# COMBINED MONITORING PLAN ERRATA LOG

| CMP Document Number | CMP Erratum Number | Regulatory Approval Dates | Description of Change |
|---|---|---|---|
| DOE/OR/01-1820&D3 | FY13-OFF-01 | EPA: 19FEB13<br>TDEC: 08JAN13 | Change the collection season from a current summer collection season [4th quarter of the fiscal year (July through September)] to a fall-early winter collection season [1st quarter of the fiscal year (October through December)] for largemouth bass in the Lower Watts Bar Reservoir (LWBR) and Clinch River/Poplar Creek (CR/PC) watershed. [See pages 12 and 13 of *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1820&D3) for changes].<br><br>Any monitoring requirements contained in the LWBR ROD (DOE/OR/02-1373&D3) and Remedial Action Work Plan (RAWP; DOE/OR/02-1376&D3), as well as the ROD and RAR for the CR/PC (DOE/OR/02-1547&D3 and DOE/OR/02-1627&D3, respectively), have been previously captured within the *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1820&D3). As previously and from this point forward, all changes to the CERCLA-stipulated monitoring for the LWBR and the CR/PC will be captured within this *Combined Monitoring Plan*, as well as in the Administrative Record for those primary documents. |
| DOE/OR/01-1820&D3 | FY18-0FF-01 | N/A | Update the tables throughout the Comprehensive Monitoring Plan to include language that takes into account the nature of sampling fish species that tend to migrate throughout large reaches of the reservoirs. Also, as sampling personnel have had to expand reaches, they have also had to often take a smaller number of fish and even obtain surrogate species as a last resort to fill a collection. All monitoring efforts will attempt to maintain consistency with the objective of the sampling at all times. |
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DOE/OR/01-1820&D3

# Lower Watts Bar Reservoir and Clinch River/Poplar Creek Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee

This document is approved for public release per review by:

| | |
|---|---|
| Dirk D. Holt | 8/6/04 |
| BJC ETTP Classification and Information Office | Date |

04-054(doc)/072904

**SCIENCE APPLICATIONS INTERNATIONAL CORPORATION**

contributed to the preparation of this document and should not be considered an eligible contractor for its review.

04-054(doc)/072904

DOE/OR/01-1820&D3

# Lower Watts Bar Reservoir and Clinch River/Poplar Creek Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee

Date Issued—August 2004

Prepared by
Science Applications International Corporation
Oak Ridge, Tennessee
under subcontract 23900-BA-YT024F
and
Environmental Sciences Division
Oak Ridge National Laboratory
under work authorization 23461

Prepared for the
U. S. Department of Energy
Office of Environmental Management

BECHTEL JACOBS COMPANY LLC
managing the
Environmental Management Activities at the
East Tennessee Technology Park
Y-12 National Security Complex Oak Ridge National Laboratory
Paducah Gaseous Diffusion Plant Portsmouth Gaseous Diffusion Plant
under contracts DE-AC05-98OR22700 and DE-AC05-03OR22980
for the
U. S. DEPARTMENT OF ENERGY

04-054(doc)/072904

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# ACRONYMS

| | |
|---|---|
| BMAP | Biological Monitoring and Abatement Program |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act of 1980 |
| COC | contaminant of concern |
| CRM | Clinch River Mile |
| CR/PC | Clinch River/Poplar Creek |
| CRWBR | Clinch River-Watts Bar Reservoir |
| DOE | U. S. Department of Energy |
| EFPC | East Fork Poplar Creek |
| EPA | U. S. Environmental Protection Agency |
| ETTP | East Tennessee Technology Park |
| GWQC | General Water Quality Criteria |
| Hg | mercury |
| IAG | interagency agreement |
| LWBR | Lower Watts Bar Reservoir |
| OEP | Office of Environmental Protection |
| ORNL | Oak Ridge National Laboratory |
| ORR | Oak Ridge Reservation |
| OU | operable unit |
| PCB | polychlorinated biphenyl |
| PCM | Poplar Creek Mile |
| RER | Remediation Effectiveness Report |
| RI/FS | remedial investigation/feasibility study |
| ROD | Record of Decision |
| TAL | Target Analyte List |
| TDEC | Tennessee Department of Environment and Conservation |
| TRM | Tennessee River Mile |
| TVA | Tennessee Valley Authority |
| TWRA | Tennessee Wildlife Resources Agency |
| USACE | U. S. Army Corps of Engineers |
| WBIWG | Watts Bar Interagency Working Group |
| WOC | White Oak Creek |
| WOCE | White Oak Creek Embayment |
| WQC | Water Quality Criteria |
| WRRP | Water Resources Restoration Program |
| Y-12 Complex | Y-12 National Security Complex |

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# 1. INTRODUCTION

This document is a revision to the U. S. Department of Energy's (DOE's) *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 1999a). The combined monitoring plan was issued by DOE in September 1999 in order to consolidate monitoring activities defined in the individual post-Record of Decision (ROD) monitoring plans for Lower Watts Bar Reservoir (LWBR) [DOE 1996a] and Clinch River/Poplar Creek (CR/PC) [DOE 1999b]. The combined monitoring plan was issued with the stated expectation that the plan would be periodically updated based on annual sampling results and/or periodic evaluations of monitoring activities. The revised monitoring program presented in this document reflects changes based on results of sampling conducted over the past 5 years in addition to changes being implemented in order to make the overall monitoring program more informative and cost-effective.

# 2. BACKGROUND

Past operations and waste management practices at DOE's Oak Ridge Reservation (ORR) have resulted in various contaminants being released to the environment via groundwater flow and surface water runoff, among other pathways. These waters ultimately flow into the Clinch River and then to Watts Bar Reservoir.

In December 1989, the U. S. Environmental Protection Agency (EPA) placed the ORR on the National Priorities List under the federal Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). As mandated by CERCLA, the ORR and all off-site areas that have received contaminants, including the Clinch River–Watts Bar Reservoir (CRWBR) system, were required to undergo a remedial investigation (RI) to (1) characterize the nature and extent of the contamination, (2) determine the risk to human health and the environment resulting from the contamination, (3) determine if remedial actions were needed to reduce the risks, and (4) identify the remedial actions that were most feasible for implementation.

In October 1993, the Tennessee Department of Environment and Conservation (TDEC), EPA, and DOE agreed to divide the CRWBR system administratively into two CERCLA operable units (OUs): the LWBR OU and the CR/PC OU. The division of the system into two OUs was primarily for the purpose of expediting remedial decisions for the reservoir.

The remedial investigation/feasibility study (RI/FS) reports for the LWBR and CR/PC OUs were issued in March 1995 and June 1996, respectively (DOE 1995a, DOE 1996b). Both RI/FS documents identified similar contaminants of concern (COCs), exposure pathways, and potential risk levels. Although practical remedial alternatives for both OUs were found to be limited, the potential human health risks were readily mitigated by existing institutional controls on sediment disturbance and fish consumption advisories established by federal and state laws. The ROD for the LWBR OU was issued in September 1995 (DOE 1995b), and the ROD for the CR/PC OU was issued in August 1997 (DOE 1997).

The selected remedy presented in the ROD for the LWBR OU and the ROD for the CR/PC OU requires that DOE continue working with regulators through the Watts Bar Interagency Agreement to implement or maintain existing institutional controls and advisories. DOE is required to undertake appropriate actions if an existing control or advisory becomes ineffective or if a sediment-disturbing activity might threaten human health or the environment. The selected remedy also includes monitoring of water, sediment, and biota to determine if "…there is a change in the currently calculated risk that would pose a threat to human health and/or the environment" (DOE 1995b, DOE 1997). Table 1 summarizes

**Table 1. Summary of risks and response actions identified in the RODs for CR/PC and LWBR and corresponding stewardship and monitoring activities**

| Primary risk identified in the ROD | Response action selected in the ROD to address the risk | Corresponding monitoring/stewardship activity |
|---|---|---|
| ***Clinch River/Poplar Creek OU*** | | |
| Risk to human health posed by exposure to PCBs, chlordane, arsenic, and mercury in fish tissue (ref: pg. 1-3, ROD for CR/PC OU) | Fish consumption advisories to reduce exposure to contaminants in fish tissue (ref: pg. 1-3, ROD for CR/PC OU) | Fish consumption advisories are issued by the TDEC Division of Water Pollution Control. |
| | Annual monitoring to detect changes in CR/PC contaminant levels (ref: pg. 1-3, ROD for CR/PC OU) | WRRP conducts annual sampling of channel catfish, largemouth bass, and striped bass. Turtle samples are collected every fifth year. Analytes include total PCBs, total mercury, and $^{137}$Cs. |
| | Survey to confirm effectiveness of fish consumption advisories (ref: pg. 1-3, ROD for CR/PC OU) | WRRP conducted the survey in 2000. Results were reported in the 2001 RER. |
| Risk to human health posed by exposure to mercury, chromium, arsenic, and $^{137}$Cs in deep sediment of the main river channel (ref: pg. 1-3, ROD for CR/PC OU) | Existing institutional controls to control potential sediment-disturbing activities. (ref: pg. 1-3, ROD for CR/PC OU) | DOE participates in the WBIWG to review permitting and use activities that could result in disturbance of sediments. Controls on sediment-disturbing activities are detailed in TDEC's ARAP process. |
| | Annual monitoring to detect changes in CR/PC contaminant levels or mobility (ref: pg. 1-3, ROD for CR/PC OU) | WRRP collects sediment samples along CR/PC. Analytes include $^{137}$Cs, mercury, and TAL metals. TVA also collects sediment samples. |
| ***Lower Watts Bar Reservoir OU*** | | |
| Risk to human health posed by exposure to PCBs, chlordane, aldrin, arsenic, and mercury in fish tissue (ref: pg. 1-3, ROD for LWBR OU) | Fish consumption advisories to reduce exposure to contaminants in fish tissue (ref: pg. 1-3, ROD for LWBR OU) | Fish consumption advisories are issued by the TDEC Division of Water Pollution Control. |
| | Annual monitoring to detect changes in LWBR contaminant levels (ref: pg. 1-3, ROD for LWBR OU) | WRRP conducts annual sampling of channel catfish and largemouth bass. Analytes include total PCBs and total mercury. |
| Risk to human health posed by exposure to metals in deep sediment of the main river channel (ref: pg. 1-3, ROD for LWBR OU). Metals in deep sediment identified in the ROD as having a hazard quotient ≥1.0 include cadmium, chromium, mercury, and zinc (ref: Table 2.1, ROD for LWBR OU) | Existing institutional controls to reduce exposure to contaminated sediment (ref: pg. 1-3, ROD for LWBR OU) | DOE participates in the WBIWG to review permitting and use activities that could result in disturbance of sediments. Controls on sediment-disturbing activities are detailed in TDEC's ARAP process. |
| | Annual monitoring to detect changes in LWBR contaminant levels or mobility (ref: pg. 1-3, ROD for LWBR OU) | WRRP collects sediment samples in LWBR. Analytes include $^{137}$Cs, mercury, and TAL metals. TVA also collects sediment samples. |

ARAP = Aquatic Resource Alteration Permit.
CR = Clinch River.
DOE = U. S. Department of Energy.
LWBR = Lower Watts Bar Reservoir.
OU = Operable Unit.
PC = Poplar Creek.
PCB = polychlorinated biphenyl.
RER = Remediation Effectiveness Report.
ROD = Record of Decision.
TAL = Target Analyte List.
TDEC = Tennessee Department of Environment and Conservation.
TVA = Tennessee Valley Authority.
WBIWG = Watts Bar Interagency Working Group.
WRRP = U. S. Department of Energy Water Resources Restoration Program.

the primary risk drivers identified in the RODs, the response actions selected in the decisions, and the corresponding stewardship and monitoring activities conducted by DOE and other members of the Watts Bar Interagency Working Group (WBIWG).

**Participation in Watts Bar Interagency Working Group**

An interagency agreement (IAG) among DOE, TDEC, EPA, the Tennessee Valley Authority (TVA), and the U. S. Army Corps of Engineers (USACE) became effective in February 1991. The IAG is used to coordinate and review permitting and other use activities that could result in the disturbance, resuspension, removal, and/or disposal of contaminated sediments or potentially contaminated sediments resulting from DOE operations in Watts Bar Reservoir and the Clinch River below Melton Hill Dam, including Poplar Creek. Existing controls on sediment-disturbing activities are detailed in *Rules of the Tennessee Department of Environment and Conservation, Chapter 1200-4-7*, "Aquatic Resource Alteration Permit Process"; Section 26A of the Tennessee Valley Authority Act of 1933; and Section 10 of the Rivers and Harbors Act of 1910 (USACE authority).

The WBIWG reviews requests for projects such as construction of beaches, boat ramps, docks, marinas, buoy anchors, fences, fish attractors, retaining walls, pump stations, culverts, and submerged lines or piping to evaluate the potential to disturb contaminated sediment.

**Fish Consumption Advisories**

The LWBR and CR/PC RODs require the continuation of fish consumption advisories to reduce exposure to contaminants in fish tissue. Under the Tennessee Water Quality Control Act, TDEC 0400-40-03, TDEC is authorized to issue fish consumption advisories to protect the public. Accordingly, TDEC's Division of Water Pollution Control posts fish consumption advisories at numerous public and private access points surrounding LWBR and CR/PC OUs.

**Monitoring**

A post-ROD monitoring program has been in place for the LWBR OU since 1996, and a similar monitoring program was initiated on the CR/PC OU in 1998. The monitoring programs for the two OUs were designed to meet the specific requirements of the individual RODs. The initial monitoring programs were described in the *Remedial Action Work Plan for Lower Watts Bar Reservoir in Tennessee* (DOE 1996a) and the *Remedial Action Report for Clinch River/Poplar Creek in East Tennessee* (DOE 1999b). However, because the two OUs are, in fact, parts of the same hydrologic system, the monitoring activities were merged, and since October 1999, monitoring activities have been conducted under the combined monitoring plan (DOE 1999a) as explained in Chap. 1.

**Exchange of Information with Other Agencies**

To provide a comprehensive picture of environmental conditions on and off the ORR, DOE's Water Resources Restoration Program (WRRP) monitoring strategy takes advantage of monitoring datasets obtained by other programs. In addition to the current WRRP monitoring in the CRPC/LWBR hydrologic system, there is extensive monitoring information available from the Biological Monitoring and Abatement Program (BMAP) [a requirement of the National Pollutant Discharge Elimination System permits issued to the three DOE facilities on the ORR], the DOE Environmental Monitoring Program (addressing DOE Order requirements), the TDEC Environmental Monitoring Program (for the purpose of DOE oversight), and the TVA Reservoir Monitoring Program. Historically, collaboration with these agencies on environmental issues, monitoring activities, and institutional controls on the CRPC/LWBR system has yielded valuable additional information and insight. WRRP will continue to maintain active

collaboration and regular exchange of data/information with these programs to take advantage of additional data and knowledge on the CRPC/LWBR system.

# 3. SOURCE AND DISTRIBUTION OF CONTAMINATION IN THE LWBR AND CR/PC OUs

The LWBR OU extends 38 miles from Tennessee River Mile (TRM) 567.5, at the mouth of the Clinch River, downstream to Watts Bar Dam at TRM 529.9 (Fig. 1). The CR/PC OU extends from the mouth of the Clinch River at TRM 567.5 [Clinch River Mile (CRM) 0.0], upstream past Melton Hill Dam at CRM 23.1 to the upstream boundary of the ORR at CRM 43.7. The CR/PC OU also includes the lower portion of Poplar Creek from the mouth of Poplar Creek on the Clinch River at CRM 12.0, upstream to its confluence with East Fork Poplar Creek (EFPC) at Poplar Creek Mile (PCM) 5.5 (Fig. 1).

All water leaving the ORR eventually enters the Clinch River, which feeds Watts Bar Reservoir. Oak Ridge National Laboratory (ORNL) is drained primarily by White Oak Creek (WOC) and the White Oak Creek Embayment (WOCE). Smaller drainages contribute water both upstream (Melton Hill Lake) and downstream of the WOCE. DOE's Y-12 National Security Complex (Y-12 Complex) is drained to the west by Bear Creek and to the east by EFPC. EFPC flows ultimately into Poplar Creek on undeveloped DOE property a few miles upstream from the East Tennessee Technology Park (ETTP). ETTP drains into both the Clinch River and a short segment of Poplar Creek before its confluence with the Clinch River.

Watts Bar Reservoir was impounded in 1942, concurrent with the construction and early development of the ORR plant sites. Because large reservoirs are efficient sediment traps (Dendy 1973, Baxter 1977), a history of ORR off-site releases of particle-reactive contaminants to surface waters resides in the Watts Bar Reservoir sediments. The most significant contaminant releases from the ORR to the Clinch River and Watts Bar Reservoir occurred in the 1950s and 1960s, when there were releases of $^{137}$Cs- and $^{60}$Co-contaminated sediments from White Oak Lake at ORNL and releases of mercury from the Y-12 Complex to EFPC (DOE 1988). As a result of those releases, elevated concentrations of $^{137}$Cs, $^{60}$Co, and mercury are readily detectable in sediment accumulation zones in the river and reservoir (Turner et al. 1985, Olsen et al. 1992).

In addition to contaminant releases from the ORR, municipal sewage outfalls, agricultural runoff, effluent from small businesses, uncontrolled leachate from old municipal landfills, and other sources contribute to the contaminant load in the water flowing into LWBR from the Tennessee River and the Clinch River. From the Tennessee River system upstream of LWBR, contaminants come from the Knoxville metropolitan area; Tennessee's tri-city area; Bristol, Virginia; Asheville, North Carolina; and many smaller communities. Large industrial operations adjacent to tributaries and government-owned facilities, such as electric-power generation and distribution facilities, represent additional potential sources of pollutants (DOE 1996a). The Clinch River, or its tributaries, receives effluent and runoff from the cities of Oak Ridge, Harriman, and Clinton, and from the Norris Lake basin (DOE 1999b).

# 4. REVISED MONITORING STRATEGY

The primary objective of the monitoring program for the CR/PC and LWBR system is to monitor the reservoir and river system to track changes in contaminant concentrations, mobility, and associated risk.

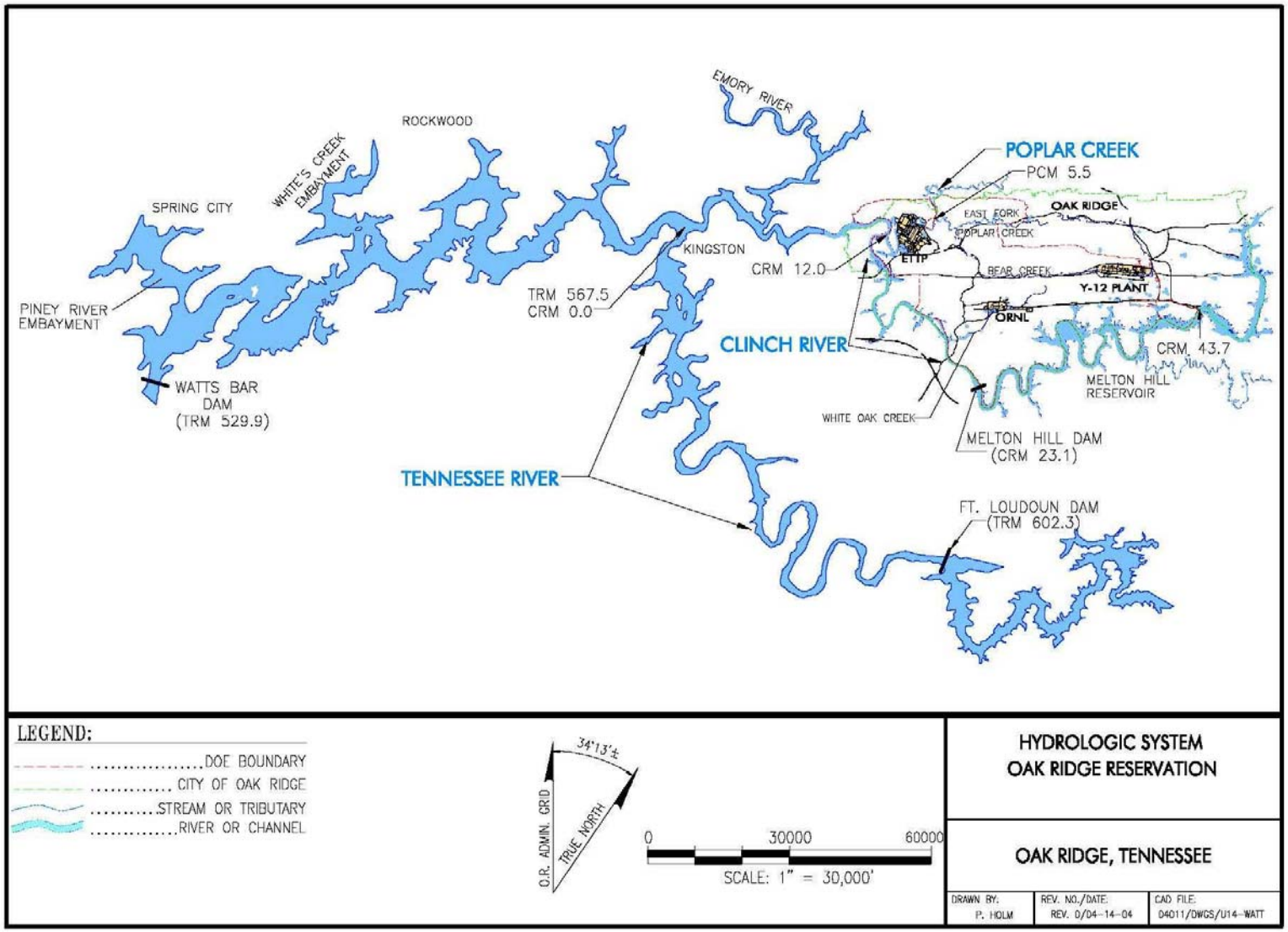


**Fig. 1. The Lower Watts Bar Reservoir and Clinch River/Poplar Creek hydrologic system.**

Changes to the current monitoring program are being implemented to provide a more unified, long-term monitoring program that: (1) meets the requirements of the RODs for both OUs, (2) is technically sound and informative, (3) is integrated with ORR watershed and exit pathway monitoring, and (4) is cost-effective.

The monitoring program will consist of two components:

- annual monitoring of major COCs in fish, and
- monitoring of sediment and surface water prior to the CERCLA Five-Year Review.

## 4.1 ANNUAL MONITORING OF COCs IN FISH

The RODs for LWBR and CR/PC determined that institutional controls (i.e., fishing advisories) were adequate to address the unacceptable risks associated with fish contamination in Watts Bar, in conjunction with annual monitoring to detect any change in contaminant levels. Watts Bar Reservoir is posted with a fishing advisory due to polychlorinated biphenyl (PCB) contamination in fish. The advisory for the Clinch River arm of Watts Bar Reservoir is that striped bass should not be consumed, and there is a precautionary advisory for catfish and sauger. There is a separate advisory that no fish be consumed from EFPC, including Poplar Creek embayment, due to mercury and PCB contamination.

Many studies, including intensive sampling as part of the LWB and CR/PC RI, have shown that the highest mercury and PCB concentrations in fish in the Clinch River arm are in the upper section of the watershed (Poplar Creek, CRM 20), and levels decrease with distance downstream. Recent data have also suggested that PCB concentrations in catfish have decreased in CR/PC and Watts Bar, and at many sites PCBs are below levels typically used to issue fish consumption advisories (DOE 2004). Sampling of fish species, sites, and contaminants that have been shown to be of minimal or no risk, or that are not related to DOE operations, will be reduced or discontinued under this new monitoring plan. Many of these sites and contaminants are currently monitored as part of other programs [e.g., TVA, BMAP, Office of Environmental Protection (OEP), etc.] and will be used as part of comparison evaluations when/where appropriate.

The focus of the new monitoring plan is to detect temporal changes in the key COCs at sites and in species that have been previously identified as posing unacceptable risks. Species like channel catfish and striped bass are the species most sensitive to changes in exposure, especially for PCBs. If concentrations in these species increase substantially, it would indicate that further study is needed to determine if the current institutional controls are adequate. Conversely, substantial decreases would be directly applicable to evaluating the efficacy of removing a fishing advisory. Recent results from the Clinch River and LWBR suggest PCBs are decreasing in fish, especially over the last 3 years (DOE 2004). The new monitoring plan uses a more scientifically rigorous sampling design so that any statistical change in fish concentrations can be determined and evaluated. Such an assessment will be directly applicable to the ROD-specified requirements to detect changes in fish contaminant levels and evaluate whether institutional controls established in the reservoir (i.e., the fish consumption advisory) are effective.

### Fish Monitoring

The previous monitoring strategy (DOE 1999a) can be described as a screening-level, spatial characterization of contamination. The strategy obtained some data from a large number of sites, media (water, sediment, and biota), species (catfish, largemouth bass, striped bass, and turtles), and contaminants (e.g., PCBs, pesticides, metals, mercury, and radionuclides), but because the number of samples per site/species/contaminant combination was small (n = 1), the strategy was limited in its ability

to detect temporal changes in the contaminants of most concern in fish (PCBs, mercury). After almost 20 years of fish monitoring in the CR/PC and LWBR, the spatial patterns of fish contamination, the types of contaminants that are of the most concern, and the differences between species are well understood (DOE 2004).

As stated previously, the focus of the new monitoring plan is to detect temporal changes in the key COCs at sites and in species that have been previously identified as posing unacceptable risks. Sites, species, and analytes that are clearly not a risk concern or that do not add to our understanding of contaminant changes in the off-site environment will be reduced or discontinued. Many of these sites and contaminants are currently monitored as part of routine screening studies by other programs (e.g., the TVA, the BMAP, and the OEP). For this new plan, the number of samples analyzed at each monitored site will be increased in order to generate a scientifically and statistically defensible sampling regime, which will be able to detect changes in fish contaminant concentrations if they should occur.

Specifically, the changes in 2004 are designed to:

1. Closely align with the monitoring objectives specified in the RODs by

    a. focusing on detecting temporal changes in contaminant concentrations in fish that could affect institutional controls;

    b. revising the sampling frequency to clearly address the annual monitoring requirement;

    c. focusing on mercury and PCBs, the primary identified COCs; and

    d. focusing on evaluating changes at key exit and integration points within the OUs.

2. Provide for a more scientifically robust program by

    a. collecting more fish per site/species combination;
    b. analyzing individual fish filets;
    c. restricting the collections of fish to sizes that are similar between sites and years; and
    d. collecting fish annually at the same time each year.

3. Take advantage of similar data collected by other agencies or groups

    a. Long-term trending possible because the type of data collected will be directly comparable to historical data collected for the original RI/FS and BMAP studies

    b. Ancillary contaminant data from other programs (e.g., TVA) are available and can be used to augment the analysis of risks in LWBR and the CR/PC, as well as for comparison purposes (as shown in DOE 2004)

## 4.2 MONITORING TO SUPPORT THE CERCLA FIVE-YEAR REVIEW

The following Five-Year Review activities will occur to ensure that the selected remedies are functioning as intended by the RODs:

- a review of the WBIWG processes and decisions over the past 5 years,

- a review of contaminant concentrations in fish to determine if they remain high enough to pose a risk, and

- sediment monitoring to update the configuration of contaminated sediment in the river system and document the mobility of any contaminated sediment.

The following Five-Year Review activities will occur to address the validity of baseline assumptions and protectiveness of the action:

- Re-evaluate the baseline risk conceptual model using all available monitoring data, primarily the contaminant source inputs to the river system and primary receptor locations, to ensure the baseline conceptual model has not changed.

- Use available fish data to evaluate trends in fish bioaccumulation to ensure that fish concentrations are not increasing above the levels identified during the baseline risk assessment.

- Compare surface water data to Tennessee General Water Quality Criteria (GWQC). Surface water samples will be collected as described in Sect. 5.2.1, with emphasis on providing surface water data to update the key conceptual model locations.

### 4.2.1 Surface Water Monitoring

Currently, surface water samples are collected each fiscal year (i.e., October 1 – September 30), alternating between spring and fall of each year, and analyzed for isotopic uranium, total mercury, and Target Analyte List (TAL) metals. In addition, the following field measurements/observations are made at each sample location: water temperature, dissolved oxygen, turbidity, pH, specific conductance, and oxidation-reduction potential. Water sampling is included in the current monitoring program even though both RIs concluded that no risk to human health was associated with contaminants in water.

Surface water contamination was not found to pose baseline risks; consequently, the ROD does not identify surface water chemicals of concern nor does it specify any contaminant-specific applicable or relevant and appropriate requirements or to-be-considered criteria. Because there is no risk associated with surface water, surface water sampling will occur every 5 years, in the year preceding the Five-Year Review, in order to re-evaluate the assumptions used in the baseline and the protectiveness of the remedy. With this in mind, surface water sample locations are selected to (1) affirm the conceptual model (source → receptor), and (2) check concentrations against Tennessee GWQC.

Surface water sampling is also conducted by TVA, TDEC, and the Tennessee Wildlife Resources Agency (TWRA) on the Tennessee River, the Clinch River, and some of its tributaries in order to assess surface water quality. Information from these activities will be used to supplement data obtained under this monitoring plan as appropriate.

### 4.2.2 Sediment Monitoring

The highest concentrations of contaminants (e.g., mercury and $^{137}Cs$) in CRWBR sediments are located in deep sediment layers, primarily in the old river channel, and are isolated from aquatic biota by layers of cleaner, more recent sediment deposits. Shallow, near-shore sediments do not pose an unacceptable risk. The deeper, contaminated sediments pose a potential risk to human health only if excavated, transported to land, and then used to grow crops that are ingested by humans. The risk associated with the presence of $^{137}Cs$ is due to potential direct exposure of a human receptor to gamma radiation. Existing institutional controls on the disturbance of contaminated sediments by means of the WBIWG are sufficiently protective to prevent such risks. Similarly, Poplar Creek sediments near the ash

disposal outfall are contaminated with arsenic, but are isolated by cleaner, more recent sediment and pose no risk to human health if undisturbed.

Currently, sediment cores are collected each fiscal year, alternating between spring and fall of each year, at multiple stations along the CRWBR hydrologic system (4 stations in LWBR, 16 stations in CR/PC). Sediment cores are analyzed for $^{137}$Cs, mercury, and TAL metals.

Under this revised monitoring plan, sediment cores will be collected once every 5 years; specifically, in the year preceding a CERCLA Five-Year Review. Annual sediment coring provides a lot of data (at great expense); however, this has not increased the current understanding of contaminant distribution, redistribution, and accumulation in the system any more than less frequent sampling would.

Cores will be collected from main channel accumulation zones in the CR and LWBR and should be at least 1 m in length to capture the $^{137}$Cs peak. Olsen et al. (1992) found that, in 1992, the $^{137}$Cs peak occurred at approximately 40- to 85-cm core depth in major sediment accumulation areas. Maximum $^{137}$Cs concentrations in the WOCE occurred at 0- to 40-cm core depth in 1990, prior to construction of the sediment-retention structure at the mouth of WOCE (Blalock et al. 1993). It may be necessary to collect "duplicate" cores to obtain sufficient material for all analyses. The depth of water in main channel areas will generally necessitate the use of a gravity corer to obtain the sediment core.

Each core should be scanned for gamma activity, prior to sectioning of the core, to determine the vertical distribution of $^{137}$Cs in the sediment core. The $^{137}$Cs activity provides an indicator of the contaminant profile in the sediment column, particularly for the $^{137}$Cs and mercury (Hg) peaks associated with the 1950–60s releases from the ORR. The number of sections per core that can be analyzed will depend on the amount of material required for the desired analyses. At a minimum, a section associated with the $^{137}$Cs peak, a section from the more recently deposited sediment overlying the $^{137}$Cs peak, and a section of near-surface (most recent) sediment should be analyzed to confirm that the accumulation of cleaner sediment is continuing to isolate the more highly contaminated sediment layer associated with the 1950–60s releases. If feasible, an additional section from below the $^{137}$Cs peak should also be analyzed (total of four sections/core).

Sediment core sections selected for further analysis will be analyzed for selected radionuclides, mercury, and TAL metals. Based on results from the CR/PC RI/FS, sediment samples from Poplar Creek will also be analyzed for PCBs. In evaluation of sediment core data, focus should be placed on (1) the depth of the $^{137}$Cs peak (as a historical marker) in the sediment column and the thickness of the overlying, more recent sediment layer; (2) the calculated sediment accumulation rate and variations from previous sediment accumulation rate estimates for that location; and (3) the magnitude and pattern of contaminants in the overlying sediment layer (i.e., are sediments cleaner, less contaminated—or is there evidence of additional contamination events or contaminant migration from upstream?).

Results of monitoring/sampling activities conducted by other programs (TVA, TWRA, and TDEC) will be used to supplement data obtained under this monitoring plan as appropriate.

# 5. MONITORING DESIGN

## 5.1 ANNUAL FISH MONITORING

The fish sampling design involves changes in the number of monitored locations, sampling frequency, and sampling methods. Turtle monitoring will remain the same as previous, with the exception of the merging of two sites (i.e., three instead of five sites will be monitored).

The fish sampling design described in the following sections reflects the monitoring locations and sample analyses that constitute the year-to-year sampling strategy. However, in years preceding the CERCLA Five-Year Review, additional sampling locations and analyses may be included in the program as needed to complete the 5-year review process as described in EPA's *Comprehensive Five-Year Review Guidance* (EPA 2001). The additional sampling locations and analyses will be presented in the Sampling and Analysis Plan for the WRRP for the year preceding the 5-year review (e.g., 2005, 2010, 2015, and so on).

### 5.1.1 Approach

**Monitoring Locations**

The sampling location for each fish species is shown in Table 2, along with the sites monitored under the previous plan. The sites were chosen based on their position below key DOE inputs and stream/river exit points, as well as their importance as long-term measures of change. Most of the designated sites have been monitored by one or more programs annually since the mid-1980s, and are important sites for evaluating long-term change (DOE 2004).

The selected sites are representative of five discrete reaches: (1) the Clinch River between the WOC and PC discharges, (2) the Clinch River between PC and the Tennessee River, (3) lower PC, downstream of all DOE inputs to PC, (4) LWBR between the Tennessee River and Clinch River confluence and Watts Bar Dam, and (5) Melton Hill and Norris Lake reservoirs, upstream of major DOE sources of targeted COCs. Sites within these downstream reaches (1-4 above) were selected based on the historical record and to target the sites where the maximum contaminant concentrations in fish were likely. For example, CRM 19.7-20.7 (at Jones Island) is the Clinch River site nearest the WOC discharge, and typically contains the highest contaminant concentrations of the three sites between the WOC and PC discharges to the Clinch River (CRM 20, CRM 18, and CRM 14). The monitoring of CRM 18-18.7 and CRM 14-15 adds little to the analysis of fish contaminant concentrations: if fish are any different in levels from CRM 19.7-20.7, they are generally lower (due to greater distance from the WOC discharge), the sites are within the routine movement range of channel catfish (the species of concern in this reach), and there are no significant additional sources of PCBs in-between the lowermost (CRM 14-15) and uppermost (CRM 19.7-20.7) sites. In addition, CRM 19.7-20.7, unlike CRM 18-18.7 or CRM 14-15, has been monitored annually since the mid-1980s.

A similar rationale was used in consolidating the Clinch River sites between the Poplar Creek discharge and the junction with the Tennessee River (CRM 0.5-1.5, CRM 6-7, and CRM 10.5-12). Like CRM 19.7-20.7, there are long-term annual data available for CRM 10.5-12, and it is the site closest to the Poplar Creek discharge and generally the most contaminated of the three sites. In Poplar Creek, the lowermost site (PCM 1) is downstream of both Mitchell Branch and the K-1007-P1 discharge and will be monitored from now on as a gauge of PC concentrations in fish. There is no significant difference between fish exposure at PCM 1 and PCM 3, as the sites are within fish ranges of movement, and sources of contamination are relatively ubiquitous due to the unique flow characteristics of Poplar Creek and the

**Table 2. Revised CR/PC and LWBR fish sampling strategy relative to the previous monitoring plan**

| Monitoring location | | Previous monitoring plan | | | | Revised monitoring plan | | | |
|---|---|---|---|---|---|---|---|---|---|
| Site[a] | Description | Largemouth bass | Channel catfish | Striped bass | Turtles | Largemouth bass | Channel catfish | Striped bass | Turtles |
| | | | | ***Clinch River sites*** | | | | | |
| CRM 19.7-20.7 | Jones Island downstream of WOC | X | X | | X | | X | | X |
| CRM 18-18.7 | Grubbs Island | X | X | | X | | | | |
| CRM 14-15 | ETTP water intake upstream of PC | X | X | | | | | | |
| CRM 10.5-12 | Brashear Island downstream of PC | X | X | | | X | X | | X |
| CRM 6-7 | Young Creek outlet | X | X | | X | | | | |
| CRM 2.6 | Kingston Steam Plant discharge | | | X | | | | X | |
| CRM 0.5-1.5 | Kingston City Park | X | X | | X | | | | |
| | | | | ***Poplar Creek sites*** | | | | | |
| PCM 3 | Near Mitchell Branch outlet | X | X | | | | | | |
| PCM 1 | Near K-1007-P1 outlet | X | X | | | X | X | | |
| | | | | ***Lower Watts Bar (Tennessee River) sites*** | | | | | |
| TRM 551-556 | Thief Neck Island | X | X | | | | | | |
| TRM 530-532 | Watts Bar Reservoir forebay[b] | X | X | X | | X | X | | |
| | | | | ***Reference sites (upstream of CR/PC-LWBR OUs)*** | | | | | |
| CRM 48[c] | Bull Run Steam Plant | | | X | | | | X | |
| CRM 23.4-24.7 | Melton Hill Reservoir forebay[b] | X | X | | X | X | X | | X |
| TRM 570-572 | Tennessee River Arm upstream of CR | X | X | | | | | | |
| WOCE | White Oak Creek Embayment | X | X | | | | | | |
| WOL | White Oak Lake | X | X | | | | | | |
| K1007-P1 | K-1007-P1 Pond | X | X | | | | | | |
| K901-A | K-901-A Pond | X | X | | | | | | |

[a]Expanded or alternate stream or river reaches may be sampled to attain target numbers of fish or biota, depending on the species and the objective of the monitoring. For example, for some wide-ranging fish species (e.g., striped bass), there is not a significant difference in contaminant concentration within a reservoir that is location dependent. Another example is when the objective of sampling is to obtain reference fish with low contaminant concentrations; in that case, multiple river reaches upstream of DOE discharges may be suitable. In addition, surrogate species may need to be collected to complete the collection, depending on target sample availability.

[b]Fish from the Watts Bar Reservoir and Melton Hill Reservoir forebays are routinely collected for polychlorinated biphenyls analysis by the Tennessee Valley Authority, and their results may be used if applicable.

[c]Samples may be collected from alternative reaches of the waterway ranging from CRM 24 to CRM99. River mile will be recorded in the field log book when collected and communicated for input into PEMS when provided for shipment to the laboratory for analysis.

CR = Clinch River
CRM = Clinch River Mile
ETTP = East Tennessee Technology Park
LWBR = Lower Watts Bar Reservoir
OU = operable unit
PC = Poplar Creek
PCM = Poplar Creek Mile
TRM = Tennessee River Mile
WOC = White Oak Creek
WOCE = White Oak Creek Embayment
WOL = White Oak Lake

widespread sediment contamination throughout the embayment. In LWBR, the WRRP will take advantage of the long-term TVA monitoring in the Watts Bar forebay. Although recent data suggest that PCBs in LWBR fish are now far below state risk concerns, the site provides a good measure of the spatial decrease in fish PCBs between CR/PC and LWBR.

As was demonstrated in the 2004 Remediation Effectiveness Report (RER) [DOE 2004], there are extensive and valuable biological monitoring datasets available to help put the CR/PC and LWBR fish concentrations in perspective with the surrounding environment. In addition to the Watts Bar Reservoir forebay, TVA also conducts routine monitoring of channel catfish in Melton Hill Reservoir and Fort Loudon Reservoir that can be used as "upstream" reference areas. At both of these sites, fish are exposed to PCBs that are not related to DOE operations. Sites on the ORR that were part of the current Off-site Monitoring Plan have been, and will continue to be, monitored as part of the BMAP and site-specific CERCLA monitoring activities. It is well demonstrated that the on-site reference locations are likely sources of PCBs to off-site; annual monitoring of these sites is useful as a measure of specific on-site changes, but is not a causal measure of off-site PCB fluxes or a predictor of off-site changes.

This revised plan will monitor a fewer number of sites, but the strategy is significantly strengthened by adding to the number of individual fish analyzed (see following section) and by focusing on key integration points that have long-term data available. As was the case in previous years, reference data from upstream of the CR/PC and LWBR areas (both on- and off-site) will continue to be used for comparison purposes.

**Sampling Frequency**

Sampling of channel catfish and largemouth bass will be conducted on an annual basis in the summer or fall of each year. Such a collection is consistent with historical catfish data collected by the BMAP, TVA, and OEP collections. The revised sampling frequency is provided in Table 3 and contrasted with the current frequency.

The revised frequency substantially improves the ability of the monitoring to detect temporal changes in fish contaminant concentrations. The current frequency of alternating spring and fall collections results in temporal data comparisons that are every other year (fall data are compared during even years, spring data during odd years). This sampling strategy results in an 18-month gap between collections. Annual sampling at approximately the same time each year is more consistent with the intent of the ROD to evaluate change over time; determining contaminant differences in fish between seasons is not a specified goal. In addition, a difference in concentrations of contaminants in muscle filet between seasons is likely to be small relative to other obfuscating factors, and the current sampling regime of only one site/species composite sample per season would not be adequate to detect a seasonal difference.

Striped bass are collected opportunistically in winter when the species is more localized; no change in sampling frequency will be made for this species.

**Sample Analysis**

The new sampling strategy is designed to detect changes in fish contamination over time. To detect change, fish samples need to be replicated so that intra-site variability can be determined. The revised sampling plan involves collecting and analyzing six individual fish of each species at each site (if possible to collect within a reasonable sampling period). By determining individual fish concentrations, any relationship between size and contaminant concentration can be adequately evaluated. Fish of similar size will be collected from all sites and years to the extent possible, with a focus on individuals large enough to be taken by anglers.

**Table 3. Current sampling frequency and revised sampling frequency for each species.**

| Strategy | Species | 2015 | | | | 2016[a] | | | | 2017 | | | | 2018 | | | | 2019 | | | | 2020 | | | | 2021[a] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sp | Su | Fl | Wi | Sp | Su | Fl | Wi | Sp | Su | Fl | Wi | Sp | Su | Fl | Wi | Sp | Su | Fl | Wi | Sp | Su | Fl | Wi | Sp | Su | Fl | Wi |
| **Current** | L Bass | | X | | | | X | | | | X | | | | X | | | (Sampling not scheduled for these years in previous versions of plan) | | | | | | | | | | | |
| | Ch. Cat | | X | | | | X | | | | X | | | | X | | | | | | | | | | | | | | |
| | St. Bass | | | | X | | | | X | | | | X | | | | X | | | | | | | | | | | | |
| | Turtles | | X[b] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Revised** | L Bass | | | X | | | | X | | | | X | | | | X | | | | X | | | | X | | | | X | |
| | Ch. Cat | | X | | | | X | | | | X | | | | X | | | | X | | | | X | | | | X | | |
| | St. Bass | | | | X | | | | X | | | | X | | | | X | | | | X | | | | X | | | | X |
| | Turtles | | X[b] | | | | | | | | | | | | | | | | | | | | X[b] | | | | | | |

[a]Year of the CERCLA Five Year Review (FYR) report. Monitoring in preparation for the FYR occurs in the prior year.
[b]Once every 5 years.

Ch. Cat = Channel Catfish
Fl = fall (FY quarter 1, approximately)
FY = Fiscal Year
L. Bass = Largemouth Bass
Sp = spring (FY quarter 3, approximately)
St. Bass = Striped Bass
Su = summer (FY quarter 4, approximately)
Wi = winter (FY quarter 2, approximately)

NOTE: Samples are collected within the designated season as much as possible, depending on factors often beyond the control of samplers (e.g., weather, water temperature, river currents, movement of the species within the noted range, etc.). Because of this, samples may be collected a week or more outside a particular FY quarter or surrogate species may be collected as a last resort.

The total number of samples analyzed for mercury and PCBs will be similar to the current monitoring (Table 4). PCB monitoring will focus on the species that is of most risk concern in the reservoir, channel catfish. Striped bass will also be monitored for PCBs (despite being relatively low in PCBs in recent years), because along with catfish they are a species listed with a fish consumption advisory. Largemouth bass from off-site will not be monitored for PCBs because their values are very low, not elevated over fish from sites upstream of DOE operations, and not high enough to warrant a fish consumption advisory (DOE 2004). However, largemouth bass and channel catfish will continue to be monitored for mercury because recent values are above commonly cited human health threshold limits.

Cesium-137 monitoring in fish will be reduced, and pesticide monitoring in fish (including analyses for chlordane and aldrin) will be discontinued. A detailed rationale for these reductions is provided in the RER (DOE 2004). Cesium-137 was never a human or ecological risk in the off-site environment (per RODs), and if measurable at all above background, the CRM 20 site below the WOC discharge would provide a suitable measure of any off-site change. Pesticide levels in fish are not likely to be related to any DOE operations, are found in fish near detection limit values, and continue to decrease nationally over time as a result of being discontinued as commercial pesticides. TVA monitoring of fish has clearly shown substantial decreases in chlordane concentrations, for example, since the early 1990s (DOE 2004).

### 5.1.2 Methods

Field sampling for the new plan will not be different from the methodologies used previously. Fish collection methods can vary, but in most cases largemouth bass and striped bass are collected by boat electrofishing, and channel catfish are collected by baited slat-baskets or hoop nets. Gill nets are used as a last resort as they can result in high mortality of fish species not targeted for collection.

Fish processing will be significantly different from current methods. Instead of compositing filets from four fish per site, individual fish filets will be homogenized and an analytical value obtained for each fish. By determining individual fish concentrations, any relationship between size and contaminant concentration can be adequately evaluated, and sound year-to-year and site-to-site comparisons can be made because site variability is determined.

Analytical methods will not change. Fish and turtle samples are analyzed for total mercury (EPA 1631M), PCBs (SW846-8082), and $^{137}Cs$ (EPA 901.1). In conjunction with the PCB analysis, lipids content (gravimetric analysis) should be obtained.

### 5.1.3 Evaluation of Results

The results from the monitoring effort will be reported annually in the RER. Mean concentrations for each site/species/analyte combination will be presented from the preceding year, and the most recent results compared graphically with historical trends.

## 5.2 MONITORING TO SUPPORT THE CERCLA FIVE-YEAR REVIEW

### 5.2.1 Surface Water

The surface water sampling design involves changes in the sampling frequency, number of monitored locations, and analytes. Sampling methods will remain the same.

**Table 4. Number of analytical samples obtained for each site and species collected for the revised monitoring plan[a]**

| Monitoring location | | Total PCBs (Aroclor 1254 + 1260) | | | Total Mercury | | | Cs-137 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site[b] | Description | Large-mouth bass | Channel catfish | Striped bass | Large-mouth bass | Channel catfish | Striped bass | Large-mouth bass | Channel catfish | Striped bass |
| ***Clinch River:*** | | | | | | | | | | |
| CRM 19.7-20.7 | Jones Island downstream of WOC | | 6 | | | 6 | | | 6 | |
| CRM 10.5-12 | Brashear Island downstream of PC | | 6 | | 6 | 6 | | | | |
| CRM 2.6 | Kingston Steam Plant discharge | | | 6 | | | | | | |
| ***Poplar Creek:*** | | | | | | | | | | |
| PCM 1 | Downstream of K-1007-P1 and MIK | | 6 | | 6 | 6 | | | | |
| ***Lower Watts Bar (Tennessee River):*** | | | | | | | | | | |
| TRM530-532 | Watts Bar Reservoir forebay | | 6 | | 6 | 6 | | | | |
| ***Reference (upstream of CR/PC-LWBR):*** | | | | | | | | | | |
| CRM 48[c] | Bull Run Steam Plant | | | 6 | | | | | | |
| CRM 23.4-24.7 | Melton Hill Reservoir forebay | | 6 | | 6 | 6 | | | | |
| | Total samples by species: | | 30 | 12 | 24 | 30 | | | 6 | |
| | *TOTAL EACH ANALYTE:* | | *PCBs: 42* | | *Hg:* | 54 | | | *Cs-137: 6* | |

[a]Quality assurance samples, such as duplicates, blanks, and spiked samples, are not included in the table.

[b]CRM= Clinch River Mile, PCM = Poplar Creek Mile, TRM = Tennessee River Mile, WOC = White Oak Creek, WOL = White Oak Lake, PC = Poplar Creek, CR = Clinch River, and MIK = Mitchell Branch kilometer.

[c]Samples may be collected from alternative reaches of the waterway ranging from CRM24 to CRM99. River mile will be recorded in the field log book when collected and communicated for input into PEMS when provided for shipment to the laboratory for analysis.

Hg = mercury.

PCB = polychlorinated biphenyl.

PEMS = Project Environmental Measurements System

NOTE: Expanded or alternate stream or river reaches may be sampled to attain target numbers of biota, depending on the species and the objective of the monitoring. For example, as noted above, for some wide-ranging species, such as striped bass, there is not a significant difference in contaminant concentration within a reservoir that is location dependent. Another example is when the objective of sampling is to obtain reference fish with low contaminant concentrations; in that case, multiple river reaches upstream of DOE discharges may be suitable. In addition, depending on target sample availability, surrogate species may need to be collected to complete the collection.

#### 5.2.1.1 Approach

The sampling locations for surface water and sediment are shown in Table 5, along with the sites monitored under the previous plan. The surface water samples will be collected at 1-m (3.3-ft) depth using a peristaltic pump. The samples will be analyzed for isotopic uranium, total mercury, and TAL metals. In addition, the following field measurements will be made at each sample location: dissolved oxygen, pH, temperature, specific conductance, water column depth, water transparency, weather conditions, and flow and wind conditions.

#### 5.2.1.2 Analysis

Surface water data will be compared to Tennessee GWQC under *Rules of the Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Chapter 1200-4-3*, "General Water Quality Criteria," that address protection of both human receptors [TDEC Water Quality Criteria (WQC) Rule 1200-4-3-.03(1), "Domestic Water Supply Criteria"] and ecological receptors (TDEC WQC Rule 1200-4-3-.03(3), "Fish and Aquatic Life Criterion Continuous Concentration"). Screening results will be presented in the RER/CERCLA Five-Year Review for the ORR.

### 5.2.2 Sediment

The sediment sampling design involves changes in the analytes, sampling frequency, and number of monitored locations. Sampling methods will remain the same as under the previous plan.

#### 5.2.2.1 Approach

Sediment sampling will focus on examining/tracking spatial patterns in net sediment and contaminant distribution/accumulation. Data from the sediment monitoring activity are also provided to the WBIWG. In recent years DOE has provided existing sediment data to the WBIWG and has collected additional sediment samples to support several dredging permit evaluations, a land use permit application, and a bridge installation at various locations along the Tennessee River and the Clinch River.

The sampling locations for sediment are shown in Table 5, along with the sites monitored under the previous plan.

#### 5.2.2.2 Analysis

All sediment samples will be analyzed for $^{137}$Cs, mercury, and TAL metals. Although $^{137}$Cs was not identified as a COC for LWBR, it has historically been a contaminant of interest in the CRWBR hydrologic system. Based on results from the CR/PC RI/FS, samples from Poplar Creek will also be analyzed for $^{99}$Tc, $^{234,235,238}$U, $^{60}$Co, and PCBs. Sediment sampling results will be compared to the concentrations required to produce a $1 \times 10^{-6}$ or greater level of cancer risk, using the dredging scenario described in the RI/FS documents. Sediment samples exceeding a cancer risk factor of $1 \times 10^{-6}$ would support the need for continued institutional controls. Contaminant concentrations will be reported in the RER/CERCLA Five-Year Review for the ORR along with text discussion of risk and change (if any) from baseline. The next Five-Year Review for the ORR will be conducted in fiscal year 2006.

**Table 5. Revised CR/PC and LWBR surface water and sediment sampling locations relative to the previous monitoring plan**

| Monitoring location | | Previous monitoring plan[a] | | Revised monitoring plan | |
|---|---|---|---|---|---|
| **Site** | **Description** | **Surface water** | **Sediment** | **Surface water** | **Sediment** |
| | | ***Clinch River sites*** | | | |
| CRM 35.8 | McCoy Branch | | X | | |
| CRM 19.7-20.7 | Jones Island downstream of WOC | X | X | | |
| CRM 18-18.7 | Grubbs Island | X | X | | |
| CRM 14-15 | ETTP water intake upstream of PC | X | X | | X |
| CRM 10.5-12 | Brashear Island downstream of PC | X | X | X | X |
| CRM 6-7 | Young Creek outlet | X | X | | X |
| CRM 1 | Kingston City Park | X | X | X | X |
| | | ***Poplar Creek sites*** | | | |
| PCM 5.5 | Confluence of PC and EFPC | | X | | |
| PCM 3 | Near Mitchell Branch outlet | X | X | | |
| PCM 1 | Near K-1007-P1 outlet | X | X | | X |
| | | ***Lower Watts Bar (Tennessee River) sites*** | | | |
| TRM 551-556 | Thief Neck Island | X | X | | X |
| TRM 530-532 | Watts Bar Reservoir forebay[b] | X | X | X | X |
| TRM 543-548 | White's Creek | | X | | |
| TRM 568.4 | Kingston Water Intake | | | X | |
| | | ***Reference sites (upstream of CR/PC-LWBR OUs)*** | | | |
| CRM 44.5-45.5 | Solway Bridge | | X | | |
| CRM 48[c] | Bull Run Steam Plant | | | X | X |
| CRM 23.4-24.7 | Melton Hill Reservoir forebay[b] | X | X | X | X |
| TRM 570-572 | Tennessee River Arm upstream of CR | X | X | | |
| WOCE | White Oak Creek Embayment | X | X | X | |
| WOL | White Oak Lake | X | X | | |
| K1007-P1 | K-1007-P1 Pond | X | X | X | |
| K901-A | K-901-A Pond | X | X | X | |

[a]*Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-1820&D2.

[b]Fish from the Watts Bar Reservoir and Melton Hill Reservoir forebays are routinely collected for polychlorinated biphenyls analysis by the Tennessee Valley Authority, and their results may be used if applicable.

[c]Samples may be collected from alternative reaches of the waterway ranging from CRM24 to CRM99. River mile will be recorded in the field log book when collected and communicated for input into PEMS when provided for shipment to the laboratory for analysis.

EFPC = East Fork Poplar Creek.
ETTP = East Tennessee Technology Park.
LWBR = Lower Watts Bar Reservoir.
OU = operable unit.
PEMS = Project Environmental Measurements System.
CRM = Clinch River Mile, PCM = Poplar Creek Mile, TRM = Tennessee River Mile, WOC = White Oak Creek, WOCE = White Oak Creek Embayment, WOL = White Oak Lake, PC = Poplar Creek, and CR = Clinch River.

# 6. SUMMARY

The primary objective of the monitoring program for the CR/PC and LWBR system is to monitor the reservoir and river system to track changes in contaminant concentrations, mobility, and associated risk. Changes to the current monitoring program are being made to provide a more unified, long-term monitoring program that: (1) meets the requirements of the RODs for both OUs, (2) is technically sound and informative, (3) is integrated with ORR watershed and exit pathway monitoring, and (4) is cost-effective.

The revised monitoring program consists of two components:

- annual monitoring of major COCs in fish, and
- monitoring of sediment and surface water prior to the CERCLA Five-Year Review.

Monitoring locations for fish, turtles, surface water, and sediment are summarized in Table 6 and shown in Fig. 2. The focus of the new biota monitoring program is to detect temporal changes in the key COCs at sites and in fish species that have been previously identified as posing unacceptable risks. Species like channel catfish and striped bass are the ones most sensitive to changes in exposure, especially for PCBs. If concentrations in these species increase substantially, it would indicate that further study is needed to determine if the current institutional controls are adequate. Conversely, substantial decreases would be directly applicable to evaluating the efficacy of removing a fishing advisory. This new monitoring plan uses a more scientifically rigorous sampling design so that any statistical change in fish concentrations can be determined and evaluated.

Surface water and sediment samples will be collected throughout the CR/PC and LWBR system once every 5 years to provide information and data necessary to support the CERCLA Five-Year Review and determine whether the selected remedies remain protective.

**Table 6. Summary of CR/PC and LWBR monitoring locations**

| Site | Description | Surface water | Sediment | Largemouth bass | Channel catfish | Striped bass | Turtles |
|---|---|---|---|---|---|---|---|
| | ***Clinch River sites*** | | | | | | |
| CRM 19.7-20.7 | Jones Island downstream of WOC | | | | X | | X |
| CRM 14-15 | ETTP water intake upstream of PC | | X | | | | |
| CRM 10.5-12 | Brashear Island downstream of PC | X | X | X | X | | X |
| CRM 6-7 | Young Creek outlet | | X | | | | |
| CRM 2.6 | Kingston Steam Plant discharge | | | | | X | |
| CRM 1 | Kingston City Park | X | X | | | | |
| | ***Poplar Creek sites*** | | | | | | |
| PCM 1 | Near K-1007-P1 outlet | | X | X | X | | |
| | ***Lower Watts Bar (Tennessee River) sites*** | | | | | | |
| TRM 551-556 | Thief Neck Island | | X | | | | |
| TRM 530-532 | Watts Bar Reservoir forebay[a] | X | X | X | X | | |
| | ***Reference sites (upstream of CR/PC-LWBR OUs)*** | | | | | | |
| CRM 48[b] | Bull Run Steam Plant | X | X | | | X | |
| CRM 23.4-24.7 | Melton Hill Reservoir forebay[a] | X | X | X | X | | X |
| TRM 568.4 | Kingston City Water Intake | X | | | | | |
| WOCE | White Oak Creek Embayment | X | | | | | |
| K1007-P1 | K-1007-P1 Pond | X | | | | | |
| K901-A | K-901-A Pond | X | | | | | |

[a]Fish from the Watts Bar Reservoir and Melton Hill Reservoir forebays are routinely collected for polychlorinated biphenyls analysis by the Tennessee Valley Authority, and their results may be used if applicable.

[b]Samples may be collected from alternative reaches of the waterway ranging from CRM24 to CRM99. River mile will be recorded in the field log book when collected and communicated for input into PEMS when provided for shipment to the laboratory for analysis.

ETTP = East Tennessee Technology Park.

LWBR = Lower Watts Bar Reservoir.

OU = operable unit.

PEMS = Project Environmental Measurements System.

CRM = Clinch River Mile, PCM = Poplar Creek Mile, TRM = Tennessee River Mile, WOC = White Oak Creek, WOCE = White Oak Creek Embayment, WOL = White Oak Lake, PC = Poplar Creek, and CR = Clinch River.

NOTE: Expanded or alternate stream or river reaches may be sampled to attain target numbers of biota, depending on the species and the objective of the monitoring. For example, as noted above, for some wide-ranging species, such as striped bass, there is not a significant difference in contaminant concentration within a reservoir that is location dependent. Another example is when the objective of sampling is to obtain reference fish with low contaminant concentrations; in that case, multiple river reaches upstream of DOE discharges may be suitable. In addition, depending on target sample availability, surrogate species may need to be collected to complete the collection.

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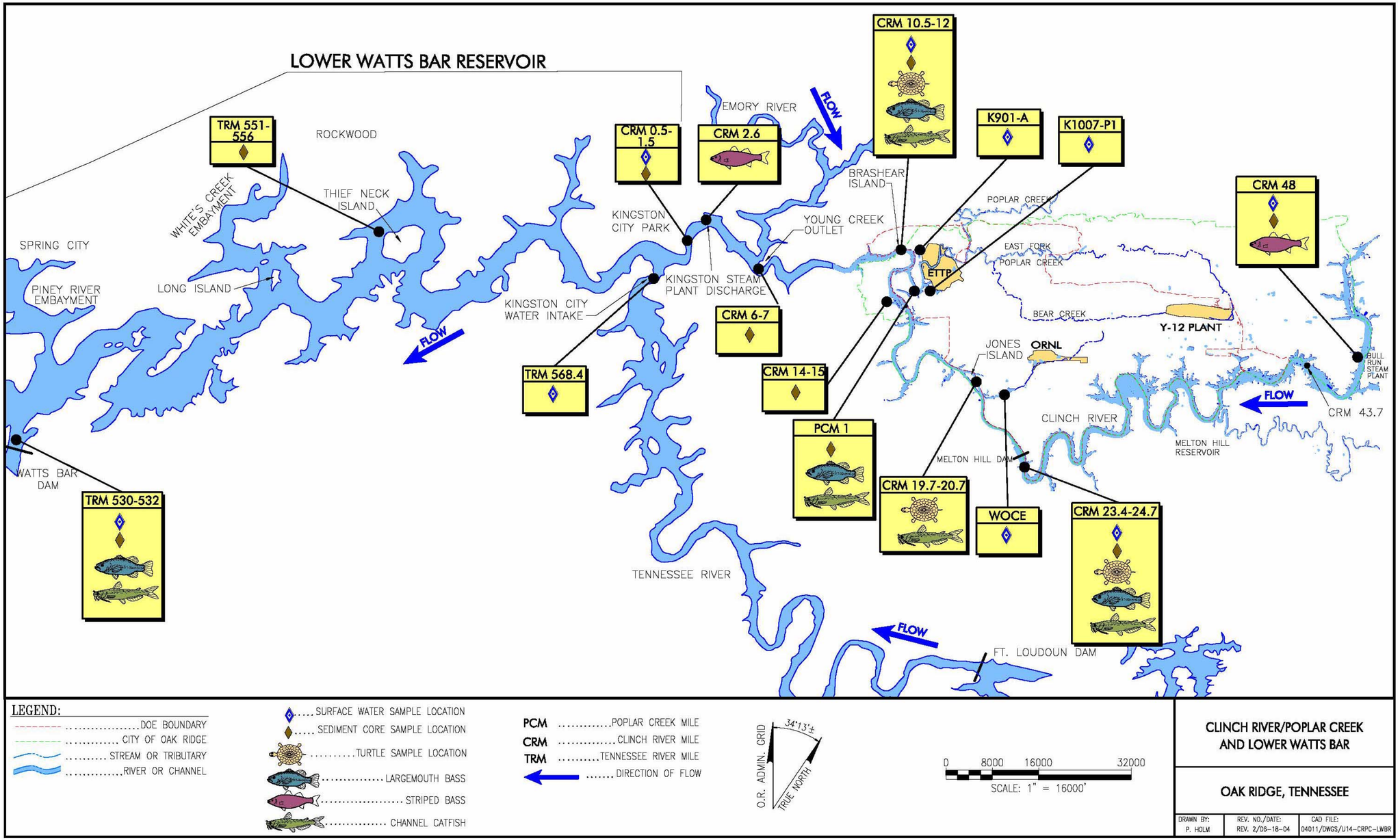


**Fig. 2. Sample collection locations in Clinch River/Poplar Creek and Lower Watts Bar Reservoir.**

# 7. REFERENCES


Baxter, R. M. 1977. "Environmental effects of dams and impoundments," *Annual Review of Ecology and Systematics*, pp: 255–283.

Blalock, B. G., et al. 1993. *White Oak Creek Embayment site characterization and contaminant screening analysis*, ORNL/ER-81, Oak Ridge National Laboratory, Oak Ridge, TN.

Dendy, F. E. 1973. "Sediment trap efficiency of small reservoirs," pp. 898–908 in *Man-Made Lakes: Their Problems and Environmental Effects*, ed. W. C. Ackermen, G. F. White, E. B. Worthington, and J. L. Ivens, American Geophysical Union Monograph 17, Washington, D.C.

DOE (U. S. Department of Energy) 1988. *Historical radionuclide releases from current DOE Oak Ridge Operations Office facilities*, OR-890, U. S. Department of Energy, Oak Ridge, TN.

DOE 1995a. *Remedial Investigation/Feasibility Study Report for Lower Watts Bar Reservoir Operable Unit*, DOE/OR/01-1282&D4, U. S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE 1995b. *Record of Decision for Lower Watts Bar Reservoir Operable Unit*, DOE/OR/02-1373&D2, U. S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE 1996a. *Remedial Action Work Plan for Lower Watts Bar Reservoir in Tennessee*, DOE/OR/01-1376&D3, U. S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE 1996b. *Remedial Investigation/Feasibility Study Report for Clinch River/Poplar Creek Operable Unit*, DOE/OR/01-1393&D3, U. S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE 1997. *Record of Decision for Clinch River/Poplar Creek Operable Unit*, DOE/OR/02-1547&D2, U. S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE 1999a. *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-1820&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 1999b. *Remedial Action Report for Clinch River/Poplar Creek in East Tennessee*, DOE/OR/02-1627&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2004. *2004 Remediation Effectiveness Report for the U. S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-2133&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

EPA (U. S. Environmental Protection Agency) 2001. *Comprehensive Five-Year Review Guidance*, EPA 540-R-01-007, Office of Emergency and Remedial Response, Washington, D.C.

Olsen, C. R., et al. 1992. *Transport and accumulation of Cesium-137 and Mercury in the Clinch River and Watts Bar Reservoir System*, ORNL/ER-7, Oak Ridge National Laboratory, Oak Ridge, TN.

Turner, R. R., Olsen, C. R., and Wilcox, Jr., W. J. 1985. "Environmental fate of Hg and $^{137}$Cs discharged from Oak Ridge facilities," pp. 329–338 in *Trace Substances in Environmental Health – XVIII*, ed. D. D. Hemphill, University of Missouri, Columbia, MO.

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