaminants that may have been acceptable in sediment, but not in water) or discharge to the reservoir.

No specific consideration was given for effectiveness in physicochemical treatment options applied to deep sediment contaminants, although those described previously (among others) may apply.

G1.6.1.2 Implementability

Chemical extraction/soil washing would be difficult to implement. It is anticipated that much of the site sediment will have a mixture of sands, silts, and clays, of which this process can treat. However, unless there is a significantly high proportion of sand in the OU, treatment with this process will yield little in the way of volume reduction.

Stabilization/solidification is moderately difficult to implement. Only those contaminants that cannot be treated to reduce concentrations by other options and would cause WAC failure for potential disposal sites can be segregated and stabilized to reduce leachability and thus be more acceptable to landfill WACs. The difficulty lies mainly in the amount of handling the sediment may require to segregate the material suitable for this option.

Chemical precipitation/flocculation and ion exchange can be implemented by constructing a dedicated on-site facility to treat the water specifically from site sediments. However, the possibility for this seems unlikely, in light of already constructed operating facilities at all three plants. Nevertheless, volumes or specific contaminants not within the capabilities of any of these treatment facilities may prompt construction of a dedicated facility or upgrade of existing facilities to treat this water.

No specific consideration was given for implementability in physicochemical treatment options applied to deep sediment contaminants, although those described previously (among others) may apply.

G1.6.1.3 Cost

Costs for all of the physicochemical treatments described previously will be high. All have high capital costs and high operating cost. Chemical precipitation/flocculation and ion exchange treatment facilities constructed specifically for the water from sediment is probably not cost effective considering the treatment facilities already in place.

G1.6.1.4 Selection of representative process option(s)

Stabilization/solidification is selected as a representative process option for its implementability and its effectiveness in reducing inorganic contaminant mobility. This option will reduce leachability for metals in sediment, particularly arsenic in McCoy Branch Embayment without overwhelmingly increasing waste volume for the entire waste stream. Volume increases will occur for the sediment to which the process is applied, but proper analysis and sediment waste stream segregation will reduce the amount of material requiring stabilization treatment. Also, some moisture in the sediment will not cause the option to become ineffective. Cement slurry will be added to the sediment and solidify the mass anyway.

Chemical extraction/soil washing was not selected as a representative process option because the reduction in volume is not significant enough to be cost effective. Potentially, little volume reduction would occur and the residual material, whatever its volume, would possibly require additional treatment such as stabilization/solidification before disposal.

Chemical precipitation/flocculation and ion exchange are not selected as representative process options. Both are site applicable and will be retained on a contingent basis, but existing facilities (see Sect. 1.7.2, water disposal) are more appropriate means of wastewater treatment at this time.

G1.6.2 Thermal Treatment

Thermal treatment uses elevated temperatures to destroy, detoxify, or physically stabilize hazardous wastes. The most site applicable thermal treatment is low-temperature thermal desorption (thermal desorption). Other thermal treatments were considered initially, but thermal desorption is the mitigating action chosen because mercury is present in portions of Poplar Creek at concentrations that may present unacceptable risk, and, when removed may fail Toxicity Characteristic Leaching Procedure (TCLP) analysis. Failure of TCLP can limit the number of disposal options as discussed later in Section 1.7.1.

Incineration is the incinerating of incomplete combustion, volatile, or off-gases in a device commonly referred to as an afterburner. Several of alternative incineration processes are available including fluidized bed, circulating bed combuster, and high-temperature slagging and rotary kiln. Fluidized bed and rotary kiln are the more widely available processes and have been used to treat hazardous materials.

Thermal desorption is a low-temperature means of removing volatile mercury (and many organic compounds, if present) from sediments. The system consists of a furnace in which the volatile mercury is desorbed from the waste feed. Desorbed organics and mercury are removed from the furnace by a purge gas and collected by a physical/chemical treatment or are destroyed in an afterburner.

Pyrolysis is the destruction of organic material in the absence of oxygen at a high temperature to reduce toxic organic constituents to elemental gas and water. The absence of oxygen allows separation of the waste into an organic fraction (gas) and an inorganic fraction (salts, metals, particulates) as char material.

Infrared thermal is a commercially available destruction process option that thermally ruptures the chemical bonds of molecules in the absence of oxygen and at high temperatures to reduce toxic organics to elemental gas and water.

G1.6.2.1 Effectiveness

Incinerators have a high destruction efficiency and are effective in treating mixed solid residues. Thermal desorption is very effective at removal of mercury contaminants from solid media (soils and sediments). Pyrolysis is also effective in the destruction of PCBs. Infrared thermal is also an effective treatment for other wastes containing halogenated and nonhalogenated organics, including PCBs. All the thermal processes are more effective than other physicochemical process options for destroying organic contaminants.

G1.6.2.2 Implementability

Implementability of thermal desorption is moderately difficult. Construction of a facility to process the material requires a high level of effort to install the primary equipment and support equipment needed to treat the sediment. However, the option operates at low temperature, thus air emissions permits would not normally be necessary because no off-gas contaminants would occur. Implementability is very good compared to other thermal treatments that operate at high temperatures and would likely require more strict operation controls to meet emissions standards.

G1.6.2.3 Cost

Cost for any of the identified thermal treatments is high, principally from initial capital costs. O&M cost is comparable to other ex situ treatments.

G1.6.2.4 Selection of representative process option(s)

Thermal desorption is selected as a representative process option for its effectiveness at reducing mercury concentrations. It is more cost efficient than most ex situ treatment options requiring specialized equipment to process contaminated sediment and has the advantage over other thermal treatments in that meeting air emissions requirements for this option are less difficult due to low-temperature operation. This process option is more than 99 percent efficient in removing volatile organic compounds from soil.

G1.6.3 Dewatering

The primary purpose of this process is to reduce the moisture content of slurries or sludges to expedite the handling and to prepare the material for further treatment or disposal. The water generated during dewatering may contain contaminants and suspended solids, and wastewater treatment may be necessary.

A belt filter press processes sediment slurry into sediment cakes by squeezing the water from the slurry as it passes across a rolling belt. Sediment is then more easily managed for any further treatment and/or disposal. Anticipated sediment volumes may require multiple units to process large volumes of sediment.

Settling ponds are constructed areas intended for impoundment of sediment/water slurry. Slurry is allowed to collect and by gravity, solids settle out of the water column. Collection of the water and separated sediment make each medium transportable and treatable. Settling ponds are useful when solids content of slurry is low.

Fly ash can be added to absorb free water in sediment slurry. Fly ash combines with the water to make the material easier to handle, transport, and dispose. Disposal (and most other treatment) criteria will necessitate the absence of free water in the material before waste acceptance. Fly ash does not reduce contaminant leachability.

A sloping dewatering pad is constructed sufficiently large enough to handle the volumes of sediment anticipated during implementation of sediment removal by excavation and/or dredging. It would be constructed such that drainage flow is directed toward the collection trench. A perimeter berm would be constructed around the facility to prevent wastewater leaving or run-on entering the facility. Water draining from the sediment will be collected in the trench and then pumped to temporary holding tanks. The net effect is two waste streams, each of which is easier to characterize and handle than previously as a mixture.

G1.6.3.1 Effectiveness

Belt filter presses are effective at actively removing free water from supersaturated sediments. Depending on the volume of sediment to dewater, the process can require several units running in parallel to continually process the sediment. The higher the water content the less efficient the process becomes, including longer process times.

Settling ponds are effective for sediment slurry separation where there is a high water content requiring separation from the solids. Effectiveness for the minimal amounts of water removed during excavation makes this option unsuitable.

Addition of fly ash is effective in absorbing small amounts of free water. Supersaturated sediment is probably not effectively treated by solely adding fly ash. Volume increases are such that the amount of fly ash needed to absorb large amounts of water will prohibitively raise the volume of total material to be disposed.

Sloping dewatering pads are effective at allowing natural processes to dewater sediment. Gravity drainage and evaporation would remove most or all the free water. Proper construction can effectively restrain contamination migration from the pad.

G1.6.3.2 Implementability

A belt filter press is commercially available, but several units may be required to dewater the sediment in a reasonable period of time.

Settling ponds are site applicable, but anticipated volumes of water/sediment slurry are probably not large enough (when excavated) to necessitate implementation of settling ponds which are perhaps most suitable for slurries with generally low solids content.

Fly ash is easily implemented, especially for the anticipated amounts of water brought in by excavating sediment; implementation for high water content sediment would be considerably more difficult.

Sloping dewatering pads would have a somewhat high initial difficulty in construction of the pad, but long-term operation difficulty would be very small because the dewatering process is basically passive.

G1.6.3.3 Cost

Capital cost and O&M cost for belt filter presses are high.

Land acquisition and construction of settling ponds cause this option to be costly. Actual costs depend largely on the expected solids content of the sediment slurry being recovered, the time for a slurry to separate adequately, and the area needed to stage the slurry while it separates.

Fly ash increases the volume of the material to be treated or disposed, raising the costs for both. Contaminated material that meets WAC of potential disposal sites without treatment(s) to reduce contaminant concentrations, mobility, etc. may be treated with only fly ash and sent directly to the disposal facility with modest increases of volume. Material that requires some form of treatment other than free water removal costs significantly more to treat the additional volume and may be considered cost prohibitive.

Cost for a sloping dewatering pad will largely be initial capital cost. Operation cost for only the pad will be minor for maintenance of the pad. Treatment cost is very low because sunlight, air, and gravity dewater the sediment naturally.

G1.6.3.4 Selection of representative process option(s)

Sloping dewatering pad is the selected dewatering treatment option. Operation of the pad is simple and cost effective. Belt filter presses cost more to operate and maintain. Expected water from excavation of shallow sediment is low, which precludes settling ponds. Fly ash is effective at binding with the small amounts of expected free water, but it does not reduce contaminant leachability, and any further treatment(s) or disposal costs will rise because of increased volumes.

G1.7 DISPOSAL

G1.7.1 On-Site Sediment Disposal

This action provides long-term containment and/or isolation of contaminated dredged material, or based on confirmatory sampling, the sediment could be placed on site if it meets applicable regulatory requirements. Characterization of dewatered sediment is imperative to determine the proper handling and disposal method. Radiological surveys and analysis as well as TCLP analysis needs to be performed.

The following discusses the general on-site/off-site disposal options for the sediment. As more specific characterization data become available, some of the disposal options presented will not be available due to potential contaminants and/or inability of the waste to meet disposal facility WAC.

With regard to on-site disposal options, it is very unlikely that a new disposal facility (cell) will be designed, constructed, and operated for Clinch River/Poplar Creek sediments only. Regulatory design criteria, volume, and cost are all factors which make implementation of this option difficult. Cost of developing the cell outweighs the anticipated volume of sediment to be disposed of. Also, regulatory drivers such as land disposal restrictions, waivers, and special waste permits necessitate additional administrative burdens that potentially increase costs, further decreasing feasibility. However, a cell is being constructed at Y-12 LF V to accommodate Lower East Fork Poplar Creek flood plain soils. This cell will have ample capacity to handle the Lower East Fork Poplar Creek floodplain soils and may be potential disposition option for a portion of the dredged Clinch River/Poplar Creek sediments.

G1.7.1.1 Effectiveness

Using an engineered LF would be effective at reducing site risks to humans and ecological receptors. Availability of this option is questionable for disposal of sediments. The effectiveness of this option is high due to an appropriately engineered disposal site with respect to reducing site, human, and ecological risks.

Reclamation of contaminants from sediments and recycling them for economical reuse can be effective at reducing site risks from contaminants.

G1.7.1.2 Implementability

Landfill disposal will be difficult to implement, but no more so than any other potential on-site disposal option. Implementability for this option or any on-site disposal option is probably the most implementable as compared to off-site disposal options, based on transportation requirements and costs, and especially elevated disposal costs.

G1.7.1.3 Cost

Cost for onsite landfill disposal at Y-12 (or any other on-site facility) is high, but likely less than any off-site disposal options.

G1.7.1.4 Selection of representative process option(s)

The Y-12 Landfill is chosen as the representative on-site sediment disposal process option. The other two site applicable process options are not very plausible, mainly based on low degree of implementability and comparatively high cost.

G1.7.2 Off-Site Sediment Disposal

An off-site disposal option that could be very expensive to implement is shipping the sediments to the Envirocare of Utah, Inc. (Envirocare) facility. This site is permitted to accept, store, and dispose of DOE-generated solid low-level Class A mixed waste. Consideration of this facility is restrained by the fact that costs to transport and dispose of untreated solid low-level or mixed waste is very high. Minimal treatment must involve dewatering because Envirocare will not accept waste with free liquids.

G1.7.2.1 Effectiveness

Envirocare is effective in reducing risks from OU contaminants in sediment. Envirocare is located in arid climates, which will reduce potential risks from leachable contaminants after disposal as well.

G1.7.2.2 Implementability

The Envirocare facility option is implementable. An agreement between DOE, USACE and Envirocare establishes facility acceptance of ORR solid LL or mixed wastes, which may eliminate certain treatment steps other than dewatering, reducing potential treatment costs.

G1.7.2.3 Cost

Envirocare is expensive. Generally, off-site disposal is very costly. Off-site mixed waste disposal is even more so. However, a certain amount of cost savings may be attributed to being able to forego treatment of the sediment (other than dewatering, which Envirocare WAC explicitly states no free liquids). Shipping the sediments as low-level versus mixed, based on analytical data, also greatly reduces costs.

Likewise, NTS is expensive. Since it does not accept mixed waste, treatment for certain RCRA metal contaminants may be necessary before acceptance by the facility.

G1.7.2.4 Selection of representative process option(s)

Envirocare is the selected representative off-site sediment disposal process option primarily for its ability to accept solid low-level as well as mixed waste. Risks to the OU are reduced and residual risks at the disposal facility are low due to climate and low potential for leaching.

G1.7.3 Water Disposal

Based on the existing limited data, only one disposal option has been identified for the disposal of the wastewaters obtained from the dewatering of the sediments. The West End Treatment Facility at the Y-12 Plant has been earmarked as the designated location. This is contingent on characterization results of the wastewaters and whether the treatment facility will be able to meet its National Pollutant Discharge Elimination System (NPDES) effluent limits. Consultation with facility officials is necessary to determine wastewater and facility limitations as well as scheduling amounts and delivery times.

G1.7.3.1 Effectiveness

The treatment facility is effective in removing the potential contaminants detected in OU sampling that may occur in drainage from removed sediments. Effectiveness will remain good assuming contaminant types and concentrations remain in the treatability range of the facility.

G1.7.3.2 Implementability

Implementability of treating water at this facility is good, so long as the facility is aware of the anticipated volumes requiring treatment, can meet its NPDES limits, and the contaminant profile remains consistent. Consistency of concentrations of existing contaminants are not anticipated to vary significantly, or, new contaminants to appear that are out of the treatment abilities of the facility. If these situations arise, a pre-treatment for these added contaminants or an alternate treatment facility may be necessary before final disposal.

G1.7.3.3 Cost

Costs for this facility are anticipated to be good. Generally on-site treatments are less expensive than off-site treatment or disposal.

G1.7.3.4 Selection of representative process option(s)

The Y-12 Plant West End Treatment Facility is selected as a representative process option. Effectiveness for OU contaminants currently identified is good. Implementability can be good, but communication with the facility is important in coordinating wastewater delivery and ensuring the facility can meet its NPDES effluent requirements.

G1.7.4 Waste Transportation

Trucks can haul saturated or dewatered sediment. Sediment being sent for dewatering would have the trucks lined to prevent leakage. Sediment not requiring treatment, once dewatered, can also be transported on site by truck.

Water derived from dewatering the sediment that fails to meet criteria for release back to the reservoir can be hauled to the West End Treatment Facility by tanker truck or have smaller polyethylene tanks loaded on flat-bed trucks to haul, depending on volume.

Rail transport of dewatered sediment can send untreated sediment to Envirocare in Utah in B-25 boxes. U.S. Department of Transportation (DOT) requirements for rail transport state that the material be packaged in "strong tight" containers specified in 49 CFR 173.

G1.7.4.1 Effectiveness

Truck transportation is good for hauling material around the ORR site to any of the on-site storage/disposal facilities.

G1.7.4.2 Implementability

Implementability may be difficult for either truck transport or rail transport. Transport of the sediment to the dewatering pad for free water removal is a primary consideration. Leakage from saturated sediments may be a public health hazard and must be avoided. Access road construction to individual areas for trucks to enter and exit will diminish ease of implementability due to the level of construction needed to access some of these areas at the site. Rail transport requires the same access roads to get the sediment out of individual sites, lining of trucks, and dewatering of sediment. Moreover, rail transport necessitates the material be brought to a suitable area with a railroad spur where the material can be packaged and loaded for transport. Water transport is easily implemented, assuming the infrastructure built for trucks to access the dewatering pad is in place.

G1.7.4.3 Cost

Transport cost for on-site transport via trucks is comparatively low. Transport of saturated sediment will likely incur the highest portion of cost due to the necessary precautions added to prevent spills or leakage. On-site transport cost of dewatered sediment is expected to be relatively low. Based on existing contaminant data for shallow sediments, dewatered material should be considered stable because leakage of liquids would no longer pose a threat. Spillage of solids would be avoided, but could be managed with relative ease. Water transport cost is also considered low. Rail transport is relatively high. The distance to be shipped and DOT requirements for shipping mixed waste increase for rail transport cost.

G1.7.4.4 Selection of representative process option(s)

Trucks for sediment and water transport on site, and, rail transport for sediment unsuitable for on-site storage or disposal are selected as representative process options. All are implementable and effective. Depending on the disposal option selected, cost can range from low for on-site trucking to high for rail transport off site.

Appendix H

COST ESTIMATES

H1. ALTERNATIVE 2—INSTITUTIONAL CONTROLS AND ADVISORIES

H1.1 GENERAL ASSUMPTIONS

- The estimate has been prepared in Automated Estimating System (AES) format using the ERNOV95a.val standard value file for labor and escalation rates.
- Costs for public advisories and permit programs have been included in the estimated cost to cover only U.S. Department of Energy (DOE) cost, not other agencies.
- A project contingency of 25 percent has been applied to this estimate because of the level of design at the feasibility study stage.
- Supporting activities and participants required for project management, planning, and engineering have been included based on historical data and best engineering judgement.
- Monitoring costs are included at $150,000 per year. This estimated cost is based on the monitoring plan for Lower Watts Bar.

H1.2 WORK BREAKDOWN STRUCTURE

Below is the Work Breakdown Structure (WBS) to the 4th level with associated participants.

WBS	Title	Participant	Title
2.0	Alternative 2		
2.1	Capital Cost		
2.1.1	Direct Cost		
2.1.1.1	Deed Restriction	Z001	Special
2.1.1.2	Public Advisories	Z001	Special
2.1.1.3	Permit Programs	Z001	Special
2.1.2	Indirect Cost		
2.1.2.1	RA Integration	C087	Environmental Restoration
2.1.2.2	Remedial Action Work Plan	TS01	Tech. Support Contractor
2.2.1	Monitoring and Maintenance		
2.2.1.1	Monitoring	C004	Analytical Services

H1.3 PROJECT SCHEDULE

Below is the assumed project schedule used to prepare the estimate.

Activity	Start		End
Remedial Action Work Plan	12/01/96		02/01/97
Remedial Action	02/01/97		10/01/97
Monitoring and Maintenance	02/01/97	30 years	02/01/27

H1.4 REPORTS

The following AES reports are available from Jacobs Engineering Group Inc.:

- Summary Report per WBS/attribute/participant
- Detail Report
- Life-Cycle Cost Analysis (present value)

H2. ALTERNATIVE 3A—SOURCE CONTAINMENT

H2.1 GENERAL ASSUMPTIONS

- The estimate has been prepared in AES format using the ERNOV95a.val standard value file for labor and escalation rates.
- Cost for deed restrictions, public advisories, and permit programs have been included in the estimated cost to cover only DOE cost, not other agencies.
- A project contingency of 25 percent has been applied to this estimate because of the level of design at the feasibility study stage.
- Supporting activities and participants required for project management, planning, and engineering have been included based on historical data and best engineering judgement.
- Monitoring costs are included at $150,000 per year. This estimated cost is based on the monitoring plan for Lower Watts Bar.

H2.2 WORK BREAKDOWN STRUCTURE

Below is the WBS to the 4th level with associated participants.

WBS	Title	Participant	Title
3.0	Alternative 3A		
3.1	Capital Cost		
3.1.1	Direct Cost		
3.1.1.1	Deed Restriction	Z001	Special
3.1.1.2	Public Advisories	Z001	Special
3.1.1.3	Permit Programs	Z001	Special
3.1.1.4	Source Containment	MK51	MK-F FP Subcontractor
		MK66	MK-F Indirect on FP
		MK67	MK-F Directs on FP
3.1.2	Indirect Cost		
3.1.2.1	RA Integration	AE01	RD A/E
		C069	Central Engineering
		C087	Environmental Restoration
		SC01	Off-site Subcontractor
		TS01	Tech. Support Contractor

WBS	Title	Participant	Title
3.1.2.2	Remedial Design Work Plan	AE01	RD A/E
		C069	Central Engineering
		MK67	MK-F Directs on FP
		TS01	Tech. Support Contractor
3.1.2.3	Remedial Design Report	AE01	RD A/E
		C069	Central Engineering
		MK67	MK-F Directs on FP
		TS01	Tech. Support Contractor
		X035	OFC Env Compliance & Doc
3.1.2.4	Remedial Action Work Plan	AE01	RD A/E
		C069	Central Engineering
		MK67	MK-F Directs on FP
		TS01	Tech. Support Contractor
3.2.1	Monitoring and Maintenance		
3.2.1.1	Monitoring	C004	Analytical Services

H2.3 PROJECT SCHEDULE

Below is the assumed project schedule used to prepare the estimate.

Activity	Start		End
Remedial Design Work Plan	06/01/96		07/15/96
Remedial Design Report	07/01/96		10/15/96
Remedial Action Work Plan	10/15/96		01/01/97
Remedial Action	01/01/97		01/01/98
Monitoring and Maintenance	01/01/98	30 years	01/01/28

H2.4 REPORTS

The following AES reports are available from Jacobs Engineering Group Inc.:

- Summary Report per WBS/attribute/participant
- Detail Report
- Life-Cycle Cost Analysis (present value)

H3. ALTERNATIVE 3B—CONTAINMENT/REMOVAL

Alternative deleted.

H4. ALTERNATIVE 4A—REMOVAL—EXCAVATION ONLY

Alternative deleted.

H5. ALTERNATIVE 4B—REMOVAL—EXCAVATION/DREDGING

H5.1 GENERAL ASSUMPTIONS

- The estimate has been prepared in AES format using the ERNOV95a.val standard value file for labor and escalation rates.
- A project contingency of 25 percent has been applied to this estimate because of the level of design at the feasibility study stage.
- Supporting activities and participants required for project management, planning, and engineering have been included based on historical data and best engineering judgement.

H5.2 WORK BREAKDOWN STRUCTURE

Below is the WBS to the 4th level with associated participants.

WBS	Title	Participant	Title
3.0	Alternative 4		
3.1	Capital Cost		
3.1.1	Direct Cost		
3.1.1.1	Removal (Dredging/Excavation)	MK51	MK-F FP Subcontractor
		MK66	MK-F Indirect on FP
		MK67	MK-F Directs on FP
3.1.2	Indirect Cost		
3.1.2.1	RA Integration	AE01	RD A/E
		C069	Central Engineering
		C087	Environmental Restoration
		SC01	Off-site Subcontractor
		TS01	Tech. Support Contractor
3.1.2.2	Remedial Design Work Plan	AE01	RD A/E
		C069	Central Engineering
		MK67	MK-F Directs on FP
		TS01	Tech. Support Contractor
3.1.2.3	Remedial Design Report	AE01	RD A/E
		C069	Central Engineering
		MK67	MK-F Directs on FP
		TS01	Tech. Support Contractor
		X035	OFC Env Compliance & Doc
3.1.2.4	Remedial Action Work Plan	AE01	RD A/E
		C069	Central Engineering
		MK67	MK-F Directs on FP
		TS01	Tech. Support Contractor

H5.3 PROJECT SCHEDULE

Below is the assumed project schedule used to prepare the estimate.

Activity	Start	End
Remedial Design Work Plan	06/01/96	09/01/96
Remedial Design Report	09/01/96	03/01/97
Remedial Action Work Plan	03/01/97	06/01/97
Remedial Action	06/01/97	06/01/2000

H5.4 REPORTS

The following AES reports are available from Jacobs Engineering Group Inc.:

- Summary Report per WBS-3/WBS-4/participant
- Detail Report
- Life-Cycle Cost Analysis (present value)

Appendix I

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS—FURTHER DISCUSSION

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS— FURTHER DISCUSSION

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) was passed by Congress and signed into law on December 11, 1980 (Public Law 96-510). This act was intended to provide for "liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive waste disposal sites." The Superfund Amendments and Reauthorization Act (SARA), adopted on October 17, 1986 (Public Law 99-499), did not substantially alter the original structure of CERCLA but provided extensive amendments to it.

In particular, § 121(d) of CERCLA specifies that remedial actions for cleanup of hazardous substances must comply with requirements or standards under federal or more stringent state environmental laws that are applicable or relevant and appropriate to the hazardous substances or particular circumstances at a site. Inherent in the interpretation of applicable or relevant and appropriate requirements (ARARs) is the assumption that protection of human health and the environment is ensured.

The purpose of this report is to supply a preliminary list of available federal and state chemical-, location-, and action-specific ARARs for the remediation of the Clinch River/Poplar Creek operable unit (OU). CERCLA on-site remedial response actions must comply only with the substantive requirements of a regulation and not the administrative requirements to obtain federal, state, or local permits [CERCLA § 121(e) and Federal Facilities Agreement (FFA) § XXII]. CERCLA defines "on-site" to mean "the areal extent of contamination and all suitable areas in very close proximity" (40 *CFR* 300.5). To ensure that CERCLA response actions proceed as rapidly as possible, the U.S. Environmental Protection Agency (EPA) has reaffirmed this position in the final National Contingency Plan (NCP) (55 *FR* 8756, March 8, 1990). ***Substantive requirements*** pertain directly to the actions or conditions at a site; ***administrative requirements*** facilitate their implementation. EPA recognizes that certain of the administrative requirements, such as consultation with state agencies and reporting, are accomplished through the state involvement and public participation requirements of the NCP. These administrative requirements should be observed if they are useful in ensuring environmental protection at the site (55 *FR* 8757). It is assumed for development of ARARs for the Clinch River/Poplar Creek OU that all remedial activities are "on-site."

I1. CHEMICAL-SPECIFIC ARARs

"Chemical-specific requirements set health- or risk-based concentration limits or discharge limitations in various environmental media for specific hazardous substances, pollutants, or contaminants" (53 *FR* 51437). These requirements generally set protective cleanup levels for the chemicals of concern in the designated media or else indicate a safe level of discharge that may be incorporated when a specific remedial activity is being considered. A comparison of analytical results for surface water in the Clinch River, Poplar Creek, and McCoy Branch to TDEC ambient water quality criteria (AWQC) for protection of human health and aquatic organisms may be found in Appendix Tables B5–B7 (in Vol. 2). Those analytes that appear to exceed a criterion at one or more location are discussed in Sect. 3.2 and summarized in Table 3.3 of the Remedial Investigation (RI) Report. Arsenic and mercury exceed one or more of the criteria in several reaches of the Clinch River/Poplar Creek OU.

The presence of man-made radionuclides was compared with AWQC for domestic water supply (4 mrem/year), and it was found that the summed dose did not exceed the criterion.

I1.1 SURFACE WATER

The purpose of the Tennessee Water Quality Control Act [Tennessee Code Annotated (TCA) 69-3-102(b)] is "to abate existing pollution of the waters of Tennessee, to reclaim polluted waters, to prevent the future pollution of waters and to plan for the future use of the waters ...." The Tennessee Water Quality Control Act (TCA 69-3-103(33) defines "waters" of the State as "any and all water, public or private, on or beneath the surface of the ground, which are (sic) contained within, flow through, or border upon Tennessee or any portion thereof...."

Tennessee has promulgated implementing regulations to fully protect existing uses of all surface waters as established under the Water Quality Control Act. Under the Tennessee Water Quality Control Act, the Tennessee Water Quality Control Board has classified the Clinch River for domestic water supply, industrial water supply, fish and aquatic life, recreation, irrigation, livestock watering and wildlife uses, and navigation [Chap. 1200-4-4 of the Rules of the Tennessee Department of Environment and Conservation (TDEC)]. Poplar Creek from mile 0.0 to 0.5 is classified for all but domestic water supply and navigation. Poplar Creek from mile 0.5 to 5.5 and McCoy Branch are classified for fish and aquatic life, recreation, irrigation, livestock watering and wildlife uses.

As part of the federal requirement for a triennial review of state water quality standards, the TDEC Division of Water Pollution Control has promulgated amendments to Chaps. 1200-4-3 and 1200-4-4 of the Rules of the TDEC, which incorporate the SDWA MCLs as WQC for domestic water supplies (effective date July, 1995). A WQC for consumption of aquatic organisms and drinking water for waters classified for both recreation and domestic water supply (the Clinch River) has been promulgated, effective July, 1995. Additional criteria for protection of recreational uses include a WQC for consumption of aquatic organisms alone. Table I1 lists AWQC for arsenic and mercury for the designated uses of domestic water supply, recreation, and fish and aquatic life; table I2 additionally lists the AWQC as ARARs for Alternative 2.

I1.2 SEDIMENT

There is no federal or state legislation available governing cleanup criteria for protection of either humans or ecological receptors from contaminated sediments.

Table I1. Tennessee water quality criteria for designated water uses ($\mu g/L$)[a]

Chemical	Domestic water supply	Recreation[b]	Recreation[c]	Fish and aquatic life	
				CMC[d]	CCC[e]
Arsenic	50	0.18	1.4[e]	360	190
Mercury	2	0.14	0.15	2.4	0.012

[a]Rules of the TDEC, Chapter 1200-4-3.
[b]Consumption of drinking water and aquatic organisms (applicable to the Clinch River, which is designated for both domestic water supply and recreation).
[c]Ingestion of aquatic organisms only (applicable to Poplar Creek and McCoy Branch, which are designated for recreation only).
[d]CMC = criterion maximum concentration.
[e]CCC = criterion continuous concentration.

I2. RADIATION PROTECTION STANDARDS

Very few applicable standards are available for the cleanup of radioactive contamination at CERCLA sites. The Atomic Energy Act (AEA) of 1954 and its amendments delegated authority for control of nuclear energy to DOE, the U.S. Nuclear Regulatory Commission (NRC), and EPA. The requirements of DOE Order 5400.5 and DOE Order 5820.2A may be considered guidance for residual radiactivity left in place in the Clinch River/Poplar Creek OU or for the storage/disposal of low-level waste (LLW), respectively. DOE Order 5820.2A is discussed in 4.3.5 as action-specific "to be considered" (TBC) guidance.

DOE has proposed radiation protection requirements for the public and environment for all sources of exposure and from all DOE sources of radiation [10 *CFR* 834, Notice of Proposed Rulemaking (NPRM) 58 *FR* 16268, March 25, 1993; final rule expected May 1995]. The proposed rule, when final, would codify the requirements of DOE Order 5400.5. The radiation exposure limits as defined in proposed 10 *CFR* 834, "Radiation Protection of the Public and the Environment," are an effective dose equivalent of 100 mrem/year from all exposure pathways and all sources of radiation from remedial activities and from all other sources (excluding dose from radon and its decay products, diagnostic or therapeutic medical radiation exposures, consumer products, and natural background). In addition, effluent releases to surface water must not result in exposures to aquatic organisms that exceed an absorbed dose of 1 rad/d. The overriding principle of the regulation is that all releases of radioactive material shall be "as low as reasonably achievable" (ALARA). Until this rule is promulgated, it or DOE Order 5400.5 may be considered TBC guidance.

Residual radioactive material is defined in DOE Order 5400.5 as that level of radioactive material that is acceptable for use of property without restrictions on use. Residual concentrations of radionuclides in soils or sediments shall be derived using the basic dose limit of 100 mrem/year, and the DOE RESRAD model (Yu et al., 1993) with site-specific input parameters or any other pathways analysis model, with DOE approval.

I3. LOCATION-SPECIFIC ARARs

Location-specific requirements "set restrictions upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations" (53 *FR* 51437). Preconstruction activities performed for alternatives 3 and 4 (see Sect. 10.2.3 and Sect. 10.2.4 of the FS), such as building of access roads or removal of bank vegetation, as well as actual containment, construction, or dredging activities may trigger certain location-specific ARARs. The following location-specific ARARs will not apply to either the no-action (see Sect. 10.2.1 of the FS) or the institutional controls (See Sect. 10.2.2 of the FS) alternatives since no such activities will be performed.

I3.1 WETLANDS AND FLOODPLAINS

The Clinch River drainage basin includes a number of wetland areas that may require protection. If any preconstruction or construction activities would impact such wetlands, consideration should be given to Executive Order 11990 and 10 *CFR* 1022 for applicable requirements. In addition, a wetlands delineation of the area has identified federal jurisdictional wetlands in several reaches of the OU (see Sect. 2.7.2 of this RI Report). Action must be taken to avoid degradation or destruction of such federally delineated wetlands under §404 of the CWA, 33 *CFR* 323, and 40 *CFR* 230. Regulations protecting floodplains are found in Executive Order 11988 and 10 *CFR* 1022. Table I2 summarizes the substantive portions of these regulations.

I3.2 AQUATIC RESOURCES

As mentioned previously, CERCLA on-site remedial response actions must comply only with the substantive requirements of a regulation and not the administrative requirements to obtain federal, state, or local permits [CERCLA § 121(e)]. However, the Tennessee Valley Authority (TVA), the U. S. Army Corps of Engineers (USACE), and the TDEC Division of Water Pollution Control retain authority for approving activities impacting TVA lands, waters of the United States, or waters of the State, respectively.

I3.2.1 TVA Authority

The TVA Act § 26a regulates lands under TVA jurisdiction within the Tennessee River Valley. Sect. 26(a) requires that TVA approval be obtained prior to the "construction, operation, or maintenance of any dam, appurtenant works, or other obstruction affecting navigation, flood control, or public lands or reservations along or in the Tennessee River or any of its tributaries." On shore capping activities within the 100- or 500-year floodplain as well as other activities, such as road construction, may require a Section 26(a) authorization; use of TVA public use boat ramps for dredging operations might require land use permits.

I3.2.2 USACE Authority

The substantive requirements of the USACE authorization for activities occurring in navigable waters, under the authority of § 10 of the Rivers and Harbors Act (RHA), or waters of the United States, under the authority of § 404 of the Clean Water Act (CWA), may also be triggered (Table I2).

Table I2. ARARs[a] and TBC[b] guidance for alternatives 1–4 for the Clinch River/Poplar Creek OU

Actions	Requirements	Prerequisites	Citation
ALTERNATIVE 1 - NO ACTION	None	No remedial actions are implemented	OSWER[c] Directive 9234.2-01/FS-A
ALTERNATIVE 2 - INSTITUTIONAL CONTROLS			
Chemical- or radionuclide-specific	Must meet ambient water quality criteria for designated use. (See Table I1.)	Applicable to point source discharges to water of the state—relevant and appropriate for CERCLA remediation.	TDEC 1200-4-3 TDEC 1200-4-4
	Residual concentrations of radionuclides in soils shall be derived using the basic dose limit of 100 mrem/year, and the DOE[d] RESRAD[e] model with site-specific input paramenters	Residual radioactive materials left in place without restrictions - **TBC**	DOE Order 5400.5(IV)
	The general public must not receive an effective dose equivalent greater than 100 mrem/year	Dose received by the general public from all sources of radiation exposure and routine activities, including remedial action, at a DOE facility - **TBC**	DOE Order 5400.5
	All releases of radioactive material must be "as low as reasonably achievable" (ALARA)	Releases of radioactive material from DOE activities - **TBC**	DOE Order 5400.5
Location-specific	None		
Action-specific			
Institutional controls	Controls include periodic monitoring, as appropriate; appropriate shielding; physical barriers to prevent access, fences, warning signs, and restrictions on land use	Interim management of residual radioactive material above acceptable guidelines - **TBC**	DOE Order 5400.5(IV)(6)(c)
	Controls recommended for long-term management of contamination left in place include restrictions on land use, deed restrictions, well-drilling prohibitions, etc.	Long-term management of contamination left in place - **TBC**	40 CFR[f] 300.430(e)(3)
	DOE must supply existing sediment data and acquire additional data if needed.	In support of dredging operations - **applicable**	Interagency agreement for Watts Bar Reservoir Permit Coordination.
ALTERNATIVE 3 - CONTAINMENT, REMOVAL AND DISPOSAL			
Chemical- or radionuclide-specific	The general public must not receive an effective dose equivalent greater than 100 mrem/year	Dose received by the general public from all sources of radiation exposure and routine activities, including remedial action, at a DOE facility - **TBC**	DOE Order 5400.5

Table I2 (continued)

Actions	Requirements	Prerequisites	Citation
	All releases of radioactive material must be "as low as reasonably achievable" (ALARA)	Releases of radioactive material from DOE activities - **TBC**	DOE Order 5400.5
	Residual concentrations of radionuclides in soils shall be derived using the basic dose limit of 100 mrem/year, and the DOE RESRAD model with site-specific input paramenters	On-shore placement of residual radioactive materials without restrictions - **TBC**	DOE Order 5400.5(IV)
Location-specific			
Presence of wetlands as defined in Executive Order 11990 §7(c)	Whenever possible, actions involving federal activities and programs affecting land use must avoid or minimize adverse impacts on wetlands and act to preserve and enhance their natural and beneficial values. New construction in wetlands areas should be particularly avoided unless there are no practicable alternatives. Wetlands protection considerations shall be incorporated into planning, regulating, and decision-making processes	Actions taken in wetlands areas - **applicable**	Executive Order 11990; 10 CFR 1022
Presence of wetlands as defined in 40 *CFR* 230.3(t) and 33 *CFR* 328.3(b)	Action to avoid degradation or destruction of wetlands must be taken to the extent possible. Discharges for which there is a practicable alternative with less adverse impacts or those which would cause or contribute to significant degradation are prohibited	Actions taken in federally delineated wetlands areas - **applicable**	Clean Water Act §404 40 *CFR* 230 33 *CFR* 323
Activities in "waters of the U.S." as defined in 40 *CFR* 230.3	Compliance with the general and specific terms and conditions of NWP[g] 13 (*Bank Stabilization*), NWP 18 (*Minor Discharges*), NWP 38 (*Cleanup of Hazardous and Toxic Waste*), or others if authorized by COE[h] for minor adverse environmental effects *	Actions taken in "waters of the U.S." - **applicable**	33 CFR 330, Appendix A
	Notification to COE to ensure compliance with the substantive requirements of the individual permitting process for alterations to "waters of the U.S." which cause more than minimal individual or cumulative adverse environmental effects *	Actions taken in "waters of the U.S." - **applicable**	33 CFR 325.1
Within area encompassing or affecting waters of the state of Tennessee as defined in TCA[i] 69-3-103(32)	Discharge of "substances" into the waters of the state which "will result or will likely result in harm, potential harm or detriment to the health of animals, birds, fish, or aquatic life" is prohibited	Actions taken in "waters of the state" - **applicable**	TCA 69-3-101 *et seq.*
	Compliance with the substantive requirements of general or individual aquatic resource alteration permit process for bank stabilization, channel relocation, wetlands disturbance *	Actions taken in "waters of the state" - **applicable**	TDEC[j] 1200-4-7

Table I2 (continued)

Actions	Requirements	Prerequisites	Citation
Activities along or in waters regulated by the Tennessee Valley Authority (TVA)	TVA approval must be obtained for construction of any . . . obstruction affecting navigation, flood control, or public lands	Actions taken along or in the Tennessee River or any of its tributaries - **applicable**	TVA Act Para. 26(a)
Within "lowland and relatively flat areas adjoining inland and coastal waters and other flood-prone areas....." [Executive Order 11988 §6(c)	Action shall be taken to reduce the risk of flood loss, minimize the impact of floods on human safety, health and welfare, and restore and preserve the natural and beneficial values of floodplains during federal activities involving acquisition, management, and disposition of lands and facilities or conducting any federal activities and programs affecting land use. The potential effects of actions in floodplains shall be evaluated and consideration of flood hazards and floodplain management ensured. If action is taken in floodplains, alternatives that avoid adverse effects and incompatible development and minimize potential harms shall be considered	Actions taken in floodplains - **applicable**	Executive Order 11988; 10 CFR 1022
Presence of endangered or threatened species or critical habitat of such species as designated in 50 CFR 17, 50 CFR 226, or 50 CFR 227	Actions that jeopardize species/habitats must be avoided or appropriate mitigation measures taken. Consultation with Department of Interior and/or state agencies is required for CERCLA off-site activities and recommended for CERCLA on-site activities*	Action that is likely to jeopardize or adversely modify critical habitat - **applicable**	Endangered Species Act (16 USC 1531 *et seq.*); 50 CFR 402; Tennessee Rare Plant Protection and Conservation Act (TCA 11-26-201 *et seq.*)
Location encompassing a state-designated natural area	The scientific, scenic, recreational, and educational values of these areas must be preserved and steps taken to prevent impairment	Actions which are likely to impact or adversely modify designated natural areas - **applicable**	TCA 11-14-101 *et seq.*
Presence of archaeological and historical resources on public land	Consultation with Tennessee State Historic Preservation Officer and Advisory Council on Historic Preservation before the initiation of any ground-breaking activities for CERCLA actions*. Steps must be taken to mitigate adverse effects on such resources.	Action that would affect archaeological or historical resources - **applicable**	National Historic Preservation Act (16 USC 470; 36 CFR 800 *et seq.*)
Presence of cemetery	It is unlawful to intentionally desecrate a place of burial	Actions which would impact a cemetery - **applicable**	TCA 39-17-311
Action-specific			
Institutional controls	Controls include periodic monitoring, as appropriate; appropriate shielding; physical barriers to prevent access, fences, warning signs, and restrictions on land use	Interim management of residual radioactive material above acceptable guidelines - **TBC**	DOE Order 5400.5(IV)(6)(c)
	Controls recommended for long-term management of contamination left in place include restrictions on land use, deed restrictions, well-drilling prohibitions, etc.	Long-term management of contamination left in place above approved limits - **TBC**	40 CFR[f] 300.430(e)(3)

Table I2 (continued)

Actions	Requirements	Prerequisites	Citation
	DOE must supply existing sediment data and acquire additional data if needed	In support of dredging permit applications - **applicable**	Interagency Agreement for Watts Bar Reservoir Permit Coordination
Turbidity controls	Use sediment and erosion controls and best management practices to control run-off from construction activities at an industrial site that result in disturbances of 5 acres or greater total land	Construction activities disturbing 5 acres or greater total land at industrial sites - **applicable; relevant and appropriate for < 5 acres**	40 CFR 122 TDEC 1200-4-10-.05
	Prohibits the presence of turbidity in such amounts or of such character that will materially affect fish and aquatic life	Containment activities in "waters of the state" - **applicable**	TDEC 1200-4-3-.03(d)
	Requires that all cost effective and reasonable best management practices for nonpoint source control shall be implemented	Containment activities in "waters of the state" - **applicable**	TDEC 1200-4-3-.06
Fugitive dust controls during preconstruction activities (road building, bank stabilization), containment, and sediment treatment	Take reasonable precautions to prevent particulate matter from becoming airborne; no visible emissions are permitted beyond property boundary lines for more than 5 min/hr or 20 min/day.	Fugitive dust emissions - **applicable**	TDEC 1200-3-8-.01
Dredging activities	See "location-specific" ARARs above		
Waste characterization (sediments, dewatering fluids, treatment residues)	A person who generates solid waste must determine whether the waste is hazardous using various methods, including TCLP or application of knowledge of the hazardous characteristics of the waste based on information regarding the materials or processes used.	Generation of solid waste - **applicable**	40 CFR 262.11(b) 40 CFR 268.7 TDEC 1200-1-11-.03(1)(b)
Storage/disposal of dewatering/decontamination fluids	Must meet waste acceptance criteria (WAC) for the receiving facility	Requirement established by the receiving facility for acceptance of LLW designated for discharge from a permitted treatment facility - **TBC**	
	Must meet National Pollutant Discharge Elimination System (NPDES) permit limitations for any discharge via permitted outfalls	Point source discharge to "waters of the state" from a permitted outfall - **applicable**	TDEC 1200-4-10-.03
	Must ensure in-stream water quality criteria for the designated uses are met.	Point source discharge to "waters of the state" - **applicable**	TDEC 1200-4-3 TDEC 1200-4-4
Storage/disposal of sediments or treatment residues	Dispose of solid waste that is RCRA hazardous waste in a RCRA Subtitle C permitted facility if it meets permit requirements	Disposal of RCRA hazardous waste - **applicable**	40 CFR 262.12 TDEC 1200-1-11-.03(1)(c)

Table I2 (continued)

Actions	Requirements	Prerequisites	Citation
	For treatment of wastes subject to the ban on land disposal, attain the Universal Treatment Standards (UTS) if waste is to be land disposed; Best Demonstrated Technology (BDT) or any other technology may be used to atain UTS	Disposal of RCRA restricted waste - **applicable**	40 CFR 268.40 40 CFR 268.48 TDEC 1200-1-11-10
	Dispose of solid waste not classified as RCRA hazardous waste in a RCRA Subtitle D permitted facility if it meets permit requirements; TDEC "special waste approval" may be necessary	Disposal of solid waste - **applicable**	TDEC 1200-1-7-.01 *et seq.*
	Permits the on-site storage of LDR[h]-mixed waste for purposes other than accumulation	On-site storage of LDR mixed wastes - **applicable**	TDEC Commissioner's Order for the ORR Site Treatment Plan, October 2, 1995
	Must meet waste acceptance criteria for LLW[j] disposal facility	On-site disposal of LLW - **TBC**	DOE Order 5820.2A
	Soil containing PCBs at concentrations <50 ppm may be disposed of in a solid waste landfill as approved by the state	Disposal of soils containing PCBs - **applicable**	TDEC 1200-1-7-.08 TDEC 1200-1-7-.03
Storage/treatment of fluids or sediments in tanks	Must meet the minimum technology requirements for tanks	Storage of RCRA hazardous waste in tanks - **applicable**	40 CFR 264.190 *et seq.* TDEC 1200-1-11-.06(10)
	At closure, remove all hazardous waste and hazardous waste residues from tanks, discharge control equipment, and discharge confinement structures and manage as hazardous waste	Clean closure of tanks used to store RCRA hazardous waste - **applicable**	40 CFR 264.197(a) TDEC 1200-1-11-.06(10)
Off-site shipments of LLW or mixed waste	Must meet manifesting, packaging, labeling, marking, placarding, and recordkeeping requirements	Transportation of RCRA hazardous waste - **applicable**	40 CFR 262 40 CFR 263
	The waste must meet packaging, labeling, marking, placarding, manifest and pretransport requirements in accordance with Department of Transportation (DOT) regulations.	Transportation of radioactive materials above exempt quantities - **applicable**	49 *CFR* 172, 173, 175, 178, and 179; DOE Order 5480.3 (TBC)
	Exemption from the TDEC radiation protection regulations for radioactive material in individual quantities which do not exceed the applicable quantity set forth in Schedule RHS 8-3	Handling of radioactive materials above exempt quantities - **applicable**	TDEC 1200-2-10-.04(3)
	Licensing requirements for shipment and delivery	Delivery of licensable quantities of radioactive material to a disposal facility within the state - **applicable**	TDEC 1200-2-10-.32(4)
	Packaging requirements are based on the maximum activity of radioactive material in a package	Packaging of radioactive materials above exempt quantities for public transport - **applicable**	49 *CFR* 173.431; 49 *CFR* 173.433; 49 *CFR* 173.435 49 *CFR* 173.411

Table I2 (continued)

Actions	Requirements	Prerequisites	Citation
	Generators must certify prior to the shipment that the waste meets the waste acceptance criteria of the receiving facility.	Off-site disposal of LLW - TBC	DOE Order 5820.2A(III.3e)
	Requirements for off-site shipment of low-level waste		DOE Order 5820.2A(III.3g)
	DOE low-level waste shall be disposed of on the site at which it is generated, if practicable		DOE Order 5820.2A(III.3)
	Off-site disposal of low-level waste to a commercial facility requires an exemption from the on-site disposal requirements of DOE Order 5820.2A; requests for exemption must be approved by the Field Office		Lytle and Whitfield, 1993
ALTERNATIVE 4 - REMOVAL AND DISPOSAL	All ARARs the same as for Alternative 3		

Note: The remedial action alternatives discussed in the FS do not address remediation of surface water (see Sect. 8.1 of the FS); therefore, TDEC ambient water quality criteria (AWQC) are not included as chemical-specific ARARs on this table. However, surface water ARARs are discussed in Sect. 1.1 of this Appendix. The use by TDEC of fish advisories per TDEC 1200-4-3-.03(j) as institutional controls to give notice to the public of the potential or actual dangers of specific uses of polluted waters will ensure protection of human health in the OU (see Sect. 4.2).

[a]ARARs = applicable or relevant and appropriate requirements.
[b]TBC = to be considered; all entries on table are potential ARARs unless noted as TBC.
[c]OSWER = EPA Office of Solid Waste and Emergency Response.
[d]DOE = U.S. Department of Energy.
[e]RESRAD = residual radioactive materials guidelines.
[f]CFR = Code of Federal Regulations.
[g]NWP = Nationwide Permit.
[h]COE = U.S. Army Corps of Engineers
[i]TCA - Tennessee Code Annotated.
[j]TDEC = Tennessee Department of Environment and Conservation.

* = Although administrative and procedural requirements are not ARARs for on-site CERCLA activities, adherence to these steps ares strongly recommended by EPA because of the effectiveness of these procedures in identifying and protecting sensitive resources.

CERCLA activities must comply with the substantive requirements of any permitting process. USACE Regulatory Guidance Letter 85-7 and its extension adopt this policy for on-site EPA or State response actions at the location of the release or threatened release pursued under the authority of CERCLA.

The USACE has established the ordinary high water mark for impoundments to be the normal summer pool elevation; for Watts Bar Lake, this elevation is El. 741.0 mean sea level (msl). A regional survey by the USACE identified "navigable waters" in the area (Public Notice ORNOR-F86-23, May 8, 1986); Poplar Creek from its mouth to River Mile 18.3 has been designated as navigable water. However, no tributaries to Poplar Creek have received such a designation.

The USACE Nationwide Permit (NWP) program establishes USACE authorization for activities having minimal impact on "waters of the U.S." (33 *CFR* 330, Appendix A). NWP 38 authorizes activities required to effect the containment, stabilization, or removal of hazardous and toxic materials by a government agency with established legal or regulatory authority, provided the USACE District Engineer is notified in accordance with the "Notification" general condition [33 *CFR* 330, Appendix A(C)(13)]. Other NWPs that might apply are NWP 13 (*Bank Stabilization*) and NWP 18 (*Minor Discharges*).

If an activity does not meet all the requirements of a NWP, or involves alterations that cause more than minimal individual or cumulative adverse effects to waters of the United States, consultation with the USACE is recommended to ensure that the substantive requirements of an individual permit are met (33 *CFR* 325.1). Note that as mentioned previously, administrative and procedural requirements are not ARARs for on-site CERCLA activities. However, adherence to the USACE notification process is strongly recommended by EPA because of the effectiveness of the USACE permitting process in identifying and protecting sensitive resources.

I3.2.3 TDEC Authority

The substantive requirements of the TDEC Aquatic Resource Alteration regulations found at Chapter 1200-4-7 may be applicable to preconstruction or construction activities. General permit requirements exist for activities that would cause minimal individual or cumulative impacts to water quality, and include such activities as bank stabilization and debris removal.Consultation with TDEC is necessary to determine the substantive requirements for activities that cannot meet the conditions of the general permits, which include a prohibition of activities in waterways containing contaminated sediments. If any remedial actions at the Clinch River/Poplar Creek OU cannot be accomplished under the substantive general permit conditions, consultation with TDEC is recommended to ensure that TDEC is aware of the portion of the river impacted and the character and scope of the project with sufficient detail to determine probable water quality impacts.

I3.3 ENDANGERED AND THREATENED SPECIES

No federally listed plant species or designated critical habitats for plants or animals have been identified on the ORR. Sect. 2.7.2 of this RI report discusses the results of rare and endangered plant surveys conducted at the ORR, with state-listed plant species identified on Table 2B of the RI. DOE has designated areas on the ORR as DOE-National Environmental Research Park (NERP) Natural Areas (NAs), which have been established to protect rare plant and animal species. One such area, NA-8, the McCoy embayment "barren" has also been registered as a state NA as it contains a state-listed endangered species of plant, the tall larkspur (*Delphinium exaltatum*). Construction activities that would impact this area must be avoided (TCA 11-14-101 *et seq.*).

The possibility exists that there may be other protected species of plants in the area of this OU. Consultation with the Department of Interior or Tennessee Wildlife Resources Agency is recommended to ensure that there are no federal or state protected species that will be impacted by remedial activities. Should any remedial activity in the Clinch River/Poplar Creek OU impact any federal-listed endangered or threatened plant species, the provisions found in the Endangered Species Act of 1973 (16 USC 1531 *et seq.*) and 50 *CFR* 402 may be applicable. State-listed plants may be protected under the Tennessee Rare Plant Protection and Conservation Act (TCA 11-26-201 *et seq.*).

I3.4 ARCHAEOLOGICAL AND HISTORICAL RESOURCES

There have been no known cultural resource surveys of the entire area found in the Clinch River/Poplar Creek OU; however, surveys that encompassed portions of the Clinch River indicate the presence of archaeological and historical resources. Therefore, before the start of any ground-breaking activities, consultation should be initiated with the Tennessee State Historic Preservation Officer and Advisory Council on Historic Preservation, pursuant to §106 of the National Historic Preservation Act (16 USC 470f) and its implementing regulations (36 *CFR* 800). Although such consultation is an administrative requirement, and not required for on-site activities, such consultation will ensure compliance with the substantive requirements of any other applicable cultural resource laws [Archaeological Resources Protection Act (16 USC 470aa-ll), 43 *CFR* 7, Archaeological and Historic Preservation Act (16 USC 469a-c)].

Several cemeteries can be found along Poplar Creek. Building of any access roads or general construction activities must avoid damaging any gravesites pursuant to TCA 39-17-311.

I4. ACTION-SPECIFIC ARARs

Performance, design, or other action-specific requirements set controls or restrictions on particular kinds of activities related to the management of hazardous waste (53 *FR* 51437). Selection of a particular remedial action at a site will invoke the appropriate action-specific ARARs that may specify particular performance standards or technologies, as well as specific environmental levels for discharged or residual chemicals. Remediation alternatives include 1) no action; 2) institutional controls and advisories; 3) containment, removal, and disposal, combined with institutional controls; and 4) removal and disposal combined with institutional controls. Section 10 of the FS report presents a detailed analysis of these alternatives. Table I2 lists specific ARARs for alternatives 1-4. The remedial action alternatives discussed in the FS do not address remediation of contaminated surface water because the primary contributors are continuing releases from upstream sources (see Sect. 8.1 of the FS report). Therefore, although AWQC are applicable for remediation of surface water, they are not listed as ARARs for the remedial alternatives that address contaminated sediments only.

I4.1 NO ACTION RESPONSE

Under this alternative, no action would be implemented and the waste material in the Clinch River/Poplar Creek OU would be left in place without implementation of any containment, removal, treatment, or other mitigating actions.

As confirmed by EPA Guidance (OSWER Directive 9234.2-01/FS-A, June 1991, "ARARs Q's and A's"), there are no ARARs for the no action alternative.

I4.2 USE OF INSTITUTIONAL CONTROLS AND ADVISORIES

Institutional controls could be implemented to limit access and exposure. There are no regulatory requirements specifying institutional controls for CERCLA units. However, the NCP at 40 *CFR* 300.430(e)(3)(ii) suggests consideration of one or more alternatives that involve little or no treatment, but provide protection of human health and the environment through the use of institutional controls. The preamble to the NCP provides examples of institutional controls which include land and water use restrictions, deed restrictions, well-drilling prohibitions, building permits, and well use advisories and deed notices (55 *FR* 3706). In addition, DOE Order 5400.5, Chapter IV, requires administrative (institutional) controls for long-term management in areas containing residual radioactivity above guidance levels. Active controls specified in the Order which may be considered TBC guidance include land restrictions, fences, and warning signs.

Although not an ARAR for the Clinch River/Poplar Creek OU, institutional controls in the form of statutory authority of either TDEC or TVA and the USACE are already in place. An Interagency Agreement (IAG) for Watts Bar Reservoir Permit Coordination has been signed by TDEC, USACE, TVA, and DOE. Under this agreement, a screening list identifies three categories of actions disturbing sediments: no significant sediment disturbance (NSSD); marginal sediment disturbance (MSD); and potential major sediment disturbance (PMSD). The screening list of action categories was amended to include in the NSSD category all proposed projects (other than between CRM 4.3 and White Oak Creek) if the project does not have any sediment disturbance below Elev. 735 msl, and provided the work is accomplished when pool elevation is below the project site (Amendment 1, IAG Watt's Bar Reservoir Permit Coordination, January 28, 1992). For permit applications for activities that fall within the MSD or PMSD categories, DOE must supply existing sediment data and acquire additional sediment data if needed [IAG, Sect. IV(C)].

Under the Tennessee Water Quality Control Act, § 69-3-107(15), authority is granted the Commission to "inspect waters of the state where good cause is shown that the public health is threatened by pollutants therein, and, upon verification by the commissioner, post or cause to be posted such signs as required to give notice to the public of the potential or actual dangers of specific uses of such waters or restrictions of uses thereof." To that end, posting of advisories is not an ARAR or TBC for DOE compliance following remediation of the Clinch River/Poplar Creek OU; however, it implements the institutional controls suggested for alternatives 2, 3, and 4; i.e., posting of warning signs by the TDEC.

The TDEC Division of Water Pollution Control revised Chap. 1200-4-3 of the TDEC Water Quality Standards (effective date July 1995) modifying and promulgating procedures for issuing fish advisories. The revision creates a new subparagraph regarding fish consumption advisories [TDEC 1200-4-3-.03(j)]. Such advisories would be warranted if the calculated risk of additional cancer risk exceeds 10^{-4} for typical consumers and 10^{-5} for atypical consumers. The revised rule includes a methodology for calculating risk. Notices are posted for "Do not consume advisories" and "Precautionary advisories."

I4.3 CONTAINMENT, REMOVAL, AND DISPOSAL

This alternative is proposed for contaminated sediments in the Clinch River, Poplar Creek, and upper and lower McCoy Branch. Source containment options include capping near-shore or on-shore contaminated sediments combined with institutional controls (see Sect. 4.2). Containment and removal activities will be combined with turbid water technologies to decrease the release of sediments into the streams. Removal is considered for deeper areas to reduce or eliminate ecological risk. All removal activities are combined with stream-side dewatering, treatment if necessary, and on-site disposal. Several action-specific ARARs may be triggered by these activities depending on the characterization of dredged sediments (i.e., whether they contain RCRA hazardous waste and/or LLW). Activities in wetlands and floodplains should be designed to minimize impacts and restore and preserve natural and beneficial uses (see Sect. 3.0 of this Appendix for location-specific ARARs).

I4.3.1 Turbidity Controls

Storm water discharges from activities at industrial sites involving construction operations that result in the disturbance of five acres or more total land have been included in the final rule for National Pollutant Discharge Elimination System (NPDES) permits for storm water discharges (40 *CFR* 122) and incorporated into the TDEC permitting regulations. Consultation with TDEC is required to ensure compliance with the substantive requirements of the NPDES permitting process for storm water discharges during construction activities (TDEC 1200-4-10-.05). These requirements are listed in Table I2 and would be applicable to remedial activities impacting five acres or more, and relevant and appropriate for those affecting less than five acres.

The Tennessee Antidegradation Statement (TDEC 1200-4-3-.06) requires that all cost effective and reasonable best management practices for nonpoint source control shall be implemented; this would be applicable for turbidity control of sediments released during construction of containment areas. In addition, the TDEC narrative WQC for protection of aquatic life prohibits the presence of turbidity in such amounts or of such character that will materially affect fish and aquatic life [TDEC 1200-4-3-.03(d)].

I4.3.2 Fugitive Dust Control

Preconstruction activities such as building of access roads or equipment movement, as well as dredging activities, may result in airborne pollutants. The primary concern is elevation of particulate concentrations. The TDEC Division of Air Pollution Control has promulgated regulations governing fugitive dust emissions (TDEC 1200-3-8-.01). These are listed in Table I2, and are applicable to remedial activities at the OU.

I4.3.3 Dredging Activities

Dredging activities may be regulated by TVA, the USACE, or TDEC; the potentially applicable requirements are discussed in Sect. 3.2 as location-specific ARARs and listed in Table I2.

I4.3.4 Use of Shoreline Facility for Treatment and/or Packaging

Dredged slurries may be pumped to a shoreline facility for dewatering and sediment containerization. It is assumed that the slurries will contain low level radioactivity. Decontamination procedures will be implemented for all equipment and personnel. A waste analysis must be performed to determine whether the sediment and dewatering/decontamination fluids also contain RCRA hazardous waste [40 *CFR* 262.11(b); 40 *CFR* 264.13; 40 *CFR* 268.7], therefore becoming classified as mixed waste. If dewatering/decontamination fluids contain mixed waste, they must be transported to the ORR and treated or stored per the TDEC Commissioner's Order for the ORR Site treatment Plan (October 2, 1995). Dewatering fluids that do not contain RCRA waste will be trucked to the ORR for treatment of LLW at a permitted wastewater treatment facility. Any such fluids must meet the waste acceptance criteria (WAC) of the receiving facility to ensure compliance with the NPDES permit limits established for the treatment facility. There are no further ARARs for this scenario.

Dewatering/decontamination fluids that are tested and determined to contain no chemical or radionuclide contaminants may be discharged directly back into the water body if such discharge can be fully protective of the existing use classification of the surface water body (TDEC 1200-4-3; 1200-4-4).

On-site treatment of dried sediments will be implemented, if necessary to meet the RCRA land disposal restrictions (LDR). Any tanks used to treat RCRA hazardous waste must be managed and closed under 40 *CFR* 264.190 *et seq.*

I4.3.5 On-site Disposal of Dredged Materials

A waste analysis must be performed to determine whether dredged materials contain RCRA hazardous waste [40 *CFR* 262.11(b); 40 *CFR* 264.13; 40 *CFR* 268.7]. Transport of dredged materials to the ORR for storage or disposal may be regulated by the RCRA transportation (40 *CFR* 262 and 40 *CFR* 263) and LDR requirements (40 *CFR* 268) if the contaminated sediment contains RCRA-characteristic waste as well as LLW. In addition, the U.S. Department of Transportation (DOT) Regulations for Transportation of Hazardous Materials and TDEC Radiation Protection Standards may apply to transportation of sediments containing radioactive materials above certain limits.

DOE is exempt from the licensing requirements of the TDEC Radiation Protection Standards for activities occurring within plant boundaries [TDEC 1200-2-10-.06(1)]. However, the TDEC requirements for packaging and transportation of radionuclide-containing materials above exempt quantities [as listed in Schedule RHS 8-3, TDEC 1200-2-10-.04(3)] will be applicable for transport of any sediments containing radioactivity from the Clinch River/Poplar Creek OU to the ORR for treatment or disposal [TDEC 1200-2-10-.30 *et seq.*]; compliance with the DOT regulations is made by reference.

The DOT regulations list general requirements for shipping and packaging at 49 *CFR* 172 and 173, and requirements for carriage by public highway at 49 *CFR* 177. Specific loading and unloading requirements for transportation of radioactive materials by public highway are in 49 *CFR* 177.842. DOE Order 5480.3, "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes," also specifies packaging requirements.

Containerized sediments will be stored at either a permitted LLW facility at the ORR, or a mixed waste storage facility allowed under the TDEC Commissioner's Order for the ORR Site Treatment Plan (October 2, 1995).

I4.3.6 Off-site Disposal of Dredged Materials

In accordance with DOE Order 5820.2A, LLW is to be disposed of on the site where it is generated, if possible, or if off-site disposal is necessary due to lack of on-site capacity, disposal must be at another DOE facility. Mixed wastes are also to be disposed of at a DOE site. The RCRA, DOT, and TDEC Radiation Protection Standards may be triggered, as discussed in Sect. 4.3.5, depending on waste characterization.

On October 12, 1993, DOE provided an exemption to the on-site storage requirements of DOE Order 5820.2A for low-level and mixed waste, with certain conditions applied (Lytle and Whitfield 1993 memorandum, signed by T. P Grumbly). The specific exemption for mixed waste is limited to small quantities of such waste, determined on a case-by-case basis. Requests for exemption may be approved by the manager of the DOE-ORO field office. Wastes generated during remedial action activities may qualify for this exemption. DOE and Energy Systems procedures require preparation of documentation under NEPA, as well as CERCLA or RCRA, if applicable. Appropriate procurement or contracting documents must be prepared, and all permits, licenses, approvals, and regulatory history of any proposed disposal facility reviewed prior to execution of the contract. Any wastes that are restricted from land disposal must be treated to meet the applicable LDR before disposal. Prior to each shipment, EM-33 shall be notified of the waste type, total volume, and destination of the waste. The regulatory status of the facility must be confirmed prior to shipment, and a periodic review and/or audits must be performed on the facility. As previously mentioned, DOE Order 5820.2A allows off-site shipments of LLW to DOE facilities. There are avenues available for shipment of LLW from the ORR to off-site commercial facilities, but compliance with applicable DOE orders and Energy Systems procedures must be strictly adhered to, including Operational Readiness Review by Central WM Division.

I4.4 REMOVAL AND DISPOSAL

This alternative is proposed for Poplar Creek and McCoy Branch. It involves dredging of both shallow and deep contaminated sediments, shoreline dewatering and packaging of dredged materials, and storage or disposal of wastes either on-site at the ORR or off-site. Implementation of institutional controls in the form of TDEC fish advisories will also be used. All of the ARARs discussed in Sect 4.3 are potentially triggered for this activity.

REFERENCES

Lytle, J. E. and Whitfield, R. P. 1993. Commercial Disposal of Department of Energy Radioactive (By-Product and Low-level) and Mixed Waste. U.S. Department of Energy Memorandum, dated October 12, 1993.

Yu, C., A. J. Zielen, J. J. Cheng, Y. C. Yuan, L. G. Jones *et al.* 1993. *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0*, (ANL/ESD/LD-2), September.

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