DEPARTMENT OF ENVIRONMENT & CONSERVATION

DOE OVERSIGHT DIVISION

ENVIRONMENTAL MONITORING REPORT

JANUARY THROUGH DECEMBER 2007

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This plan was published
With 100% Federal Funds
DE-FG05-96OR22520
DE-FG05-96OR22521

Tennessee Department of Environment and Conservation, Authorization No. 327040, 36 copies. This public document was promulgated at a cost of $6.47 per copy. March 2008.

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EXECUTIVE SUMMARY

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the Division) is providing a report of its independent environmental monitoring for the 2007 calendar year. The report is a series of individual reports completed by Division personnel. General areas of interest determine the substance of the reports: Air Quality, Biological/Fish and Wildlife, Drinking Water, Groundwater, Radiation, and Surface Water/Sediment. An abstract is provided in each report. All supporting information and data used in the completion of these reports are available for review in the Division's files.

Air Quality Monitoring

RadNet Air Monitoring Program (previously called Environmental Radiological Ambient Monitoring Systems or ERAMS) This EPA-sponsored program detected slightly elevated radionuclides in air samples taken at the Y-12 National Security Complex. It is probable these results are associated with Y-12's campaign to modernize operational facilities and tear down unneeded buildings, but the exact cause is unknown. Data for RadNet samplers at ETTP and ORNL were similar to background measurements. All radiological results for air sampling in 2007 were below Clean Air Act standards. While slightly higher results were reported at monitoring stations located east of the Y-12 National Security Complex, the results for 2007 do not indicate a significant impact on the environment or public health from Oak Ridge Reservation emissions.

Fugitive Radiological Air Emissions Monitoring High-volume mobile air samplers are used in this program to monitor radioactive contaminants at locations where there is a potential for the release of fugitive/diffuse air emissions released on the Oak Ridge Reservation from remedial or waste management activities. The program uses four high-volume air samplers mounted on trailers for the monitoring *performed* in the program. One sampler was positioned to monitor waste disposal activities at the Environmental Management Waste Management Facility in Bear Creek Valley. One unit was used to monitor emissions from the Tank W-1a/Corehole 8 remedial action at ORNL. The two remaining samplers were placed at the East Tennessee Technology Park to monitor the decontamination and demolition of contaminated facilities at the site. A fifth unit is stationed at Fort Loudoun Dam in Loudon County to collect background information. Results for fugitive air monitoring performed in 2007 at the EMWMF, the Corehole 8/Tank W-1a remedial site at ORNL, to the southeast of the K-25 facility at ETTP, and at the site of the previously demolished K-1420 building at ETTP fluctuated somewhat, but remained near background levels. The annual average concentration above background for *each* of the locations monitored were each below Clean Air Act Standards (10 mrem/yr). However, ALARA needs to be a consideration during remedial and/or waste management activities on the Oak Ridge Reservation.

*Ambient VOC Monitoring of Air on the Oak Ridge Reservatio*n This project was not completed in 2007. Changing priorities, staffing moves and equipment issues mandated that the pilot project not be completed. Ambient air was to be sampled at one or more locations on the Oak Ridge Reservation (ORR). The results were to be assessed to monitor the "overall health" of the ambient environment and to measure possible impacts from present or past DOE operations.

RadNet Precipitation Monitoring The precipitation monitoring project measures radioactive contaminants that are washed out of the atmosphere and carried to the earth's surface by precipitation. There are no standards that apply directly to contaminants in precipitation. However, the data *provide* an indication of the presence of radioactive materials that may not be evident in the particulate samples collected by the Division's air monitors. The Environmental Protection Agency (EPA) has provided two monitors to date, both of which are co-located with the RadNet air stations. The first monitor was placed at the Melton Valley sampling location, in the vicinity of ORNL, in December 2004. The second monitor was placed off of Blair Road, east of ETTP in April 2007. Precipitation at the sampling station in Melton Valley had higher levels of tritium than the national average most months, though not the highest value nationwide. However, the other sampling stations are located near major population areas while the one in Melton Valley is near nuclear sources. While there is not a regulatory limit for tritium in precipitation, the limit for tritium in drinking water (20,000 pCi/L) is relatively high compared to levels found in precipitation elsewhere in the United States.

The gross beta values in precipitation at the Melton Valley site, for December 2004 through March 2007, were lower than the national average, and gross beta values at the Blair Road site were lower than gross beta values found at the Melton Valley site each month. Also, the highest gross beta values seen on the Oak Ridge Reservation have all been well below the highest values seen in Tennessee, in adjacent states, and nationwide. Consequently, gross beta values in precipitation on the Oak Ridge Reservation are unlikely to have posed a hazard to the public or the environment during the periods these sites have been monitored.

Oak Ridge Reservation Perimeter Ambient Air Monitoring Program The perimeter air monitoring program, in conjunction with associated air monitoring programs, provides information used to assess the impact of Department of Energy activities on the local environment and public health. In the program, samples are collected from twelve low volume air monitors stationed near the boundaries of the reservation and at a background location. Each sample is analyzed for gross alpha and gross beta radiation at the state radiochemistry laboratory. Results from the reservation samplers are compared to the background measurements and environmental standards provided in the Clean Air Act. A composite sample from each location is analyzed annually for gamma emitters. Background measurements and environmental standards provided in the Clean Air Act are compared against the results from the perimeter monitoring stations. Anomalous results were reported for station 38 (August-December) and station 46 (August-September). In each of these cases, the concentrations reported had dropped significantly below background levels. The anomalous results may be due to equipment failure and/or sampling error, although the exact cause is not known. This anomaly is currently being investigated by Division staff. Data for 2007 were not indicative of a significant impact on local air quality from activities on the reservation.

Hazardous Air Pollutants Metals Monitoring at ETTP, Y-12 and ORNL The results of the 2007 monitoring conducted by TDEC at the ETTP sites indicate no apparent elevated levels of hazardous air pollutants (HAPs) metals of concern. Total chromium levels are above risk-specific background for chromium VI, but only if total chromium results from blank filters are not subtracted. Chemical speciation of chromium in the samples remains uncertain, and concentrations are far below reference levels for chromium III in air. Analyses for all other metals of concern were well below regulatory standards or guidelines. The results of the 2007 monitoring conducted by TDEC at the Y-12 sites indicate no apparent elevated levels for HAPs metals of concern. HAPs metals monitored were arsenic, beryllium, cadmium, total chromium, lead, nickel and uranium metal. Analyses for all metals of concern were below guidelines. ORNL was not monitored for hazardous metals during 2007.

Biological/Fish and Wildlife Monitoring
Benthic Macroinvertebrate Biomonitoring Using a Semi-Quantitative Approach: Rapid Bio-Assessment Protocol (RBP III) Semi-quantitative benthic macroinvertebrate samples were collected from study sites on four streams impacted by Department of Energy (DOE) operations. Samples were collected and processed following the State of Tennessee standard operating procedures for macroinvertebrate surveys. Generated data was analyzed using applicable metrics. A score was calculated from the metrics and a stream-site health rating was assigned. In general, results showed signs of biotic improvement with increasing water quality downstream of DOE influences. The biotic integrity of streams on the ORR is less than optimal compared to reference conditions. Two sites, both in the White Oak Creek watershed, showed signs of supporting, non-impaired conditions. The remaining sites had biological condition ratings of partially supporting systems with slight to moderate impairment. Surface water sampling results indicated mercury remains persistent in East Fork Poplar Creek and nutrient inputs continue to affect Bear Creek. Continued water sampling in Mitchell Branch will be a useful tool in documenting the effectiveness of chromium clean-up activities. Monitoring benthic macroinvertebrate communities should provide more thorough and accurate assessments of stream conditions by capturing temporal and spatial changes due to DOE-related activities. Environmental remedial actions taken by DOE continue to have an impact on the aquatic environments in East Fork Poplar Creek, Mitchell Branch, the White Oak Creek watershed, and Bear Creek. Results from two qualitative sampling sites on Scarboro Creek indicated supporting, non-impaired conditions exist, although results from the lower Scarboro Creek site suggest more data may be needed to substantiate this claim. The effectiveness of remedial activities over time can be monitored by documenting changes in the benthic macroinvertebrate communities.

Diatom (Periphyton) Environmental Monitoring The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (division), Environmental Monitoring Section, continued monitoring diatom communities in Oak Ridge Reservation (ORR) watersheds during 2007. Communities of attached benthic algae contain diatom taxa with individual tolerance to anthropogenic stress (e.g., heavy metals), which may explain community compositional changes or shifts such as decreased taxa diversity and richness. Periphyton samples were collected during March, July and November in East Fork Poplar Creek and Bear Creek (note: White Oak Creek samples collected during March, May and November) using artificial substrates deployed in ten impacted and four reference streams. The goal was to use diatoms as biomonitoring tools to examine the water quality and ecological recovery of East Fork Poplar Creek, Bear Creek, and White Oak Creek (Melton Branch) watersheds impacted by Department of Energy (DOE) operations at Y-12 National Security Complex and the Oak Ridge National Laboratory respectively. Thus, water quality can be characterized by evaluating the results of qualitative and quantitative measurements of the benthic algal community. Results of the 2007 periphyton (diatom) biomonitoring continue to indicate a general trend of improving water quality for both Bear Creek and East Fork Poplar Creek with longitudinal distance from the upstream Y-12 contamination source. The diatom biomonitoring evidence suggests that part of the upper Bear Creek impairment may be related to north tributary outfalls from the EMWMF site. This year the White Oak Creek/Melton Branch monitoring data proved to be inconclusive.

Vascular Plant Surveys (Field Botany) Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (TDEC DOE-O, or Division) staff provided oversight of Department of Energy (DOE) botanical assessments of remedial action sites at various ORR locations during 2007. Survey sites included ORR aquatic ecosystems and the opening of the new Dyllis Orchard Road greenway trail on the Blackoak Ridge Conservation Easement. Priority was given to locating rare plants and documentation of pest-plant invasion areas on the ORR. Division staff also provided botanical support to the TDEC Division of Natural Areas (TDEC DNA) including the rare plant program, the natural areas program, and the inventory program. Field botany and rare plant mapping formerly planned for the Blackoak Ridge Conservation Easement were not completed during 2007 due to scheduling and personnel constraints.

Canada Geese Monitoring On June 27 and 28, 2007, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) conducted oversight of the annual Canada geese (*Branta canadensis*) monitoring project on the Oak Ridge Reservation (ORR). The objective of this study was to determine if geese are becoming contaminated on the ORR. The captured geese were transported to the Tennessee Wildlife Resources Association (TWRA) game check station on Bethel Valley Road and tested for radioactive contamination. None of the geese captured this year showed elevated gamma counts above the 5 pCi/g game release level. Since no contaminated geese were captured, the DOE-Oversight Division did not conduct additional offsite sampling of Canada geese.

Biological Sampling and Radiochemical Analysis of Aquatic Plants (Macrophytes) at Spring Habitats on the Oak Ridge Reservation This project is an expansion of a pilot vegetation (watercress) sampling and radiochemical analysis effort begun by Division staff in 1995 as part of environmental surveillance in accordance with the Tennessee Oversight Agreement. The project was revitalized in 2002. The 2007 study was designed to collect samples from never-before-sampled areas in the vicinity of areas that radiological contamination had been found in the past or in areas that had a strong possibility of present or future contamination. Samples were collected from Oak Ridge Reservation springs and engineered drainage areas as an aid in determining if aquatic vegetation is bioaccumulating radiological contaminants above the Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs). The SDWA MCL for gross alpha is 15 pCi/L. The SDWA MCL for beta and photon emitters is four (4) mrem/yr to the total body or any given internal organ. Division staff gathered vegetation monitoring data in support of the groundwater monitoring and sampling of springs and surface water impacted by hazardous substances. “Vegetation” sampled included watercress (*Rorippa nasturtium-aquaticum*), other aquatic macrophytes (i.e., *Salvinia* sp., *Sagittaria latifolia, Typha latifolia*, etc), and green algae. Fourteen vegetation samples from reference springs/creeks/ponds offsite and springs/creeks/ponds onsite were sampled during 2007. Sample collection times were random as there was no need in this case to organize a schedule into wet and dry season sampling events. Adequate evidence of vegetation bioaccumulation of radionuclides has been determined to warrant further investigations. The radionuclide levels did not indicate that these fourteen locations sampled could be considered "hot spots" because the results for all locations were below the SDWA MCLs.

Fish Tissue Monitoring The Tennessee Department of Environment and Conservation (TDEC) posts warning signs around streams and lakes where public health is endangered. In Tennessee, the most common reason for a river or lake to be posted is the when the presence of contaminants (e.g. sewage and/or metals) is noted in the water, sediment, or fish of a water body. An annual fish tissue meeting is held each year to exchange data and coordinate sampling efforts among the many organizations that sample fish tissue in Tennessee. The 2007 meeting focused primarily on efforts around the Oak Ridge Reservation (ORR). Review of PCB levels in catfish on Watts Bar Reservoir indicated that these levels declined over the past several years. However, due to coordination problems with TVA and personnel changes, samples were not collected and therefore not analyzed. This project was not completed for 2007. If fish tissue becomes available analysis may take place in 2008.

Drinking Water Monitoring

Implementation of EPA's RadNet (formerly the Environmental Radiation Ambient Monitoring Systems or ERAMS) Drinking Water Program RadNet, formerly the Environmental Radiation Ambient Monitoring System, was developed by the U.S. Environmental Protection Agency to monitor potential pathways for significant population exposures from routine and/or accidental releases of radioactivity from major sources in the United States (U.S. EPA, 1988). This program provides for radiochemical analysis of finished water at five public water supplies located near and on the Oak Ridge Reservation. In this effort, quarterly samples are taken by staff from the Tennessee Department of Environment and Conservation to be analyzed at the Environmental Protection Agency's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. Radioactive contaminants migrate from the ORR to the Clinch River, which serves as a raw water source for area public drinking water supplies. The impact of these contaminants is diminished by the dilution provided by waters of the Clinch River. Contaminant concentrations are further reduced in finished drinking water by conventional water treatment practices employed by area utilities. RadNet/ERAMS results over the last nine years have all been well below drinking water criteria. Gross beta, strontium-90, and tritium, while below drinking water standards, have all been reported at higher levels in samples taken from the Gallaher (K-25) Water Treatment Plant than at the other facilities monitored in the program, with the exception of the fourth quarter 2007 tritium result at the Oak Ridge/Y-12 sampling location, which is being re-analyzed. The Gallaher plant is the closest facility downstream of White Oak Creek, the major pathway for radiological pollutants entering the Clinch River from the ORR.

Sampling of Oak Ridge Reservation Potable Water Distribution Systems The scope of TDEC DOE-O's independent sampling includes oversight of potable water quality on, or impacted by, the ORR. TDEC conducted oversight of backflow prevention devices and sanitary surveys at ORR facilities. As the three Department of Energy (DOE) Oak Ridge Reservation (ORR) plants become more accessible to the public, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) has expanded its oversight of the DOE facilities' safe drinking water programs. The results of these inspections revealed that the three reservation systems provide water that meets state regulatory levels. The distribution system at Y-12 does have some deficiencies in their Cross Connection Control

Program, as noted in the sanitary survey. The Division also observed the repair and construction of several water lines at Y-12. The monitoring activities, through oversight and independent sampling of the sanitary water distribution systems on the ORR, met the regulatory requirement of 0.2 mg/L for residual chlorine. No elevated levels of bacteria above the regulatory limits were reported after several tests at the three facilities. TDEC conducted oversight of backflow prevention devices and sanitary surveys at ORR facilities. The 2007 results of these inspections revealed that the three reservation systems provide water that meets State regulatory levels. The distribution system at Y-12 does have some deficiencies in its Cross Connection Control Program, as noted in the Sanitary Survey performed by the TDEC Drinking Water Supply Knoxville field office.

Groundwater Monitoring

Tracing Studies in the Y-12 Landfill Area on Chestnut Ridge The tracing studies were not carried out in 2007. The tracing studies are being carried forward to CY 2008. This accommodation of scheduling is due to project priorities affecting the availability of staff at times when hydrogeologic conditions were favorable for tracing.

Oak Ridge Reservation and Vicinity Independent Sampling Report In calendar year 2007, groundwater-sampling projects included fifty-seven springs/seeps, and wells, and four surface water sites, and one soil sample for a total of sixty-two sites. The Melton Valley Picket wells located on the ORR just to the East of the Clinch River and directly across from the impacted USGS and domestic wells show significant radiochemical, heavy metal, volatile organic and inorganic contamination. Further, the Melton Valley Picket wells show that this contamination exists at considerable depths (400-500 feet below the ground surface). The presence of specific radionuclides strontium-90, cesium-137, and cobalt-60 indicate that wastes injected during the hydrofracture project are at least in part responsible for the contamination seen at depth. The Melton Valley Picket Well Data, on its own merits suggests that first, groundwater resources across the Clinch River are at risk and secondly, wells that are completed below the base of the Clinch River are particularly at risk of inducing the flow of contaminated groundwater beneath and across the river. Identification of contaminated exit pathway wells down from the Melton Valley disposal areas and the identification of a number of wells in the area with anomalous water parameters (in particular alkalinity), encourages refined monitoring on both sides of the Clinch River. The Union Valley plume from Y-12 continues to show abatement as seen by analysis at its former terminal point of Cattail Spring. Just where the plume terminates has not been established but it is obvious that the Y-12 pump- and-treatment program has had a welcome measure of success. The plume originating at the Y-12 Security Pits and emerging at Bootlegger Spring in the UT Arboretum continues to show sporadic results in analysis and appears to be governed by ambient conditions. Division groundwater monitoring in and around ETTP continued to show contamination reaching several offsite areas. In particular, TDEC sampling showed volatile organic solvents at spring USGS 10-895 north of the main plant area and at PCO Seep on the bank of the Clinch River west of the plant. Spring 21-002, which is known to drain the K-1070-A Burial Ground, did show increasing concentrations of contaminants in the latter part of 2007.

Contaminated Groundwater Discharges from the ORNL 7000 Area into White Oak Creek Groundwater discharging into White Oak Creek from the 7000 area of Oak Ridge National

Laboratory is known to be contaminated with volatile organic compounds. This sampling project was initiated to better define discrete discharges of contaminated groundwater into White Oak Creek and its tributaries near the 7000 area. At least three such contaminated discharges were located or confirmed. A seep on the south bank of White Oak Creek previously reported to have been contaminated and a discharge from a steam line sump pump were found to be contaminated with the solvent trichloroethene and its decomposition products. The distribution of these discharges, relative to flow paths inferred from local gradients and geology, indicates that multiple sources of these compounds may be present in the 7000 area, and that multiple plumes of contamination may be migrating toward the creek.

Radiological Monitoring

Ambient Radiation Monitoring on the Oak Ridge Reservation Using Environmental Dosimetry The Tennessee Department of Environment and Conservation began monitoring ambient radiation levels on the Oak Ridge Reservation in 1995. The program provides conservative estimates of the dose to members of the public from exposure to gamma and neutron radiation attributable to Department of Energy activities on the reservation and establishes baseline values for measuring the need and effectiveness of remedial activities. In this effort, environmental dosimeters have been placed at selected locations on and near the reservation. Results from the dosimeters are compared to background values and the State dose limit for members of the public. In 2007, the doses reported for locations monitored off the reservation were all at levels below the primary dose limit. There was however, an overall increase, compared to the previous year, in the potential of doses reported. Offsite and background locations were slightly increased as well. However, several locations dropped due to remediation and removal actions. Noteworthy mention is the removal of the UF_6 cylinders from ETTP and the subsequent removal of the storage yards from the program due to their return to background levels, and the demolition and removal of debris of the K-1420 building. As in the past, results above the public dose limit were common at locations in restricted areas of the reservation.

Real Time Ambient Gamma Monitoring of the Oak Ridge Reservation In 2007, the Tennessee Department of Environment and Conservation placed gamma exposure rate monitors at seven locations: one at a background location (Fort Loudoun Dam), one at the ORNL Truck Monitor Station (7000 Area), one located on the fence near the front gate at Oak Ridge National Laboratory’s Molten Salt Reactor, one at a weigh-in station at the Environmental Management Waste Management Facility in Bear Creek Valley (near the Y-12 National Security Complex), one at a weigh-in station at the ETTP haul road scale (located at Portal 6 on the haul road connecting ETTP and the EMWMF), one at the TRU Processing Facility at ORNL, and one at the Oak Ridge National Laboratory’s Corehole 8 area. Measurements collected from these sites ranged from background levels to 802 μrem/hour. Measurements taken at the EMWMF ranged from 5 to 34 μrem/hour and averaged 7.8 μrem/hour. The highest value in the previous year was 8928 μrem/hour, and represents approximately 446% of the State maximum dose to an unrestricted area in any one-hour period (2,000 μrem/hour). The highest measurements recorded were during the delivery of wastes from the remediation of the Homogeneous Reactor Experiment. All results, were below limits specified by State and Nuclear Regulatory Commission regulations, requiring their licensees to conduct operations in such a manner that assures external potential dose in any unrestricted area does not exceed 2.0 millirem (2,000 μrem) in any one-hour period.

Facility Survey and Infrastructure Reduction Program Like other Department of Energy (DOE) research facilities across the nation, the Oak Ridge Reservation released large quantities of chemical and radiological contamination into the surrounding environment during nearly five decades of nuclear weapons research and development. In response to this history, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the Division) developed a Facility Survey Program to document the histories of facilities on the Reservation. Since 1994 the division's survey team has characterized 185 facilities and found that thirty-eight percent pose a relatively high potential-for-release of contaminants to the environment. In many cases, this high potential-for-release is related to legacy contamination that escaped facilities through degraded infrastructures over decades of continual industrial use (e.g. leaking underground waste lines, substandard sumps and tanks, or unfiltered ventilation ductwork). Since the inception of the program, DOE corrective actions (including demolitions) have removed twenty-six facilities from the Division's list of "high" Potential Environmental Release (PER) facilities. In 2007, one facility from this list (K-1401-L3) was removed through demolition. The program evaluates facilities' potential for release of contaminants to the environment under varying environmental conditions ranging from catastrophic (i.e. tornado, earthquake) to normal everyday working situations. This information is essential for effective local emergency preparedness planning.

Haul Road Radiological Surveys The purpose of Footprint Reduction was to identify portions of the ORR that have not been environmentally impacted by past federal (Department of Energy - DOE) activities. The mission was to determine which land parcels could be conditionally released from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. CERCLA 120-(h) was used as the guideline by the footprint team for the footprint investigations. The haul road segment of the project began in 2005 as an oversight of the transport/hauling of radioactive materials on haul roads on the Oak Ridge Reservation. This oversight activity was generated in response to a spill of radioactive materials along a portion of Bear Creek Valley Road and State Route 95. After this spill occurred, haul roads were built in order for the radioactive materials to be transported to the new EMWMF waste cell in Bear Creek Valley without traveling on public roads. In 2007, the Division conducted weekly walkover surveys of Reeves Road and the new haul road. In October 2007, TDEC was informed by DOE contractors that Reeves Road was not currently being used for waste transport, therefore, no further surveys were performed on this section for the remainder of 2007. With this change, TDEC began a weekly schedule for portion surveys on the new haul road. This project will expand as more haul roads are utilized and/or areas of potential for radioactive contamination and transport are identified. The Footprint Reduction process will be ready for additional surveys when DOE raises their priority on the areas or when their budget designates them for assignment.

Surplus Material Verification The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the Division), conducts random radiological surveys of surplus materials that are destined for sale to the public on the Oak Ridge Reservation (ORR). The Division, as part of its larger radiological monitoring role on the reservation, conducts these surveys to help ensure that no potentially contaminated materials reach the public. A total of 13 inspection visits were conducted at various Oak Ridge Reservation (ORR) facilities. No sales were conducted at the ETTP facility. In the event that radiological activity is detected, the

Division immediately reports the finding to the responsible supervisory personnel of the surplus sales program and follows their response to the notification to see that appropriate steps (removal of items from sale, resurveys, etc.) are taken to protect the public. Four items were observed that required further evaluation.

Ambient Gamma Radiation Monitoring of the Uranium Hexafluoride (UF_6) Cylinder Yards at the East Tennessee Technology Park (a.k.a. K-25 Gaseous Diffusion Plant) The Tennessee Department of Environment and Conservation, Division of DOE Oversight (the Division) used environmental dosimeters to monitor radiation levels at the Uranium Hexafluoride (UF_6) Cylinder Storage Yards at the East Tennessee Technology Park (ETTP). The storage yards were being remediated and the cylinders were moved to the Portsmouth Gaseous Diffusion Plant, where the UF_6 is to be converted into a form more suitable for use and/or disposal. The post remediation baseline dose was determined for all the storage yards and the project was terminated. There will be no report in this document as the dosimeters were rolled into the Ambient Radiation Monitoring on the Oak Ridge Reservation Using Environmental Dosimetry project report.

Surface Water Monitoring

Ambient Surface Water Monitoring Program One key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments is general monitoring of the ambient surface water. In 2007, the DOE Oversight Division conducted sampling at 20 sites. The samples were analyzed for standard water quality parameters and radionuclides. Based on comparisons with the Tennessee Water Quality Criteria (TWQC) for recreation, two samples exceeded Tennessee water quality criteria for *E. coli*, Clinch River Mile 52.6 (site 2) and East Fork Walker Branch Mile 0.1 (site 12). The radionuclides lead-212 and lead-214 were found at levels higher than the DOE Preliminary Remediation Goals (recreation), but these isotopes are a naturally occurring part of the environment. These *E. coli* values are unusual when past data at these sites is taken into consideration. It should be recognized that sites very close to or within contaminated burial areas were not part of this scope. Specialized surface water investigations aid in evaluating point and non-point sources.

Rain Event Surface Water Monitoring The potential for contamination to impact surface waters on the ORR during excessive rain events exists due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR). These events could cause the displacement of contamination that would not normally impact streams around the ORR. To assess the degree of surface water impact caused by these rain events, a sampling of streams were conducted following heavy rain events to determine the presence or absence of contaminants of concern. Select locations on five streams originating on the ORR were to be sampled quarterly if a heavy rain event occurs in that quarter. Overall, the results indicate that, with the exception of Melton Branch and Mitchell Branch, there appears to be no significant movement of contaminants into the sampled streams due to the heavy rainfall event. The Melton Branch sampling results are not conclusive at this point, but they do appear to indicate that remedial activities are having a beneficial effect on levels of contaminants entering the stream. The chromium results on Mitchell Branch indicate there has been at least a short term insult to the stream. Continued sampling at this site will assist in determining the effectiveness of remedial activities.

Oak Ridge Reservation Surface Water Monitoring (Physical Parameters) Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for this pollution to impact surface waters on the ORR as well as offsite aquatic systems. The local structural geology and related karst topography influences the fate and transport of contaminants that may further degrade the groundwater and surface water quality of aquatic systems adjacent to the ORR. Therefore, during 2007, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (TDEC DOE-O, or Division), collected ambient water quality data at seven ORR and at one offsite stream locations twice a month. The data met all State water quality criteria for the parameters observed at the seven ORR monitoring stations. The station at Bear Creek km 12.3 (BCK 12.3) shows consistently high conductivity readings suggesting degraded water quality due to high nutrients in the aquatic system. BCK 12.3 is located downstream and west of the capped S-3 Ponds site and the Y-12 West End water treatment facility.

Monitoring of Liquid Effluents at the Environmental Management Waste Management Facility The availability of the Environmental Management Waste Management Facility (EMWMF) has expedited remedial activities, but the water-rich environment of the region has presented challenges to the containment of contaminants in the facility. State monitoring of liquid effluents at the site was developed into a program in 2006 after sporadic sampling in 2005. The intent of the program is to help ensure that any releases from the EMWMF are identified quickly in order to control associated damage and to verify that effluents released from the EMWMF and associated contaminant control mechanisms are consistent with criteria agreed upon by Federal Facility Agreement entities (i.e. the Department of Energy, the Environmental Protection Agency, and the State). Radionuclides can be released from the EMWMF to North Tributary 5, based on the current DOE Order, provided the quantities do not exceed concentrations that would be equivalent to an annual average dose of 25 mrem/year. State data for 2007 indicate the levels of radionuclides released from the facility were below the agreed upon dose limit.

Ambient Sediment Monitoring Program Sediment analysis is a good way to assess what contaminants have been present in a water body in the past. These contaminants are often incorporated into the clay and organic matter fraction of sediment through mechanisms such as cation exchange capacity and organic functional groups. Sediment samples from ten Clinch River and fifteen tributary sites were analyzed for metals, extractable organics, and radiological parameters in 2007. Since there are no federal or state sediment cleanup levels, the data are compared to soil background levels, EPA Region 4 sediment screening levels and consensus-based sediment quality guidelines. Where contaminants are found in sediments, the levels are at low concentrations that do not pose a threat to human health. Nine ten-day whole-sediment toxicity tests were conducted on selected sites (four tributary and five river samples) with *Hyalella azteca* by Advent-Environ of Brentwood, Tennessee. Toxicity testing sites were selected based on elevated metals values from the 2006 sediment sample analyses. Only one sampling location (Clinch River Mile 35.5) demonstrated a detrimental effect to *H. azteca* in terms of significantly reduced survival using the t Test at an alpha of 0.05 as compared to the toxicity control.

Ambient Trapped Sediment Monitoring Project Sediment analysis is a good way to assess what contaminants have been present in a water body in the past. These contaminants are often incorporated into the clay and organic matter fraction of sediment through mechanisms such as cation exchange capacity and organic functional groups. Sediment samples from six Clinch River sites and one tributary site will be collected with passive sediment traps and analyzed for metals and radiological parameters. The goal of this project is to assess currently transported sediments in streams as compared to grab samples scooped from the bottom of the water body. Since there are no federal or state sediment cleanup levels, the data are compared to soil background levels, EPA Region 4 sediment screening levels and consensus-based sediment quality guidelines. Although this project was implemented in 2007, an insufficient amount of sediment was collected by the passive sediment traps in order to run metals and radiological analyses in 2007. Spring of 2008 should yield enough sediment to complete the initial data set for this project. Traps deployed again after spring sampling should accumulate a sufficient amount of sediment for analyses in the fall of 2008.

Underwater Survey New technology now allows the use of relatively inexpensive equipment, the side scan sonar, to possibly identify underwater structures. The DOE Oversight Division conducted underwater surveys along the Clinch River and Poplar Creek using a side-scan sonar unit in 2006. This project was not completed in 2007. Changing priorities, staffing moves and equipment issues mandated that the project not be completed. It is anticipated that further attempts will be made to search for underwater structures and/or springs in 2008.

EMWMF Storm Water Sampling Heavy rainfall events have the capability of transporting significant quantities of sediment into nearby bodies of water. This mass transport can, in turn, impact the quality of the receiving waters. Due to the extensive area of disturbed soils at the Environmental Management Waste Management Facility (EMWMF), sampling of the receiving waters for total residue would aid in determining the extent of their impact from the EMWMF. This project was not completed in 2007 due to staffing and project priorities.

Conclusion

The 2007 monitoring results showed effort by DOE to improve the overall health of the public and the environment. Many of the pollutant anomalies measured were a result of remediation activities and resulting fugitive emissions. However, none of these resulted in an unacceptable risk to the public. The State continues to recognize that when environmental cleanup is done some releases are inevitable. The short-term negative impact outweighs the overall benefit of cleanup. There are still significant sources of contaminants that could be released as a result of engineering and/or administrative control failure. Additionally, sources of gamma radiation exposure that still exist must be effectively isolated from the public. The probability of offsite groundwater contamination is also a concern that must be addressed. It is necessary and prudent for the State and DOE to continue monitoring efforts in order to detect and evaluate, as early as possible, potential releases and radiation that could affect the public.

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INTRODUCTION

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the Division), in accordance with the Tennessee Oversight Agreement, Attachment A.7.2.2, is providing this annual environmental monitoring report of the results of its monitoring and analysis activities during the calendar year of 2007 for public distribution. The Division was established in 1991 to administer the Tennessee Oversight Agreement and the CERCLA-required Federal Facility Agreement. These agreements are designed to assure the citizens of Tennessee that the Department of Energy (DOE) is protecting their health, safety, and environment through existing programs and substantial new commitments.

This report consists of a series of individual reports that involve independent environmental monitoring by the Division. The individual reports are organized by general areas of interest: Air Quality; Biological/Fish and Wildlife; Drinking Water; Groundwater; Radiation and Surface Water. Abstracts and conclusions are available in each report to provide a quick overview of the content and outcome of each monitoring effort. All supporting information and data used in the completion of these reports are available for review in the Division's program files. Overall, this report characterizes and evaluates the chemical and radiological emissions in the air, water, and sediments both on and off the Oak Ridge Reservation (ORR).

The Division has considered location, environmental setting, history, and on-going DOE operations in each of its environmental monitoring programs. The information gathered provides information for a better understanding of the fate and transport of contaminants released from the Oak Ridge Reservation into the environment. This understanding has led to the development of an ambient monitoring system and increased the probability of detecting releases in the event that institutional controls on the Oak Ridge Reservation fail.

Currently, the Division's monitoring activities have not detected any imminent threats to public health or the environment outside of the Oak Ridge Reservation. Unacceptable releases of contaminants from past DOE operational and disposal activities continue to pose risk to the environment and it is imperative to note that, if current institutional controls fail or if the present contaminant source controls can no longer be maintained, the public would be at risk of environmental contamination.

Site Description

The DOE Oak Ridge Reservation (ORR), as shown in Figure 1, encompasses approximately 35,000 acres and three major operational DOE facilities: the Oak Ridge National Laboratory (ORNL), the Oak Ridge Y-12 Plant (Y-12), and the East Tennessee Technology Park (ETTP, formerly the K-25 Gaseous Diffusion Plant). The initial objectives of the ORR operations were the production of plutonium and the enrichment of uranium for nuclear weapons components. In the 60+ years since the ORR was established, a variety of production and research activities have generated numerous radioactive, hazardous, and mixed wastes. These wastes, along with wastes from other locations, were disposed of on the ORR. Early waste disposal methods on the ORR were rudimentary compared to today's standards.

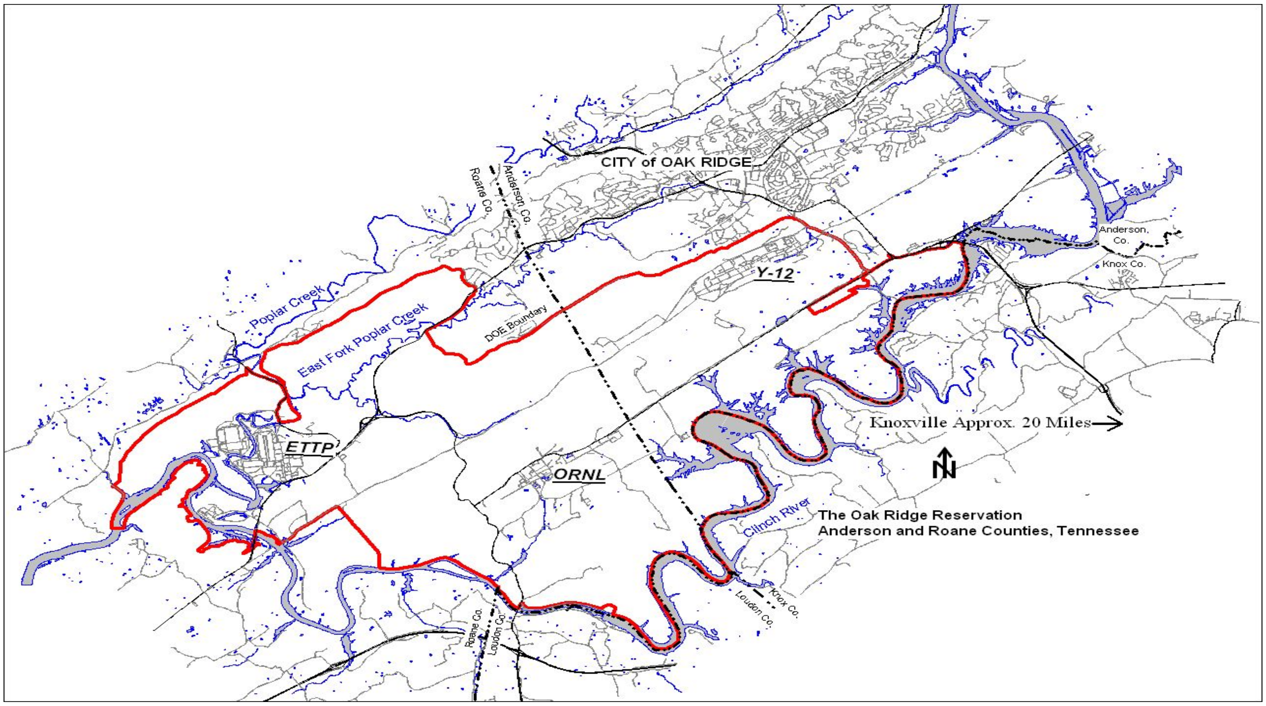

Figure 1: The Oak Ridge Reservation

The ORR is located within the corporate boundaries of the City of Oak Ridge, Tennessee, in the counties of Anderson and Roane. The Reservation is bound on the north and east by residential areas of the City of Oak Ridge and on the south and west by the Clinch River. Counties adjacent to the Reservation include Knox, Loudon, and Morgan. Meigs and Rhea counties are immediately downstream on the Tennessee River from the ORR. The nearest cities are Oak Ridge, Oliver Springs, Kingston, Lenoir City, Harriman, Farragut, and Clinton. The nearest metropolitan area, Knoxville, lies approximately 20 miles to the east. Figure 2 depicts the general location of the Oak Ridge Reservation and nearby cities.

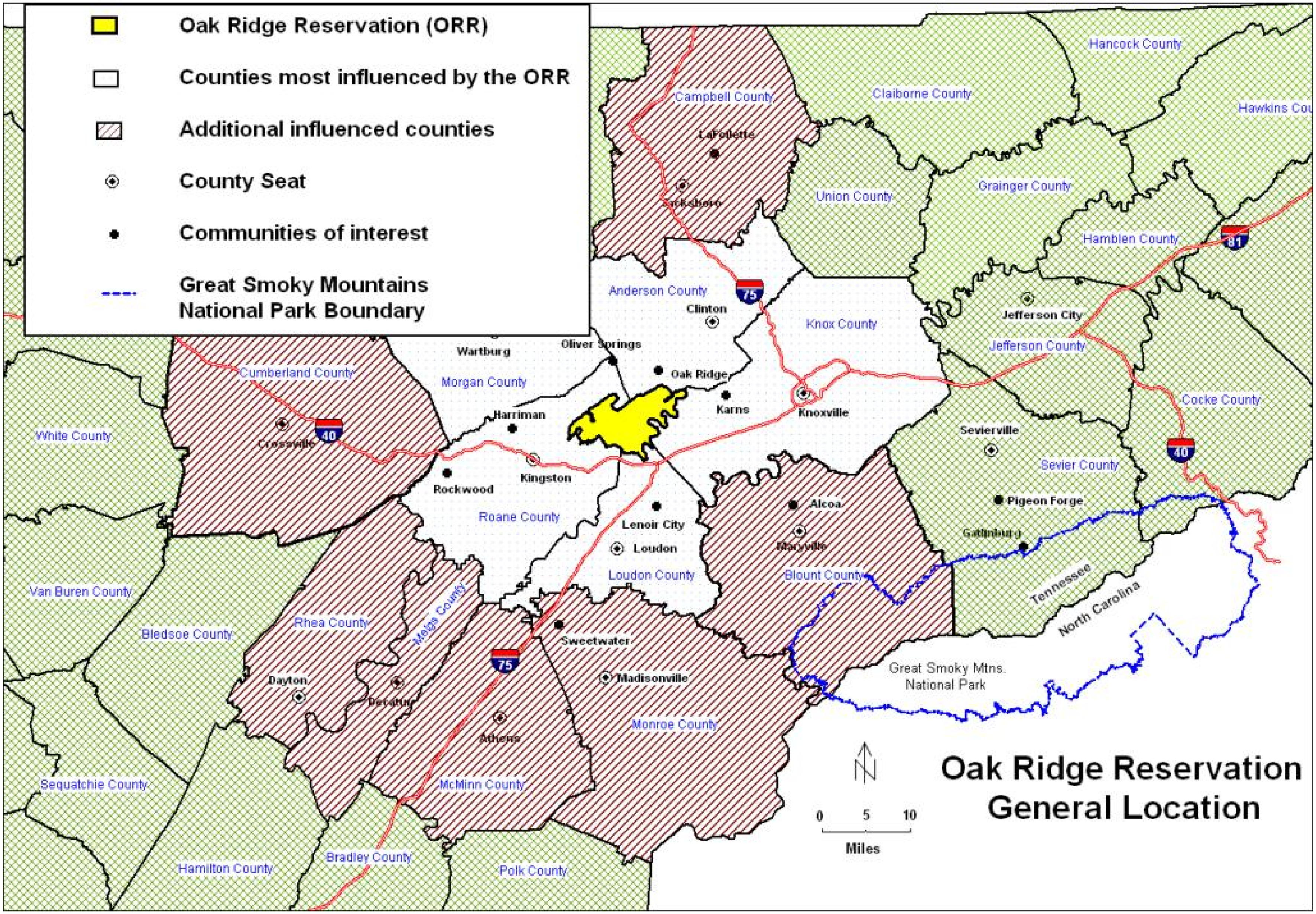

Figure 2: Location of the Oak Ridge Reservation in relation to surrounding counties.

The ORR lies in the Valley and Ridge Physiographic Province of East Tennessee. The Valley and Ridge Province is a zone of complex geologic structures dominated by a series of thrust faults and characterized by a succession of elongated southwest-northeast trending valleys and ridges. In general, sandstones, limestones, and/or dolomites underlie the ridges that are relatively resistant to erosion. Weaker shales and more soluble carbonate rock units underlie the valleys.

The hydrogeology of the ORR is very complex with a number of variables influencing the direction, quantity, and velocity of groundwater flow that may or may not be evident from surface topography. In many areas of the ORR, groundwater appears to travel primarily along short flow paths in the storm flow zone to nearby streams. In other areas, evidence indicates substantial groundwater flow paths possibly causing contaminant transport preferentially in fractures and solution cavities in the bedrock for relatively long distances.

As seen in Figure 3, streams on the ORR drain to the Clinch River. Melton Hill Dam impounded the Clinch River in 1963. Contaminants released on the Oak Ridge Reservation that do not remain permanently in the groundwater enter area streams (e.g., White Oak Creek, Bear Creek, East Fork Poplar Creek, and Poplar Creek) and are transported into the Clinch River and Watts Bar Reservoir on the Tennessee River.

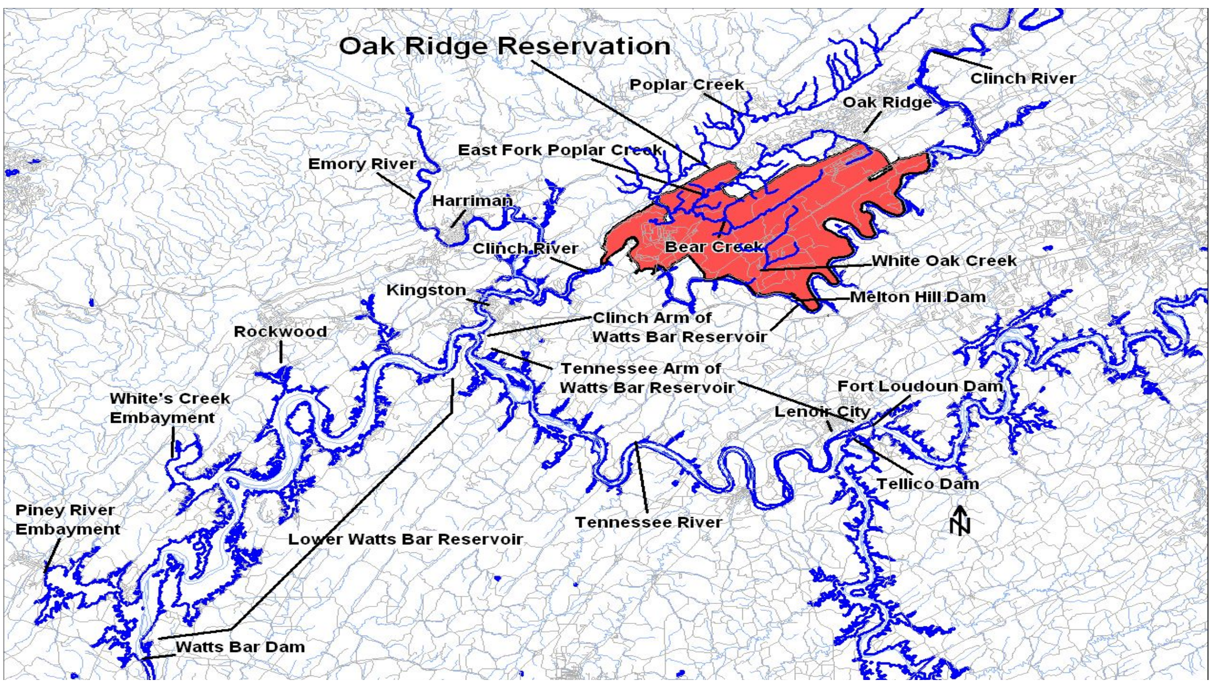

Figure 3: Watts Bar Reservoir

The climate of the region is moderately humid and the annual average precipitation is around 55 inches. Winds on the reservation are controlled, in large part, by the valley and ridge topography with prevailing winds moving up the valleys (northeasterly) during the daytime and down the valleys (southwesterly) at night.

AIR QUALITY MONITORING

Hazardous Air Pollutants Metals Monitoring at East Tennessee Technology Park

Principal Author: Sid Jones

Abstract

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division's (DOE-O) Hazardous Air Pollutants (HAPs) Monitoring Program was developed to provide continued independent monitoring at the East Tennessee Technology Park (ETTP) and to verify the Department of Energy's (DOE) reported monitoring results. Monitoring is currently conducted for arsenic, beryllium, cadmium, total chromium, lead, nickel, and uranium.

The results of the 2007 monitoring conducted by TDEC at the ETTP sites indicate no apparent elevated levels of hazardous metals of concern. A change in analytical methods initiated in 2006 has resulted in lower limits for detection and quantification of all metals. Analytical results for all metals of concern except chromium were below all regulatory standards and risk-specific doses listed in 40 CFR 266 Appendix V. Total measured chromium concentrations were about twice the risk-specific level for chromium in the +6 oxidation state (chromium VI) in air. However, chromium concentrations in unused (blank) filters were found to be over half those in the samples, so total chromium levels in ambient air for 2007 are thought to be below the restrictive risk levels for chromium VI. Concentrations of lead in ambient air were comparable to those found in previous years, and were less than one percent of the national quarterly ambient air quality standard of 1.5 micrograms per cubic meter (µg/m3). Atmospheric lead concentrations were also more or less consistent with those reported by DOE for past years.

This project will continue to monitor for potential effects on Oak Ridge Reservation (ORR) ambient air at ETTP. The goal is to provide independent air monitoring to assure protection of human health and the environment. Data generated by this office and by DOE will be reviewed to refine or change sampling techniques, analytical methods, or location of samplers.

Introduction

Title III of the Clean Air Act Amendments (CAAAs) has identified 189 toxic chemicals. These chemicals, called hazardous air pollutants or HAPs, are associated with adverse health effects and are used widely in variety of industries. Major stationary sources of HAPs are subject to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) found in Title III of the CAAAs of 1990. Rather than set NESHAPs limits for each pollutant, the 1990 CAAAs directed EPA to set technology-based standards using maximum achievable control technologies (MACT) for 175 source categories to achieve sharp reductions of routine emissions of toxic air pollutants.

This independent monitoring project is conducted under authority of the Tennessee Oversight Agreement, and was initiated in 1997 in response to the heightened level of public concern regarding potential impacts to public health from the TSCA incinerator emissions. As the DOE plans to extend operation of the TSCA incinerator for several more years and to continue D&D activities at the site, monitoring of the potential impacts of these projects on the ambient air quality on and around the ETTP site seems warranted. This program was designed to provide an independent verification of monitoring results reported by the DOE in the Oak Ridge Annual Site Environmental Report (ASER).

Methods and Materials

Background data was originally collected at a site located near Norris Lake. This data was used in a comparative manner as a baseline for the area surrounding the ORR. The ambient air-sampling for this project has since been primarily conducted at stations co-located with DOE monitors K-2 (Blair Rd opposite the TSCA Incinerator), Perimeter Air Monitor K-42 (next to Poplar Creek) and Perimeter Air Monitor K-35 (Gallaher Road Bridge area). The locations of these monitoring stations are shown in Figure 1.

The monitoring sites selected were chosen based upon wind data that indicated the sites were in the prevailing wind flow patterns for the region surrounding the ORR. The wind flow during the day is a southwest to northeast pattern. During the night, the flow pattern is reversed. Placement of TDEC monitors allowed for sampling that would be more or less representative of a 24-hour wind flow pattern at the ORR. An additional factor in selecting these locations was the availability of a power source. The monitoring schedule was modified somewhat in 2004, based on past sampling results and data reported in the Oak Ridge Reservation Annual Site Environmental Report (ASER). These data indicate that both lead and uranium average values are typically highest at the K-2 as opposed to the K-35 and K-42 sites. Due to the historically higher levels of air pollutants, ease of access, and close proximity of K-2 to the TSCA incinerator, the monitor was located preferentially at that site. In 2005, the air monitor was located permanently at K-2 to facilitate comparison with DOE air-monitoring data.

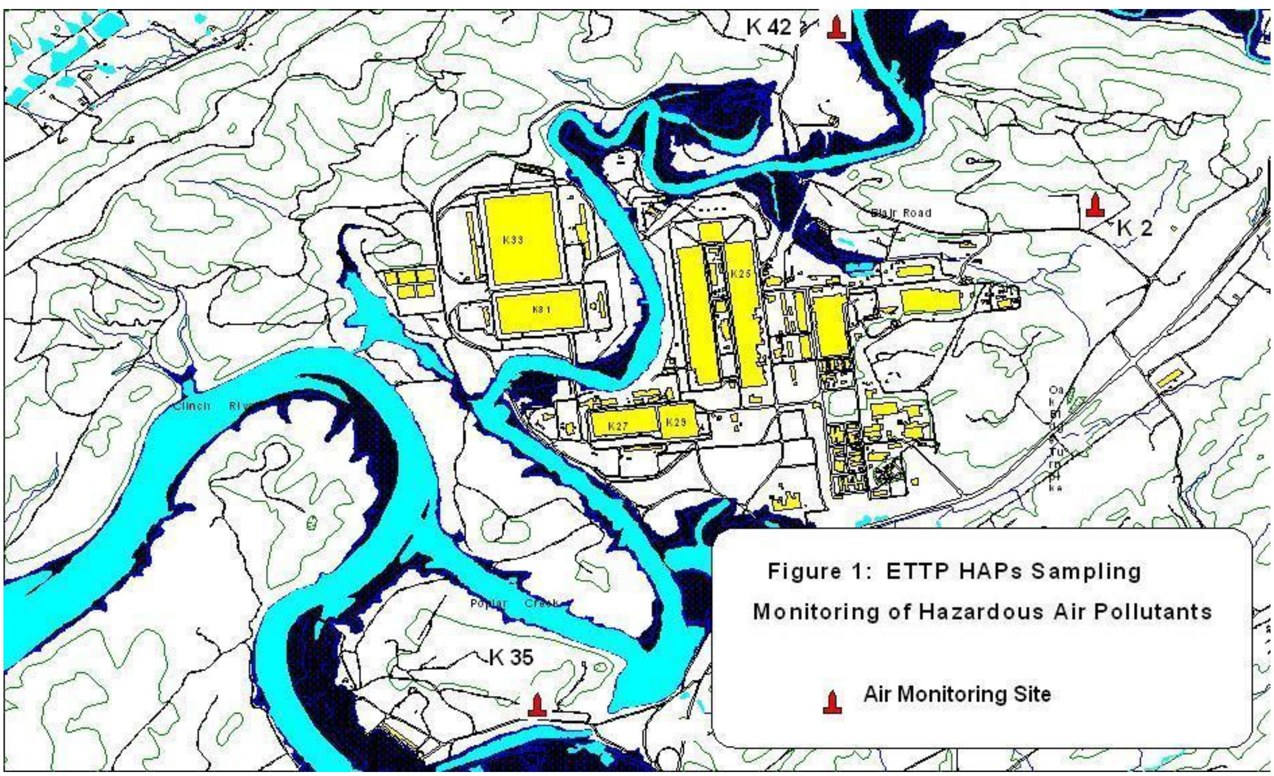

Figure 1: ETTP HAPs Sampling Locations

When the program was initiated in the 1990s, sampling for arsenic, beryllium, cadmium, chromium, and lead was performed. In 1999, nickel and uranium were added to the list of analytes. Filter samples were collected on a weekly basis and mailed to the state laboratory in Nashville for analysis through 2005. In 2006, laboratory analysis was performed quarterly on composited weekly samples and the analytical method was changed from inductively coupled plasma (ICP) analysis of metals to analysis by ICP – mass spectroscopy. Table 1 lists the frequency of sample collection and analysis during 2007.

Table 1: HAPs metals ambient air sampling schedule for ETTP during 2007

Monitoring period	Sampling Location	Sampling period	Collection frequency	Analysis frequency
01/01/06-12/31/07	K-2	Continuous	Weekly	Quarterly

Results and Discussion

Analyses of hazardous air pollutant metals (arsenic, beryllium, cadmium, chromium, lead, nickel, and uranium) were performed on quarterly composites from weekly samples. Lead analytical results are summarized in Table 2 and are compared with the Tennessee and national quarterly ambient air quality standard of 1.5 μg/m3. The results obtained indicate that this value was less than 1% of the quarterly standard.

At the time of this report, neither the final quarterly result from 2007 nor the ORR Annual Site Environmental Report (ASER) for 2007 was available. However, analytical results from the HAPs monitoring program were compared with results from the 2001 through 2006 data from previous ASERs. In general, levels of lead found by TDEC and DOE were comparable in the ambient air at ETTP over this period. The recent change in analytical technique by the Tennessee Department of Health (TDH) Environmental Laboratory in Nashville has apparently resulted in better resolution at low values, and reported concentrations of lead for 2007 are one half to one third those reported for most of the previous years. These values are closer to those obtained by DOE during the past five years than older TDEC results obtained without mass spectroscopy.

Table 2: Lead concentration in ambient air at the ETTP for 2007

Station	Quarterly composite sample results (μg/m3)				Max quarterly result (μg/m3)	Max percent of quarterly standard (μg/m3)*
	1	2	3	4		
K-2	0.0013	0.0012	0.0012	0.013	0.013	<1

*Tennessee and national air quality standard for lead is 1.5 μg/m3 quarterly arithmetic average.

Results of the analyses of all hazardous metals except lead are summarized in Table 3. The quarterly results are given in Table 4. As there are no current Tennessee or national ambient air quality standards for these hazardous air pollutants, concentrations were compared to risk specific doses and reference air concentrations as listed in 40 CFR 266. Arsenic, uranium and cadmium were detected at levels considerably less than concentration guidelines (also shown in Table 3). Beryllium was not detected, while concentrations of nickel were only slightly more elevated than values from unused filters.

As stated above, results from the ORR Annual Site Environmental Report (ASER) for 2007 are not available at this time. However, analytical results generated by the HAPs monitoring program over the past five years were compared with the ASER results since 2001. The ASER data indicated sporadic detection of hazardous air pollutant metals, with no quarterly concentrations exceeding the risk-specific doses. Older TDEC data include some weekly concentrations that significantly exceed both the 2007 TDEC results and averages reported by DOE for total chromium. Some TDEC results were higher than the risk-specific dose level for chromium VI, although significantly below standards for chromium III. Laboratory analyses for the air data reported in the DOE ASER were also done using inductively coupled plasma mass spectrometry (ICP-MS), perhaps with better detection or quantification limits than those done by the TDH laboratory. Older TDEC metals data also suffered from relatively high detection limits, so many results were non-detect, making meaningful comparison with DOE data impossible. Nickel was not included as a monitoring parameter in the 2001-2006 ASERs.

Table 3: Summary table of hazardous air pollutant carcinogenic metals concentration in ambient air at the ETTP K2 site for 2007

Analyte	**Ambient air concentration (µg/m3)**			**Minimum quantitation limit (µg/m3)**	**Minimum detection limit (µg/m3)**
	Annual avg. concentration	**Quarterly Maximum**	**Annual concentration guideline**		
Arsenic	0.0005	0.0007	0.0023[a]	0.00005	0.00005
Beryllium	U	U	0.004[a]	0.00005	0.00005
Cadmium	0.00011	0.0002	0.0056[a]	0.00005	0.00005
Chromium	0.0013	0.0017	Cr-VI 0.00083[a] 1000.0[a] Cr-III	0.00005	0.00005
Nickel	0.0002	0.0003	0.042[a]	0.00005	0.00005
Uranium	0.002	0.0028	0.15[b]	0.00001	0.00001

U - Analyte not detected in laboratory analysis

[a] - Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266, Appendix V.

[b] - DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/m3, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/m3 assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% 235U.

Table 4: Concentration of hazardous metals in ambient air at the ETTP K2 site for 2007

Analyte	Quarterly composite sample results (µg/m3)				Results for blank filter (µg/m3)	Max percent of guideline (µg/m3)*
	Quarter 1	Quarter 2	Quarter 3	Quarter 4		
Arsenic	0.0007	0.0005	0.0007	0.0003	0.0003	22
Beryllium	<0.00004	<0.00004	<0.00005	<0.0001	<0.00005	NA
Cadmium	0.0002	0.00008	0.00009	0.00006	<0.00005	2
Chromium	0.0015	0.0014	0.0017	0.0004	0.0011	NA
Nickel	0.0003	0.0002	0.0002	0.0002	0.0002	1
Uranium	0.0021	0.001	0.0028	0.0002	0.001	1

Conclusion

The results of the 2007 monitoring conducted by TDEC at the ETTP sites indicate no apparent elevated level of hazardous air pollutants (HAPs) metals of concern. Total chromium levels are above risk-specific background for chromium VI, but only if total chromium results from blank filters are not subtracted. Chemical speciation of chromium in the samples remains uncertain, and concentrations are far below reference levels for chromium III in air. Analyses for all other metals of concern were well below regulatory standards or guidelines. This project has been re-authorized to continue into 2008 with no anticipated changes in sampling or analysis. Weekly samples will be collected and quarterly composite samples will be analyzed using the Tennessee Department of Health Laboratory Services using the inductively coupled plasma – mass spectrometer method.

References

Boiler and Industrial Furnace Regulations - 40 CFR Part 266 Appendix V.

Guidelines for the Control of Toxic Ambient Air Contaminants, Draft New York State Air Guide-1, Appendix B, Ambient Air Quality Impact Screening Analyses, 1994 Edition.

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Hazardous Air Pollutants Metals Monitoring at Y-12 and ORNL (X-10)

Principal Author: Sid Jones

Abstract

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy (DOE) Oversight Division's (the division) Hazardous Air Pollutants (HAPs) Monitoring Program was developed as an extension of the HAPs monitoring at East Tennessee Technology Park (ETTP). A number of DOE operations on and around the Oak Ridge Reservation (ORR) have the potential to emit hazardous metals, but DOE currently monitors metals only at ETTP. The TDEC HAPs monitoring program at the Oak Ridge National Lab (ORNL or X-10) and Y-12 National Security Complex (Y-12) has thus continued as an independent monitoring effort to provide data on hazardous metals in ambient air at these sites. Monitoring with high volume air samplers was conducted for arsenic, beryllium, cadmium, total chromium, lead, nickel, and uranium as a metal.

The results of the 2007 monitoring conducted by TDEC indicate no locally-elevated levels of HAP metals of concern. Due to use of the ORNL monitor for the collection of radiological samples, all 2007 samples were collected from the Y-12 site. A change in analytical methods initiated in 2006 has resulted in lower limits for detection and quantification of all metals. Analytical results for all metals of concern except chromium were below all regulatory standards and risk-specific doses listed in 40 CFR 266 Appendix V. Total measured chromium concentrations were about twice the risk-specific level for chromium in the +6 oxidation state (chromium VI) in air. However, chromium concentrations in unused (blank) filters were found to be over half those in the samples, so total chromium levels in ambient air for 2007 are thought to be below the restrictive risk levels for chromium VI. Lead concentrations remain at less than one percent of the air quality standard.

In 2007, weekly samples from the Y-12 site were composited for quarterly analysis. However, the division retains the ability to analyze archived weekly samples. In 2008, the program will split filters taken for radiological purposes at the X-10 facility. The goal is to provide independent air monitoring to assure protection of human health and the environment. Data generated by this office and by DOE will be reviewed to refine or change sampling techniques, analytical methods, or location of samplers.

Introduction

Title III of the Clean Air Act Amendments (CAAAs) identified 189 toxic chemicals. These chemicals, called hazardous air pollutants or HAPs, are associated with adverse health effects and are used widely in variety of industries. Major stationary sources of HAPs are subject to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) found in Title III of the CAAAs of 1990. Rather than set NESHAPs limits for each pollutant, the 1990 CAAAs directed EPA to set technology-based standards using maximum achievable control technologies (MACT) for 175 source categories to achieve reductions of routine emissions of toxic air pollutants.

In 1997, concerns were raised by members of the public regarding potential health effects due to possible concentrations of HAPs in the ambient air on and around ORR. In response to these concerns, the division's Waste Management (WM) program developed a monitoring program for the ORR in order to determine what effects, if any, DOE operations were having on levels of hazardous metals in the ambient air on and around the reservation. This program was designed to provide an independent verification of monitoring results as reported by the DOE and to extend the range of monitoring beyond the East Tennessee Technology Park area to other sites on the reservation. Background data was collected at a site located near Norris Lake. These data were used to establish a baseline for the area surrounding the ORR.

ORNL

ORNL was not monitored for hazardous metals during 2007. Historical monitoring site at the east and west end of the plant are shown in Figure 1. The sampler remained in the main ORNL campus facility near the Tank W1A removal action (where it was moved in 2006) to monitor airborne radionuclides. Filters are currently being split with the radiological monitoring program to provide hazardous metals samples for 2008.

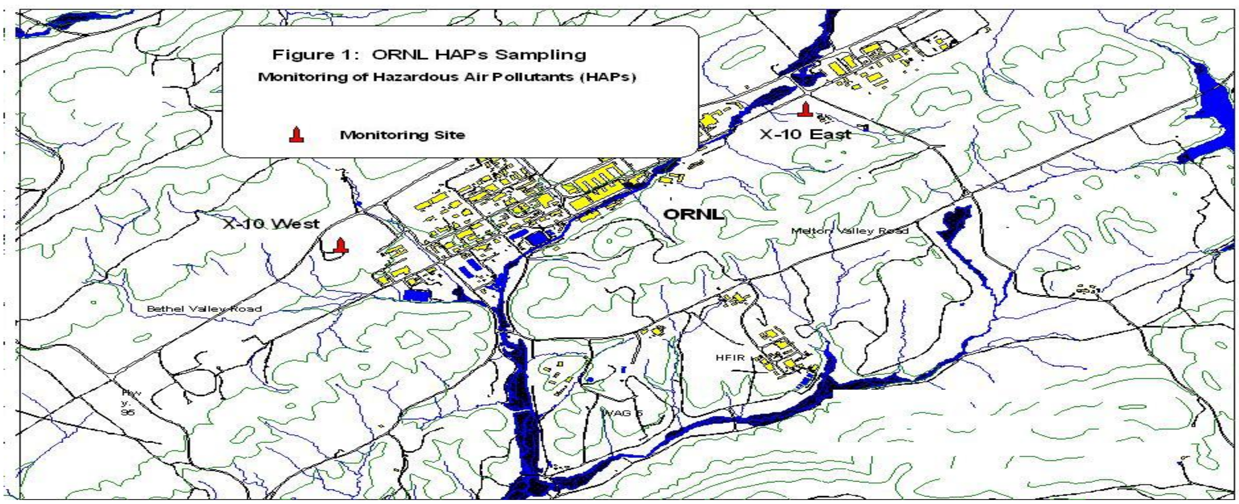

Figure 1: ORNL HAPs Sampling Stations

Y-12

Monitoring at Y-12 was conducted at the station located at the east end of this facility, shown in Figure 2. The monitoring site at the west-end of Y-12, unused in 2007, is west of the main plant area north of Bear Creek Valley Road.

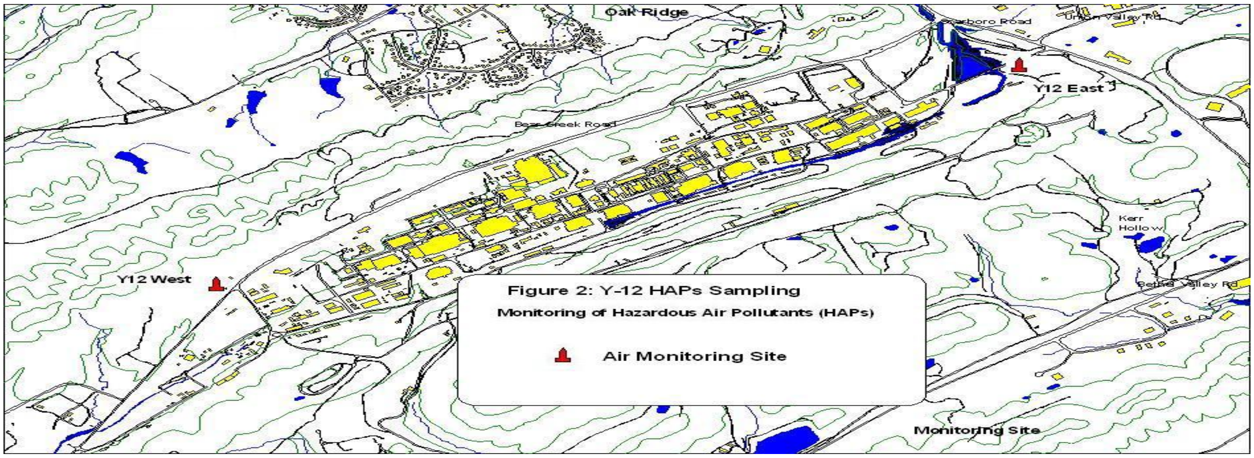

Figure 2: Y-12 HAPs Sampling Locations

Methods and Materials

The monitoring sites selected were chosen based upon wind rose data that indicated the sites were in the prevailing wind flow patterns downwind of potential sources on the ORR. The wind flow during the day is a southwest to northeast pattern. During the night the flow pattern is reversed. The placement of TDEC's monitoring sites allowed for sampling that would be representative of a 24-hour wind flow pattern at the ORR. An additional factor in selecting these locations was the availability of a power source.

When the program was initiated in the 1990s, sampling for arsenic, beryllium, cadmium, chromium, and lead was performed. In 1999, nickel and uranium were added to the list of analytes. Filter samples were collected on a weekly basis and mailed to the state laboratory in Nashville for analysis through 2006. In 2007, laboratory analysis was performed quarterly on composited weekly samples and the analytical method was changed from inductively coupled plasma (ICP) analysis of metals to analysis by ICP – mass spectroscopy (ICP-MS). Table 1 lists the frequency of sample collection and analysis during 2007.

Table 1: HAPs metals ambient air sampling schedule, 2007 at ORNL and Y12

Monitoring period	Sampling Locations	Sampling period	Collection frequency	Analysis frequency
1/1/07-12/31/07	X-10	Not used		
1/1/07-12/31/07	Y-12 E	Continuous	Weekly	Weekly

Results and Discussion

Quarterly lead results were determined from composite analyses of continuous weekly samples from station Y-12 E at the Y-12 site. Lead analytical results are summarized in Table 2 and are compared with the Tennessee and national quarterly ambient air quality standard of 1.5 μg/m3. The results obtained indicate that lead levels in ambient air at the Y-12 East site were less than 1% of the quarterly standard in 2007.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2007 was not available. Analytical results generated from the HAPs monitoring program over the past five years were compared with the ASER results since 2001, indicating comparable levels of lead in the ambient air in and around the ORR. The recent change in analytical technique by the Tennessee Department of Health (TDH) Environmental Laboratory in Nashville has apparently resulted in better resolution at low values, and reported concentrations of lead for 2007 are typically one half to one third those reported for most of the previous years. These values are closer to those obtained by DOE during the past five years than older TDEC results obtained without mass spectroscopy.

Table 2: Lead concentration in ambient air, 2007 at Y12

Station	Quarterly composite sample results (µg/m3)				Max quarterly result (µg/m3)	Max percent of quarterly standard (µg/m3)*
	1	2	3	4		
Y-12 East	0.0016	0.0014	0.0017	0.0018	0.0018	<1

*Tennessee and national air quality standard for lead is 1.5 µg/m3 quarterly arithmetic average.

Results of the analyses of all hazardous metals except lead are summarized in Table 3. The quarterly results are given in Table 4. As there are no current Tennessee or national ambient air quality standards for these hazardous air pollutants, concentrations were compared to risk specific doses and reference air concentrations as listed in 40 CFR 266. Arsenic was detected at levels of approximately one quarter of the annual guideline. Uranium, nickel and cadmium were detected at levels considerably less than concentration guidelines (also shown in Table 3). There was a single detection of beryllium, at about one percent of the guideline.

As stated above, results from the ORR Annual Site Environmental Report (ASER) for 2007 are not available at this time. However, analytical results generated by the HAPs monitoring program over the past five years were compared with the ASER results since 2001. The ASER data indicated sporadic detection of hazardous air pollutant metals, with no quarterly concentrations exceeding the risk-specific doses. Older TDEC data from both X-10 and Y-12 include some weekly concentrations that significantly exceed both the 2007 TDEC results and averages reported by DOE for total chromium. Some TDEC results were higher than the risk-specific dose level for chromium VI, although significantly below standards for chromium III. Laboratory analyses for the air data reported in the DOE ASER were also done using inductively coupled plasma mass spectrometry (ICP-MS), perhaps with better detection or quantification limits than those done by the TDH laboratory. Older TDEC metals data also suffered from relatively high detection limits, so many results were non-detect, making meaningful comparison with DOE data impossible. Nickel was not included as a monitoring parameter in the 2001-2006 ASERs.

Table 3: Summary table of hazardous air pollutant carcinogenic metals concentration in ambient air at the Y-12 East site for 2007

Analyte	Ambient air concentration (µg/m3)			Minimum quantitation limit (µg/m3)	Minimum detection limit (µg/m3)
	Annual avg. concentration	Quarterly Maximum	Annual concentration guideline		
Arsenic	0.0007	0.0008	0.0023[a]	0.00005	0.00005
Beryllium	<0.0001	<0.0001	0.004[a]	0.00005	0.00005
Cadmium	0.0001	0.0001	0.0056[a]	0.00005	0.00005
Chromium	0.0014	0.0016	Cr-VI 0.00083[a] 1000.0[a] Cr-III	0.00005	0.00005
Nickel	0.0004	0.0004	0.042[a]	0.00005	0.00005
Uranium	0.002	0.0032	0.15[b]	0.00001	0.00001

[a] - Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266.
[b] - DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/m3, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/m3 assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% 235U.

Table 4: Hazardous air pollutant metals concentrations in ambient air at Y-12 in 2007

Analyte	Quarterly composite sample results (µg/m3)				Results for blank filter (µg/m3)	Max percent of guideline (µg/m3)*
	Quarter 1	Quarter 2	Quarter 3	Quarter 4		
Arsenic	0.0007	0.0006	0.0008	0.0005	0.0003	30
Beryllium	<0.00004	<0.00005	<0.00005	<0.0001	<0.00005	NA
Cadmium	0.0001	0.0001	0.0001	0.0001	<0.00005	2
Chromium	0.0014	0.0015	0.0016	0.0006	0.0011	NA
Nickel	0.0004	0.0003	0.0003	0.0004	0.0002	1
Uranium	0.0032	0.0028	0.0018	0.00003	0.001	2

Conclusions

The results of the 2006 monitoring conducted by TDEC at ORNL and Y-12 sites indicate no apparent elevated levels of HAPs metals of concern. Analyses for all metals of concern were below guidelines. This project has been re-authorized to continue into 2008. The monitors will remain at the east Y-12 sampling site and in the X-10 main campus area for the year 2007 unless changes in DOE operations dictate a change in monitoring locations. Samples will continue to be taken each week, but will be composited for analysis quarterly.

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RadNet Air Monitoring Program

Principal Authors: Natalie Pheasant, Howard Crabtree

Abstract

The RadNet air monitoring program provides radiochemical analysis of air samples taken from five air monitoring stations located on the Oak Ridge Reservation near major sources of radioactive air emissions. RadNet samples are collected by staff of the Tennessee Department of Environment and Conservation, and analysis is performed at the Environmental Protection Agency's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. The results are provided to the State and are available at the RadNet website. In 2007, as in past years, the data for each of the five RadNet air monitors exhibited similar trends and concentrations. While slightly higher results were reported at monitoring stations located east of the Y-12 National Security Complex, the results for 2007 do not indicate a significant impact on the environment or public health from Oak Ridge Reservation emissions.

Introduction

In the past, air emissions from Department of Energy (DOE) activities on the Oak Ridge Reservation (ORR) were believed to have been a potential cause of illnesses affecting area residents. While these emissions have substantially decreased over the years, concerns have remained that air pollutants from current activities (e.g., incineration of radioactive wastes, production of radioisotopes, and remedial activities) could pose a threat to public health and/or the surrounding environment. As a consequence, the Tennessee Department of Environment and Conservation (TDEC) has implemented four air monitoring programs to assess the impact of ORR air emissions on the surrounding environment and the effectiveness of DOE controls and monitoring systems.

TDEC's perimeter and fugitive air monitoring programs (described in associated reports) focus on monitoring exit pathways off the reservation and non-point sources of emissions. TDEC's participation in the Environmental Protection Agency's (EPA) RadNet* programs, monitoring both air and precipitation, supplements information generated by the other two programs, targets specific operations (e.g., the High Flux Isotope Reactor, or HFIR, and the Toxic Substance Control Act Incinerator, or TSCAI), and provides independent verification of both State and DOE monitoring data.

Methods and Materials

The approximate locations of the five RadNet air samplers are provided in Figure 1 and EPA's analytical parameters and frequencies are listed in Table 1. The RadNet air samplers run continuously, collecting suspended particulates on synthetic fiber filters (10 centimeters in diameter) as air is drawn through the units by a pump at approximately 35 cubic feet per minute. TDEC staff collect the filters from each sampler twice weekly, estimate the radioactivity on each filter (following EPA protocol), then ship the filters to EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama, for analysis.

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* The RadNet program was formerly known as the Environmental Radiation Ambient Monitoring System (ERAMS). In 2005, EPA changed the name to RadNet to reflect upgrades planned for the program and Internet access to associated data. Substantial changes to the ORR program are not anticipated in the near future, though some new sampling equipment is now in use.

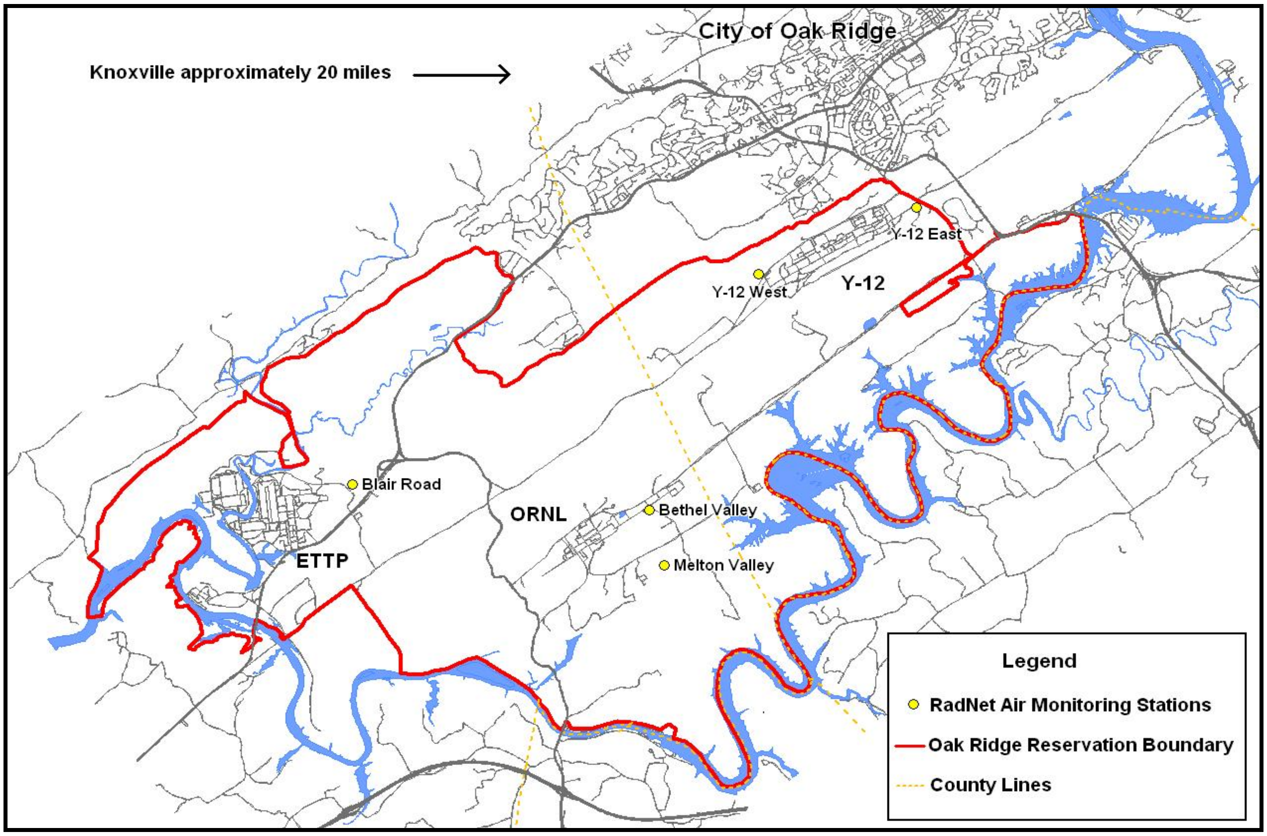

Figure 1: Approximate locations of air stations monitored by TDEC on the Oak Ridge Reservation in association with EPA's RadNet air monitoring program

NAREL performs gross beta analysis on each sample collected. If the gross beta result for a sample exceeds one picocurie per cubic meter (pCi/m^3), gamma spectrometry is performed on the sample. A composite of the air filters collected from each monitoring station during the year is analyzed for uranium and plutonium isotopes annually.

Table 1: EPA Analysis of Air Samples Taken in Association with EPA's RadNet Program

ANALYSIS	FREQUENCY
Gross Beta	Each sample, twice weekly
Gamma Scan	As needed on samples showing greater than 1 pCi/m^3 of gross beta
Plutonium-238, Plutonium-239, Plutonium-240,Uranium-234, Uranium-235, Uranium-238	Annually on a composite of the filters from each station

The results of NAREL's analysis are provided to TDEC and published in quarterly reports (Environmental Radiation Data), which are available at NAREL's Internet web site (http://www.epa.gov/narel/radnet/erdonline.html). In 2007, none of the gross beta results reported for the program exceeded the screening level (1 pCi/m^3) that would have required analysis by gamma spectrometry. The 2007 results for the uranium and plutonium analysis performed on annual composites of the air filters were not available at the time of this report.

Results and Discussion

As seen in Figure 2, the results for the gross beta analysis in 2007 were very similar for each of the five ORR RadNet monitoring stations and nearly all were lower than the results reported for the Fugitive Air Monitoring Program background station (located at Fort Loudoun Dam in Loudon County). While it is not uncommon for concentrations to be less on the ORR than at the background station, data reported for the RadNet stations has consistently been lower than the results reported for the Fugitive and Perimeter Monitoring Programs. This tendency is illustrated in Figures 2 and 3. This bias is believed to be an artifact of the different sampling equipment and monitoring frequency used in the different programs. The fluctuations that can be seen in the results in Figure 2 are largely attributable to natural phenomena (e.g., wind and rain) that influence the amount of particulates suspended in the air and, thus, what is ultimately deposited on the filters.

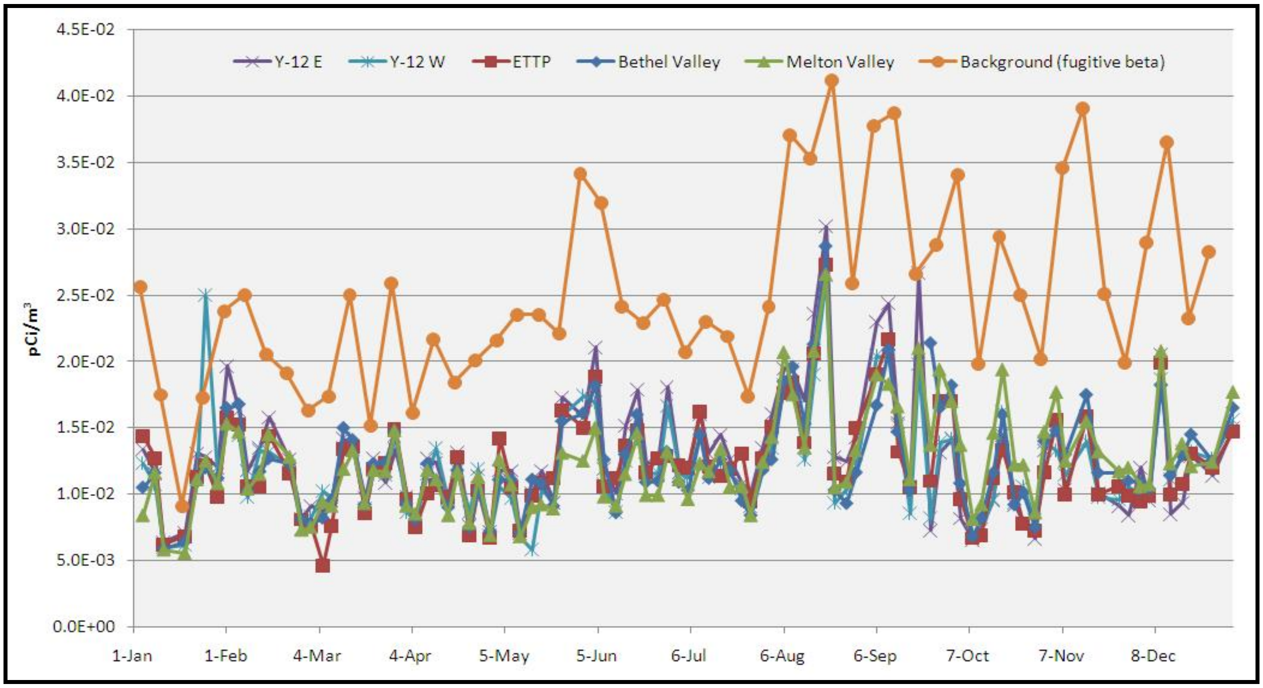

Figure 2: 2007 Gross beta results from air samples taken on the ORR in association with EPA's RadNet air monitoring program and background measurements from the Division's fugitive air monitoring program

Notes: This figure is intended to convey the correlation of the results for the various monitoring stations, not to depict individual results. Individual measurements are available at the Division's offices.

The results for the RadNet program were higher overall for the station immediately east of the Y-12 National Security Complex (i.e., station Y-12 East). It is probable that these slightly higher results are associated with Y-12's campaign to modernize operational facilities and demolish unneeded buildings, but the exact cause is unknown.

Figure 3 depicts (1) the 2007 average gross beta results for each of the five stations in the ORR RadNet Program, (2) the average background concentration measured at Fort Loudoun Dam by the Division's Fugitive Air Monitoring Program, and (3) the Clean Air Act (CAA) environmental limit for strontium-90.

The CAA specifies that exposures to the public from radioactive materials released to the air from DOE facilities shall not cause members of the public to receive an effective dose equivalent greater than 10 mrem in a year above background measurements. For point source emissions, compliance with this standard is generally determined with air dispersion models that predict the dose at offsite locations. However, the CAA also provides environmental concentrations for radionuclides equivalent to a dose of 10 mrem in a year. Staff use these concentrations to assess the compliance of the emissions measured with the CAA dose limit.

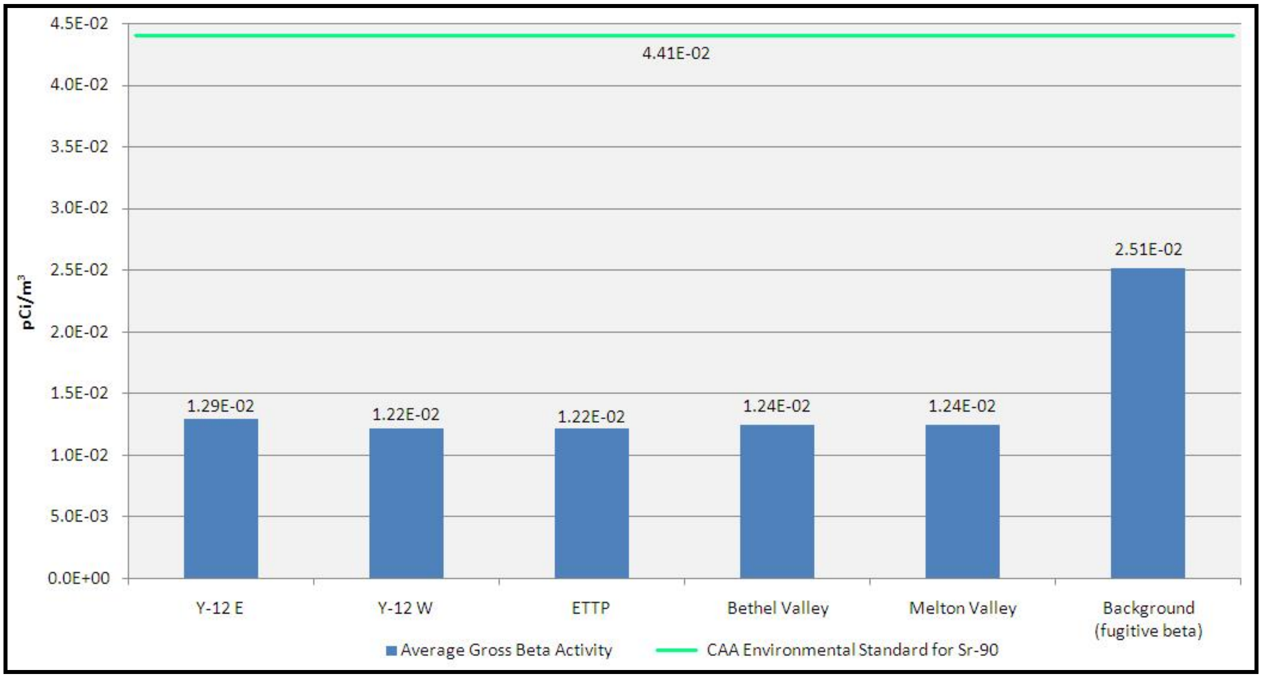

Figure 3: 2007 Average gross beta results for air samples taken on the ORR in association with EPA's RadNet air monitoring program

Note: Typical Background values for gross beta range from 0.005- 0.1 pCi/m^3 (ORISE, 1993)

- The standards provided by the Clean Air Act apply to the dose above background; therefore, the standard provided for reference in this figure has been adjusted to include the background measurements taken from the Division's Fugitive Air Monitoring Program during the same period.
- The CAA's Environmental Limit for strontium-90 is used as a screening mechanism and is provided here for comparison.

It is unlikely that this isotope contributes a major proportion of the gross beta activity reported for the samples.

To evaluate the RadNet data, staff compare the average gross beta results reported for the program to the CAA limit for strontium-90, which has one of the most stringent standards of the beta emitting radionuclides. The standards apply to the dose above background, so the limit represented in Figure 3 has been adjusted to include the average gross beta measurement taken at the background station for the Fugitive Air Monitoring Program. It is important to note that strontium-90 is unlikely to be a large contributor to the total beta measurements reported here and is used only as a reference point to determine if further analysis is warranted.

As can be seen in Figure 3, the average results for the Y-12 East monitoring station is slightly higher than the remaining stations; however, the average results from each of the RadNet monitoring stations fall well below the strontium-90 limit.

Conclusion

As in the past, the gross beta results for each of the five RadNet air monitoring stations exhibited similar trends and concentrations. While slightly higher results were reported at the monitoring location east of the Y-12 National Security Complex, the available RadNet data for 2007 do not indicate a significant impact on the environment or public health from ORR emissions.

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Fugitive Radiological Air Emissions Monitoring

Principal Authors: Howard Crabtree, Natalie Pheasant

Abstract

The Tennessee Department of Environment and Conservation uses mobile, high volume air samplers to monitor non-point radioactive air emissions released on the Oak Ridge Reservation. The program focuses on airborne emissions released during remedial and/or waste management activities. In 2007, the Division deployed five air samplers in the program. One of the samplers was placed at Fort Loudoun Dam to collect background data. The remaining units were used to monitor emissions from waste disposal operations at the Environmental Management Waste Management Facility near Y-12, the demolition of contaminated buildings at the East Tennessee Technology Park (previously known as the K-25 Gaseous Diffusion Plant), and next to the Tank W-1a/Corehole 8 site at ORNL. In most instances, the results for the monitoring stations were similar to the background measurements. The annual average concentrations for each of the monitoring locations were below the Clean Air Act standard (10 mrem per year).

Introduction

The Tennessee Department of Environment and Conservation (TDEC) Department of Energy (DOE) Oversight Division performs routine monitoring of fugitive air emissions on the Oak Ridge Reservation (ORR). Sampling in the program focuses on locations where there appears to be potential for the release of radioactive air emissions from non-point sources of contaminants. Over the last few years, the emphasis on accelerating remedial activities and plans to demolish hundreds of facilities across the reservation have resulted in the monitoring locations primarily being associated with remedial and/or waste management activities. In 2007, the reservation samplers were used to monitor waste disposal operations at the Environmental Management Waste Management Facility (EMWMF) in Bear Creek Valley, the decontamination and demolition of contaminated buildings at the East Tennessee Technology Park, and emissions at ORNL adjacent to the Tank W-1a/Corehole 8 Superfund site.

To monitor for fugitive emissions, staff mounted four air samplers on trailers, so each could be positioned near locations or activities of interest. A fifth sampler was placed at Fort Loudoun Dam in Loudon County to collect background data. When the results are compared, samples from the reservation that have no contribution from reservation sources/activities other than those that occur naturally should be similar to the background data. Conversely, results exhibiting significantly higher concentrations of radioactive contaminants are indicative of a release subject to the provisions of the Clean Air Act (CAA). In this regard, Title 40 CFR Part 61, Subpart H, of the CAA limits DOE radiological emissions to quantities that would not cause a member of the public to receive an effective dose equivalent greater than 10 mrem in a year. In addition, DOE is required to meet provisions of the law that require all radioactive emissions to be as low as reasonably achievable (ALARA).

Methods and Materials

The project's five high volume air samplers use 8x10-inch, glass-fiber filters to collect particulates from air, which is drawn through the units at a rate of approximately 35 cubic feet per minute. To help assure the accuracy of the measurements, airflow through each sampler is calibrated quarterly, using a Graseby General Metal Works Variable Resistance Calibration Kit (#G2835). To verify the quality of the analysis, results from the program are compared annually with data collected in the RadNet Air Program, which is analyzed at EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama.

After the results are received from the lab, staff compare data from the reservation samplers to the background results (to assess if a release has occurred) and screening levels set by the CAA to determine if additional analysis is warranted. Since the CAA does not provide standards for gross analysis, the gross alpha and gross beta results are compared to the standards for uranium-235 and strontium-90 respectively. These radionuclides are found routinely on the reservation and have some of the more restrictive limits provided in the act. If the results exceed the screening levels, additional analysis is performed to identify the specific radionuclides responsible for the elevated results and the data is reevaluated based on the isotopic analysis.

Results and Discussion

2007 Monitoring Locations

The approximate locations of the sites monitored for fugitive air emissions in 2007 are depicted in Figure 1. A description of each of these locations/facilities is provided below.

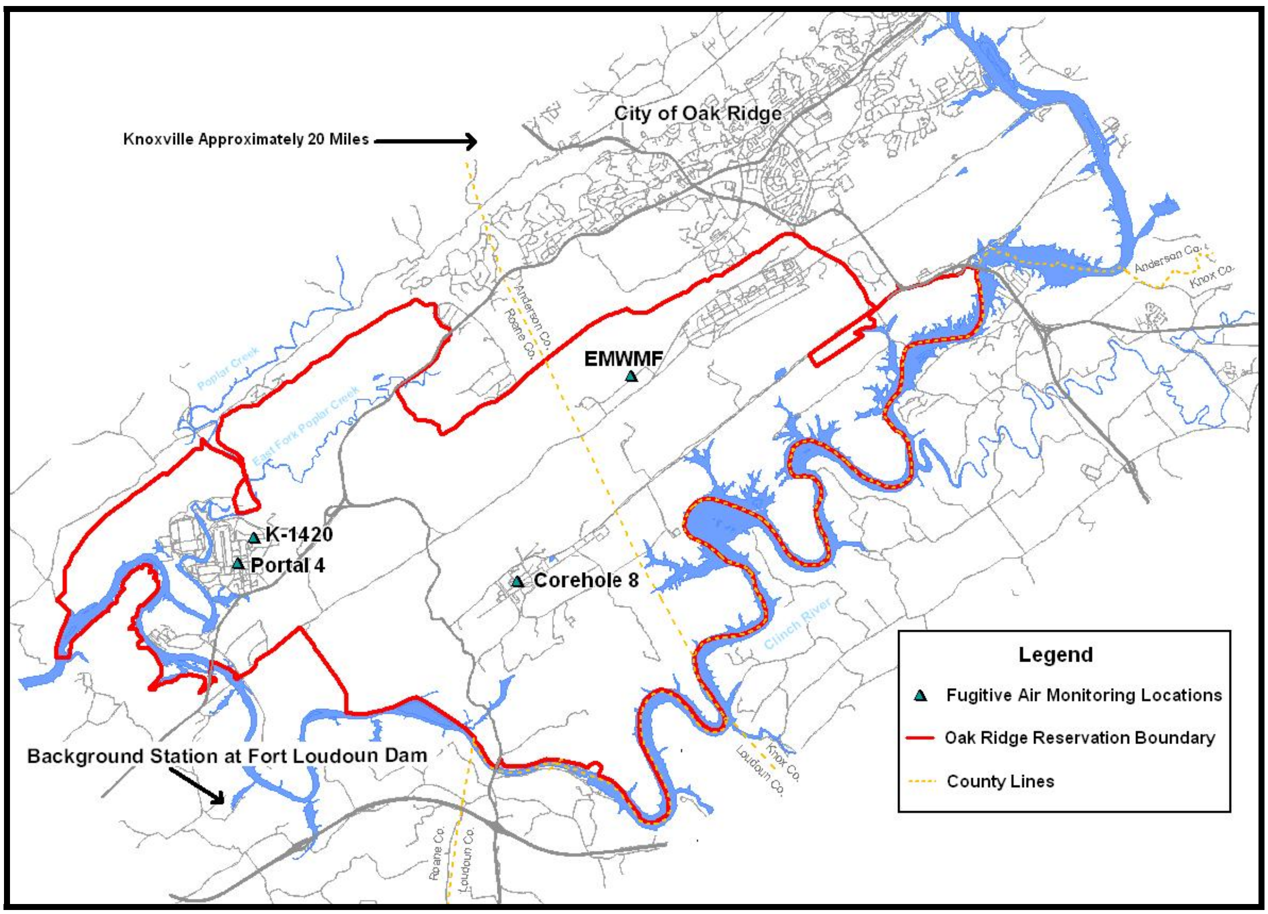

Figure 1: Approximate locations of sites monitored for fugitive air emissions in 2007

One of the mobile units was placed at the southeast corner of the Environmental Management Waste Management Facility (EMWMF) in December 2004. Located in Bear Creek Valley, EMWMF was opened in 2002 to dispose of waste generated by remedial activities on the ORR. During disposal and prior to being covered, wastes disposed of in the facility are subject to dispersion by winds that tend to blow up the valley (northeast) in the daytime and down the valley (southwest) at night. Waste disposed of at the EMWMF is not covered daily with clean soils as is practiced at most disposal facilities, though a fixative is applied to the surface wastes to suppress the dispersion of contaminants by the wind.

Two more samplers were stationed at the East Tennessee Technology Park (ETTP) to monitor the decontamination and demolition of contaminated buildings. Most of the these facilities were constructed during the World War II and cold war eras to produce or support the production of enriched uranium. As a consequence of operational practices and accidental releases, many of the approximately 400 facilities scheduled for demolition at ETTP are contaminated to some degree. Uranium isotopes are the primary contaminants, but technetium-99, neptunium-237, americium-241, plutonium-238, and plutonium-239/240 are also present due to the periodic processing of recycled uranium obtained from spent nuclear fuel.

One of the ETTP air samplers was positioned next to the K-1420 Decontamination and Uranium Recovery Facility in October 2005. This facility was constructed in 1954 to accommodate decontamination and uranium recovery operations. During decontamination, the surfaces of equipment were cleaned by both mechanical means (e.g., scraping, brushing, vacuuming, and wiping) and chemical dissolution in cleaning solutions. The uranium recovery operations filtered, purified, dried, and fluorinated the uranium captured in the cleaning solutions. The product was then fed back into the enrichment cascades. The nature of the uranium compounds produced by the procedure and leaks in the systems resulted in high airborne concentrations of uranium oxides and significant deposition of these materials within the facility. During operations, the facility was known to be one of the most hazardous for workers, due to the threat of inhaling insoluble compounds of uranium. While the K-1420 building has been removed from this site (the demolition was completed in October 2006), this sampler allows for monitoring of other decontamination and demolition of contaminated buildings at the ETTP, including the K-25 Process Building which is located to the west of this air sampler.

The second sampler at ETTP was placed to the southeast of the K-25 Process Building in May 2006. This also allowed for the monitoring of the demolition of the K-29 Process Building (completed August 2006) and the K-1401 Maintenance Building (completed August 2007). The K-25 Process Building housed the first production facility built to produce highly enriched uranium by gaseous diffusion. The largest building in the nation when it began operations in 1945, the K-25 Process Building stands four stories high and covers approximately 40 acres. Both the building and its equipment were extensively contaminated during operations. The K-29 Process Building contained a portion of the enrichment cascades. While in poor condition, the facility was initially designated for reuse, but DOE decided to demolish the facility when decontamination efforts fell short of the clean-up standards.

The K-1401 Maintenance Building housed maintenance operations that cleaned and serviced equipment used in the enrichment process. Much of the equipment maintenance occurred in the basement of the building, which was designated as a radiation area at one point. The basement contains the ventilation system for the building and a series of sumps where contaminated groundwater entering the building collected. The discovery in the 1990s of elevated levels of volatile organic compounds in the basement air resulted in the treatment of the water in these sumps. This building was later leased, but access to the basement and much of the rest of the building was prohibited because of contamination issues. For example, access to areas above eight feet was restricted due to contaminants found in dust that had settled on lighting and other overhead fixtures. The demolition of this site was completed in August 2007.

The fourth mobile unit was placed at ORNL's North Tank Farm in July 2006 to monitor activities planned at the Corehole 8/Tank W-1a remedial site. The North Tank Farm is located near the center of ORNL's main campus, across from the old ORNL cafeteria (which was demolished late in 2007). During the 1950s, a number of underground storage tanks were buried at this location to store and/or treat the highly radioactive wastes from ORNL process operations. In the 1990s, it was discovered that a drain line leading to one of these tanks, W-1a, had broken near the inlet allowing process effluents to flow into adjacent soils and groundwater, contaminating the soils and forming the Corehole 8 groundwater plume.

The Corehole 8 plume covers a large area adjacent and to the west of the tank farm. Contaminants include fission products, activation products, and transuranic radionuclides. In 1998, DOE proposed to remove Tank W-1a and associated soils feeding the plume. The removal action began in 2001, but was suspended after radiation levels were encountered that were much higher than DOE's contractor had anticipated. An air sampler was subsequently placed at the site to monitor planned characterization activities and the completion of the removal action.

2007 Results vs. Background Data

Figures 2 and 3 illustrate the correlation between the gross alpha and beta results at the four ORR monitoring stations and the background location. To a large degree, the fluctuations that can be observed in the figures are attributable to regional weather conditions (e.g., wind and rain) that increase or decrease the amount of particulates in the air and, thereby, the amount deposited on the sampling filters. If there have been no releases, the data from the background and ORR samplers should be relatively similar, given allowances for localized conditions and analytical uncertainties. Results that significantly exceed the measurements at the background station are considered indicative of a release.

As can be seen in Figure 2, the gross alpha data for all four sampling locations on the ORR were similar to background measurements during most of 2007. While results for various collection periods were higher than the background measurements at some stations, all gross alpha results for 2007 at sampling locations on the Oak Ridge Reservation were less than two times background levels.

Figure 3 shows the beta results for the fugitive air sampling program in 2007. While the alpha emitters found at ETTP generally include the uranium isotopes and trace amounts of transuranic radionuclides due to the processing of recycled nuclear fuel, the most common beta emitter at ETTP is technitium-99 (Tc-99), a fission product that was introduced to the site in recycled uranium, along with the transuranic radionuclides. In the cascades, Tc-99 followed the uranium-235 up the enrichment side of the system to the K-25 Process Building, where it was vented to the air at the purge cascade. The practice of venting Tc-99 to the air, along with the radionuclides mobility, has spread the Tc-99 throughout the ETTP site.

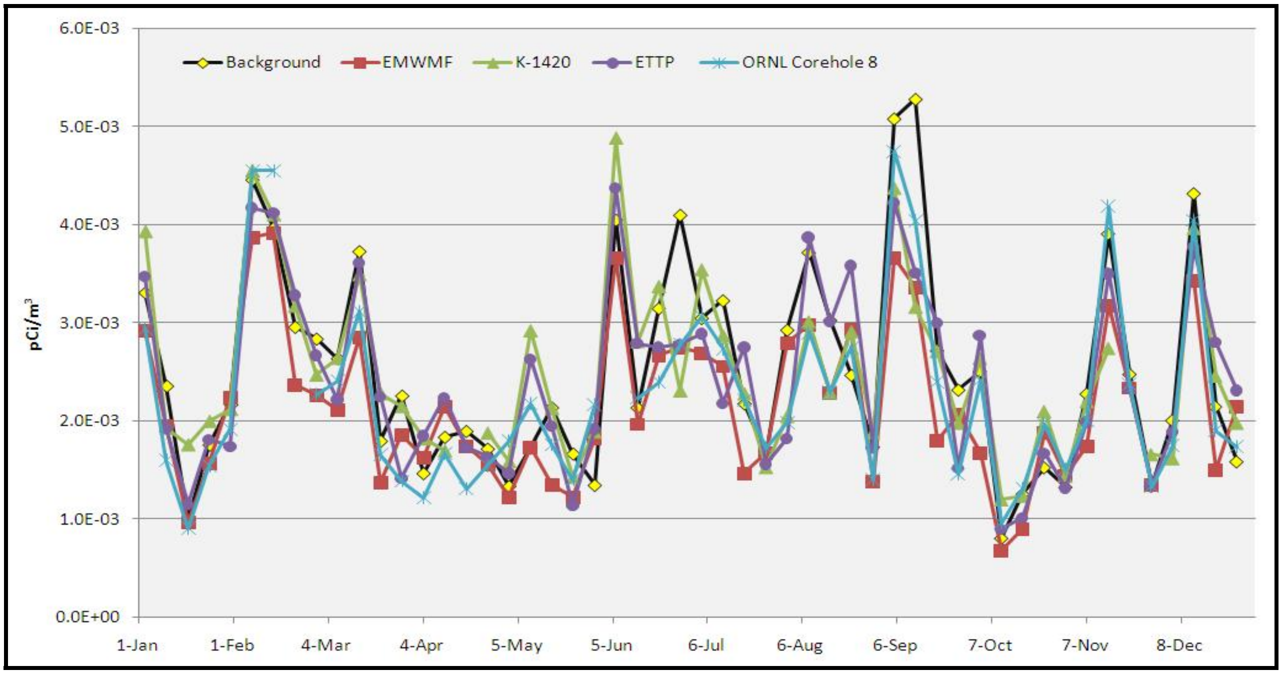

Figure 2: Gross alpha results from TDEC fugitive air monitoring performed in 2007*.
*Figure 2 is intended to convey the correlation of the results for the various monitoring stations: not depict individual results. Individual measurements are available at the Division's offices.

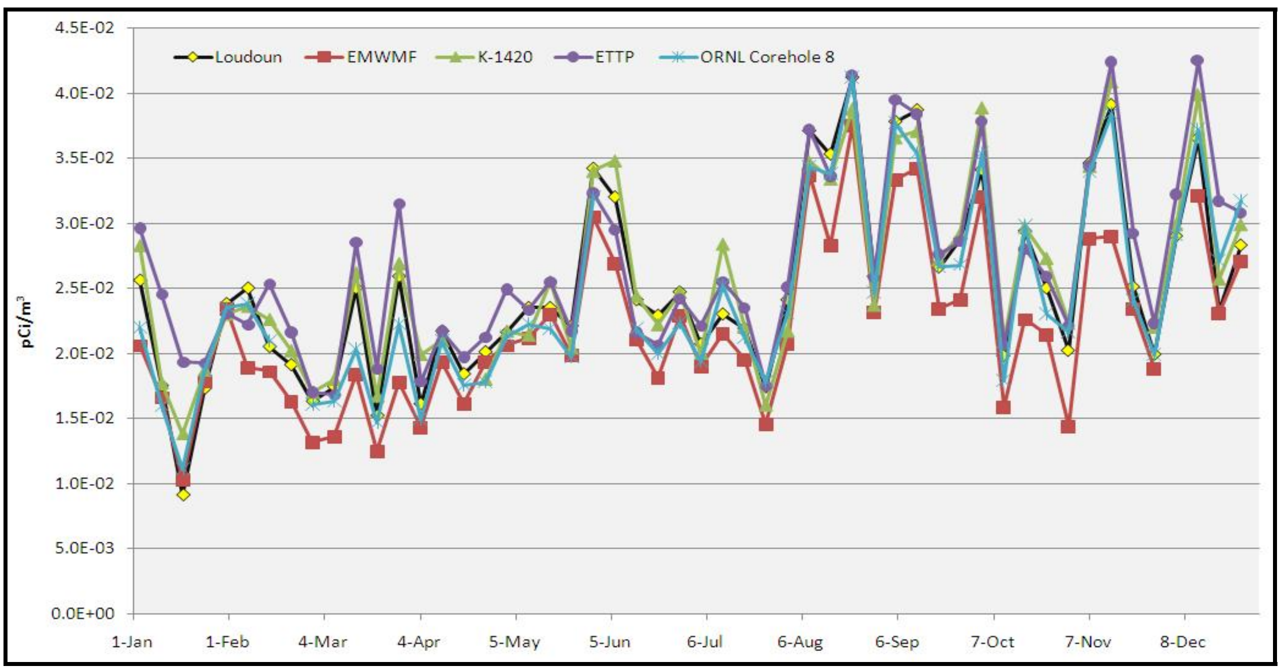

Figure 3: Gross beta results from TDEC fugitive air monitoring performed in 2007*.
*Figure 3 is intended to convey the correlation of the results for the various monitoring stations: not depict individual results. Individual measurements are available at the Division's offices.

In Figure 3, the gross beta results for all four fugitive air monitoring locations on the ORR were similar to background measurements during most of 2007. While results for various collection periods were higher than the background measurements at some stations, all gross beta results for 2007 at sampling locations on the Oak Ridge Reservation were less than two times background levels with only one exception. This value was seen for the sample collected January 17, 2007 from the ETTP site located close to Portal 4, near the southeast portion of the K-25 building and not far from the K-1401 building (demolition began on this building in August 2006). The value was 2.12 times that seen at the background location for the same time period. While this may be indicative of an actual release of contamination with beta radiation, the value itself is less than or near most gross beta results for samples taken at the background location for most of 2007.

2007 Results vs. CAA Standards

The Clean Air Act (CAA) specifies that exposure from radioactive materials which have been released to the air from DOE facilities shall not cause members of the public to receive an effective dose equivalent greater than 10 mrem in a year above background measurements. Compliance with this standard is generally assessed for point-source emissions that employ air dispersion models to predict doses at off-site locations. The CAA also provides environmental concentrations for radionuclides equivalent to a dose of 10 mrem/year. Staff use these concentrations to assess the compliance of the emissions measured with the CAA dose limit.

Because the hazards associated with the various radionuclides differ significantly, the CAA requires specific analysis of each isotope determined to be of concern. Consequently, the CAA standards do not include limits for gross alpha and gross beta activities. Nevertheless, the more economical gross measurements, when treated as surrogates for the more hazardous isotopes, provide an effective screening mechanism to determine if further evaluation is warranted. The standards used in the program to screen the data are uranium-235 (primarily an alpha emitter) and strontium-90 (a beta emitter). Both have relatively restrictive limits and both are routinely encountered on the reservation. However, it is unlikely that these isotopes would be responsible for more than a small proportion of the gross activities reported.

Figures 4 and 5 show the average activity for gross alpha and beta results measured at the ORR monitoring stations during 2007, the average background concentration during the same period, and the CAA standard used as a reference. The CAA standards only apply to the concentration above background.

In Figures 4 and 5, the average concentrations for the gross alpha and gross beta activity seen at the ORR and background sites are similar and that all results were below the CAA standard. However, there is no level of radiation that has been agreed to be totally safe. Consequently, both state and federal laws require radiations released from a facility to be held to levels as low as reasonably achievable (ALARA). In all decontamination and demolition efforts, ALARA needs to be one of the prime considerations.

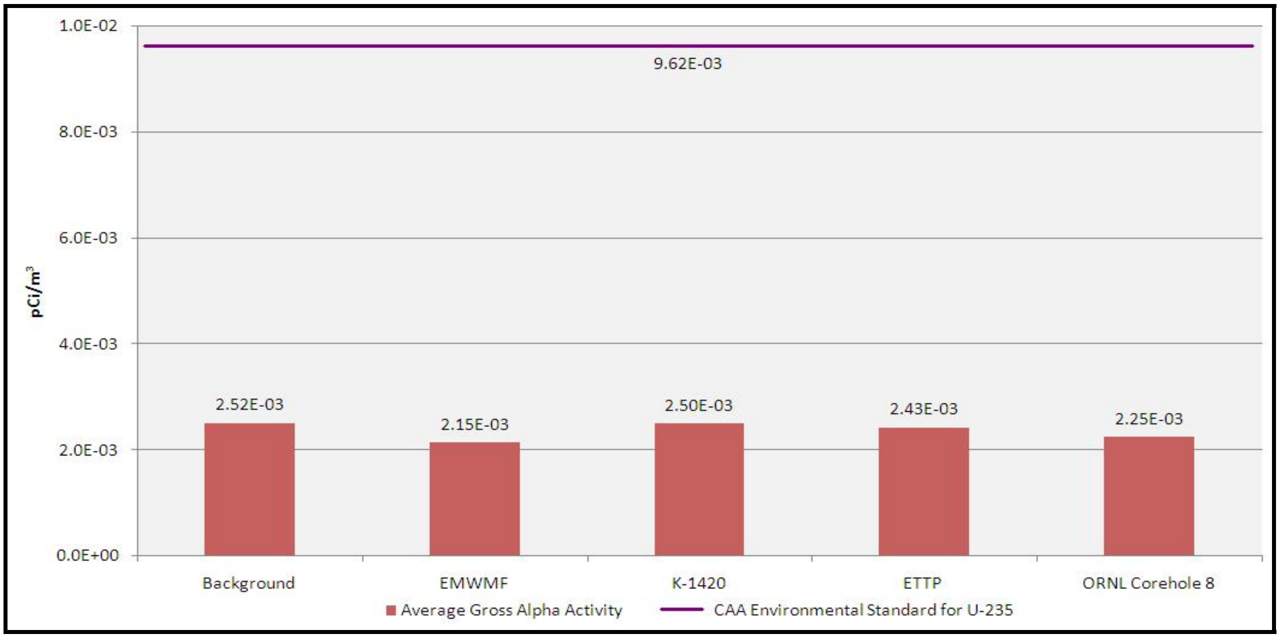

Figure 4: 2007 Average gross alpha activities measured at each of the fugitive monitoring locations compared with equivalent background periods and the corresponding CAA environmental standard for uranium-235

Note: -The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include background measurements taken during the same period.

-The CAA's environmental limit for uranium-235 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

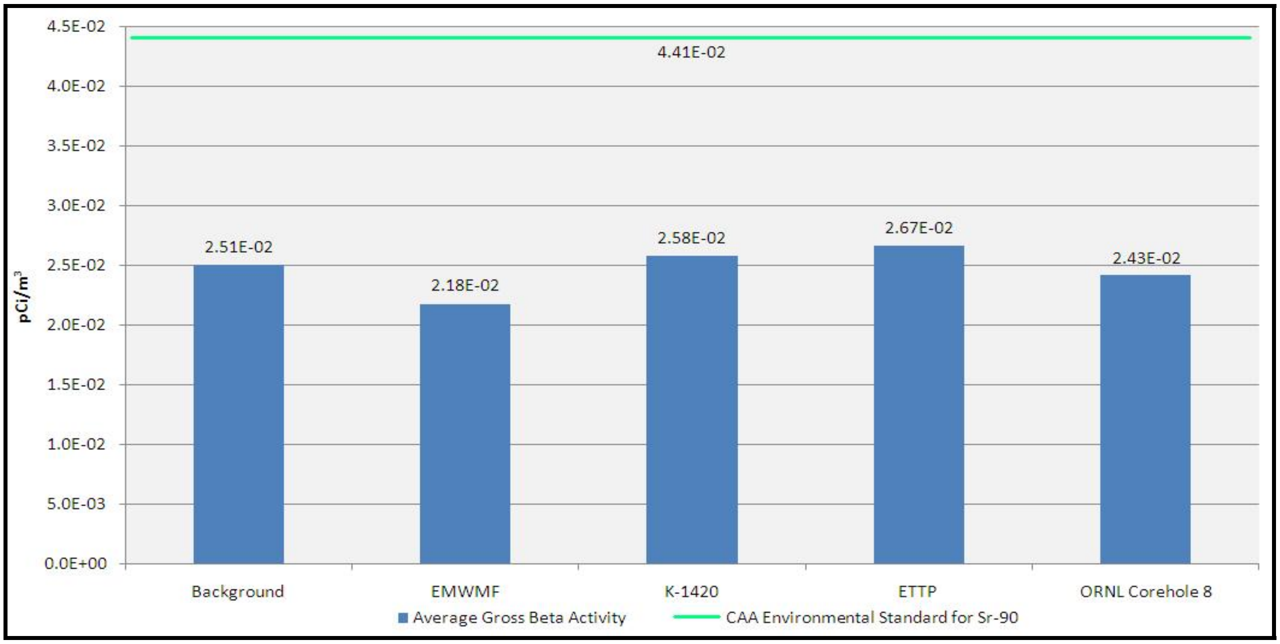

Figure 5: 2007 Average gross beta activities measured at each of the fugitive monitoring locations compared with equivalent background periods and the corresponding CAA environmental standard for strontium-90

Note: -The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include background measurements taken during the same period.

-The CAA's environmental limit for strontium-90 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

Conclusion

Results for fugitive air monitoring performed in 2007 at the EMWMF, the Corehole 8/Tank W-1a remedial site at ORNL, to the southeast of the K-25 facility at ETTP, and at the site of the previously demolished K-1420 building at ETTP fluctuated somewhat, but remained near background levels. The annual average concentration above background for each of the locations monitored were each below Clean Air Act Standards. However, ALARA needs to be a consideration during remedial and/or waste management activities on the Oak Ridge Reservation.

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Ambient VOC Monitoring of Air on the Oak Ridge Reservation

Principal Authors: Don Gilmore, Eddie Worthington

Abstract

The objective of this program is to monitor ambient air for volatile organic compounds (VOCs) at selected locations on the Oak Ridge Reservation (ORR), in an effort to determine the "overall health" of the ambient environments and to measure the degree of impact from past or present DOE operations. Due to the lack of VOC-monitoring experience in the Division, this is considered a pilot project. The ambient monitoring of air for VOCs was to be accomplished by using a data-logging Photoionization Detector (PID) deployed over several days. Total volatile organic compounds were successfully measured in a previous project. This project was not completed due to equipment issues, scheduling conflicts and changing priorities.

Introduction

The Division conducts several periodic air sampling efforts on the ORR. However, ambient VOC-monitoring has not been attempted until this project. The location expected to be monitored was Mitchell Branch at the East Tennessee Technology Park (ETTP). Figure 1 shows the general location of the area to be monitored. All work associated with this program was to be completed in compliance with the Division's Health, Safety, and Security Plan.

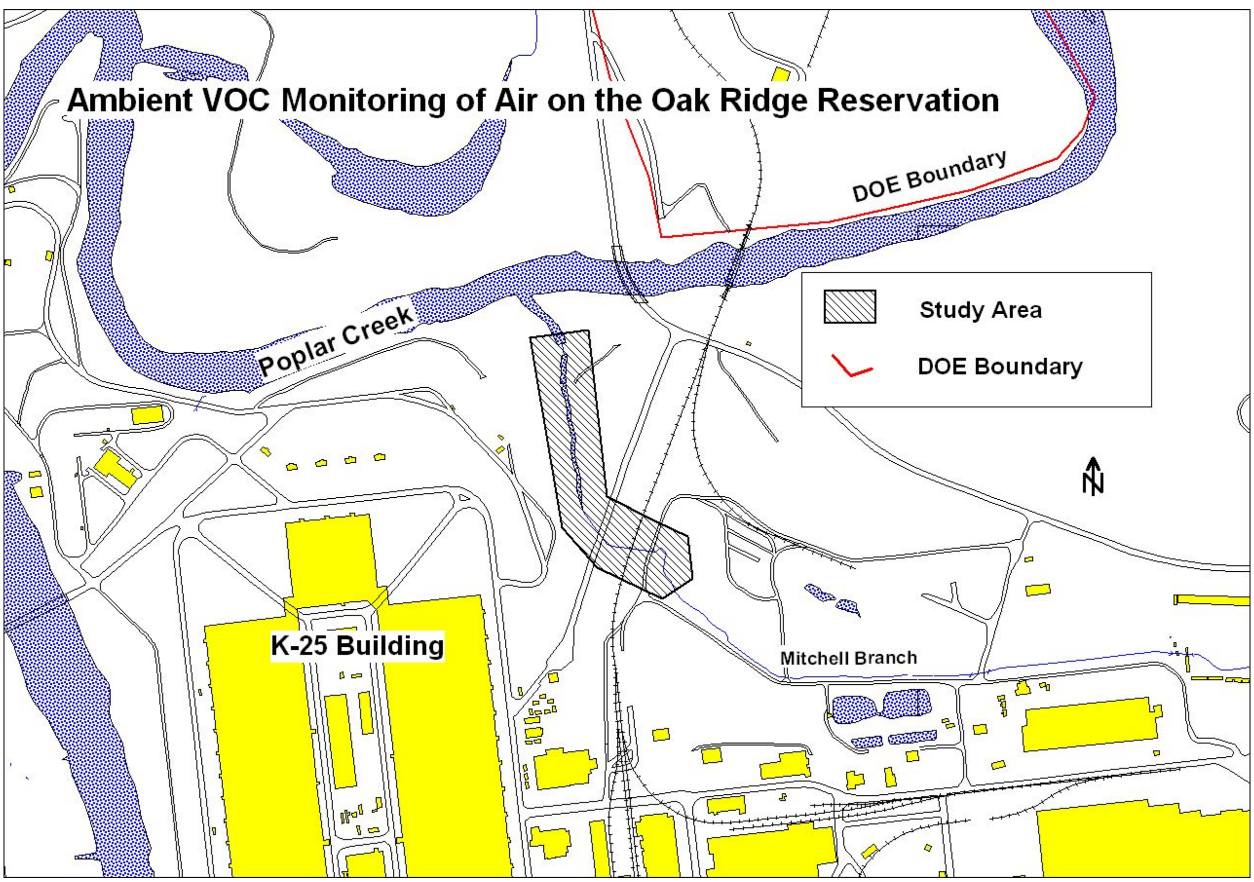

Figure 1: General Location of Groundwater/Surface Water and Ambient Air Samples

Methods and Materials

A decision was made to use the data-logging photoionization detector (PID) to collect total VOC readings instead of collecting actual air samples for analysis. The PID, a Photovac 2020ProPlus, was selected for use by the Division because of its data-logging capabilities and its ability to operate from a 12-volt battery. A deep-cycle marine battery was to be used as the power source. The PID would be protected from the environment by placing it into an inverted galvanized steel trash receptacle. Extreme care was to be taken to limit the amount of plastics used in the construction of the enclosure. This would eliminate any VOCs that could be emitted from this source.

The monitoring equipment consisted of the photoionization detector (PID) equipped with a data logger for recording data on a continuous basis. This was attached to a threaded steel rod inside a galvanized trash receptacle which was mounted upside down on two steel fence posts. A deep-cycle marine battery supplying 12 volts of electricity powered the PID. All electrical connections would be protected from the weather. The entire apparatus would have been placed approximately 18 inches above the sample surface. After emplacement, aluminum screen wire would be attached around the opening of the receptacle as a protective barrier from biological intruders. This would allow air to enter the receptacle for measurement by the PID without interference.

Field Placement of the Unit

Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight Division (DOEO) personnel were to deploy the monitoring equipment to measure total concentrations of volatile organic compounds (VOCs) in the ambient air at the Mitchell Branch area of the East Tennessee Technology Park (ETTP), formerly known as the K-25 Plant (See Figure 2). Within the Mitchell Branch area, the equipment was to be placed above a groundwater spring/seep known as Tom's Seep that enters Mitchell Branch from the south bank approximately 50 to 75 feet upstream from a railroad culvert.

The equipment was to be deployed over Tom's Seep for six days (See Figure 3). The PID was to be retrieved from the field and taken back to the DOEO office. At this point, the PID would be attached to a computer and the data downloaded from the PID's data-logger. Once the data was downloaded it would be exported into an excel spreadsheet for ease of analysis. Analysis would demonstrate if VOCs were detected, possibly in concentrations that could cause potential health concerns.

Figure 2: Installation of PID Ambient Air Apparatus

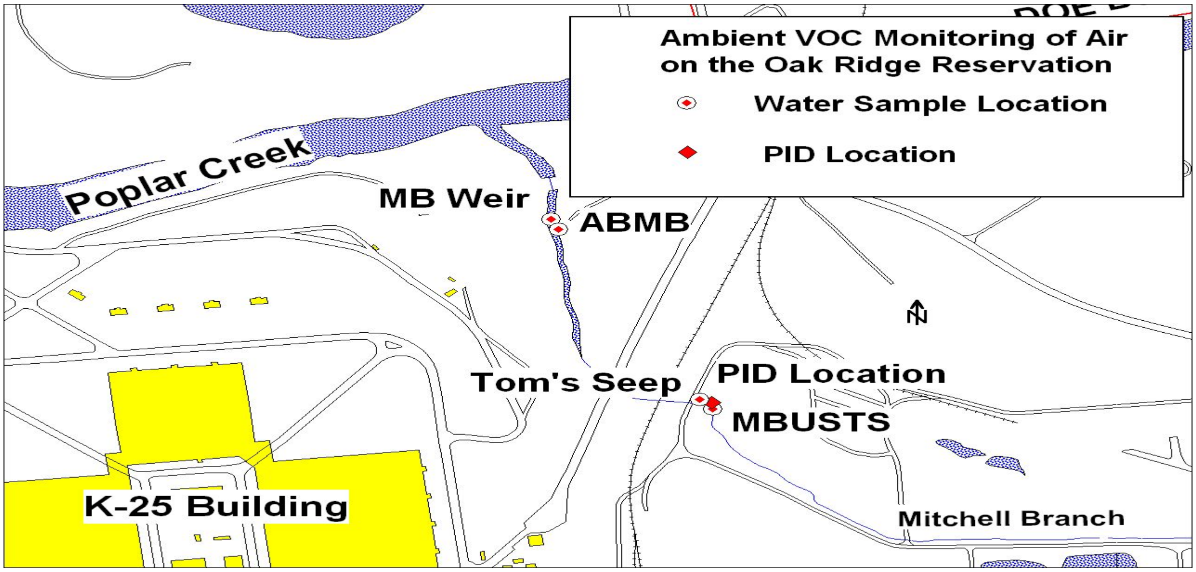

Figure 3: Detailed Location of Groundwater/Surface Water and Air Monitoring Sites

Figure 4: PID Ambient Air Apparatus In Operation

In conjunction with the PID samples, groundwater/surface water samples were to be collected from four locations prior to deployment of the apparatus, during the sample test period, and after retrieval of the apparatus. These samples would have been collected in an attempt to determine the correlation of the VOC contaminants (known from previous data to be in the groundwater / surface water) to the ambient air of the surrounding area. This would have been completed by volatilization of the contaminants. The Division also hoped to discover what conditions are conducive to VOCs volatilizing and entering the air.

The sample locations were above the spring (MBUSTS), at the spring (TOMSSEEP), and in Mitchell Branch, both above and below the weir (ABMB, MBWEIR), as shown in Figure 3. Collected water would be analyzed for VOCs only. Samples would have been collected from all four sites using TDEC and EPA standard operating procedures.

Collected samples would have been placed into laboratory prepared vials for analysis by the state laboratory in Nashville. The samples would also be placed into plastic bags before being placed into coolers with ice for the trip to the Knoxville branch of the Department of Health environmental laboratory.

Air Data Collected

Upon completion of the test period, the unit would be retrieved and brought back to the division's office. The data would be downloaded from the unit and analyzed. A graph would then be constructed. A maximum reading of almost 3500 parts per billion Total VOCs was seen in December 2006, as were two other peaks. It appears that VOCs that collected in the PID apparatus gathered there and remained concentrated at this higher rate for an extended period due to a lack of ventilation in the apparatus. The apparatus design has been corrected and may be implemented next year.

Water Data Collected

Water samples were to be collected before, during and after the project. The state's Environmental Laboratory in Nashville would have analyzed the samples for Volatile Organic Compounds.

Conclusion

The main thrust of this project was to have been measuring ambient airborne VOCs. This site was chosen because of its greatly elevated VOC levels in water. Samples taken in October 2006 indicated elevated VOCs. In the recent past, the groundwater in this area was being remediated by a groundwater collection trench and removal wells. Due to cost-effectiveness issues, the wells and trench remediation system were turned off. It is possible that, since the trench is still collecting groundwater and the pumps are turned off, the contaminated groundwater is finding a new path to the surface, namely Tom's Seep.

Volatile Organic Compounds have been measured at elevated levels at Tom's Seep and Mitchell Branch. A Photoionization Detector with data-logging capability (Photovac 2020Plus) and an external power supply was able to measure total VOCs from the ambient air in 2006. This data was downloaded and analyzed. The measured levels, if attributed to a single compound (vinyl chloride), would violate Occupational Safety and Health Administration (OSHA) standards for air (1000 parts per billion over 10 hours Time Weighted Average). Vinyl Chloride was measured in the water from Tom's Seep ranging from 65 ppb to 98.4 ppb. The levels measured by the PID were elevated above 1000 parts per billion for three and a half days. As a pilot project there are adjustments that will be made to the sampling apparatus and the test is expected to be run again. Due to scheduling problems and priority changes this project was not attempted during 2007.

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Oak Ridge Reservation Perimeter Ambient Air Monitoring Program

Principal Authors: Howard Crabtree, Betsy Gentry

Abstract

The Tennessee Department of Environment and Conservation's Perimeter Air Monitoring Program performs radiochemical analysis on samples collected at exit pathways from the Oak Ridge Reservation. This program, in conjunction with associated air monitoring programs, provides information used to assess the impact of Department of Energy activities on the local environment and public health. In the program, samples are collected from twelve low volume air monitors stationed near the boundaries of the reservation and at a background location. Each sample is analyzed for gross alpha and gross beta radiation at the state radiochemistry laboratory. Results from the reservation samplers are compared to the background measurements and environmental standards provided in the Clean Air Act. Data for 2007 were not indicative of a significant impact on local air quality from activities on the reservation.

Introduction

The Tennessee Department of Environment and Conservation (TDEC) Department of Energy (DOE) Oversight Division provides radiochemical analysis of air samples taken from twelve low volume air monitors located on and in the vicinity of the Oak Ridge Reservation (ORR). Data derived from this program, along with information generated by the other air monitoring programs on the reservation, are used to:

- assess the impact of DOE activities on the public health and environment,
- identify and characterize unplanned releases,
- establish trends in air quality, and
- verify data reported by DOE and its contractors.

Methods and Materials

The twelve low-volume air samplers used in the program are owned by DOE and DOE contractors are responsible for their maintenance and calibration. Nine of the samplers are also used by DOE contractors to collect tritium samples for their perimeter monitoring. For these nine samplers, the division's samples are collected on pre-filters, which are removed by DOE contractors every two weeks. Division staff collect the remaining three samples from samplers previously used by the Y-12 complex for their ambient air-monitoring program (which was terminated).

All the samplers in the program use forty-seven millimeter borosilicate glass fiber filters to collect particulates as air is pulled through the units. The ORR perimeter monitors employ a pump and flow controller to maintain airflow through the filters at approximately two standard cubic feet per minute. The Y-12 monitors use a pump and rotometer, which are set to average approximately two standard cubic feet per minute.

The filters from each monitor are collected biweekly and shipped to the state's radiochemical laboratory in Nashville, Tennessee for analysis. Gross alpha and gross beta analysis is performed on each of the biweekly samples. Gamma spectrometry is performed on samples that exhibit elevated gross alpha or gross beta results and annually on a composite sample from each monitoring location.

The locations of twelve air-monitoring stations used in the program are listed in Table 1. Eleven of these stations are located around the perimeter of the ORR and Y-12 facility (Figure 1). The twelfth site is a background station located near Fort Loudoun Dam in Loudon County.

Table 1: Perimeter air monitoring stations

Station	Location	County
4	Y-12 perimeter near portal 2	Anderson
5	Y-12 perimeter near building 9212	Anderson
8	Y-12 perimeter west end near portal 17	Anderson
35	East Tennessee Technology Park	Roane
37	Bear Creek at Y-12 / Pine Ridge	Roane
38	Westwood Community	Roane
39	Cesium Fields at Oak Ridge National Laboratory	Roane
40	Y-12 east	Anderson
42	East Tennessee Technology Park off Blair Road	Roane
46	Scarboro Community	Anderson
48	Deer check station on Bethel Valley Road	Anderson
52	Fort Loudoun Dam (background station)	Loudon

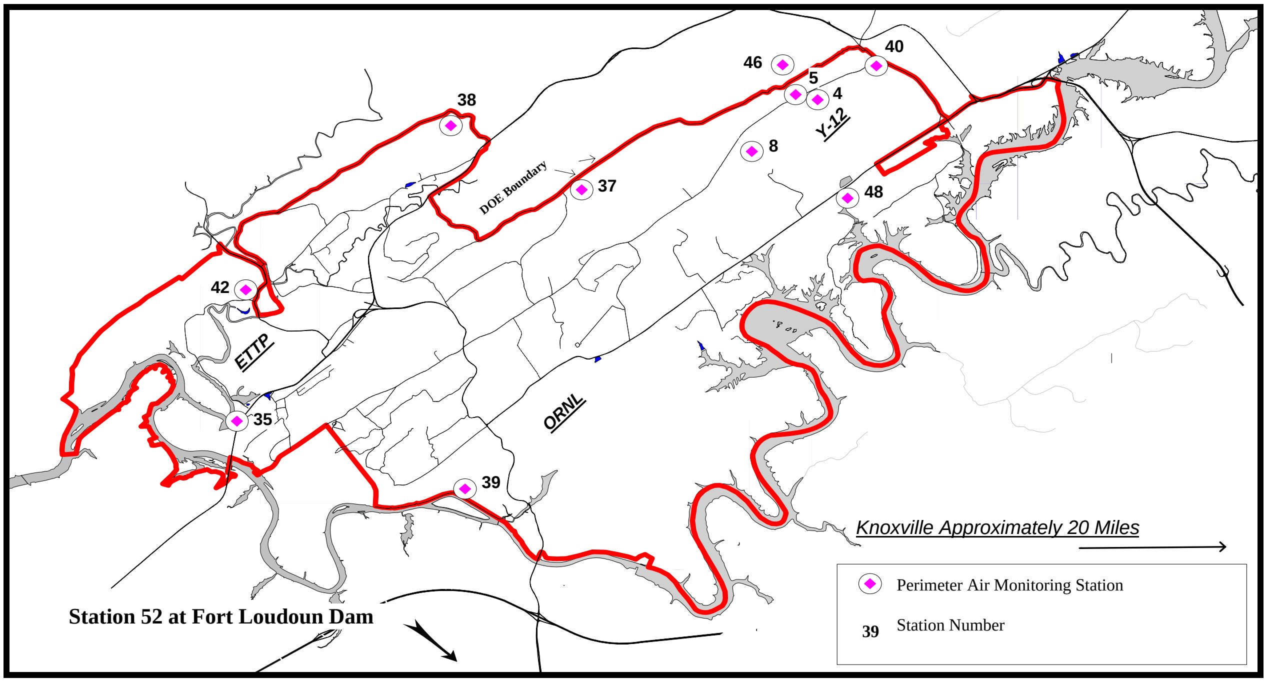

Figure 1: Approximate location of TDEC perimeter air monitoring stations

Results and Discussion

Figures 2 and 3 illustrate the correlation between fluctuations in the gross alpha and gross beta results at the perimeter stations and the background location. These fluctuations, to a large degree, can be attributed to natural phenomena or changing environmental conditions, which increase or decrease the amount of particulate deposited on the sampling filters. For example, concentrations of potassium-40 and radionuclides in the uranium and thorium decay series may increase since soils in which they naturally occur have been dispersed in the air as a consequence of dry conditions, heavy winds, and/or local activities (e.g., building demolition). Conversely, precipitation can remove materials suspended in the air, reducing the concentration of contaminants deposited on the air filters.

The simplest method of assessing the impact of ORR air emissions on the local environment is to compare results from the perimeter monitoring stations to those of the background station located at Fort Loudoun Dam (station 52). As seen in Figures 2 and 3, the activities reported for gross alpha and gross beta for the perimeter stations in 2007 were relatively consistent with the background values, although exceptions can be noted. Anomalous results were reported for station 38 (August-December) and station 46 (August-September). In each of these cases, the concentrations reported dropped significantly below background levels. The anomalous results may be due to equipment failure and/or sampling error, although the exact cause is not known. This anomaly is currently being investigated by Division staff.

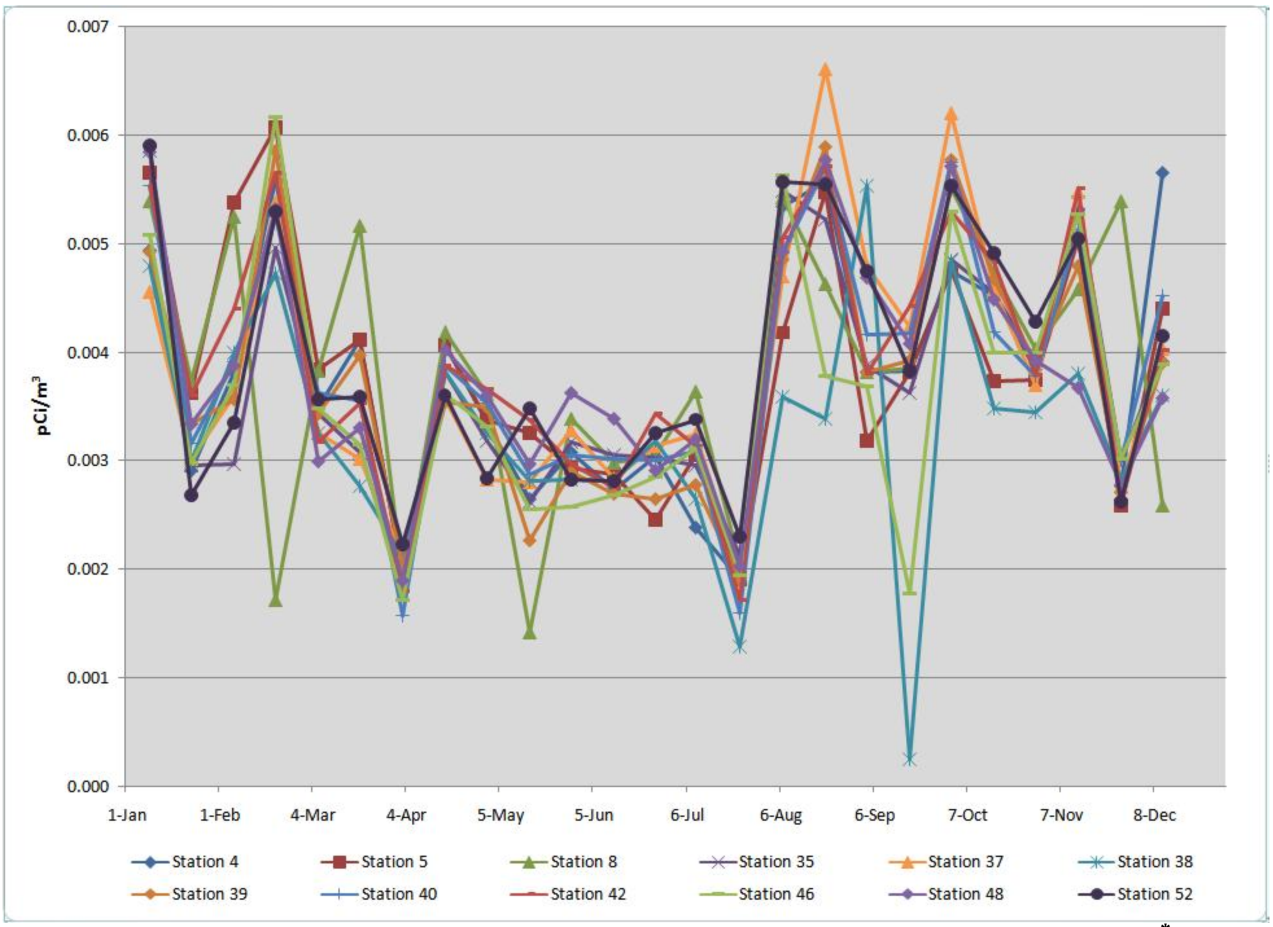

Figure 2: 2006 Gross alpha results for TDEC ORR perimeter air monitoring stations*

*Figures 2 and 3 are intended to convey the correlation of the results for the various monitoring stations, not to depict individual results. Individual measurements are available at the Division’s offices.

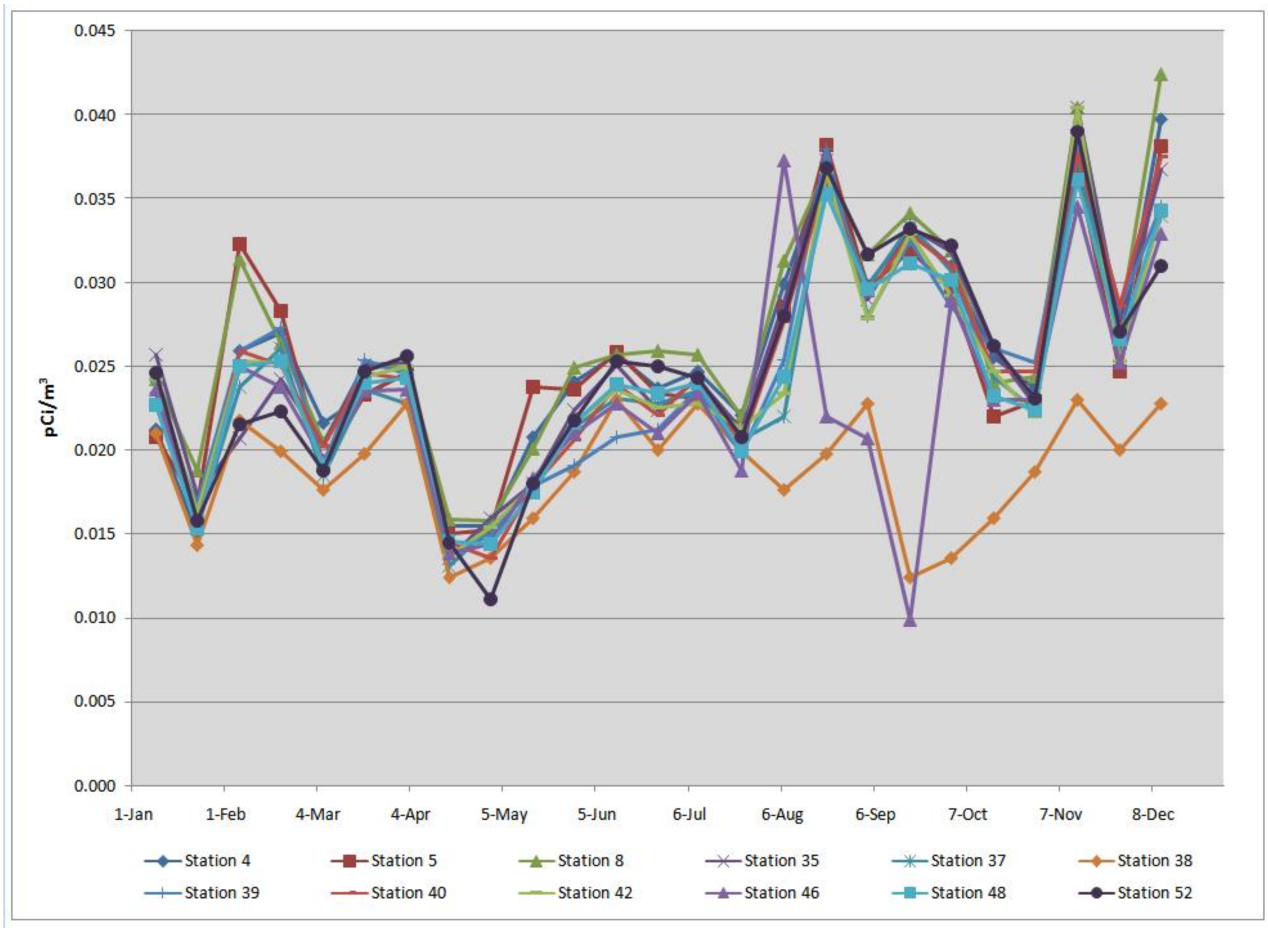

Figure 3: 2006 Gross beta results for TDEC ORR perimeter air monitoring stations*
*Figures 2 and 3 are intended to convey the correlation of the results for the various monitoring stations, not to depict individual results. Individual measurements are available at the Division's offices.

The Clean Air Act (CAA) specifies that exposures from radioactive materials released to the atmosphere from DOE facilities shall not cause members of the public to receive, in a year, an effective dose equivalent greater than 10 mrem above background levels. Data from TDEC's air monitoring is compared to ambient air concentrations provided in the CAA for demonstrating compliance with the 10 mrem/year limit.

Because the hazards associated with the various radionuclides differ significantly, the CAA requires specific analysis of each isotope determined to be of concern. Consequently, the CAA standards do not include limits for gross alpha and gross beta activities. Nevertheless, the more economical gross measurements, when treated as surrogates for the more hazardous isotopes, provide an effective screening mechanism to determine if further evaluation is warranted. The standards used in the program to screen the data are uranium-235 (primarily an alpha emitter) and strontium-90 (a beta emitter). Both have relatively restrictive limits and both are routinely encountered on the reservation. It is important to note that it is very unlikely that these isotopes would be responsible for the major proportion of the gross activities reported.

Figures four and 5 show the average activity for gross alpha and gross beta measured during 2007 at each of the perimeter air monitoring stations. The analytical findings are reported in picocuries per cubic meter (pCi/m^3). The CAA environmental standards for uranium-235 and strontium-90 are provided for comparison. Since the CAA standards only apply to the dose above background, the limits represented in Figures 4 and 5 have been adjusted to include the average gross alpha and gross beta measurements taken at the background station.

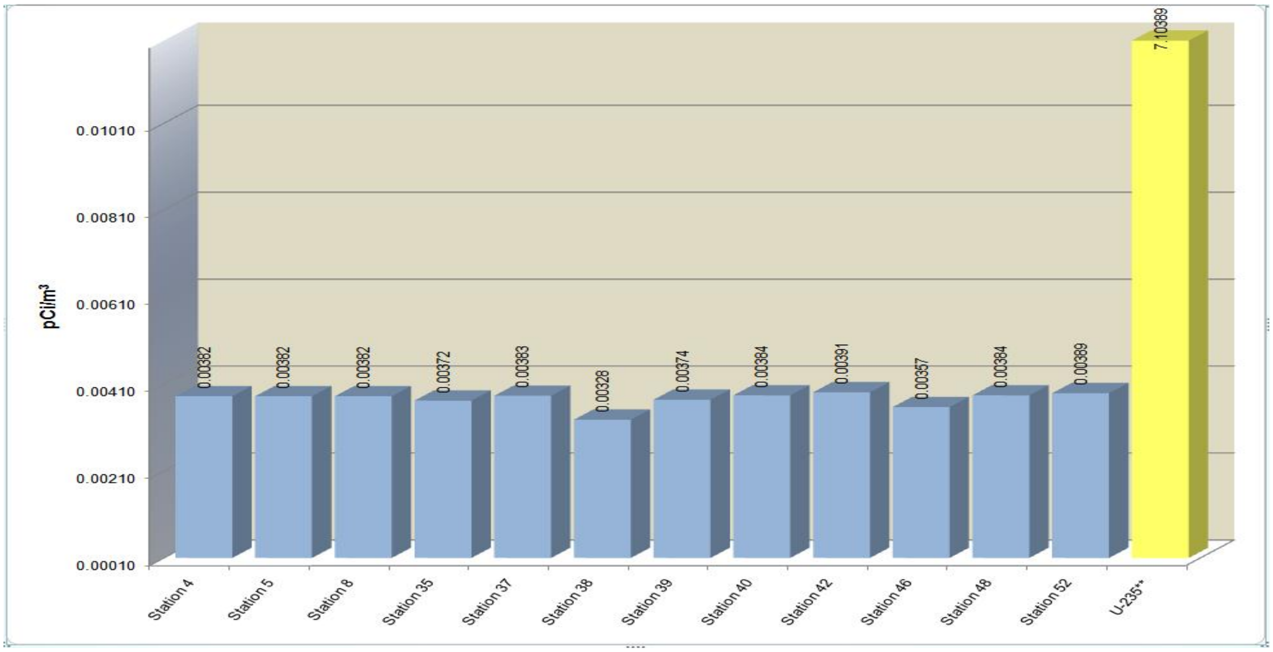

Figure 4: 2007 Average gross alpha results for TDEC perimeter air monitoring stations on the ORR*

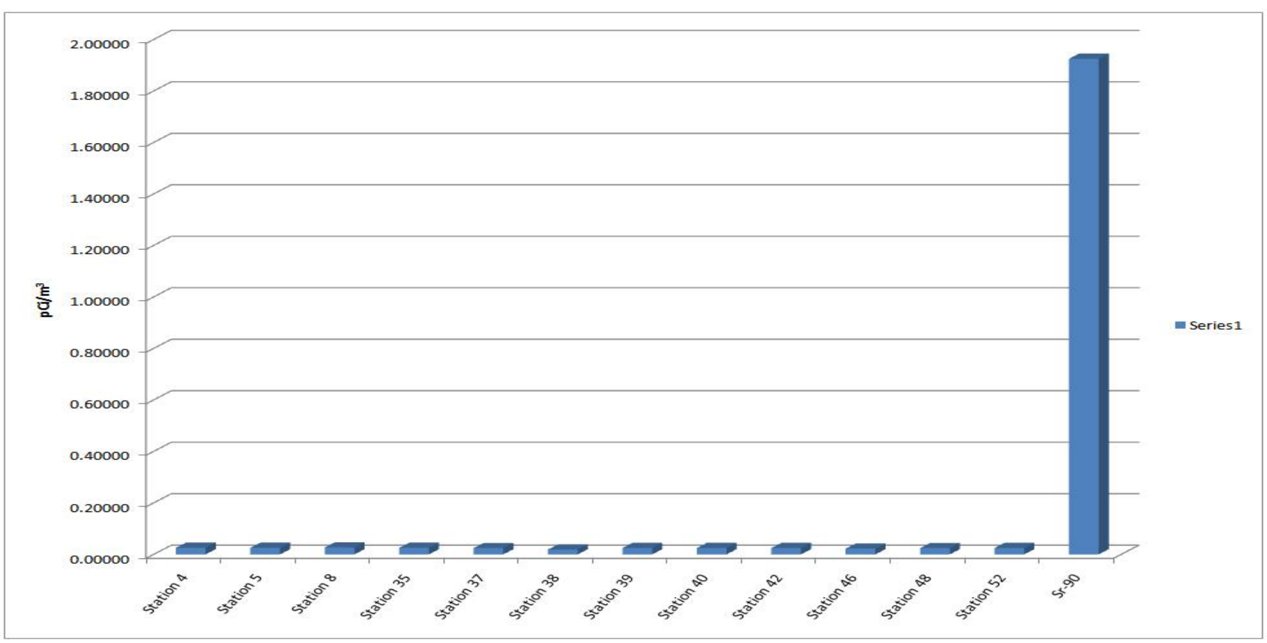

Figure 5: 2007 Average gross beta results for TDEC perimeter air monitoring stations on the ORR*

*The standards provided by the Clean Air Act apply to the dose above background; therefore, the standard provided for reference in the figure has been adjusted to include the background measurement.

**The CAA's Environmental limit for uranium-235 is provided for comparison. It is unlikely that this isotope contributes a major proportion of the gross activity reported for the samples.

**The CAA's Environmental Limit for strontium-90 is provided for comparison. It is unlikely that this isotope contributes a major proportion of the gross activity reported for the samples.

The annual gamma analysis performed on composite samples from each station has not yet been completed for the 2007 samples; consequently, these results were not available for this report. In the past, the gamma results have been considered consistent with background measurements. 2007 results will be reported in the 2008 Environmental Monitoring Report.

Conclusion

Environmental concentrations of radionuclides in the atmosphere tend to vary from location to location and seasonally in response to natural and anthropogenic influences. The results of the radiochemical analysis of samples taken at ORR perimeter air monitoring stations in 2007 were similar to those reported for the background station, with some exceptions. Anomalous results were reported for station 38 (August-December) and station 46 (August-September). In each of these cases, the concentrations reported dropped significantly below background levels. The anomalous results may be due to equipment failure and/or sampling error, although the exact cause is not known. This anomaly is currently being investigated by Division staff.

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RadNet Precipitation Monitoring

Principal Authors: Natalie Pheasant, Howard Crabtree

Abstract

The RadNet precipitation monitoring program began in December 2004 and provides radiochemical analysis of precipitation samples taken from precipitation monitoring stations located on the Oak Ridge Reservation. Samples are collected by staff from the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division and analysis is performed at the Environmental Protection Agency's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. The results are provided to the State and are available on the RadNet website. In 2007, data for samples from the RadNet precipitation monitors varied considerably throughout the year. Since there is not a regulatory limit for tritium in precipitation, the results from sampling locations are generally compared with data from other sites, both from around the nation and in adjacent states. The tritium in precipitation results at the Oak Ridge Reservation sampling location in Melton Valley tended to be among the highest in the United States when compared with other RadNet precipitation monitoring from December 2004 through March 2007. However, this station is located near a reactor and nuclear waste burial grounds while most of the other stations are located in major population centers. Tritium in precipitation results at the Blair Road location appear to be similar to those seen at the Melton Valley location for the same time period (April through November 2007). The gross beta precipitation results on the Oak Ridge Reservation tended more towards the national average.

Introduction

Precipitation monitoring was added to the RadNet program on the Oak Ridge Reservation in December 2004. The project measures radioactive contaminants that are washed out of the atmosphere and carried to the earth's surface by precipitation. There are no standards that apply directly to contaminants in precipitation. However, the data provide an indication of the presence of radioactive materials that may not be evident in the particulate samples collected by the Division's air monitors. The Environmental Protection Agency (EPA) has provided two monitors to date, both of which are co-located with the RadNet air stations. The first monitor was placed at the Melton Valley sampling location, in the vicinity of ORNL, in December 2004. The second monitor was placed off of Blair Road, east of ETTP (Figure 1), in April 2007. A third monitor will be added to the program in 2008 and will be co-located with the RadNet air station east of Y-12.

One of the radioactive contaminants of concern in the atmosphere above the Oak Ridge Reservation is tritium. Small amounts of this radionuclide are produced naturally, but the isotope is also released as water vapor in reactor effluents and from the evapotranspiration associated with buried wastes. Based on this knowledge, the initial precipitation monitor provided by EPA was placed at an existing RadNet air station near ORNL's High Flux Isotope Reactor (HFIR) and the SWSA #5 Burial Grounds (Solid Waste Storage Area) in Melton Valley, which is the major source area for tritium on the Oak Ridge Reservation. Tritium data received to date at the Melton Valley station have been among the higher values reported for the RadNet monitoring stations across the nation. However, it should be noted that the Melton Valley station was the only station located near nuclear sources at the time. The second precipitation monitor was placed off of Blair Road, near the TSCA Incinerator and east of ETTP in April 2007. A third station, which should come on line in 2008, will be used to monitor Y-12 as well as provide an indication of any tritium traveling towards the city of Oak Ridge from Melton Valley where elevated tritium levels have been found.

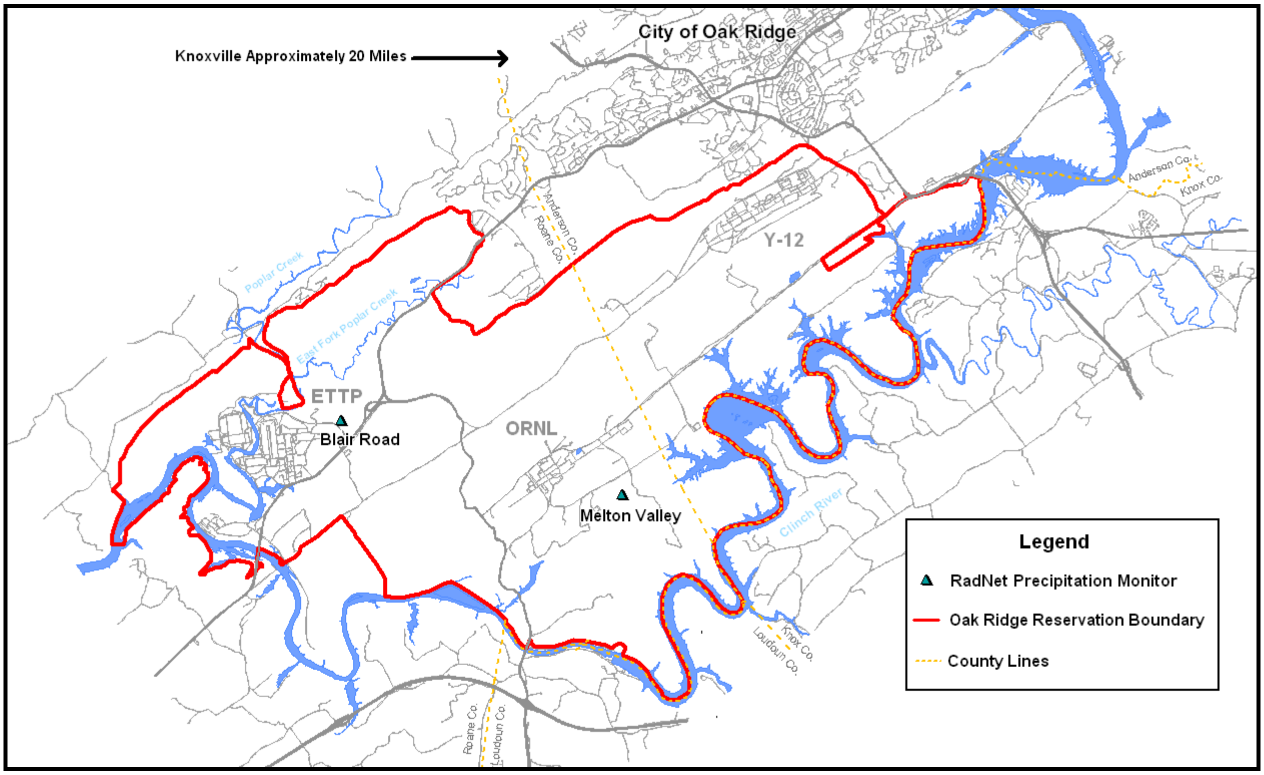

Figure 1: Locations of the RadNet precipitation samplers on the Oak Ridge Reservation

Methods and Materials

The precipitation samplers provided by EPA's RadNet program are used to collect samples for the program. Each sampler drains precipitation that falls on a 0.5 square meter fiberglass collector into a five-gallon plastic collection bucket. A sample is collected from the bucket (in a four-liter Cubitainer®) when a minimum of one liter of precipitation has accumulated in the collection bucket. The sample is processed as specified in the *Environmental Radiation Ambient Monitoring System (ERAMS) Manual* (U.S. EPA, 1988) and shipped to EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama, for analysis (Table 1). After the analysis has been completed, the results are provided to the Division and posted on EPA's RadNet website (http://www.epa.gov/enviro/html/erams). The data is used to identify anomalies (e.g., unknown contaminants), to assess the significance of precipitation in contaminant pathways, to evaluate associated control measures, and to appraise conditions on the Oak Ridge Reservation compared to other locations in the RadNet program.

Table 1: EPA analysis of RadNet precipitation samples

ANALYSIS	FREQUENCY
Gross Beta	Monthly from composite samples
Gamma Scan	Monthly from composite samples
Tritium	Monthly from composite samples

Results and Discussion

As seen in Figure 2, the results of the 2007 monthly tritium analyses on the precipitation samples taken at the precipitation stations in Melton Valley (ORNL) and off of Blair Road (ETTP), both near Oak Ridge, TN, vary throughout the year. These values reflect the original counts minus background values. When the original counts are close to background values, it is possible to obtain negative values.

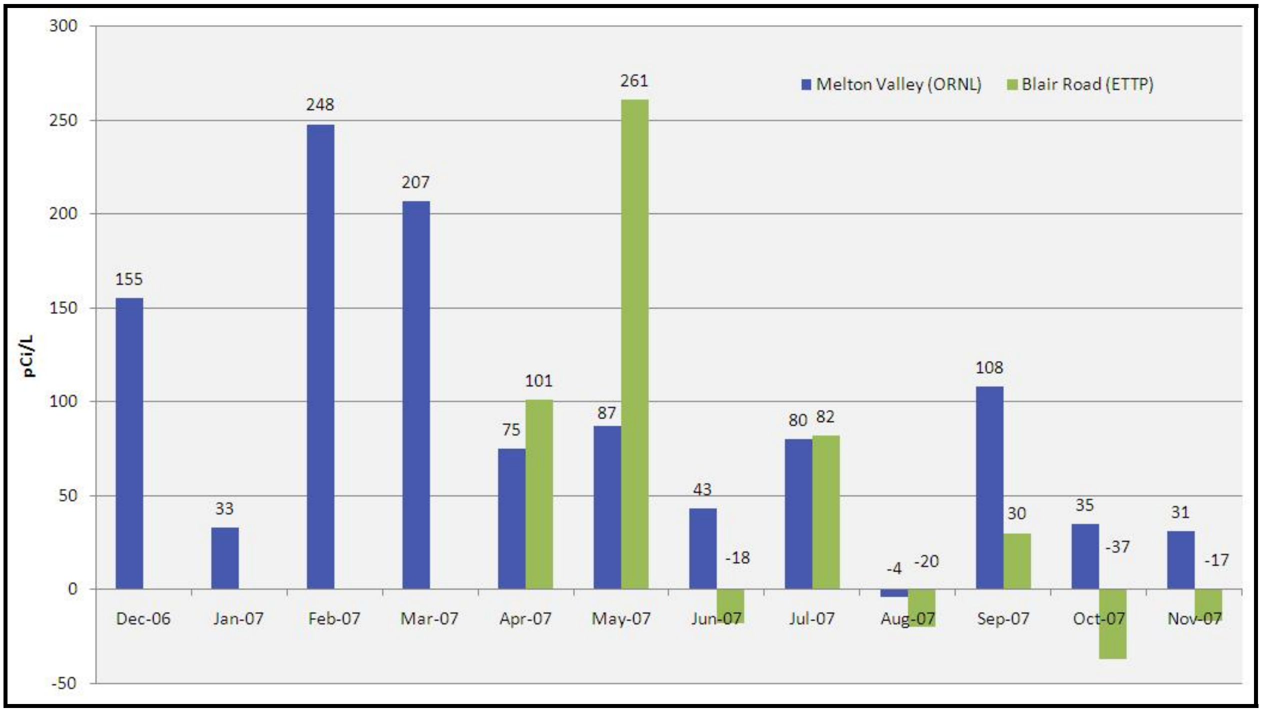

Figure 2: 2007 Monthly tritium results from precipitation samples taken at Melton Valley (ORNL) and Blair Road (ETTP)

Table 2 presents the comparison of the mean, median, and highest tritium values seen at the Oak Ridge Melton Valley location with results seen in Tennessee, in adjacent states (Arkansas, Alabama, Georgia, North Carolina, and Virginia), and across the nation (includes 38 stations in 31 states) from December 2004 through March 2007. The Blair Road station was not placed until April 2007, so it is not used in the following comparisons.

Table 2: Tritium in precipitation, December 2004 through March 2007

Location(s)	Mean	Median	Highest
Oak Ridge/Melton Valley, TN	140.1	110.0	621
TN (with Oak Ridge/Melton)	57.1	29.5	621
TN (without Oak Ridge/Melton)	15.6	16.0	357
TN and adjacent states (without Oak Ridge/Melton)	10.0	3.0	739
Adjacent states (AR, AL, GA, NC, VA)	8.0	0.0	739
National (with Oak Ridge/Melton)	18.6	8.0	1718
National (without Oak Ridge/Melton)	14.2	6.0	1718

Some stations did not report values for all months; therefore, the basic statistics were calculated from the results reported. Additionally, while the TDEC DOE Oversight office received results through November 2007 for both the Melton Valley and Blair Road locations, the results published on the website (http://www.epa.gov/narel/radnet/eramsdbase.html) for all RadNet precipitation monitoring locations across the United States were only available through March 2007. Consequently, the statistics were applied to values from locations with sample results between December 2004, when the sampler was placed in Melton Valley, and March 2007. Results for the Blair Road station were not available for this time period as the sampler was not placed until April 2007. The mean (average) tritium in precipitation value for Oak Ridge (Melton Valley) was noticeably higher than averages for adjacent states and nationwide for the same time period. Despite the fact that a median is less sensitive to extreme values, Oak Ridge/Melton Valley still had the highest median, indicating that the results for the Oak Ridge/Melton Valley site were generally higher overall. However, Oak Ridge/Melton Valley did not have the highest value for the nation or even for states adjacent to Tennessee, though sites with the highest values had lower means and medians than the Melton Valley site near Oak Ridge.

Figure 3 depicts the 2007 monthly gross beta results from precipitation samples in Melton Valley (ORNL) and Blair Road (ETTP). Again, these values can be better understood by comparing the mean, median, and highest values at the Melton Valley (Oak Ridge) location to the mean, median, and highest values at other locations (Table 3). Unlike tritium results, the gross beta results at the Melton Valley location (near Oak Ridge) were similar to results from around the nation, as seen by comparing the mean and median for each. The highest results from Tennessee (53.7 pCi/L), were from the precipitation station in Knoxville. While nationwide data for the same time period was not available for comparison with results from the Blair Road site, all results from the Blair Road site were below the associated results at the Melton Valley location.

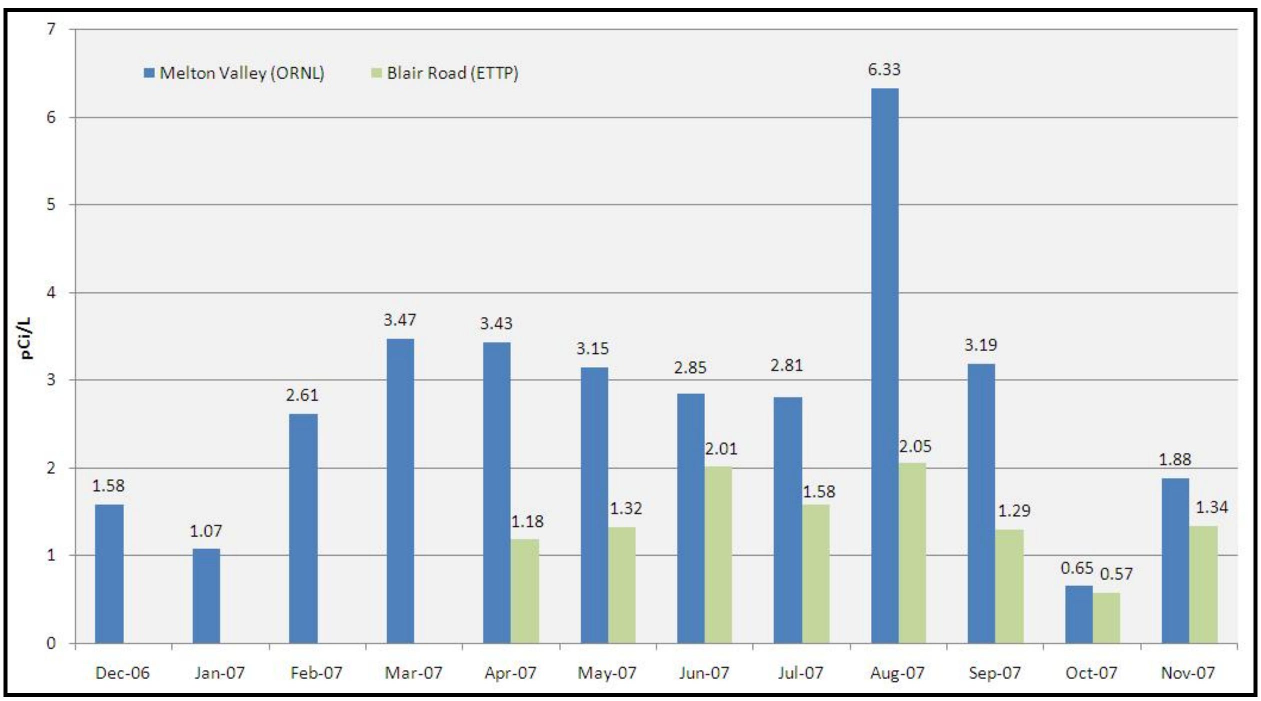

Figure 3: 2007 Monthly gross beta results from precipitation samples taken at Melton Valley (ORNL) and Blair Road (ETTP)

Table 3: Gross beta in precipitation, December 2004 through March 2007

Location(s)	Mean	Median	Highest
Oak Ridge/ Melton (Valley), TN	2.3	1.9	4.6
TN (with Oak Ridge/Melton)	5.1	2.0	53.7
TN (without Oak Ridge/Melton)	6.5	2.0	53.7
TN and adjacent states (without Oak Ridge/Melton)	3.1	1.4	53.7
Adjacent states (AR, AL, GA, NC, VA)	1.8	1.3	27.5
National (with Oak Ridge/Melton)	2.5	1.3	76.2
National (without Oak Ridge/Melton)	2.5	1.3	76.2

Conclusion

Precipitation at the RadNet precipitation sampling station in Melton Valley had higher levels of tritium than the national average most months for December 2004 through March 2007, though not the highest value nationwide or even in the adjacent states. Tritium levels in precipitation at the Blair Road site were usually at levels similar to those at the Melton Valley site, though national data was not yet available online during the same time period for comparison. While the values at the two Oak Ridge Reservation precipitation sampling sites had some of the higher values, the other sampling locations are located near major population areas while the ones on the Oak Ridge Reservation are near nuclear sources. Also, while there is not a regulatory limit for tritium in precipitation, the limit for tritium in drinking water is 20,000 pCi/L, which is relatively high compared to levels found in precipitation at RadNet precipitation stations throughout the United States. Since the drinking water limits are restrictive to protect public health, the levels of tritium in precipitation on the Oak Ridge Reservation are unlikely to pose a hazard to the public or the environment.

The gross beta values in precipitation at the Melton Valley site, for December 2004 through March 2007, were lower than the national average, and gross beta values at the Blair Road site were lower than gross beta values found at the Melton Valley site each month. Also, the highest gross beta values seen on the Oak Ridge Reservation have all been well below the highest values seen in Tennessee, in adjacent states, and nationwide. Consequently, gross beta values in precipitation on the Oak Ridge Reservation are unlikely to have posed a hazard to the public or the environment during the periods these sites have been monitored.

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BIOLOGICAL MONITORING

Fish Tissue Monitoring

Primary Author: Donald F. Gilmore

Introduction

The Tennessee Department of Environment and Conservation (TDEC) posts warning signs around streams and lakes where public health is endangered. In Tennessee, the most common reason for a river or lake to be posted is the when the presence of contaminants (e.g. sewage and/or metals) is noted in the water, sediment, or fish of a water body.

When fish tissue samples show levels of a contaminant higher than established criteria, the water body is posted and the public is advised of the danger. If needed, Tennessee Wildlife Resources Agency (TWRA) can enforce a fishing ban. Approximately 84,100 lake acres and 142 river miles across the state are currently posted due to contaminated fish. When TDEC issues new advisories, signs are placed at significant public access points and a press release is submitted to local newspapers. Table 1 shows current criteria used for issuing fish consumption advisories in Tennessee.

Table 1: State of Tennessee Fish Tissue Advisory Criteria

Contaminant	Level (ppm)
PCBs	1.00
Hg	0.50

An annual fish tissue meeting is held each year to exchange data and coordinate sampling efforts of TDEC, the Tennessee Valley Authority (TVA) and the DOE that sample fish tissue in Tennessee. The 2006 meeting focused primarily on efforts around the Oak Ridge Reservation (ORR). Review of PCB levels in catfish on Watts Bar Reservoir indicates that these levels have continued to decline over the past several years.

This was to be a multi-agency effort with the Tennessee Valley Authority (TVA) and Oak Ridge National Laboratory (ORNL) conducting the sampling, during the course of their normal collection activities. TDEC DOE-Oversight would conduct the analysis, and TDEC Division of Water Pollution Control (WPC) would evaluate the results. Samples were to consist of a homogenized five fish composite for each site and species. The species to be collected from four sites in Watts Bar Reservoir consisted of Channel Catfish, Largemouth Bass, Sauger, Smallmouth Buffalo, Striped Bass, Hybrid Bass, White Bass and Carp.

However, due to coordination problems with TVA and personnel changes, samples were not collected and therefore not analyzed. This project was not completed for 2007. If fish tissue becomes available analysis may take place in 2008.

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Benthic Macroinvertebrate Biomonitoring Using a Semi-Quantitative Approach: Rapid Bioassessment Protocol (RBP III)

Principal Author: Randy Hoffmeister

Abstract

The biotic integrity of streams originating on the Oak Ridge Reservation (ORR) was determined by collecting semi-quantitative benthic macroinvertebrate samples from study sites in four aquatic systems impacted by Department of Energy (DOE) operations. Three offsite study locations were sampled for qualitative purposes. Samples were collected and processed following the State of Tennessee standard operating procedures for macroinvertebrate surveys. Generated data was analyzed using applicable metrics. An assessment score was calculated from the metrics and a site rating was assigned. Results indicate the biotic integrity in all four systems is less than optimal compared to reference conditions. Continued benthic macroinvertebrate monitoring is necessary to provide a more thorough and accurate assessment of stream conditions. The effectiveness of DOE remedial activities can be assessed with long term monitoring efforts.

Introduction

Benthic macroinvertebrates are organisms that inhabit the bottom substrates of aquatic systems. Examples include insects, crustaceans, annelids, and mollusks. Because of their relatively long life spans and sedentary nature, benthic macroinvertebrate community structures can be useful in assessing the biological integrity of streams. A continuous biomonitoring program is a proven method of assessing and documenting any changes that may occur within the impacted system.

Historically, four aquatic systems originating on the Oak Ridge Reservation (East Fork Poplar Creek, Bear Creek, Mitchell Branch, and the White Oak Creek/Melton Branch watershed) have been impacted by DOE- related activities. East Fork Poplar Creek and Bear Creek have received inputs from the Y-12 Plant, Mitchell Branch from the East Tennessee Technology Park (ETTP), and the White Oak Creek/Melton Branch watershed from the Oak Ridge National Laboratory (ORNL). Benthic macroinvertebrate samples were collected from various locations on these streams for semi-quantitative analysis. Surface water samples were collected at the sites and analyzed for various constituents in support of the biomonitoring. Parameters analyzed included nutrients, microbiologicals (*E. Coli* and *Enterococcus*), mercury, metals, hardness, residue, and radiological constituents. Benthic macroinvertebrate samples were also collected from offsite locations on Scarboro Creek and Ernie's Creek. Although these two streams do not originate on the ORR, they were identified as potential receiving streams and were incorporated into the sampling program for qualitative assessments. The objectives of this study were to quantify benthic macroinvertebrate communities and to assess the degree of impact compared to reference conditions.

Methods and Materials

Benthic macroinvertebrate communities were semi-quantitatively and qualitatively sampled between April 30, 2007, and May 10, 2007, using the current Tennessee Department of Environment and Conservation, Division of Water Pollution Control *Quality System Standard Operating Procedure (SOP) for Macroinvertebrate Stream Surveys*. Benthic organisms were collected at each site from two similar riffles using a one-square-meter kick net.   One individual held the double-handle kick net perpendicular to the current with the net's weighted bottom resting firmly on the streambed. Another person disrupted the substrate with a kicking and sweeping motion in a one-square-meter stretch just upstream of the net. Benthic organisms were dislodged and drifted into the waiting net. After allowing suitable time for all the debris to flow into the net, the person performing the kick lifted the bottom of the net at each end in a smooth, continuous motion while the person holding the net at the top was careful not to let the top edge dip below the water's surface. After a second riffle kick was sampled in an identical fashion, the collected organisms were picked from the net and transferred into a container as a composite sample.

Benthic macroinvertebrate samples were preserved in 80% ethanol with internal and external site-specific labels. Labeling information included site name, sampling date, and sampler's initials. If more than one sample container was needed at a site, the debris was split evenly with internal and external labels completed for each container.

Sample collection methods were modified in the White Oak Creek watershed due to the presence of radioactive contamination in the stream sediments. The two one-meter kick samples were combined in a five-gallon bucket, creek water was added and the sample swirled to suspend the lighter material (including invertebrates) with elutriate then being poured through a sieve. This process was repeated five times to ensure a thorough collection of organisms. Any material not needed was returned to the creek. Samples from the White Oak Creek watershed were stored and later sorted in-house following sub-sampling procedures.

The semi-quantitative samples and White Oak Creek watershed subsamples were transported to the Tennessee Department of Health Environmental Laboratory in Nashville for processing. Following the current State SOP, samples were sorted and benthic macroinvertebrates were enumerated and identified to the genus level. Biological metrics were calculated from the raw data in order to develop an overall site assessment rating. Calculated metrics included Taxa Richness, EPT (*Ephemeroptera, Plecoptera, Trichoptera*) Richness, Percent EPT, Percent OC (oligochaetes and chironomids), NCBI (North Carolina Biotic Index), Percent Clingers, and Percent Nutrient Tolerant organisms. Once values were obtained for the seven metrics, a score of 0, 2, 4, or 6 was given to each metric based on comparison to the metric target values for Bioregion 67F, the reference ecoregion for Oak Ridge Reservation streams. The seven scores were totaled and the overall index score (IS) was compared to the Target Index Score (TIS) for Bioregion 67F, TIS = 32. The biological condition rating of the sampling site was estimated within the range of Non-Supporting/Severely Impaired (IS < 10) to Supporting/Non-Impaired (IS >= 32).

Samples from Scarboro Creek and Ernie's Creek were processed in-house following the State SOP for qualitative analysis. Three metrics, Taxa Richness, Number of EPT, and Number of Intolerant Taxa, were calculated based on family level identifications. A score of 1, 3, or 5 was assigned to each metric based on comparison to the metric target values for Bioregion 67F. The three scores were totaled to determine the overall scoring value. A Severely Impaired (partially or not supporting system) assessment was given if the overall score was 5 or less. A score of 6-10 indicated the results were ambiguous and additional data was needed. The site was considered Non-impaired (supporting) if the score was 11-15. A description of the metrics and the equations used to calculate them can be obtained by referencing the State SOP. The biometrics used to generate stream ratings and the expected response of each metric to stress introduced to the system are presented in Table 1.

Table 1: Description of Metrics and Expected Responses to Stress

Category	Metric	Description	Response to Stress
Richness Metrics	Number of taxa	Measures the overall variety of the macroinvertebrate assemblage	number decreases
	Number of EPT taxa	Number of taxa in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	number decreases
	Number of Intolerant taxa	Number of taxa in the families listed in State SOP as being intolerant to stress	number decreases
Composition Metrics	% EPT	% of Ephemeroptera, Plecoptera, and Trichoptera	% decreases
	% OC	% of oligochaetes (worms) and chironomids (midges)	% increases
Tolerance Metrics	% Dominant	% contribution of single most dominant taxa	% increases
	NCBI	North Carolina Biotic Index which incorporates richness and abundance with a numerical rating of tolerance	number increases
	% Nutrient Tolerant	% of organisms considered tolerant of nutrients	% increases
Habit Metric	% Clingers	% of macroinvertebrates having fixed retreats or attach to surfaces	% decreases

Results and Discussion

Semi-quantitative Assessments

East Fork Poplar Creek

The metric values, metric scores, overall index scores, and biological condition ratings of the impacted streams on the ORR are presented in Table 2. Stream biotic integrity in East Fork Poplar Creek appeared to improve with distance from the Y-12 Plant. The three sites inside the Plant, EFK 25.1, EFK 24.4, and EFK 23.4, had index scores of 16, 20, and 20, respectively, and rated partially supporting/moderately impaired. The index scores increased to 22 and 24 at EFK 13.8 and EFK 6.3, respectively. These two most downstream sites rated partially supporting/slightly impaired compared to ideal reference conditions. Taxa Richness, EPT Richness, and %EPT generally increased with distance from the plant suggesting improved conditions downstream. Despite the appearance of relatively good conditions downstream, East Fork Poplar Creek continued to show signs of impaired conditions with index scores well below the target index score. Surface water results (Appendix B) show mercury levels remain slightly elevated in East Fork Poplar Creek compared to other ORR streams.

Mitchell Branch

Index scores and condition ratings in Mitchell Branch decreased with distance through ETTP. Marked decreases in the Taxa Richness, EPT Richness, and Percent EPT were observed (Table 2). The number of individual taxa at MIK 0.71 (n=28) and MIK 0.45 (n=29) represents a 35% decrease from the Taxa Richness at the upstream reference site, MIK 1.43 (n=43). Percent EPT decreased over 60% at MIK 0.71 (12.3%) and over 90% at MIK 0.45 (3.2%). Pollution tolerant aquatic worms and midges dominated the downstream samples as evidenced by a 70% increase in Percent OC at MIK 0.45 (79.2%) compared to MIK 1.43 (46.1%).

Evidence of chromium releases in lower Mitchell Branch was captured in surface water sampling in 2007. Appendix B shows total chromium and hexavalent chromium results found in water samples collected at MIK 0.71 and MIK 0.45. Elevated chromium levels correspond to elevated radionuclide levels at these sites. Although the specific source of contamination is not known, it is suspected that these levels are related to CERCLA clean-up activities in the vicinity of the stream.

Table 2. Metric Values, Scores, and Biological Condition Ratings for ORR streams, Spring 2007.

	East Fork Poplar Creek					Mitchell Branch		
METRIC	EFK 25.1	EFK 24.4	EFK 23.4	EFK 13.8	EFK 6.3	MIK 1.43	MIK 0.71	MIK 0.45
Taxa Richness	25 (4)	13 (2)	25 (4)	26 (4)	20 (4)	43 (6)	28 (4)	29 (6)
EPT Richness	3 (0)	3 (0)	2 (0)	4 (2)	5 (2)	6 (2)	4 (2)	3 (0)
% EPT	11.4 (0)	14.4 (0)	3.9 (0)	14.3 (0)	23.6 (2)	32.2 (4)	12.3 (0)	3.2 (0)
% OC	63.1 (2)	74.9 (2)	71.8 (2)	68 (2)	63.4 (2)	46.1 (4)	59.4 (2)	79.2 (0)
NCBI	6.07 (4)	4.34 (6)	5.29 (4)	4.59 (6)	4.26 (6)	3.73 (6)	4.41 (6)	4.15 (6)
% Clingers	68.2 (6)	46.1 (4)	54.1 (6)	42.9 (4)	42.4 (4)	14.4 (0)	34.2 (2)	29.4 (2)
% Nutrient Tolerant	81.3 (0)	34.1 (6)	56.4 (4)	48.0 (4)	37.2 (4)	15.0 (6)	29.4 (6)	23.1 (6)
INDEX SCORE	16	20	20	22	24	28	22	20
RATING	**C**	**C**	**C**	**B**	**B**	**B**	**B**	**C**

	White Oak Creek					Bear Creek	
METRIC	WCK 6.8	WCK 3.9	WCK 3.4	WCK 2.3	MEK 0.3	BCK 12.3	BCK 9.6
Taxa Richness	40 (6)	19 (2)	20 (4)	26 (4)	27 (4)	26 (4)	21 (4)
EPT Richness	11 (6)	5 (2)	5 (2)	8 (4)	8 (4)	4 (2)	4 (2)
% EPT	32.8 (4)	72.0 (6)	77.2 (6)	64.7 (6)	59.4 (6)	13.2 (0)	23.6 (2)
% OC	53.5 (2)	11.9 (6)	11.2 (6)	8.3 (6)	23.7 (6)	68.8 (2)	22.5 (6)
NCBI	4.65 (6)	4.24 (6)	4.45 (6)	4.41 (6)	3.83 (6)	4.09 (6)	5.72 (4)
% Clingers	28.3 (2)	52.8 (4)	52.2 (4)	70.6 (6)	57.5 (6)	26.3 (2)	8.9 (0)
% Nutrient Tolerant	34.8 (6)	67.0 (2)	75.0 (2)	61 (2)	49.3 (4)	20.0 (6)	52.9 (4)
INDEX SCORE	32	28	30	34	36	22	22
RATING	**A**	**B**	**B**	**A**	**A**	**B**	**B**

Key:

A - Fully Supporting - Non-impaired…………………………………….. >= 32
B - Partially Supporting - Slightly Impaired…………………………….. 21 - 31
C - Partially Supporting - Moderately Impaired………………………… 10 - 20
D - Non-Supporting - Severely Impaired………………………………… < 10

White Oak Creek and Melton Branch

Table 2 shows ratings in White Oak Creek improved with distance through the Oak Ridge National Laboratory. The lowest index score (IS=28) was calculated at WCK 3.9. The increased presence of the pollution-sensitive organisms (mayflies, stoneflies, and caddisflies), coupled with a decrease in the Oligochaetes and Chironomids (organisms that tend to dominate stressed environments) downstream of WCK 3.9 produced index scores and ratings at WCK 3.4 and WCK 2.3 that are comparable to reference conditions at WCK 6.8.

The metric values and index score at MEK 0.3 (Table 2) indicated fully supporting/non-impaired conditions existed within this remediated portion of Melton Branch. Taxa Richness and EPT Richness values mirrored those found at WCK 2.3. Results from continued sampling at this site will be useful in assessing the effectiveness of ORNL remedial activities. Surface water results from samples taken in White Oak Creek and Melton Branch are reported in Appendix B.

Bear Creek
Low EPT Richness values (n=4) and Percent EPT suggest impaired conditions exist in Upper Bear Creek relative to ideal reference conditions. A near two-fold increase in the Percent EPT at BCK 9.6 (23.6%) compared to BCK 12.3 (13.2%) and a near 70% decrease in the Percent OC suggests slight biotic improvement with distance from the Y-12 Plant. The relatively high Percent OC (68.8%) at BCK 12.3 further supports the assessment of an impaired system. Appendix B provides results of surface water samples taken at these two sites.

Qualitative Assessments
Results from two sampling sites on Scarboro Creek indicated supporting, non-impaired conditions exist, although results from the lower Scarboro Creek site suggest more data may be needed to substantiate this claim. The site on Upper Scarboro Creek adjacent to the UT arboretum had an overall scoring value = 13. The Taxa Richness, Number of EPT, and Number of Intolerants values were 22, 9, and 3, respectively. The Lower Scarboro Creek site located across Bethel Valley Road and just downstream of the old beaver dam had an assessment score = 9. The metric values for Taxa Richness, Number of EPT, and Number of Intolerants were 19, 5, and 1, respectively. Suppressed metric values in Ernie's Creek (Taxa Richness = 14, Number of EPT = 3, and Number of Intolerant Taxa = 0) suggested the stream is being impacted. The rating score = 5 indicated severely impaired, partial or non-supporting conditions exist.

Conclusions
The biotic integrity of streams on the ORR is less than optimal compared to reference conditions. Two sites, both in the White Oak Creek watershed, showed signs of supporting, non-impaired conditions. The remaining sites had biological condition ratings of partially supporting systems with slight to moderate impairment. Surface water sampling results indicated mercury remains persistent in East Fork Poplar Creek and nutrient inputs continue to affect Bear Creek. Continued water sampling in Mitchell Branch will be a useful tool in documenting the effectiveness of chromium clean-up activities. Monitoring benthic macroinvertebrate communities should provide more thorough and accurate assessments of stream conditions by capturing temporal and spatial changes due to DOE-related activities. Environmental remedial actions taken by DOE continue to have an impact on the aquatic environments in East Fork Poplar Creek, Mitchell Branch, the White Oak Creek watershed, and Bear Creek. The effectiveness of remedial activities over time can be monitored by documenting changes in the benthic macroinvertebrate communities.

References
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Diatom (Periphyton) Environmental Monitoring

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Abstract

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (Division), Environmental Monitoring Section, continued monitoring diatom communities in Oak Ridge Reservation (ORR) watersheds during 2007. Periphyton samples were collected during March, July and November in East Fork Poplar Creek and Bear Creek (note: White Oak Creek samples collected during March, May and November) using artificial substrates deployed in ten impacted and four reference streams. The goal was to use diatoms as biomonitoring tools to examine the water quality and ecological recovery of East Fork Poplar Creek, Bear Creek, and White Oak Creek (Melton Branch) watersheds impacted by Department of Energy (DOE) operations at Y-12 National Security Complex and the Oak Ridge National Laboratory respectively. Communities of attached benthic algae contain diatom taxa with individual tolerance to anthropogenic stress (e.g., heavy metals), which may explain community compositional changes or shifts such as decreased taxa diversity and richness. Thus, water quality can be characterized by evaluating the results of qualitative and quantitative measurements of the benthic algal community. Project objectives included: (1) prepare a comprehensive flora of diatom and non-diatom taxa comprising the periphyton communities on the ORR, (2) evaluate shifts in the periphyton community composition and succession at ORR stream sites utilizing diatom counting data, and (3) relate diatom genera composition and abundance to distance from the origin of industrial contamination. Diatoms and non-diatom taxa were identified to the generic level including identifications to the species level.

Introduction

Periphyton have been used for over 50 years for the biomonitoring of streams and rivers (Davis & Simon 1995). It is well known that periphyton, among them diatoms, are excellent indicators of heavy metal toxicity (Genter 1996, Pérès 1996, Ivorra et al 1999). Periphyton is a primary producer and basal food web assemblage of algae and other microorganisms (fungi, bacteria, detritus, microbes, protozoa, diatoms, green algae, macroinvertebrates, and blue-green algae) that colonize benthic substrates in aquatic systems (Stoermer and Smol 1999, Stevenson et al. 2001). Diatoms, a major algal component of periphyton, are unicellular microscopic algae that belong to the phylum Heterokontophyta (Chrysophyta), class Bacillariophyceae. Unlike soft-bodied filamentous algae, diatoms sequester silica from their environment, and produce intricately complex rigid glass structures called frustules (valves) that fit together like the lid on a petri dish. Taxonomic classifications of diatom taxa are keyed on the diagnostic ornamented morphology, size and shape of respective diatom valves. A list of diatom taxa present in a sample and their disproportionate abundance can be analyzed using several indices to determine biotic integrity and to diagnose specific stressors (Davis and Simon 1995).

Aquatic organisms (i.e. periphyton), that integrate all the biotic and abiotic parameters in their habitat, can provide a continuous record of environmental quality and reveal various environmental changes of natural and anthropogenic origin (Gold et al. 2002). Shifts in genera composition and abundance of diatoms and other freshwater algae can be used to infer rapid community response to environmental change in aquatic systems (Sullivan 1999, Stevenson et al. 2002). Diatoms exist within narrow environmental conditions (light, temperature, pH, turbidity, water chemistry), and are thus powerful indicators of different levels and causes of anthropogenic stress due to industrial pollution and high nutrient loads (Dixit et al. 1992, Bahls 1993). Therefore, incorporating a diatom-monitoring task with other sensitive aquatic bioindicators (i.e., macroinvertebrates) provides an additional set of biocriteria to the assessment of the ecological integrity of a stream. Environmental stressors to ORR aquatic systems include heavy metals, nutrients, chemicals, and radionuclides.

Methods and Materials

Artificial substrates comprised of unglazed ceramic tiles were deployed in impaired and reference streams to allow periphyton colonization for a predetermined period of time (January 2007-November 2007). Locations in East Fork Poplar Creek, Bear Creek, and White Oak Creek (Melton Branch) were sampled to evaluate diatom community composition and taxa richness (see Figures 1a and 1b). Associated reference sites included Brushy Fork Creek, Hinds Creek, Mill Branch, and a White Oak Creek headwater site. These are low order streams that have substantially different canopy cover.

Field sampling methods and protocols employed during this project included the U.S. EPA “Periphyton Sampling Protocol” (Barbour et al. 1999), the Kentucky Division of Water (KDOW 2002), the New Jersey Protocol Manual (Ponader & Charles 2005), and the USGS “Methods for Collecting Algal Samples as Part of the National Water Quality Assessment Program” (Porter et al. 1993, Moulton et al. 2002).

Different stages of periphyton development were obtained at each site by deploying unglazed ceramic tiles (*see* Hill and Boston 1991, Rosemond et al. 1993, Hill et al. 1997) to allow periphyton colonization for a period of one year. Three replicates of 24 tiles apiece were attached with silicon glue to bricks and submerged in riffle-run sections at each site (depths ranged from 15-45 cm). Replicates were secured to the streambed with steel reinforcing bars driven 20 cm into the substrata. Artificial substrates were deployed during January and then an in-stream incubation period of 4-8 weeks was allowed prior to initial sample collections in March 2007. Following the initial incubation and development period, 1-2 tiles were collected from each brick at approximately monthly intervals. Tiles were removed while keeping the replicates submerged and later transported to the laboratory in labeled water-filled containers. Care was taken to avoid dislodging periphyton during the collection process.

Ambient water parameters were taken at each location using a Horiba® U-10 Water Quality Checker (pH, temp, conductivity, dissolved oxygen, and turbidity). Field data were recorded in a logbook at each monitoring station. Site photographs and global positioning system (GPS) readings were obtained for each field monitoring station. Water quality samples (analytical chemistry data) were collected in spring and fall 2007 during concurrent macroinvertebrate monitoring.

On returning to the laboratory, field samples were preserved with Lugol’s solution, and stored at 4° C until further processing. Diatom sample preparation protocols follow the methods of Bahls (1993), PAI (1998), Barbour et al. (1999), KDOW (2002), and Moulton et al. (2002). Sample preparation consisted of dislodging the attached periphyton from the tiles by brushing, then rinsing the dislodged algae with deionized water, and collecting the resultant algal slurry in a small laboratory pan. Approximately 25 ml of slurry was transferred into a labeled plastic vial for permanent storage until taxonomic processing could be completed. The initial slurry volume of each sample was carefully measured in a graduated cylinder and recorded in the laboratory logbook. Identification labels with site specific information was attached to each sample slurry container.

Algal slurry samples were examined by Division staff using the Olympus® BH-1 Stereomicroscope and the Zeiss® inverted microscope. Laboratory analysis included taxonomic identification and enumeration of diatom species for each sampling site. Fresh and digested diatom material was prepared, and taxonomically identified using Smith (1950), Patrick and Reimer (1966, 1975), Prescott (1978), and Wehr and Sheath (2003). Enumeration of diatoms was completed on at least ten fields-of-view or continued counting additional fields-of-view until 500 diatom valves were counted per sample at 400x-power magnification. Identifications were made at least to the genus level, and often species were determined. Digital photographic images of diatoms were archived on CD-ROM for future reference and taxonomic verification.

Results and Discussion

Specific metrics were applied to the generated data to quantitatively characterize stream periphyton communities and water quality conditions (Bahls 1993, Barbour et al. 1999, KDOW 2002, Moulton et al. 2002). A biological metric or indicator is a shorthand numerical representation of a biological community (Bahls et al. 1992). Diatom metric analysis for Tennessee diatoms were generated from a multitude of literature, including Casterlin and Reynolds (1977), Descy (1979), Lange-Bertalot (1979), Bahls (1993), Van Dam et al. (1994), Kelly and Whitton (1995), St-Cyr (1997), PAI (1998), Barbour et al. (1999), Chessman et al. 1999, Hill et al. (2000), Fore and Grafe (2002), and KDOW 2002. Table 1 illustrates the overall periphyton assemblage on the ORR. Table 2 is a list and description of metrics used for this project.

Figures 1a and 1b are location maps of the ORR diatom stations monitored during 2007. Local precipitation data for January 2007 through December 2007 was obtained from the National Oceanic and Atmospheric Administration (NOAA) Oak Ridge air sampling station (NOAA ASOS 2007, Figure 2).

Statistical means were calculated for all field data, laboratory sample analyses, and diatom counting results, and metrics were derived. Raw data is available for review on request at the TDEC DOE-Oversight office in Oak Ridge. The laboratory chemistry data for samples collected during 2007 are within normal ranges for surface waters in the ORR area.

Tables 1 and 3 (algal families and genera), Figures 3-5 (water quality), Figures 6-11 (stacked bar graphs), Figures 12-13 (pollution tolerant/pollution sensitive taxa), and Figures 14-20 (pie charts) characterize water quality and the community composition of the overall periphyton assemblage in the ORR streams. The data represented in the figures and tables are discussed in more detail below, relating the metrics and diatom-counting data to specific monitoring sites. Overall, 2007 laboratory analysis of periphyton samples yielded 75 genera, 32 families, and six phyla of freshwater algae and diatoms from ORR streams.

Site-specific information will now be presented relating monitoring sites to 2007 metrics and periphyton laboratory data (μ = mean, n= number of months sampled):

***Bear Creek 12.3 (Bear Creek Watershed)*:**
Diatoms dominated the BCK 12.3 periphyton community during 2007. Total number of diatom taxa (TNDT) ranged from 92-95% of the total biomass (μ= 93.69%, n= 3), and the balance of the biomass was non-diatom taxa (NDT) including Chlorophytes (green algae) and Cyanophytes (blue-green bacteria). Algal genera richness ranged from 19-20 for 2007 (μ= 20, n= 3). Table 3 (comprehensive periphyton community metrics) indicates the disturbance and siltation indices are indeed high for this site relative to the downstream BCK 0.63 site. The dominant periphyton genera include *Achnanthes*, *Campylodiscus, Cymbella*, *Gomphonema*, *Navicula, Nitzschia*, and *Pinnularia*. The percent relative abundance for each taxon is represented in Figures 9-11. Figure 13 (Bear Creek pollution tolerance) suggests pollution-tolerant taxa decrease slightly downstream and pollution-sensitive taxa increase slightly with distance from the Y-12 source of pollution. BCK 12.3 indicates a significantly higher percentage of pollution-tolerant taxa as compared to the downstream sites BCK 9.6 and BCK 0.63. Figure 14 (pie chart) shows the most dominant taxonomic family for this site is *Achnanthaceae* (μ= 29%). Dominance by one taxonomic group suggests impaired water quality.

The 2007 water chemistry samples collected at this site indicate the NO_2 & NO_3 nitrogen reported values ranged from 51.0-83.0 mg/l. Additionally, water hardness ranged from 456-743 mg/L and total dissolved solids (TDS) ranged from 636-1090 mg/L. These are not surprising results because Bear Creek receives nutrient-rich outfall from the Y-12 West End water treatment facility located upstream about 0.2 km. Also, the colonized tiles were coated with a thick brown (probably mineral) scum (non-algal). This coating may be due to manganese (830-890 µg/L). Metals (Zn = 9-12 µg/l, Cd = 4-5 µg/l) and radionuclides (79-322 pCi/L gross α / 22-584 pCi/L gross β) were reported at elevated concentrations at the location. Conductivity was consistently high (851-1711 µS/cm) for this site suggesting impaired water quality plus the high TDS mentioned above. BCK 12.3 site features heavy canopy cover and the historical photosynthetically active radiation (PAR) mean was quite low at 50 µmol quanta m^{-2} s^{-1} (light intensity measured in 2006).

In summation, BCK 12.3 continues to exhibit impaired water quality. The siltation and disturbance indices plus the conductivity are high suggesting impaired water quality. Also, the site is dominated by one taxonomic group further indicating water impairment. Several distorted diatom frustules (e.g., *Fragilaria*) were observed during cell counting of BCK 12.3 samples. Several BCK 12.3 sample sets exhibited diatom cell size reduction in +75% of the biomass. This may represent a diatom response to elevated metals, high nutrients and radioactive contamination. McFarland et al. (1997), Ruggiu et al. (1998), and Gold et al. (2003) reported abnormalities in *Fragilaria* morphology in periphyton samples impacted by high metals concentrations.

***Bear Creek 9.6*:**
Diatoms dominated the BCK 9.6 periphyton community during 2007. TNDT ranged from 72-99% of total biomass (μ= 89.38%, n= 3), and the balance of algal taxa biomass included Chlorophytes and Cyanophytes. Algal genera richness ranged from 15-20 for 2007 (μ= 18, n= 3).

The dominant periphyton genera include *Achnanthes, Cocconeis, Cymbella, Denticula, Fragilaria, Gomphonema, Navicula, Nitzschia, Rhoicosphenia and Synedra*. The percent relative abundance for each taxon is represented in Figures 9-11. Figure 13 plots Bear Creek pollution-sensitive diatoms versus pollution-tolerant diatoms. The dramatic increase in pollution sensitive taxa at this location suggests an influence from the north tributary outfalls (NT-3, NT-4, NT-5 / Y-12 Environmental Management Waste Management Facility, i.e., EMWMF) entering Bear Creek upstream of BCK 9.6. This may be due to increased nutrient loads from the EMWMF creating eutrophic conditions and resultant algal blooms. Figure 15 (pie chart) shows the most dominant taxonomic families for this site include *Achnanthaceae* (μ= 24%), *Cymbellaceae* (μ= 21%) and *Fragilariaceae* (μ=19%). BCK 9.6 shows a significantly lower percentage of pollution tolerant taxa as compared to the upstream BCK 12.3 site.

Diminished (as compared to BCK 12.3) yet still elevated NO_2 & NO_3 nitrogen values (13.4-23.0 mg/l) were reported for BCK 9.6 during 2007. This is not surprising because Bear Creek receives nutrient-rich outfall from the Y-12 West End water treatment facility located upstream about 0.2 km; also BCK 9.6 is downstream of north tributary outfalls from the EMWMF. Metals (Zn = 6 μg/l) and radionuclides (28.5-74 pCi/L gross α / 46.1-108.7 pCi/L gross β) were reported at elevated concentrations for BCK 9.6. Conductivity was consistently high (518-741 μS/cm) for this site suggesting impaired water quality. BCK 9.6 site features heavy-moderate canopy cover and the historical photosynthetically-active radiation (PAR) mean was 153 μmol quanta m^{-2} s^{-1} (light intensity measured in 2006). Diatom community taxa respond to changing light conditions (PAR) often resulting in fluctuating community compositions.

In summation, BCK 9.6 continues to exhibit impaired water quality exacerbated by recent waste disposal activities in west Bear Creek valley (EMWMF outfall). The increase in pollution-sensitive diatoms may represent an algal bloom resultant of high nutrient outfalls from the EMWMF north tributaries located upstream of BCK 9.6. Nitrogen, metals, and gross alpha and gross beta concentrations were also elevated compared to non-impacted reference streams. The disturbance index is higher at BCK 9.6 than BCK 0.63 suggesting improving water quality downstream. Also, several distorted diatom frustules (e.g., *Fragilaria*) were observed during cell counting of BCK 9.6 samples. Several BCK 9.6 sample sets exhibited diatom cell size reduction in +75% of the biomass. This may represent a diatom response to elevated metals, high nutrients and radioactive contamination. McFarland et al. (1997), Ruggiu et al. (1998), and Gold et al. (2003) reported abnormalities in *Fragilaria* morphology in periphyton samples impacted by high metals concentrations.

***Bear Creek 4.55*:**
Diatoms dominated the BCK 4.55 periphyton community during 2007. TNDT ranged from 71-99% of total biomass (μ= 80.87%, n= 3), and the balance of algal taxa biomass included Chlorophytes and Cyanophytes. Algal genera richness ranged from 18-21 for 2007 (μ= 19, n= 3), and the balance of algal taxa included Chlorophytes and Cyanophytes. The dominant periphyton genera include *Achnanthes, Chlorococcum, Cocconeis, Cymbella, Denticula, Fragilaria, Gloeotrichia, Gomphonema, Navicula, Nitzschia,* and *Rhoicosphenia*. The percent relative abundance for each taxon is represented in Figures 9-11. Figure 13 plots Bear Creek pollution-sensitive diatoms versus pollution-tolerant diatoms. Generally, the percent tolerant taxa at BCK 4.55 drops slightly compared to the upstream BCK 12.3, but per cent tolerant taxa is

considerably higher than the BCK 9.6 site. Although BCK 4.55 is almost 8 km downstream of the highly impaired BCK 12.3 monitoring site, Table 3 (comprehensive periphyton community metrics) indicates the disturbance index is elevated for this site relative to the upstream sites and downstream BCK 0.63. Figure 16 (family pie chart) indicates the dominant diatom family is *Achnanthaceae* (μ = 44% of the total biomass). Dominance by one or only a few taxonomic groups implies impaired water quality. Conductivity for BCK 4.55 was more normal (305-386 μS/cm) compared to unimpaired reference streams for all months during 2007.

Water chemistry data was not collected during 2007 for this site. BCK 4.55 site features moderate canopy cover and the historical photosynthetically active radiation (PAR) mean was 334 μmol quanta m^{-2} s^{-1} (light intensity measured during 2006). Boston and Hill (1991) reported that algal biomass tended to increase with increasing incident light, and that photosynthesis-irradiance responses of algal periphyton under light and shade conditions differ substantially.

In summation, BCK 4.55 exhibits generally improving water quality conditions evidenced by a lower conductivity compared to the impaired upstream sites. However, there are lingering indications of impaired water quality due to the elevated disturbance index in BCK 4.55 and the large increase of pollution tolerant diatoms compared to the upstream BCK 9.6 site.

***Bear Creek 0.63*:**

Diatoms dominated the BCK 0.63 periphyton community during 2007. TNDT ranged from 92-100% of total biomass (μ= 95.15%, n= 3), and the balance of algal taxa biomass included Chlorophytes and Cyanophytes. Algal genera richness ranged from 18-20 for 2007 (μ= 19, n= 3). and the balance of algal taxa included Chlorophytes and Cyanophytes. The dominant periphyton genera include *Achnanthes, Cocconeis, Fragilaria, Gomphonema, Navicula, Nitzschia, Rhoicosphenia,* and *Synedra*. (see Figures 9-11 stacked bar-graphs for monthly genera relative abundance). Conductivity was relatively normal (237-386 μS/cm) for all months during 2007 for BCK 0.63. Figure 13 plots Bear Creek pollution sensitive diatoms versus pollution tolerant diatoms. BCK 0.63 exhibits an obvious increase of pollution sensitive taxa as compared to the more impaired upstream sites. Also, the site exhibits high siltation scores perhaps due to beaver dam-building activity both upstream and downstream of the site. Figure 17 (family pie chart) shows the most dominant families that form the community composition are *Achnanthaceae* (μ = 32%), *Fragilariaceae* (μ = 15%), and *Nitzschiaceae* (μ = 12%).

Water chemistry data was not collected during 2007 for this site. BCK 0.63 site features heavy canopy cover and the historic photosynthetically active radiation (PAR) mean was 106 μmol quanta m^{-2} s^{-1} (light intensity measured during 2006). The low mean PAR value for BCK 0.63 results in correspondingly low algal biomass as compared to other ORR stream and reference sites exhibiting higher PAR values. The corresponding diatom taxa respond to changing light conditions often resulting in fluctuating community compositions and biomass.

In summation, BCK 0.63 exhibits considerably higher water quality conditions with distance downstream from the pollution source and compared to impaired upstream Bear Creek sites. Based on the diatom monitoring, BCK 0.63 approximates water quality expected from a reference stream. In addition to beaver activity, the paradoxical siltation scores may also be a result of the higher stream velocity and increased sediment-load capacity of the stream at this location.

***East Fork Poplar Creek 23.4 (East Fork Poplar Creek Watershed)*:**
Diatoms dominated the EFK 23.4 periphyton community during 2007. TNDT ranged from 85-92% of total biomass (μ= 88.02 %, n= 3), and the balance of algal taxa biomass included Chlorophytes and Cyanophytes. Algal genera richness ranged from 20-21 for 2007 (μ= 21, n= 3). and the balance of algal taxa included Chlorophytes and Cyanophytes. The dominant periphyton genera include *Achnanthes, Diatoma, Fragilaria, Gomphonema, Navicula, Nitzschia,* and *Rhoicosphenia* (see Figures 6-8 stacked bar-graphs for monthly diatom relative abundance trends). EFK 23.4 is a relatively open canopy site and is also fairly eutrophic due to Y-12 outfall. Thus, EFK 23.4 exhibits high diatom diversity. Table 3 (comprehensive periphyton community metrics) indicates the disturbance index to be higher for EFK 23.4 (μ = 28.52) relative to the downstream EFK 13.8 (μ = 16.40) and EFK 6.3 (μ = 7.85). The siltation indices for EFK 23.4 (μ = 18.65%) are higher than for downstream site EFK 13.8 (μ = 13.59%) but downstream site EFK 6.3 has the highest siltation index (μ = 22.16%). Conductivity was plotted but failed to be statistically significant for the East Fork Poplar Creek sites. Figure 12 plots East Fork Poplar Creek pollution-sensitive diatoms versus pollution-tolerant diatoms. EFK 23.4 shows a slightly higher percentage of pollution tolerant taxa as compared to the to the downstream EFK 13.8 and EFK 6.3 sites. As expected, sensitive diatom taxa were highest at the downstream EFK 6.3 site following the Bear Creek trend of improving water quality with distance from the Y-12 source of pollution. Figure 18 (pie chart) shows the most dominant families that form the community composition of the site: *Achnanthaceae* (μ = 31%) and *Fragilariaceae* (μ = 16%).

The 2007 water chemistry samples collected at this site indicated NO_2 & NO_3 nitrogen values of 1.5-2.1 mg/l. Ammonia was reported in concentrations ranging from 0.12-0.41 mg/L. These results are not surprising because this section of upper East Fork Poplar Creek watershed receives nutrients and outfall from within the Y-12 site. Metals such as Zn (10-16 μg/l), Hg (0.2 μg/l), and Cu (2-3 μg/l) were reported from the site in 2007. Phosphate was reported at 0.07 mg/l in one 2007 water sample. EFK 23.4 site features a mostly open canopy and the historical photosynthetically-active radiation (PAR) mean was 644 μmol quanta m^{-2} s^{-1} (light intensity measured in 2006). The high mean PAR value for EFK 23.4 has a correspondingly high algal biomass as compared to other ORR stream and reference sites exhibiting lower PAR values. This trend agrees with the findings of Boston and Hill (1991) that algal biomass tended to increase with increasing incident light, and that photosynthesis-irradiance responses of algal periphyton under light and shade conditions differ substantially.

In summation, EFK 23.4 exhibits slight water quality impairment compared to the downstream EFK 6.3 site. On the other hand, the site exhibits high diatom diversity that may be due to the nutrient load and receiving high PAR (light intensity). Metals (including Hg) and elevated nutrient concentrations are suspected sources of impairment.

***East Fork Poplar Creek 13.8*:**
Diatoms and green algae dominated the EFK 13.8 periphyton community during 2007. TNDT ranged from 64-99% of total biomass (μ= 76.99 %, n= 3), and the balance of algal taxa biomass

included additional Chlorophytes and Cyanophytes. Algal genera richness ranged from 18-26 for 2007 (μ= 23, n= 3). and the balance of algal taxa included Chlorophytes and Cyanophytes. The dominant periphyton genera include *Achnanthes, Chlorococcum, Cocconeis, Diatoma, Gomphonema, Navicula, Nitzschia,* and *Rhoicosphenia* (see Figures 6-8 stacked bar-graphs for monthly diatom relative abundance trends). EFK 13.8 is a relatively open canopy site and is also fairly eutrophic due to close upstream proximity to the City of Oak Ridge sewage treatment plant and to non-point source pollution from the local community. Thus, EFK 13.8 exhibits high diatom diversity. Table 3 (comprehensive periphyton community metrics) indicates the disturbance and siltation indices to be slightly higher for this site relative to the downstream EFK 6.3 site. Figure 12 plots East Fork Poplar Creek pollution-sensitive diatoms versus pollution-tolerant diatoms. EFK 13.8 exhibits a slightly lower percentage of pollution-tolerant taxa as compared to the upstream EFK 23.4 site. Figure 19 shows the most dominant families that form the community composition of the site are: *Achnanthaceae* (μ = 34%) and *Chlorococcaceae* (μ = 14%). Conductivity was plotted but failed to be statistically significant for the East Fork Poplar Creek sites.

The 2007 water chemistry samples collected at this site indicated elevated NO_2 & NO_3 nitrogen values (1.1-1.6 mg/l). Metals such as Zn (5-6 μg/l), and Cu (2 μg/l) were reported at slightly elevated concentrations at EFK 13.8. One EFK 13.8 sample had elevated gross α = 18.4 pCi/L; this is above the 15 pCi/L limit for alpha. Phosphate was reported at 0.03 mg/l in one 2007 water sample. EFK 13.8 site features open canopy cover and the historical photosynthetically active radiation (PAR) was 864 μmol quanta m^{-2} s^{-1} (light intensity measured in 2006). The high mean PAR value for EFK 13.8 is correlated with a high diatom biomass as compared to other ORR stream and reference sites exhibiting lower PAR values. This trend agrees with the findings of Boston and Hill (1991) that algal biomass tended to increase with increasing incident light, and that photosynthesis-irradiance responses of algal periphyton under light and shade conditions differ substantially.

In summation, the recovery status of EFK 13.8 water quality seems to indicate signs of stream recovery based on the high diatom diversity and higher genera richness than upstream EFK 23.4, but the disturbance/siltation indices reflect marginal results at best. The site is easily prone to flooding from light-moderate rain (see Figure 2, precipitation data) as evidenced by the large amounts of high water debris deposited in tree limbs. Nitrogen, phosphate, and metals concentrations plus non-point source pollution from the local community may explain the impaired water quality. Also, the site may receive a backflow of nutrients from the downstream City of Oak Ridge water treatment plant during flooding events.

***East Fork Poplar Creek 6.3*:**

Diatoms dominated the EFK 6.3 periphyton community during 2007. TNDT ranged from 87-96% of total biomass (μ= 91.31 %, n= 3), and the balance of algal taxa biomass included Chlorophytes and Cyanophytes. Algal genera richness ranged from 22-25 for 2007 (μ= 24, n= 3). and the balance of algal taxa included Chlorophytes and Cyanophytes. The dominant periphyton genera include *Achnanthes, Cocconeis, Gomphonema, Navicula, Nitzschia,* and *Rhoicosphenia* (see Figures 6-8 stacked bar-graphs for monthly diatom relative abundance trends). Table 3 (comprehensive periphyton community metrics) indicates the disturbance index for EFK 6.3 is lower than the upstream sites, yet the siltation index is higher than the upstream sites. The reason for the higher siltation index may be the fact that the site is flood prone. Figure 12 plots pollution-sensitive diatoms versus pollution-tolerant diatoms. EFK 6.3 exhibits marginally higher pollution-sensitive diatoms compared to the upstream EFK 23.4 site. Figure 20 shows the most dominant families that form the community composition of the site are: *Achnanthaceae* ($\mu = 36\%$), *Fragilariaceae* ($\mu = 11\%$), and *Naviculaceae* ($\mu = 11\%$). Conductivity was plotted but failed to be statistically significant for the East Fork Poplar Creek sites.

The 2007 water chemistry samples collected at this site indicated elevated NO_2 & NO_3 nitrogen values (3.6 mg/l). Metals such as Zn (11-12 µg/l), and Cu (2 µg/l) were reported from samples collected at EFK 13.8. Phosphate was reported at 0.52 and 0.55 mg/l in two 2007 water samples. EFK 6.3 site features moderate canopy cover and the historic photosynthetically active radiation (PAR) was 343 µmol quanta m^{-2} s^{-1} (light intensity measured in 2006). The site exhibited a proportionally increasing biomass with increasing PAR. This trend agrees with the findings of Boston and Hill (1991) that algal biomass tended to increase with increasing incident light, and that photosynthesis-irradiance responses of algal periphyton under light and shade conditions differ substantially.

Based on the diatom monitoring program, the data generally suggests a slight improvement downstream for East Fork Poplar Creek with distance from the source of Y-12 pollution. However, the high siltation index at the downstream site (EFK 6.3) indicates impaired water quality. This may be because EFK 6.3 receives nutrient contributions from the upstream City of Oak Ridge sewage treatment. Metals, nitrogen and phosphate concentrations may explain the cause of impaired water quality. Also, the site has high stream velocity and frequently experiences flash-flood events from moderate rain (scouring reduces the periphyton biomass; see Figure 2, precipitation data).

White Oak Creek 6.8 (White Oak Watershed headwaters): Diatoms, when present, exhibited inconsistent results within the periphyton community during 2007 at WCK 6.8. There is a large snail population (algal grazers) at this site that significantly reduced biomass colonization on the artificial substrates (ceramic tiles). Accordingly, diatom and non-diatom algae population counts were extremely low (i.e., <100 individuals per sample) during all 3 sampling events (March, May & November) and the resulting data are likely compromised (biased). Unfortunately, this outcome does not allow a reasonable nor scientific interpretation of the diatom community composition for WCK 6.8. Water quality data was collected during 2007 and summarized as follows: Zinc was detected in low concentrations (5-6 µg/L) in surface water samples collected from this site. No unusual pH or conductivity trends were recorded for this location during 2007. The recommendation is to cease sampling activities at this site for at least one year to allow the aquatic system time to stabilize from recent construction disturbances relating to activities at the Spallation Neutron Source (SNS) located on Chestnut Ridge just north and upstream of this monitoring location. Available results are presented in Figures 21-22 for this monitoring station.

White Oak Creek 3.9 (White Oak Watershed): Diatoms, when present, exhibited an inconsistent variation within the periphyton community during 2007 at WCK 6.8. There is a large snail population (algal grazers) at this site that significantly reduced biomass colonization on the artificial substrates (ceramic tiles). Accordingly, diatom and non-diatom algae population counts were extremely low (i.e., similar to WCK 6.8 above) and the resulting data are likely compromised (biased) and therefore misleading. Unfortunately, this outcome does not allow a reasonable nor scientific interpretation of the diatom community composition for WCK 3.9. Water quality data was collected during 2007 and summarized as follows: Zinc (22 µg/L), copper (4-7 µg/L), nitrite/nitrate ($NO_2 + NO_3$ = 0.57-0.89 mg/L), total phosphorus (0.12-0.15 mg/L), and ammonia (NH_3 = 0.25 mg/L) were detected in surface water samples collected from this site. Gross beta was detected at elevated concentrations (117.1-141.2 pCi/L). The nutrients detected suggest slight eutrophic conditions at this stream location. No unusual trends were noted in 2007 per pH or conductivity data recorded for this location. The recommendation is to cease sampling activities at this site for at least one year to give the aquatic system time to stabilize from recent disturbances at ORNL associated with CERCLA cleanup activities. Figures 21-22 represent the available data for this monitoring station.

***White Oak Creek 2.3*:**
Artificial substrate samples (colonized ceramic tiles) collected at WCK 2.3 during 2007 generally developed a higher biomass of periphyton colonization although there were occasional losses of biomass due to scouring of ceramic tiles (storm events). Because data collected from the upstream BCK 6.8 and BCK 3.9 locations are strongly biased, it is neither scientifically ethical nor reasonable to correlate WCK 2.3 diatom community data with those locations. Therefore, it is only possible to present the data as shown in Figures 21-27 with basically a flora of the local taxa (community composition) and related water quality data. The periphyton community is dominated by diatom taxa as collected from three sample sets (March, May and November). Water quality data was collected during 2007 and summarized as follows: Zinc (12 µg/L), copper (2-4 µg/L), total phosphorus (0.26-0.28 mg/L), and nitrite/nitrate ($NO_2 + NO_3$ = 1.2-2.0 mg/L) were detected in surface water samples collected from this site. Gross beta was detected at elevated concentrations (103.5-188.0 pCi/L). No unusual trends were noted in 2007 per pH or conductivity data recorded for this location. The recommendation is to cease sampling activities at this site for at least one year to give the aquatic system time to stabilize from recent disturbances in Melton Valley associated with CERCLA cleanup activities.

***Melton Branch 0.3 (Melton Branch Watershed)*:**
Artificial substrate samples (colonized ceramic tiles) collected at MEK 0.3 during 2007 generally developed a higher biomass of periphyton colonization although there were occasional losses of biomass due to scouring of ceramic tiles (storm events). It is important to note that MEK 0.3 is a tributary of White Oak Creek. Because the periphyton community at MEK 0.3 is dominated by non-diatom taxa (green and blue-green algae), it is difficult to correlate this site with the downstream WCK 2.3 location which is dominated by diatom taxa. Therefore, it is only possible to present the data as shown in Figures 21-27 with basically a flora of the local taxa (community composition) and related water quality data. The high abundance of non-diatom algae is likely due to eutrophic conditions in Melton Valley related to CERCLA cleanup activities. Water quality data was collected during 2007 and summarized as follows: Zinc (5-7 µg/L), total phosphorus (0.69-0.91 mg/L), and nitrite/nitrate ($NO_2 + NO_3$ = 0.27-0.41 mg/L) were detected in surface water samples collected from this site. Gross beta was detected at elevated concentrations (57.1-93.5 pCi/L). No unusual trends were noted in 2007 per pH or conductivity data recorded for this location. The recommendation is to cease sampling activities at this site for at least one year to give the aquatic system time to stabilize from recent disturbances in Melton Valley associated with CERCLA cleanup activities.

Conclusions

Results of the 2007 periphyton (diatom) biomonitoring continue to indicate a general trend of improving water quality for both Bear Creek and East Fork Poplar Creek with longitudinal distance from the upstream Y-12 contamination source. The diatom biomonitoring evidence suggests that part of the upper Bear Creek impairment may be related to north tributary outfalls from the EMWMF site. This year the White Oak Creek/Melton Branch monitoring data proved to be inconclusive.

The ORR diatom biomonitoring project spanning the past three years (supported by 1998-2000 diatom monitoring by Division staff) offers strong evidence for the continued use of benthic algae as a bioassessment tool and as bioindicators of stream ecosystems affected by anthropogenic pollution. This contention is supported by a convincing and exhaustive body of scientific literature (short list: Dixit et al. 1992, Genter 1996, Ivorra et al. 1999, Sullivan 1999, and Stevenson et al. 2002). Periphyton have been used for over 50 years in the monitoring of streams and rivers (Davis & Simon 1995). Accordingly, several states actively employ diatoms as part of their overall biological assessments (in addition to fish and macroinvertebrates) of streams, lakes and wetlands: Florida, Idaho, Kentucky, Massachusetts, Montana, New Jersey, and Wyoming. Because of periphyton characteristics, and the work done by the states listed, periphyton can be a very useful tool in development of biocriteria. Furthermore, the U. S. Environmental Protection Agency and the U. S. Geological Survey have developed periphyton sampling and monitoring protocols for rapid bioassessments of aquatic ecosystems. The stream metrics and protocols used by the states for periphyton are well developed and are actively used to determine if a stream is supporting aquatic life use as designated under the Clean Water Act (Davis & Simon 1995).

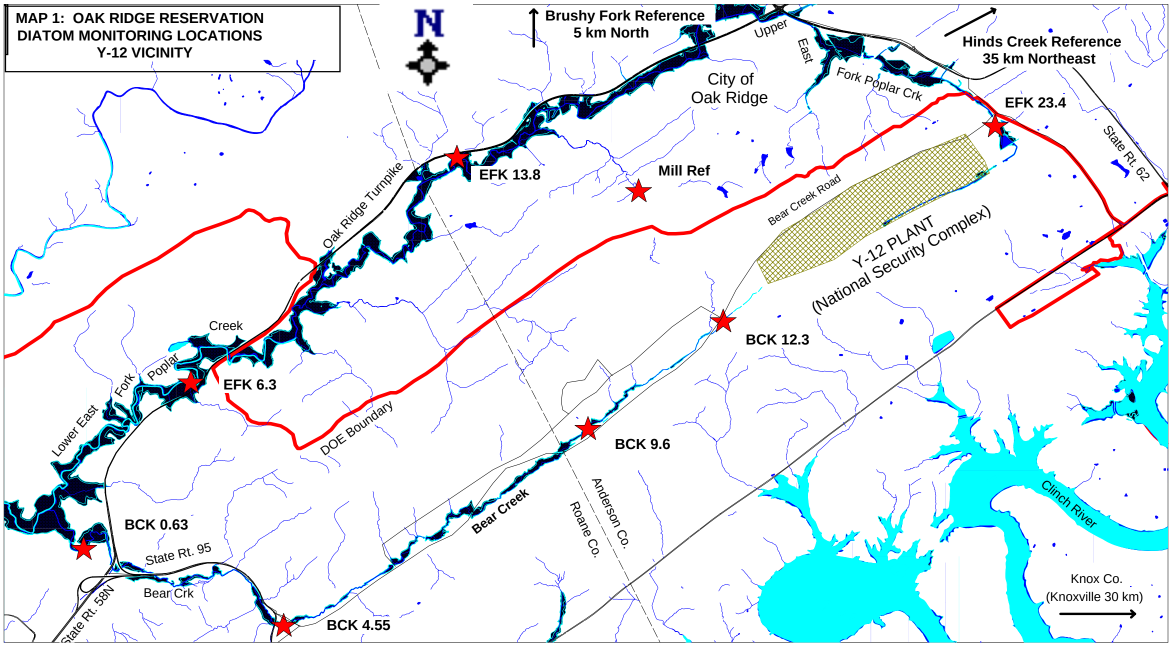

Figure 1a: Oak Ridge Reservation Diatom Monitoring Locations (Y-12 Vicinity)

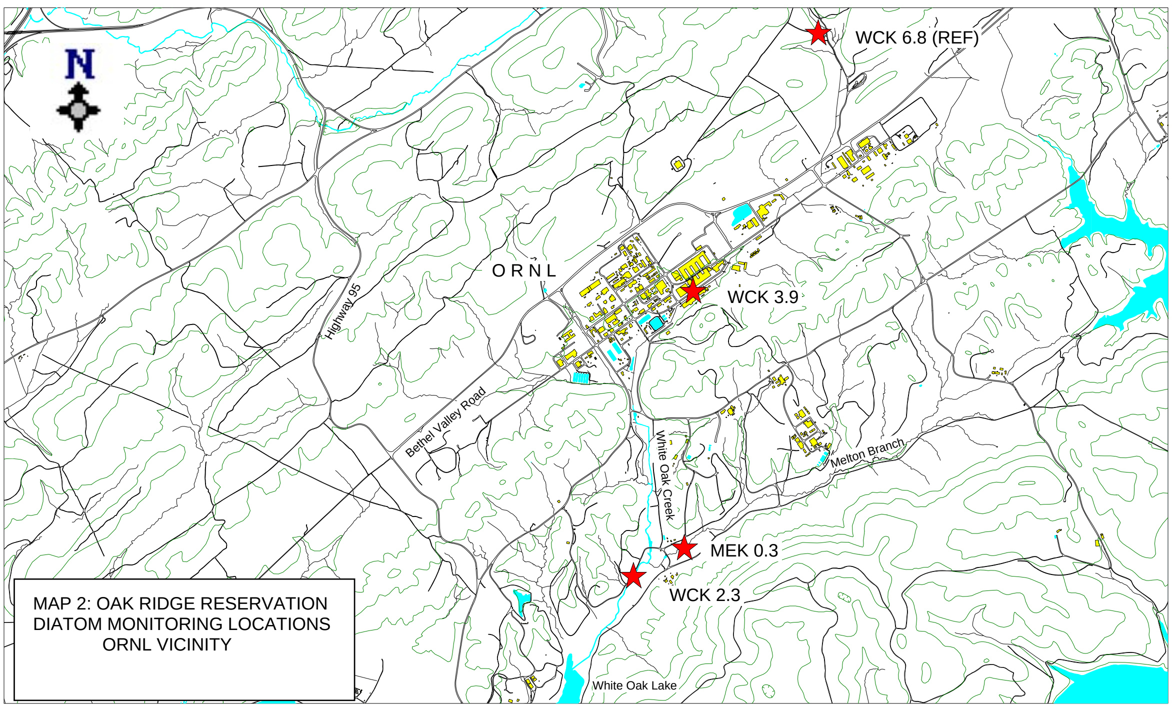

Figure 1b: Oak Ridge Reservation Diatom Monitoring Locations (ORNL Vicinity)

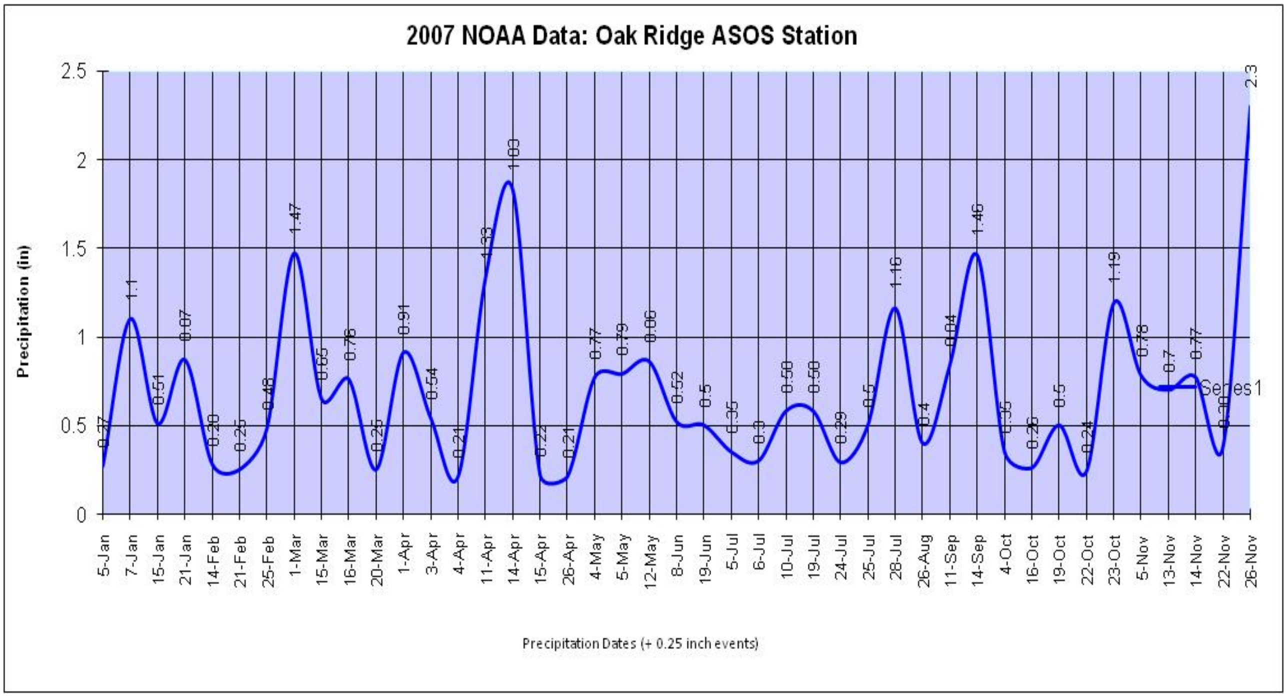

Figure 2: 2007 NOAA Weather Data: Oak Ridge ASOS Station (Precipitation)

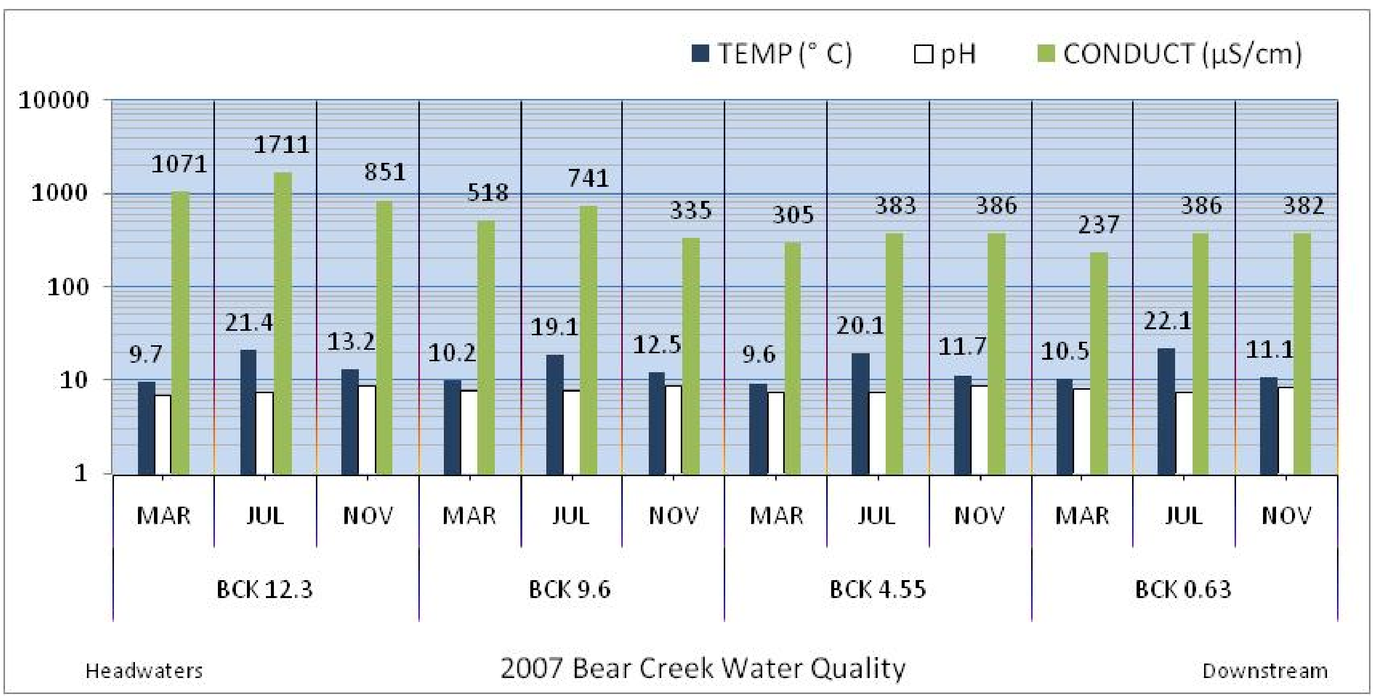

Figure 3: 2007 Bear Creek Water Quality Data

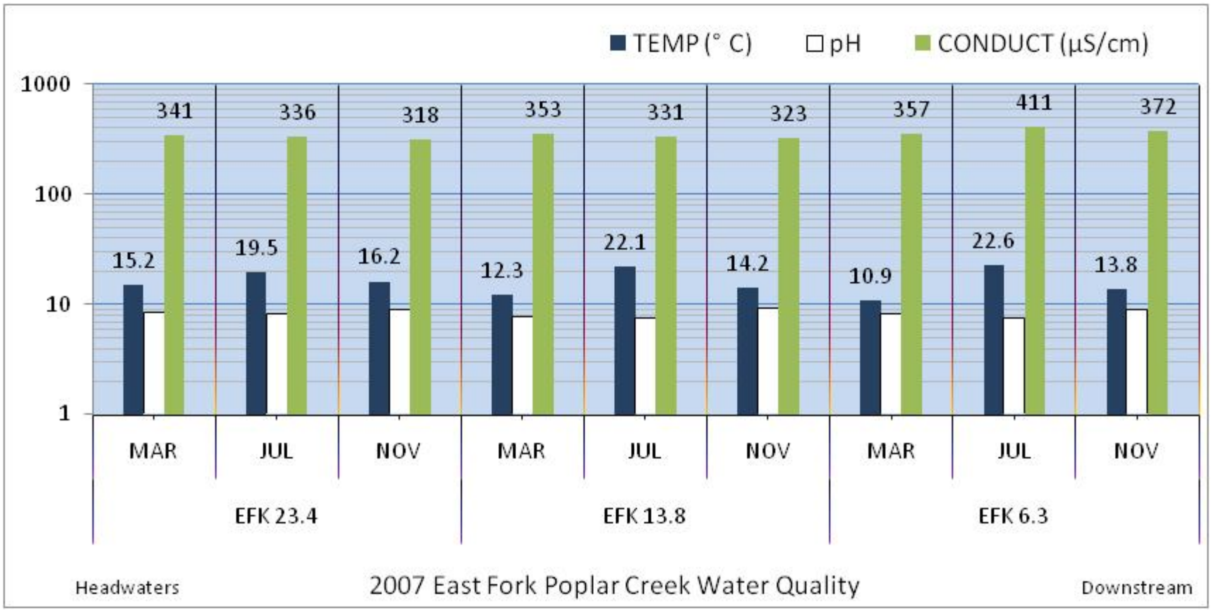

Figure 4: 2007 East Fork Poplar Creek Water Quality Data

ORR Water Quality		EFK 23.4		EFK 13.8		EFK 6.3		BCK 12.3		BCK 9.6	
TEST	**UNIT**	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Enterococcus	CFU/100ml	27	34	123	235	86	770	4	10	285	1120
E. Coli	CFU/100ml	49	111	162	276	219	291	23	55	51	148
Ammonia	mg/L	0.12	0.41	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Hardness	mg/L	179	161	199	166	189	170	456	743	248	396
Nitrate and Nitrite	mg/L	1.5	2.1	1.1	1.6	3.6	3.6	51	83.0	13.4	23
Total Dissolved Solids	mg/L	165	178	165	176	193	208	636	1090	247	472
Sulfate	mg/L	34	38	30	36	34	38	N/A	N/A	N/A	N/A
TKN	mg/L	<0.5	0.56	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Phosphorus	mg/L	0.07	<0.07	0.03	<0.07	0.52	0.55	<0.01	<0.07	<0.01	<0.07
Iron	µg/L	192	120	146	177	126	196	103	72	246	46
Manganese	µg/L	61	50	39	38	21	30	830	890	39	12
Zinc	µg/L	10	16	6	5	12	11	9	12	6	6
Cadmium	µg/L	<1	<1	<1	<1	<1	<1	4	5	<1	<1
Copper	µg/L	3	2	2	2	2	2	N/A	N/A	N/A	N/A
Lead	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Mercury	µg/L	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<1	<1	<1	<1
gross alpha	pCi/L	3.2	5.7	2.8	18.4	4.1	7.7	79	322	28.5	74
gross beta	pCi/L	3.4	3.1	1.3	3.7	3.5	4.4	222	584	46.1	108.7

Figure 5: ORR Water Chemistry Matrix (2007)

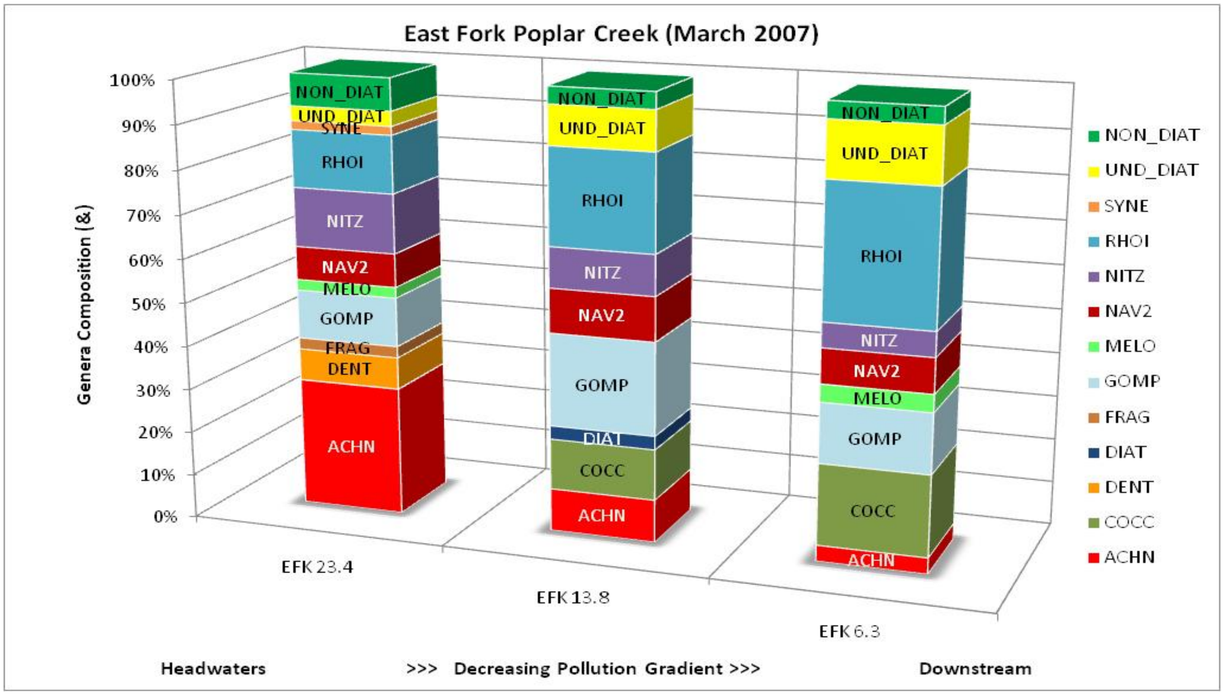

Figure 6: East Fork Poplar Creek Genera Composition (March 2007)

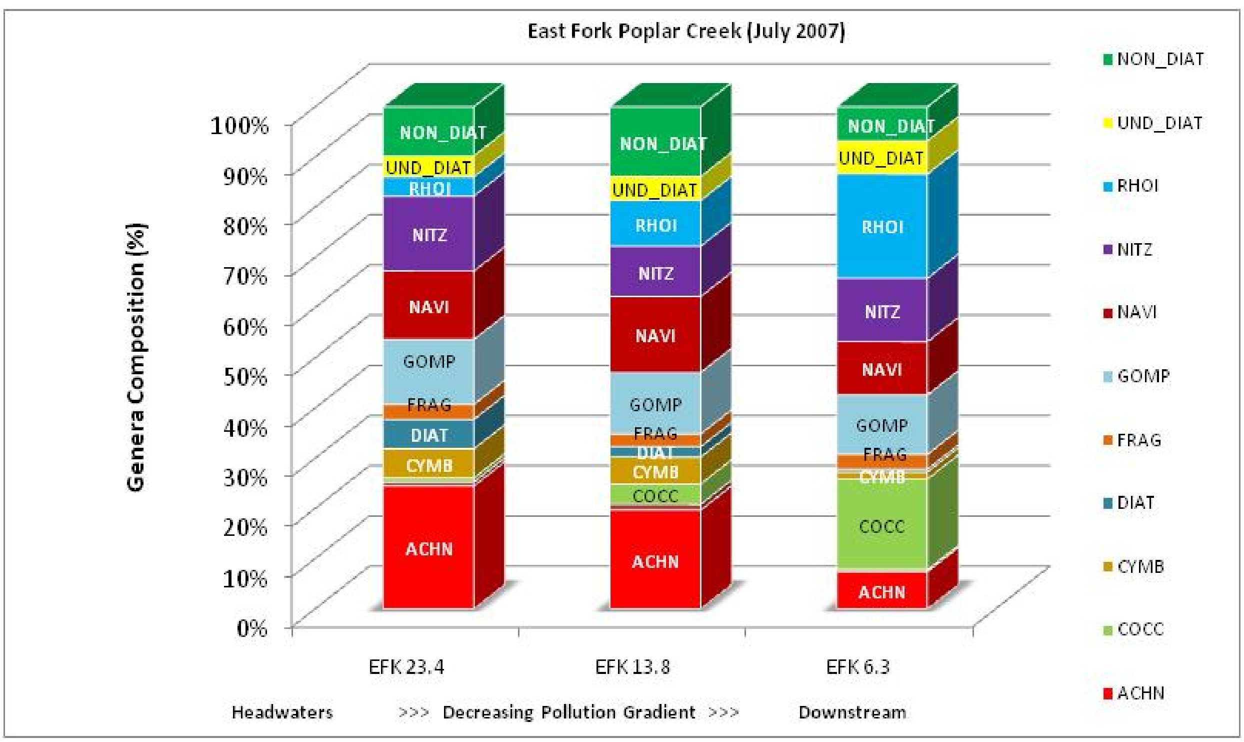

Figure 7: East Fork Poplar Creek Genera Composition (July 2007)

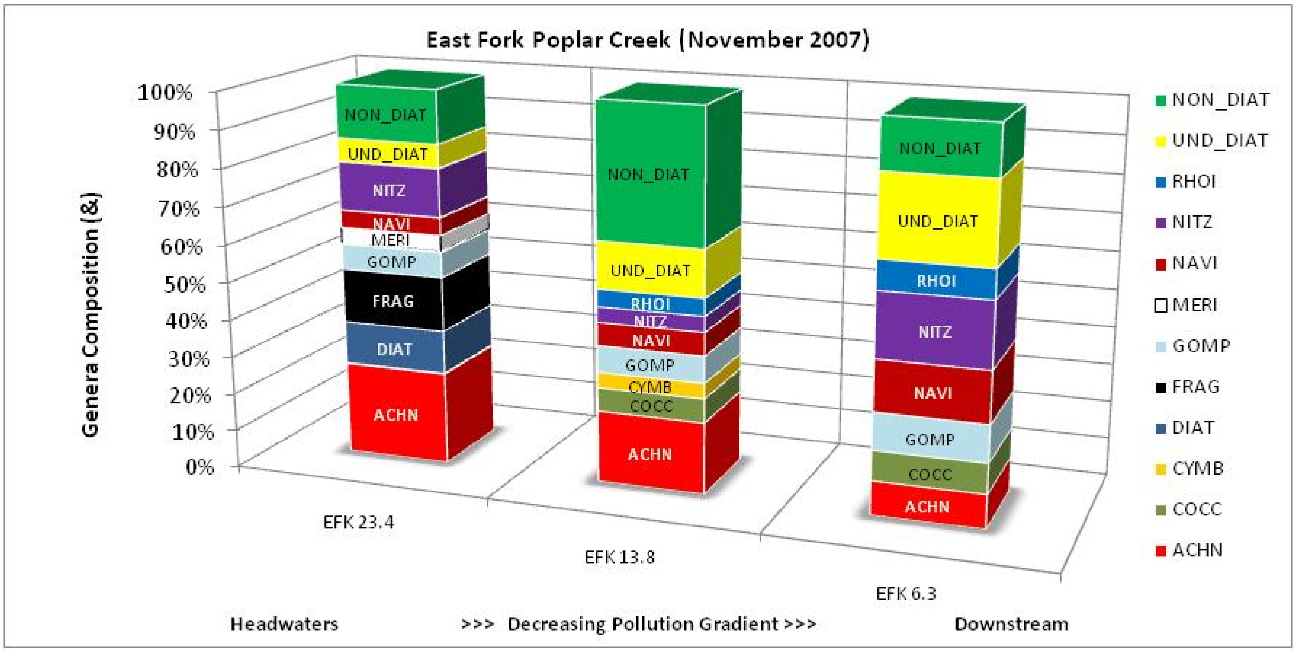

Figure 8: East Fork Poplar Creek Genera Composition (November 2007)

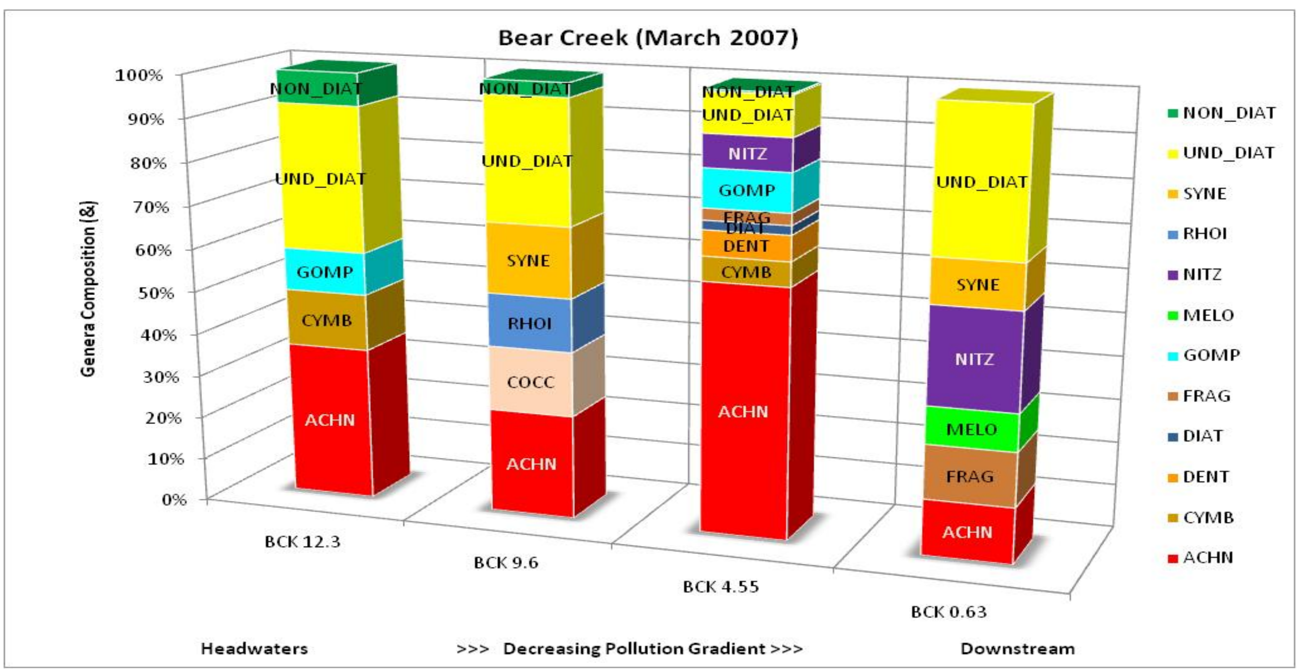

Figure 9: Bear Creek Genera Composition (March 2007)

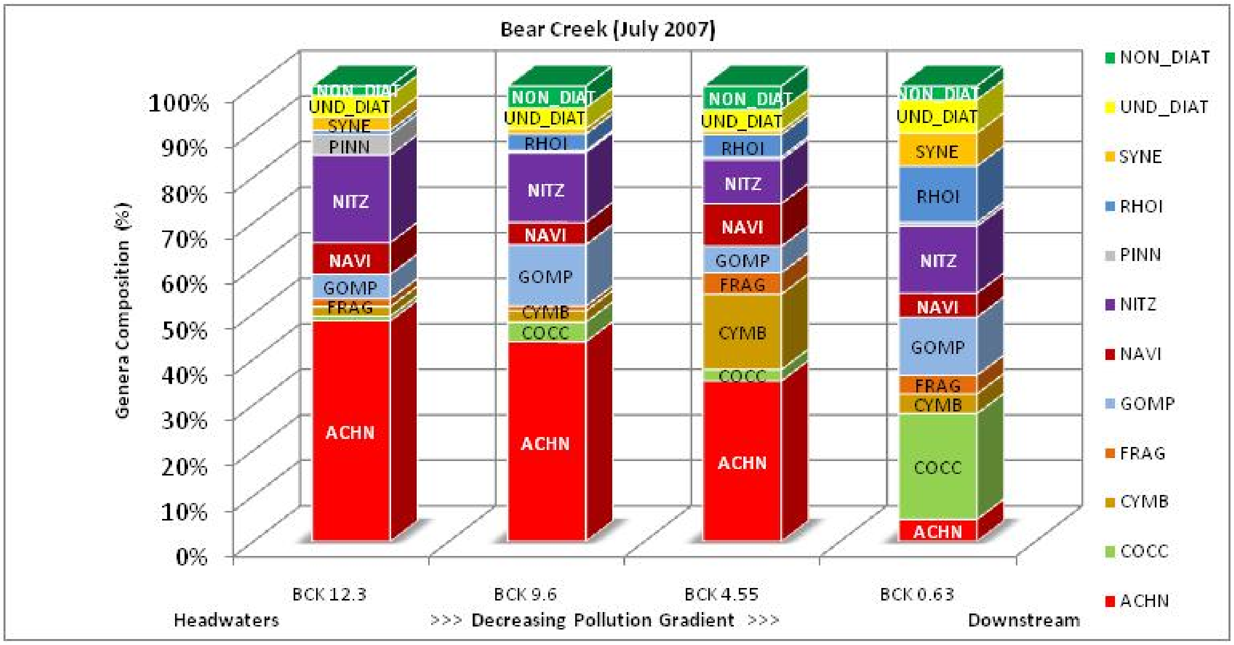

Figure 10: Bear Creek Genera Composition (July 2007)

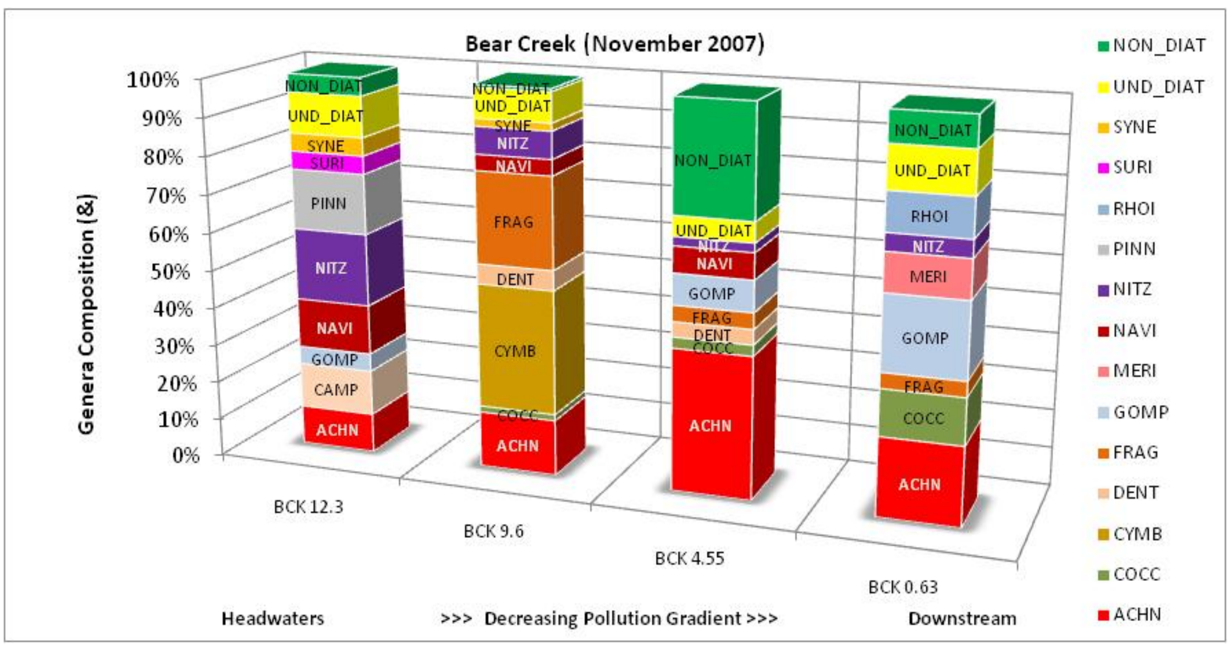

Figure 11: Bear Creek Genera Composition (November 2007)

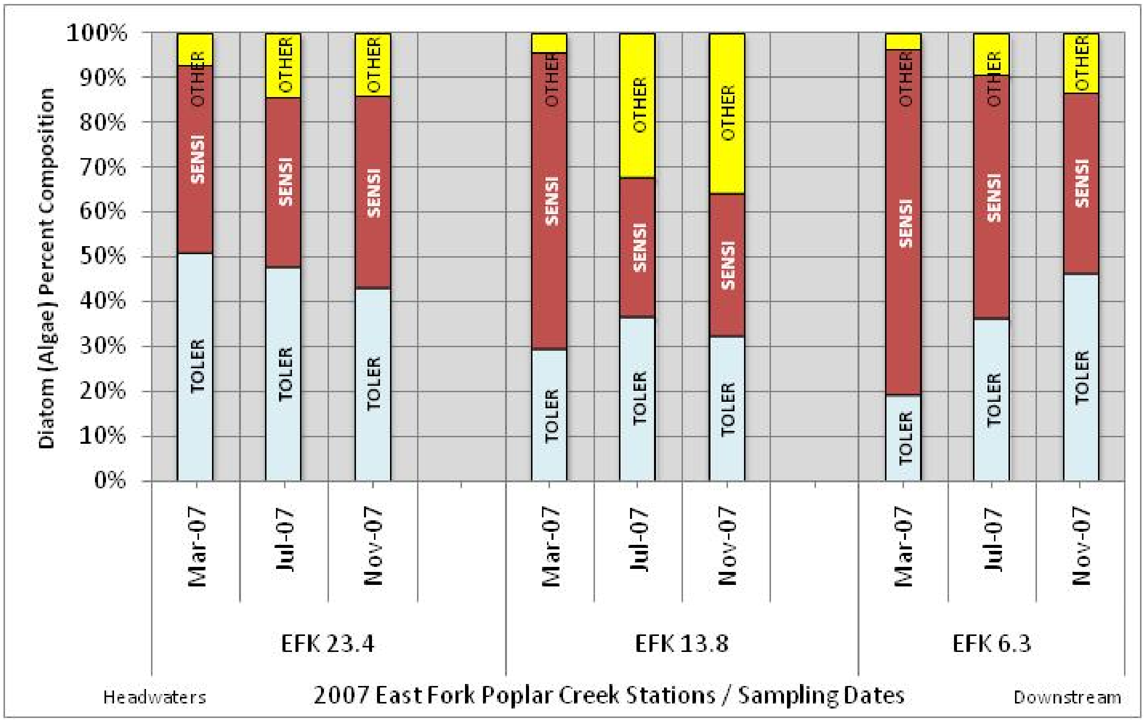

Figure 12: 2007 East Fork Poplar Creek Pollution Tolerant/Sensitive Diatoms

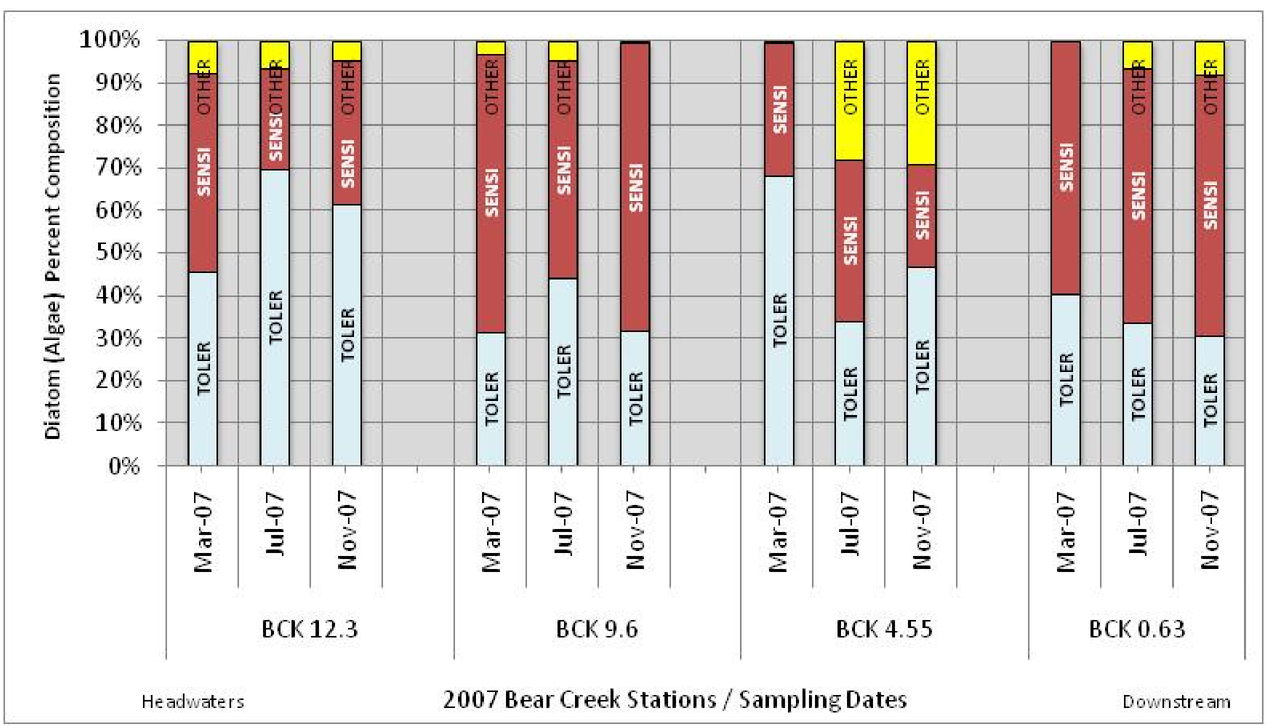

Figure 13: 2007 Bear Creek Pollution Tolerant/Sensitive Diatoms

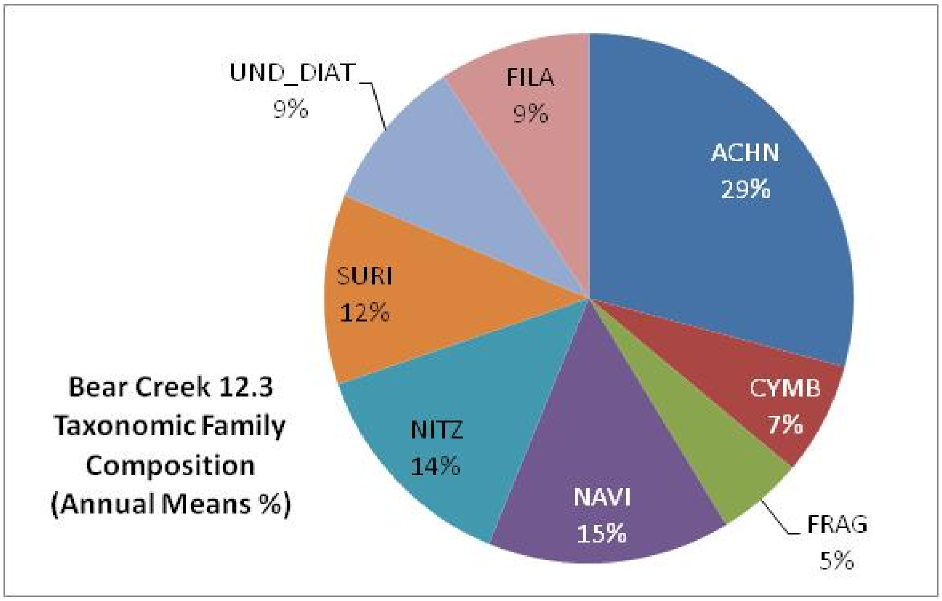

Figure 14: Bear Creek 12.3 Pie Chart

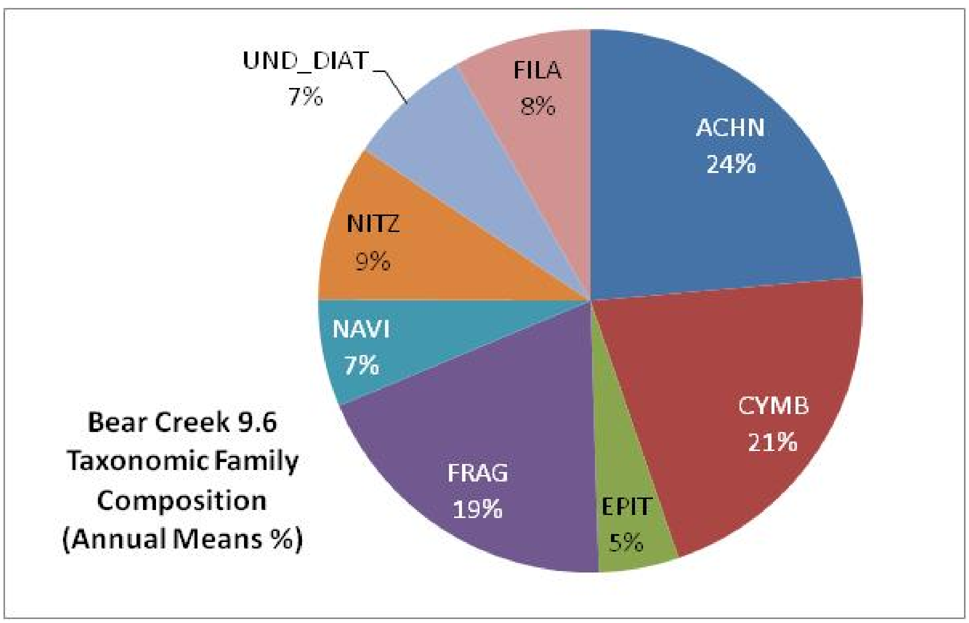

Figure 15: Bear Creek 9.6 Pie Chart

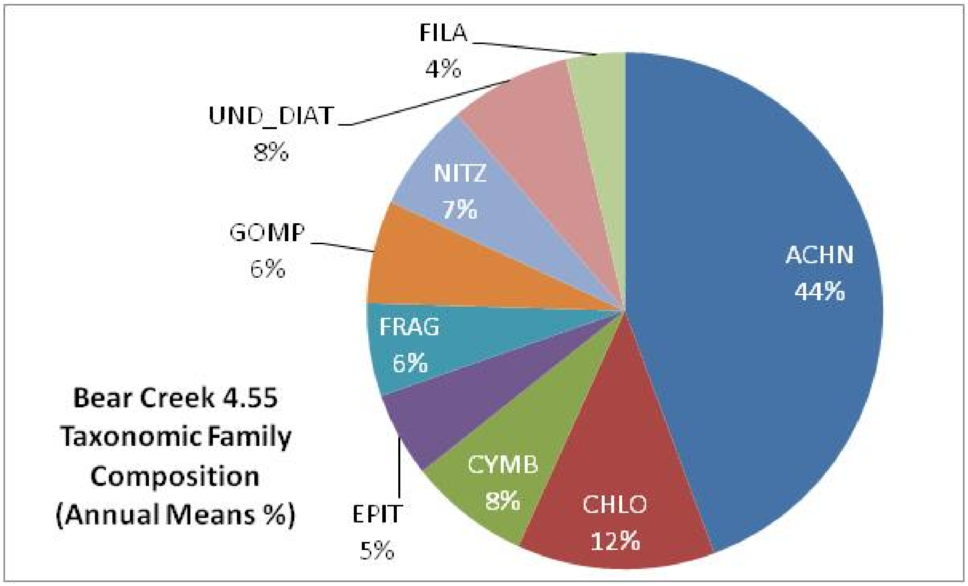

Figure 16: Bear Creek 4.55 Pie Chart

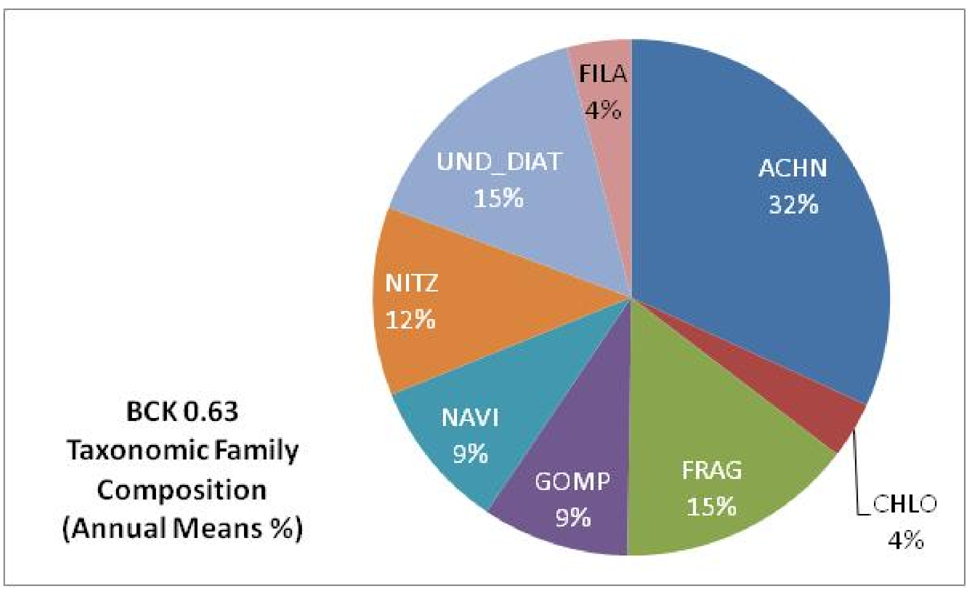

Figure 17: Bear Creek 0.63 Pie Chart

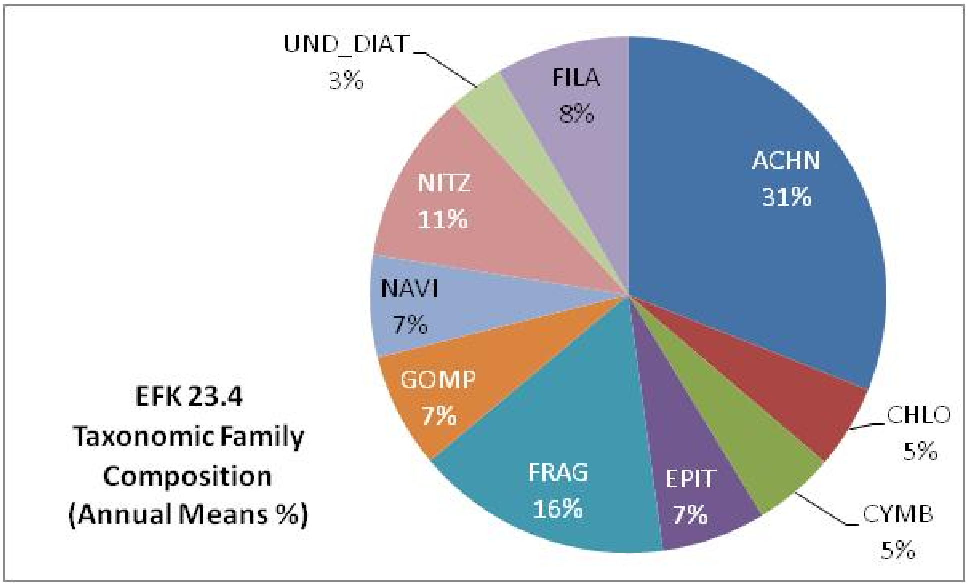

Figure 18: East Fork Poplar Creek 23.4 Pie Chart

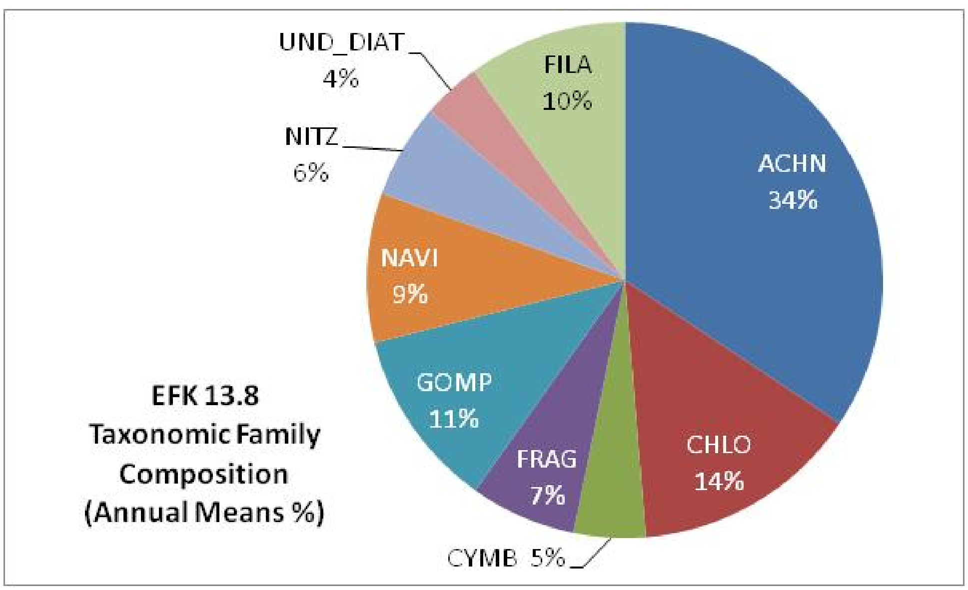

Figure 19: East Fork Poplar Creek 13.8 Pie Chart

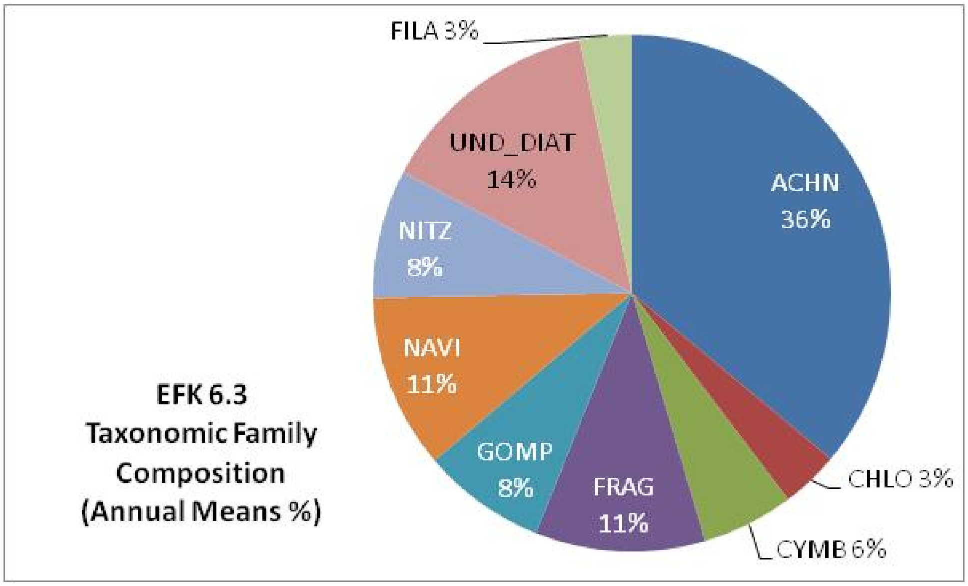

Figure 20: East Fork Poplar Creek 6.3 Pie Chart

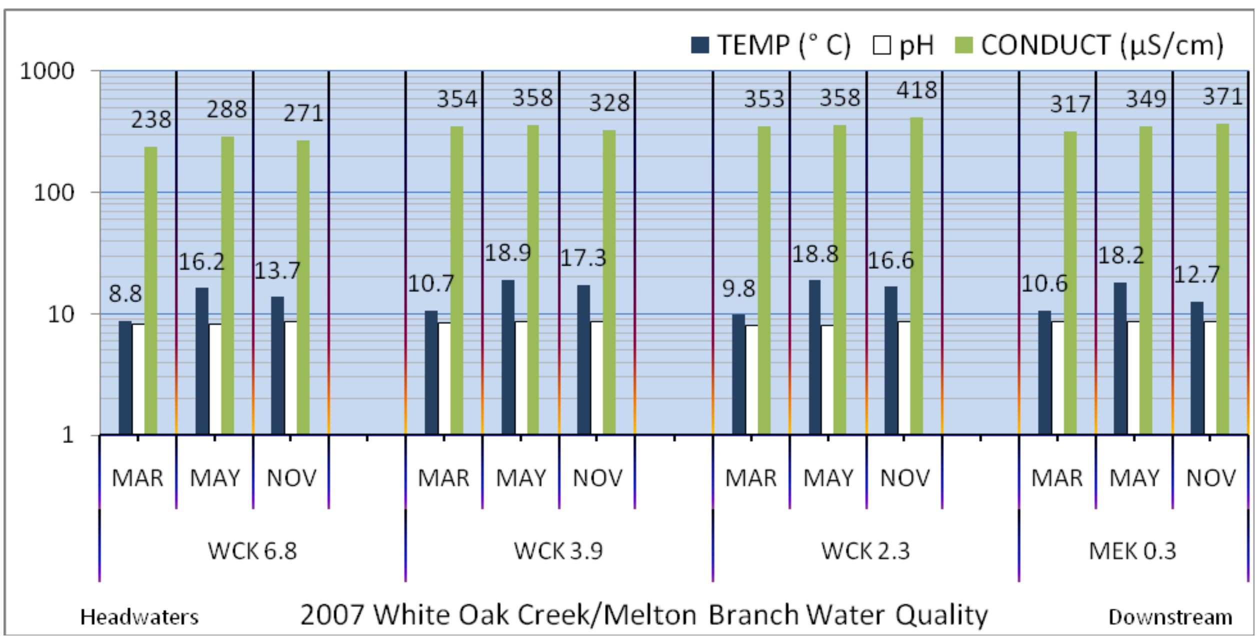

Figure 21: 2007 White Oak Creek/Melton Branch Water Quality Data

		White Oak Creek							
		WCK 6.8		WCK 3.9		WCK 2.3		MEK 0.3	
TEST	**UNIT**	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Enterococcus	CFU/100ml	29	14	285	122	86	58	66	33
E. Coli	CFU/100ml	23	23	308	548	45	108	236	91
Ammonia	mg/L	<0.1	<0.1	<0.1	0.25	<0.1	<0.1	<0.1	<0.1
Total Hardness	mg/L	152	169	164	178	171	154	184	202
Nitrate and Nitrite	mg/L	<0.10	<0.10	0.89	0.57	1.2	2.0	0.27	0.41
Total Diss Solids	mg/L	119	159	192	214	201	274	190	235
Total Susp Solids	mg/L	<10	<10	<10	<10	<10	<10	<10	<10
Sulfate	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TKN	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Phosphorus	mg/L	0.02	<0.07	0.12	0.15	0.28	0.26	0.69	0.91
Iron	µg/L	76	84	135	86	118	96	185	72
Manganese	µg/L	13	19	24	12	45	18	34	19
Zinc	µg/L	5	6	22	22	12	12	7	5
Arsenic	µg/L	<1	<1	<1	<1	<1	<1	<1	<1
Cadmium	µg/L	<1	<1	<1	<1	<1	<1	<1	<1
Chromium, Total	µg/L	<1	<1	<1	<1	<1	<1	<1	<1
Copper	µg/L	<1	<1	4	7	2	4	1	<1
Lead	µg/L	<1	<1	<1	<1	<1	<1	<1	<1
Mercury	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Pb-210	pCi/L								
Pb-214	pCi/L	27.7		30.6		17.9			
Bi-214	pCi/L	42.8		50.0		20.7		20.0	
Cs-137				42.4					
gross alpha	pCi/L	2.1	0.4	4.2	3.5	3.5	10.4	4.8	1.2
gross beta	pCi/L	0.9	0.4	117.1	141.2	188	103.5	57.1	93.5

Figure 22: 2007 White Oak Creek/Melton Branch Water Chemistry Matrix

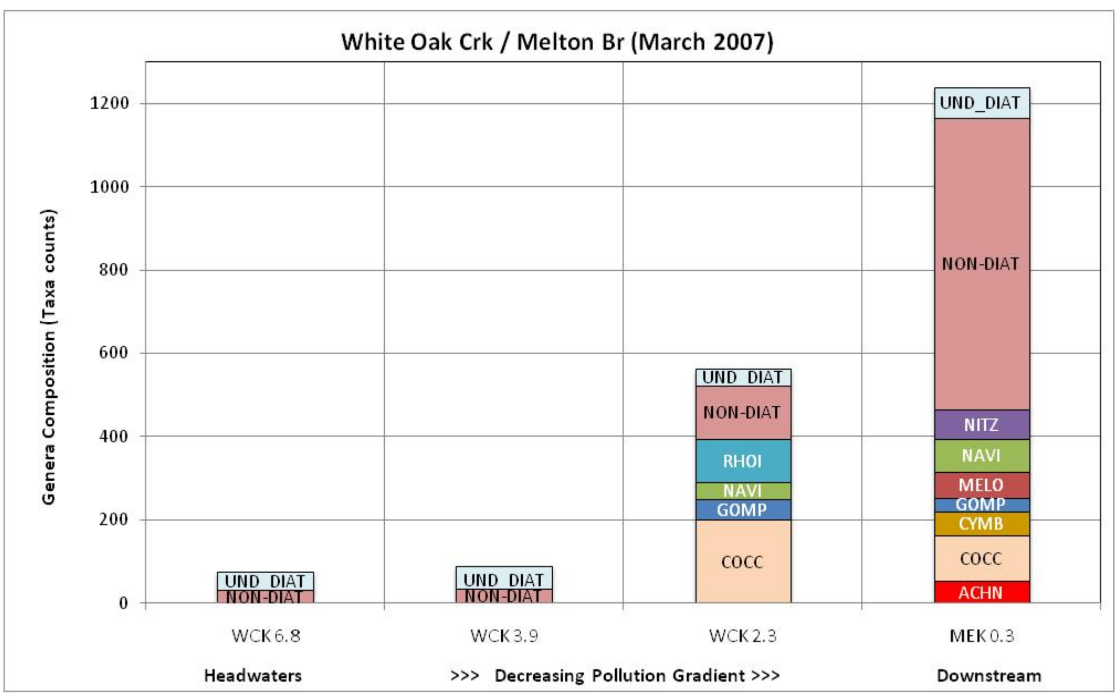

Figure 23: 2007 White Oak Creek / Melton Branch

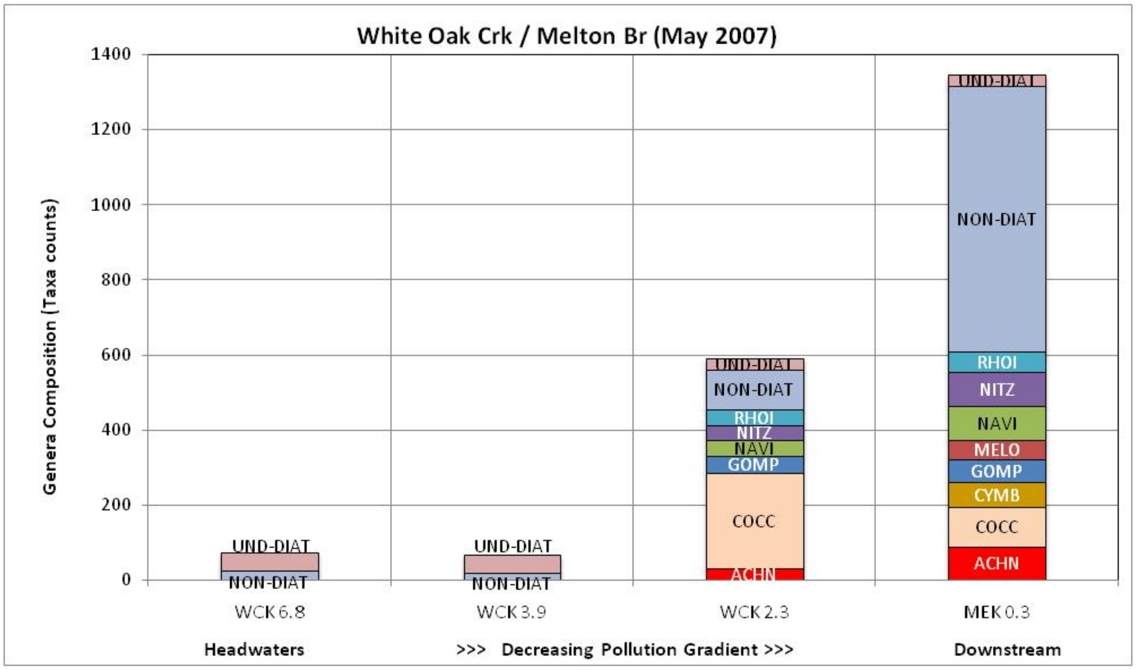

Figure 24: 2007 White Oak Creek / Melton Branch

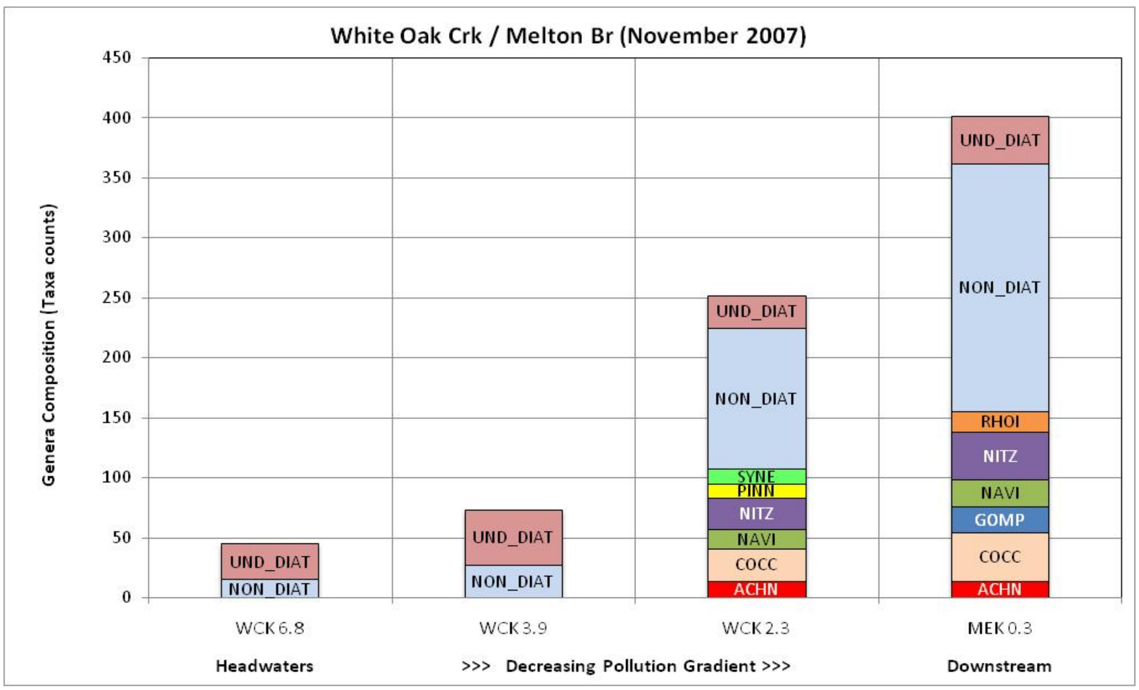

Figure 25: 2007 White Oak Creek / Melton Branch

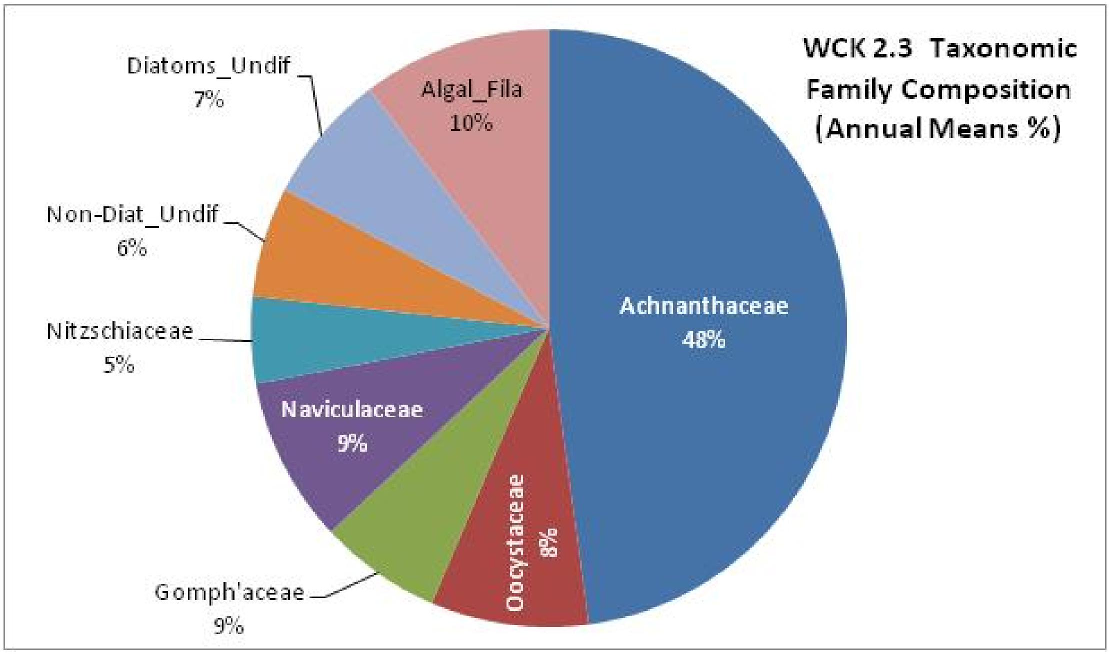

Figure 26: 2007 White Oak Creek 2.3 Periphyton Composition

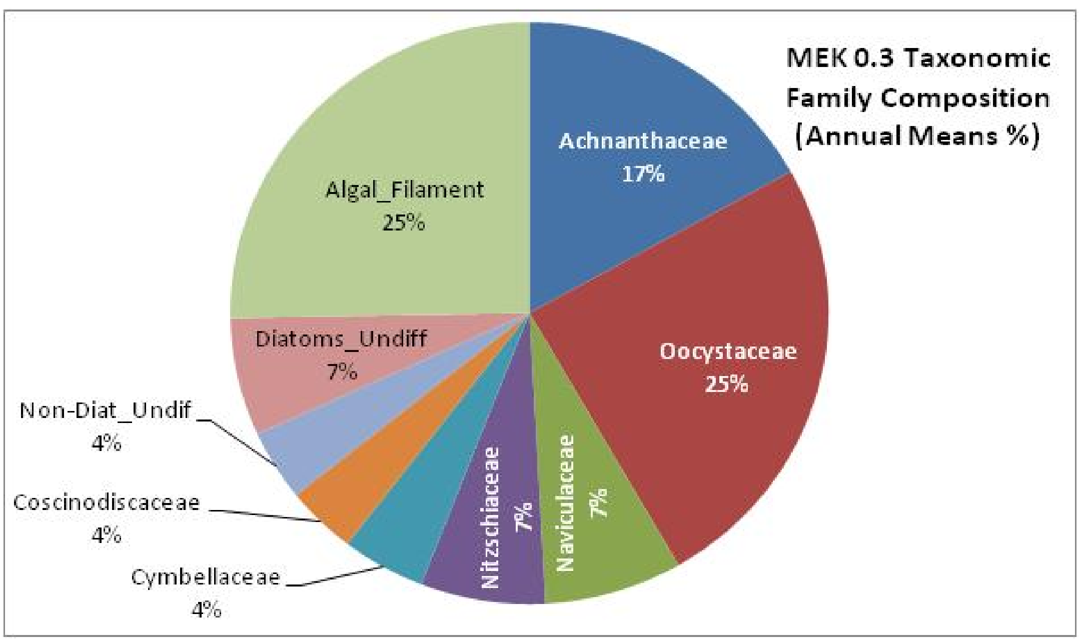

Figure 27: 2007 Melton Branch 0.3 Periphyton Composition

Table 1: Taxonomic Families and Genera Indentified in ORR Streams in 2007

Algal Family	**Phylum/ Subphylum**	**Genera**
Achnanthaceae	Bacillariophyceae	*Achnanthes Cocconeis Rhoicosphenia*
Aulacoseiraceae	Bacillariophyceae	*Aulacoseira*
Batrachospermaceae	Rhodophyta	*Batrachospermum*
Biddulphiaceae	Bacillariophyceae	*Biddulphia Pleurosira*
Chaetophoraceae	Chlorophyta	*Chaetophora Draparnaldia Stigeoclonium*
Chlamdomonadaceae	Chlorophyta	*Chlamydomonas*
Chlorococcaceae	Chlorophyta	Chlorococcum Planktosphaeria Schroederia
Chroococcaceae	Cyanophyta	*Anacystis Aphanothece Chroococcus Microcystis*
Cladophoraceae	Chlorophyta	*Basicladia Cladophora*
Coccomyxaceae	Chlorophyta	*Elakatothrix*
Coleochaetaceae	Chlorophyta	*Coleochaete*
Coscinodiscaceae	Bacillariophyceae	*Melosira*
Cymbellaceae	Bacillariophyceae	*Amphora Cymbella Encyonema*
Desmidiaceae	Chlorophyta	*Closterium Cosmarium Desmidium Micrasterias Penium Pleurotaenium Staurastrum*
Epithemiaceae	Bacillariophyceae	*Denticula Epithemia Rhopalodia*
Euglenaceae	Euglenophyta	*Euglena Trachelomonas*
Eunotiaceae	Bacillariophyceae	*Eunotia*
Fragilariaceae	Bacillariophyceae	*Diatoma Fragilaria Meridion Synedra Tabellaria*
Gomphonemataceae	Bacillariophyceae	*Gomphonema*
Hydrodictyaceae	Chlorophyta	*Pediastrum*
Microsporaceae	Chlorophyta	*Microspora*
Naviculaceae	Bacillariophyceae	*Craticula Frustulia Gyrosigma Mastogloia Navicula Neidium Pinnularia*
Nitzschiaceae	Bacillariophyceae	*Hantzschia Nitzschia*
Oedogoniaceae	Chlorophyta	*Bulbochaete Oedogonium*
Oocystaceae	Chlorophyta	*Closteriopsis Oocystis Quadrigula Selenastrum*
Oscillatoriaceae	Cyanophyta	*Oscillatoria Phormidium*
Peridiniaceae	Pyrrophyta/ Dinophyceae	*Peridinium*
Rivulariaceae	Cyanophyta	*Gloeotrichia*
Scenedesmaceae	Chlorophyta	*Coelastrum Scenedesmus Tetradesmus*
Scytonemataceae	Cyanophyta	*Scytonema*
Surirellaceae	Bacillariophyceae	*Campylodiscus Surirella*
Zygnemataceae	Chlorophyta	*Mougeotia Spirogyra Zygnema*
32 Families	**6 Phylum/Subphylum**	**75 Genera**

Table 2: Description of Metrics and Expected Algal Community Responses to Stress

Metric	Description	Expected Response to Stress (Pollution)
Genera Richness	Measures the number of taxa in a periphyton community assemblage. Expressed as total number of taxa counted per sample.	Number decreases.
Disturbance Index (% *Achnanthes*)	*Achnanthes* is a common pioneer species and often dominates substrates that have been disturbed. The percent relative abundance (PRA) of this taxon provides a useful index of disturbance.	Percent increases.
Total Number of Diatom Taxa (% TNDT)	Measures total diatom taxa (only) expressed as a percentage (or cell count) of a periphyton community assemblage (per sample).	Number decreases.
Non-Diatom Algal Taxa (% NDT)	Measures total number of non-diatom algal taxa comprised of *Chlorophyta, Cyanophyta, Rhodophyta, and Dinoflagellates*. Expressed either as a total cell/filament count or percentage of a periphyton community assemblage (per sample).	May create problematic blooms; percent increases.
Siltation Index (%NNS)	The percent motile diatoms is expressed as the relative abundance of *Navicula* + *Nitzschia* + *Surirella* (% NNS). Their frequency is thought to reflect the amount and frequency of sedimentation.	Percent NNS increases.
Fragilaria Group Richness (FGR %)	The percent (or number) of taxa represented in the sample from the genera *Ceratoneis, Diatoma, Fragilaria, Meridion, Staurosira, Synedra*, and *Tabellaria*.	Percent FGR decreases.
Cymbella Group Richness (CGR %)	The percent (or total number) of taxa represented in the sample from the genera *Amphora, Cymbella, Encyonema*, and *Reimeria*.	Percent CGR decreases.
	***Casterlin and Reynolds (1977), Descy (1979), Lange-Bertalot (1979), Bahls (1993), Van Dam et al. (1994), Kelly and Whitton (1995), St-Cyr (1997), Chessman et al. 1999, Hill et al. (2000), Fore and Grafe (2002), and KDOW 2002.	

Table 3: 2007 Comprehensive Periphyton Community Metrics (Means)

Bear Creek	(µ 2007) Genera Richness	(µ 2007) Disturb Index (%)	(µ 2007) Silt Index (%)	(µ 2007) FGR %	(µ 2007) CGR %	(µ 2007) %TNDT	(µ 2007) Non-Diatom Algae (%)	Dominant Algal Taxa (Genera)
BCK 12.3 (n= 3)	20	29.39	21.25	7.82	7.39	93.69	6.31	ACHN CAMP CYMB GOMP NAVI NITZ PINN
BCK 9.6 (n= 3)	18	21.58	12.37	18.76	20.06	97.04	2.96	ACHN COCC CYMB DENT FRAG GOMP NAVI NITZ RHOI SYNE
BCK 4.55 (n= 3)	19	39.49	9.75	6.36	2.63	80.87	19.13	ACHN CHLO COCC CYMB DENT FRAG GLTR GOMP NAVI NITZ RHOI
BCK 0.63 (n= 3)	19	12.94	21.88	5.53	7.53	95.15	7.28	ACHN COCC FRAG GOMP MELO MERI NAVI NITZ RHOI SYNE
East Fork Poplar Creek	(µ 2007) Genera Richness	(µ 2007) Disturb Index (%)	(µ 2007) Silt Index (%)	(µ 2007) FGR %	(µ 2007) CGR %	(µ 2007) %TNDT	(µ 2007) Non-Diatom Algae (%)	Dominant Algal Taxa (Genera)
EFK 23.4 (n= 3)	21	28.52	18.65	19.14	2.62	88.02	11.98	ACHN DIAT FRAG GOMP NAVI NITZ RHOI
EFK 13.8 (n= 3)	23	16.40	13.59	6.23	4.45	76.99	23.01	ACHN CHLO COCC DIAT GOMP NAVI NITZ RHOI
EFK 6.3 (n= 3)	24	7.85	22.16	8.64	3.21	91.31	8.69	ACHN COCC GOMP NAVI NITZ RHOI
								Achnanthes = ACHN *Campylodiscus* = CAMP *Chlorococcum* = CHLO *Cocconeis* = COCC *Cymbella* = CYMB
								Denticula = DENT *Diatoma* = DIAT *Fragilaria* = FRAG *Gloeotrichia* = GLTR
								Gomphonema = GOMP *Melosira* = MELO *Meridion* = MERI *Navicula* = NAVI
								Nitzschia = NITZ *Pinnularia* = PINN *Rhoicosphenia* = RHOI *Synedra* = SYNE

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Canada Geese Monitoring

Principal Author: Randy Hoffmeister

Abstract

On June 27 and 28, 2007, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) conducted oversight of the annual Canada Geese (*Branta canadensis*) monitoring project on the Oak Ridge Reservation (ORR). The objective of this study was to determine if geese are becoming contaminated on the ORR. The captured geese were transported to the Tennessee Wildlife Resources Association (TWRA) game check station on Bethel Valley Road and tested for radioactive contamination. None of the geese captured this year showed elevated gamma counts above the 5 pCi/g game release level. Since no contaminated geese were captured, the DOE-Oversight Division did not conduct additional offsite sampling of Canada Geese.

Introduction

A large population of Canada geese, both resident and transient, frequents the Oak Ridge Reservation (ORR) (Crabtree 1998). The thriving goose population in this area makes this animal an easily accessible food for area residents. Geese with elevated levels of Cs137 in muscle tissue have been found on the ORR (MMES 1987 and Loar 1994). Studies in the 1980s demonstrated that geese associated with the contaminated ponds/lakes on the ORR can accumulate radioactive contaminants quickly and that contaminated geese frequent offsite locations (Loar 1990, Waters 1990, MMES 1987).

Every year the Department of Energy (DOE) and Tennessee Wildlife Resource Agency (TWRA) capture geese on the ORR during the annual "Goose Roundup" and perform whole body counts on them to determine if the birds are radioactively contaminated. During the 1998 "Goose Roundup," 38 geese at ORNL contained Cesium 137 concentrations that exceeded the game release limit of 5 pCi/g (ORNL 1998). A subsequent study in September 1998 found elevated levels of Cs137 in grass and sediment at two stretches of White Oak Creek south of 3513 Pond and in grass around the 3524 pond (ORNL 1998). In 2002, three young-of-the-year geese from the west end of ORNL were found to have Cesium 137 levels above the game release level. In 2003 through 2006, no geese were found to have Cesium 137 levels above the game release level.

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) has a sampling plan that is implemented when geese with elevated gamma readings are detected during the regular "Goose Roundup." If any geese with elevated gamma readings are detected, arrangements are made to sample geese that are found in the vicinity of the ORR on non-DOE property. This is to determine if contaminated geese are leaving the reservation and are presenting a risk to area hunters.

Results and Discussion

During the 2007 sampling, a total of 202 birds were captured. Most of the adult geese were banded and all were released, except one bird at the ETTP Front Pond on 6/27/07, which was euthanized due to a pre-existing, debilitating injury. None of the birds analyzed had levels of gamma above the 5 pCi/g game release level. Table 1 shows results of the 2007 DOE "Goose Roundup".

Table 1: 2007 Goose Roundup Results

Site	**Date**	**# Captured**	**Adults**	**Juveniles**	**# > 5 pCi/g**
Clark Park	6/27	2	2	0	0
ETTP Front Pond	6/27	127	127	0	0
ORNL West End	6/27	26	17	9	0
Clark Park	6/28	18	16	2	0
ETTP Front Pond	6/28	15	5	10	0
Y-12	6/28	14*	5	5	0
Totals		**202**			**0**

*****ages of 4 animals were not recorded

Since none of the birds analyzed showed signs of contamination, no additional offsite sampling was conducted.

Conclusion

Although none of the birds analyzed showed signs of contamination, historical information indicates that this species is still susceptible to contamination from sources on the ORR. It does, however, indicate that there is a reduced likelihood of this situation existing.

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Biological Sampling and Radiochemical Analysis of Aquatic Plants (Macrophytes) at Spring Habitats on the Oak Ridge Reservation

Principal Authors: Robert Storms, Betsy Gentry

Abstract

This project is an expansion of a pilot vegetation (watercress) sampling and radiochemical analysis effort begun by Division staff in 1995 as part of environmental surveillance in accordance with the Tennessee Oversight Agreement. The project had been idle since that time due to inconclusive results and laboratory budget constraints. The project was revitalized in 2002. Metals were added in 2004 as potential contaminants of interest. After reviewing the laboratory data for metals from 2004, the metals constituents were dropped from the sampling protocol in 2005. The concentrations of metals in the samples collected and analyzed posed little to no threat to the public and/or the environment. The 2006 study was designed to collect samples from never before sampled areas in the vicinity of areas that radiological contamination had been found in the past or an area that had a strong possibility of present or future contamination. The Division planned to correlate this new data with previous information regarding known contaminated areas and to gather new data for use in the future for comparison with samples collected later. Samples were collected from Oak Ridge Reservation springs and engineered drainage areas as an aid in determining if aquatic vegetation is bioaccumulating radiological contaminants above the Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs). The SDWA MCL for gross alpha is 15 pCi/L. The SDWA MCL for beta and photon emitters is four (4) mrem/yr to the total body or any given internal organ. Division staff gathered vegetation monitoring data in support of the groundwater monitoring and sampling of springs and surface water impacted by hazardous substances. “Vegetation” sampled included watercress (*Rorippa nasturtium-aquaticum*), other aquatic macrophytes (i.e., *Salvinia sp*., *Sagittaria latifolia, Typha latifolia,* etc), and green algae. Fourteen vegetation samples from reference springs/creeks/ponds offsite and springs/creeks/ponds onsite were sampled during 2007. Sample collection times were random as there was no need in this case to organize a schedule into wet and dry season sampling events.

Introduction

Aquatic macrophytes (i.e., watercress, water spangles, arrowhead and cattails), lichens, mosses and green algae are environmental bioindicators and important pathways by which contaminants infiltrate the Oak Ridge Reservation (ORR) ecosystem and food chain creating ecological and human health risks. Watercress, a floating, rooted, aquatic plant (macrophyte or angiosperm) was selected for its affinity to thrive around its natural habitat in clear, lotic water near the mouth of springs and spring-fed creeks. Emerging spring water, if impacted by hazardous substances, will deposit these substances in sediments. In turn, plants will uptake the contaminants both from the water and the sediments. Watercress is naturally high in calcium, alkaline salts, sulfur and potassium, so it is likely that strontium (a beta emitter) would be uptaken as well, since calcium and strontium belong to the same group (Group IIA) of the periodic chart of the elements. Additionally, potassium and cesium belong to Group IA, creating a similar scenario. Watercress sample analytical results collected during Phase 1 sampling (2002) support this theory as two samples exhibited low cesium-137 concentrations. During the first year of this project, watercress was the main bioindicator sampled supplemented with a few green algae, periphyton and macrophyte samples. Sampling of algae or other aquatic macrophytes was initiated and substituted when watercress was absent or too sparse for sampling at spring habitats.

Green algae and periphyton (benthic algae – diatoms) occur in most all the aqueous and many terrestrial habitats on the ORR (algae is ubiquitous). Algae forms colonies or filamentous mats ("blooms" or slick gelatinous mucilage) often covering a large area of a pond, waterfall ledges, lentic (still) or lotic (moving) water, or lakes. Often they are attached to various substrates such as submerged logs and snags, aquatic plants, sand, gravel and rocks. Periphyton biomass is a primary producer generating much of the low-end of the food chain for many aquatic macroinvertebrates, fish and herbivores. Periphyton are sensitive indicators of environmental physiochemical change in lotic waters. Since they are benthic, the assemblage or population serves as a good bioindicator due to their tolerance or sensitivity to specific changes in environmental conditions known for many algal species including diatoms (modified from U.S. DOE, April 2001).

Table 1: Locations and Aquatic Vegetation Sampled for Radiochemical Analysis

NAME	LOCATION	Sample Media	LATITUDE (Degrees)	LONGITUDE (Degrees)	DATE SAMPLED
BIO 21	Clear Creek *Reference*	Watercress	36.21611	-84.05194	6/8/2007
BIO 48	Cattail Spring East	Watercress	35.99784	-84.22550	6/8/2007
BIO 74	EMWMF #2 Underdrain	Algae/Cattail	35.97060	-84.28712	6/8/2007
BIO 86	EMWMF #5 Discharge	Algae	35.96975	-84.28834	6/8/2007
BIO 66	SS-5 Bear Creek Valley	Watercress	35.95656	-84.30100	6/15/2007
BIO 65	SS-4 Bear Creek Valley	Watercress	35.96238	-84.29290	6/15/2007
BIO 75	EMWMF #3 Sediment Basin Outfall	Watercress	35.96635	-84.29018	6/27/2007
BIO 70	1st Creek (high) ORNL	Watercress	35.92474	-84.32114	6/26/2007
BIO 72	SNS-1 (SNS South)	Watercress	35.94153	-84.30315	8/23/2007
BIO 79	Cress Spring @ Y-12	Watercress	35.94438	-84.31858	8/23/2007
BIO 83	SS-7 Spring (west end of Y-12)	Watercress	35.93724	-84.33791	8/23/2007
BIO 86	Regina Loves Bobby Spring	Watercress	35.95096	-84.41467	9/7/2007
BIO 87	SS6 East Bear Creek Rd @ Cemetery	Vegetation	ND	ND	9/13/2007
BIO 88	SS8 Triangle @ Bear Creek/Hwy 95	Watercress	ND	ND	9/13/2007

ND: No data

Fourteen habitats both offsite and onsite the ORR consisting of springs, seeps, wetlands, ponds and spring-fed creeks were sampled in 2007. Table 1 provides field data collected at the time of sampling and Table 2 provides the laboratory radiochemical data for each sampling station. Figure 1 depicts the locations of the samples collected on the ORR.

Methods and Materials

Procedures employed during the project are consistent with those contained in the TDEC DOE-O Work Plan for the Walkover Survey Program for field radiological surveys and aquatic sampling. Radiological instruments were used to scan bagged samples for beta and gamma radiation prior to delivery to the state environmental laboratory in Knoxville under appropriate chain-of-custody. Subsequently, the Knoxville laboratory forwards all radiological samples to Nashville (State of Tennessee Environmental Laboratories) for radiochemical analysis.

All samples collected in the field were double bagged in plastic Ziploc® baggies, marked and tagged, and packed in coolers with ice for transport to the lab. Field notes and chain-of-custody forms were recorded and documented at each field sampling station. Field sample names were assigned using previous identification numbers (i.e., "BIO-1", "BIO-2", etc.). If the previously assigned identification number was not in the same format as shown above, it was renamed with a new unused number. QA/QC measures and field sampling equipment decontamination procedures were practiced to prevent cross-contamination and scrambling of field samples. Field

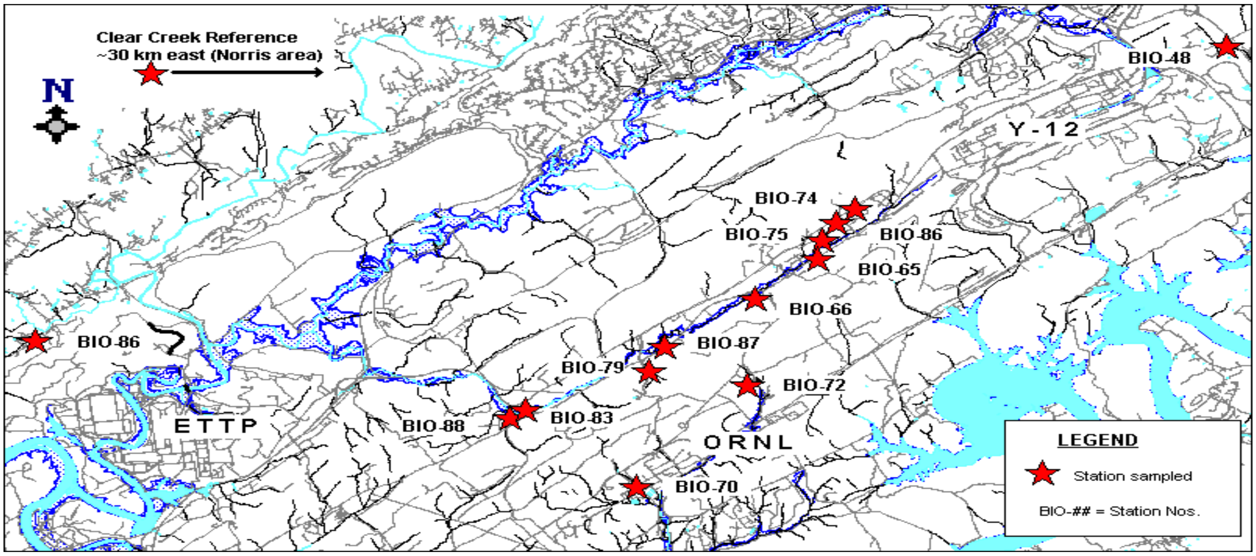

Figure 1: Location map of aquatic vegetation sites visited and sampled on and off the oak ridge reservation in 2006

coordinates (latitude/longitude) were recorded at each sampling station using a Garmin™ GPS II Plus field unit. Field sampling protocols and methods followed currently accepted and suggested guidelines of the Federal Radiological Monitoring and Assessment Center (FRMAC, 1998), the USGS (Porter, et al., 1993), the ASTM (Patrick, 1973), the TDEC DOE-O *Health, Safety, and Security Plan* (Thomasson, 2005), and the EPA (Barbour, et al., 1999).

Table 2: Results for Radiochemical Analysis of Aquatic Vegetation

Name	Date Sampled	Alpha Activity	Beta Activity	Gamma Activity						
				Pb-212	Pb-214	Bi-214	Ac-228	Be-7	K-40	Tl-208
BIO 21	6/8/2007	0.02	2.91	ND	0.079	0.081	ND	ND	2.800	ND
BIO 48	6/8/2007	0.15	1.99	0.061	0.065	0.083	0.085	ND	2.860	ND
BIO 74	6/8/2007	0.60	2.82	0.137	0.186	0.194	0.292	0.800	3.810	ND
BIO 86	6/8/2007	0.85	5.86	0.138	0.142	0.126	0.190	1.450	4.340	0.064
BIO 66	6/15/2007	0.07	4.04	0.017	0.166	0.219	ND	ND	2.390	ND
BIO 65	6/15/2007	1.24	3.89	ND	0.186	0.234	ND	ND	2.320	ND
BIO 75	6/27/2007	0.66	10.26	0.031	ND	0.062	ND	0.452	2.830	ND
BIO 70	6/26/2007	0.11	3.57	ND	0.085	0.116	ND	ND	2.560	ND
BIO 72	8/23/2007	0.31	1.57	ND	ND	0.122	ND	0.659	1.260	ND
BIO 79	8/23/2007	0.23	1.93	0.023	0.072	0.082	0.093	ND	1.950	0.015
BIO 83	8/23/2007	0.35	2.81	0.025	0.064	0.076	ND	ND	2.350	ND
BIO 86	9/7/2007	0.06	1.94	0.013	0.075	0.129	ND	ND	2.510	ND
BIO 87	9/13/2007	0.08	0.70	0.050	0.057	0.064	0.127	ND	3.000	ND
BIO 88	9/13/2007	0.31	2.49	0.016	0.040	0.048	ND	ND	1.563	ND

ND: not detected in sample/Activity is in units of pCi/g wet weight

Target radionuclides being mobile and occurring in the ORR environment as contamination include but are not limited to:

- cesium-137
- strontium-90
- cobalt-60
- technetium-90
- uranium isotopes and daughter products

Samples were analyzed for gross alpha, gross beta and gamma radionuclide parameters. Samples are ashed in a muffle furnace and analyses are performed on the ashed sample material. The gamma analysis follows the standard EPA (gamma) 901.1 method. The gross alpha and gross beta analysis is determined by counting two grams of ashed sample for two separate counts of 100 minutes.

Results and Discussion

The objectives of this oversight activity and study are the detection and characterization of radionuclides that are bioaccumulated by both aquatic macrophytes and algal species in ORR spring habitats and aquatic ecosystems that affect the low-end food chain. The 2006 objective widened the scope to include sites that had not been sampled by the division. The division gathered 14 vegetation samples during 2007. A purpose of the study was to show that contaminated groundwater emerging from springs was impacting aquatic plant species in the same sampling reach of the spring-fed creeks and streams.

The data collected from this most recent round of sampling events (Table 1) does indicate limited areas of elevated radionuclide concentrations in the watercress/vegetation both on and off the ORR; however, the elevated radionuclide concentrations in the vegetation are below their respective SDWA MCLs. Future activities will focus on pinpointing areas of concern within the ORR in conjunction with our groundwater monitoring program to more closely evaluate the potential for bioaccumulation of radionuclides in historically contaminated springs and seeps. Fieldwork will consist of walkover surveys, spring seep surveys and watercress/vegetation sampling.

Conclusions

Adequate evidence of vegetation bioaccumulation of radionuclides has been determined to warrant further investigations. The radionuclide levels did not indicate that these fourteen locations sampled could be considered “hot spots” because the results for all locations were below the SDWA mcls. The 2008 plan is to further investigate the ORR and evaluate previously sampled locations to see if natural attenuation is occurring. The plan will also add some of the sampling sites from the groundwater monitoring program with known contamination to check bioaccumulation in the aquatic biota. The Division will continue to sample and monitor aquatic vegetation both offsite and on the ORR to monitor aquatic ecosystem health and stream recovery.

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Vascular Plant Surveys (Field Botany)

Principal Author: Gerry Middleton

Abstract

Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (TDEC DOE-O, or division) staff provided oversight of Department of Energy (DOE) botanical assessments of remedial action sites on the Oak Ridge Reservation (ORR) locations during 2007. Independent field botany surveys on the ORR included threatened and endangered species (T & E species) that were completed on an as-needed basis. This project is an extension of the 2006 Plant Surveys (Field Botany) Environmental Monitoring Plan (EMP). Monitoring sites included ORR aquatic ecosystems and the Black Oak Ridge Conservation Easement (BORCE). Priority was given to locating rare plants and documentation of pest-plant invasion areas on the ORR. Division staff also provided botanical support to the TDEC Division of Natural Areas (TDEC DNA) including the rare plant program, the natural areas program, and the inventory program. A highlight of 2007 was the opening of the Dyllis Orchard Road Greenway located on the section of the BORCE located north of the East Tennessee Technology Park. This area potentially has a rich flora.

Introduction

Major goals of the project included:

- to provide oversight support and local botanical expertise to the TDEC Division of Natural Areas as needed relating to ORR issues,
- to inventory and map the biological diversity that exists on the ORR,
- to provide floristics survey information about plant species on the BORCE,
- to independently monitor and confirm biological survey and sampling information provided by DOE,
- to protect plants and natural communities that represent biological diversity on the ORR, and
- to provide flexibility in biomonitoring the full spectrum of the plant kingdom taxa (both vascular and non-vascular plants) as recognized by the International Code of Botanical Nomenclature (ICBN).

The project incorporated the division’s oversight role of environmental surveillance and monitoring. Additionally, several federal and state laws support this effort. The federal Endangered Species Act of 1973 (ESA), as amended, provides for the inventory, listing, and protection of species in danger of becoming extinct and/or extirpated. It also provides for conservation of the habitats on which such species thrive. The National Environmental Policy Act (NEPA) requires that federally-funded projects avoid or mitigate impacts to listed species. The Tennessee Rare Plant Protection and Conservation Act of 1985 (Tennessee Code Annotated Title 11-26, Sects. 201-214), provides for a biodiversity inventory and establishes the State list of endangered, threatened, and special-concern taxa. National Resource Damage Assessments (NRDA), directed by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by SARA (Superfund Amendments and Reauthorization Act of 1986), relates to damages to natural resources.

Methods and Materials

Geomorphic habitats such as small drainage ravines, floodplains, wetlands, watersheds, cedar barrens, rock outcroppings, cliffs, and karst features (springs, caves, sinkholes) were to be surveyed for rare plant taxa. Field locations of rare plants were to be mapped and located using a Global Positioning

System (GPS) hand-held field unit (Garmin™). The plan was to identify plant taxa in the forest canopy, subcanopy, shrub, herbaceous, and groundcover layers. Digital camera images of plants were to be made to document sensitive communities and rare species. Plant specimens collected in the field would have been pressed and vouchered as herbarium specimens. Field monitoring methods and health and safety procedures followed the guidelines in the division's *Standard Operating Procedures* and *Health, Safety, and Security Plan.*

Results and Discussion

Vascular plant field surveys planned for the BORCE (Blackoak Ridge Conservation Easement) site were not completed on the ORR during 2007. Division staff provided botanical oversight by participating in several ecological field site walkovers. In October 2007, the new Dyllis Orchard Road Greenway was officially opened adding approximately 9 miles of new trails. Located on the western portion of the BORCE in Roane County, the site is managed by the Tennessee Wildlife Resources Agency in consultation with the TDEC Division of Natural Areas (TDEC DNA). Staff provided geographic information system (GIS) mapping support and field reconnaissance to the TDEC DNA during 2007. Additionally, division staff surveyed portions of the ORR for populations of several Tennessee-listed rare plants (e.g., *Delphinium exaltatum* and *Hydrastis canadensis*). Documents reviewed for content included the current ASER draft document relating to T & E species.

Conclusions

Fieldwork remains to be completed on portions of the BORCE, especially to survey areas with potential for rare plants and exotic pest-plant invasions. The division will continue to report new rare plant findings to the TDEC DNA and provide field support as needed. Specific rare plant locations are available upon request from the TDEC DNA in Nashville.

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DRINKING WATER MONITORING

Sampling of Oak Ridge Reservation Potable Water Distribution Systems

Principal Author: Robert G. Middleton

Abstract

As the three Department of Energy (DOE) Oak Ridge Reservation (ORR) plants become more accessible to the public, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (the Division) has expanded its oversight of the DOE facilities' safe drinking water programs. The scope of the Division's independent sampling includes oversight of potable water quality on or impacted by the ORR. TDEC conducted oversight of backflow prevention devices and sanitary surveys at ORR facilities. The 2007 results of these inspections revealed that the three reservation systems provide water that meets State regulatory levels.

Introduction

Public consumption of the water on the Oak Ridge Reservation (ORR) continues to increase. In order to facilitate technology transfer, work for non-governmental sectors, and utilization of surplus buildings by private companies, security has been relaxed or reprioritized in recent years at some portions of the sites, most notably at East Tennessee Technology Park (ETTP). In turn, the composition of the workforce at the ORR has changed substantially. Oak Ridge National Laboratory (ORNL) has always hosted foreign dignitaries and accommodated visiting scientists in an openly cooperative manner. The other two facilities, ETTP and Y-12, allowed only limited public visitation until recent years. Current facility use involves a substantial public presence at ETTP and ORNL, and to a lesser extent at Y-12.

Methods and Materials

Although TDEC will conduct independent sampling when situations indicate that the quality of drinking water in an ORR distribution system may be compromised or that the general integrity of the system is in doubt, the objective of this task was to conduct oversight of all aspects of drinking water supply at the three ORR facilities. The oversight included checking inspection dates on backflow prevention devices as well as attendance at sanitary surveys conducted by personnel from the TDEC Division of Water Supply (DWS). In addition, some random inspections were made of free residual chlorine levels and bacteriological levels.

Results and Discussion

The Division received copies of the Sanitary Survey results from the Division of Water Supply (DWS) for each of the three ORR facilities. ORNL and ETTP received "APPROVED" ratings for their respective systems. The Y-12 system received a rating of "PROVISIONAL".

On 1/17/07 and 1/18/07, Division personnel investigated a 24-inch raw water line break at the Y-12 plant near the monitoring station 17 (East Fork Poplar Creek). DOE subcontractor sampling crews had reported turbid water conditions and elevated pH in EFPC at 0900 on 1/17/07. The cause was a pipeline rupture located upstream between the monitoring station and Lake Reality. City of Oak Ridge water department crews had repaired the pipeline by 1/19/07. No fish kills or environmental impacts were noted.

On March 9th, 2007, DOE-O personnel collected free residual chlorine readings at three locations at ORNL. These locations included building 2008, building 2518 and the aquatic ecology building. All chlorine levels were well above the regulatory limit of 0.2 ppm.

On April 26th, 2007, DOE-O personnel collected free residual chlorine readings at three locations at ORNL. These locations included building 1505, building 3130 and the new visitor center. All chlorine levels were well above the regulatory limit of 0.2 ppm.

On June 4th, 2007, DOE-O personnel provided oversight of the OMI, Inc. monthly sampling at three ETTP locations. These locations included building K-1007, building K-1310 and building K-1652. The activity included the collection of bacteria samples and free residual chlorine readings. All chlorine levels were well above the regulatory limit of 0.2 ppm.

July 23, 2007: Division personnel examined three backflow preventers at ORNL (buildings 2003 and 2521). All were up to date, had been inspected and tagged by ORNL potable water staff during May 2007.

On September 28th, 2007, DOE-O personnel took free residual chlorine readings at three locations at ORNL. These locations were building 2008, building 3017, and building 2518. All chlorine levels were well above the regulatory limit of 0.2 ppm.

Conclusion

The results of these inspections revealed that the three reservation systems provide water that meets State regulatory levels. The distribution system at Y-12 does have some deficiencies in its Cross Connection Control Program, as noted in the Sanitary Survey performed by the TDEC Drinking Water Supply Knoxville field office.

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Implementation of EPA's RadNet Drinking Water Program

Principal Authors: Natalie Pheasant, Howard Crabtree

Abstract

RadNet, formerly the Environmental Radiation Ambient Monitoring System, was developed by the U.S. Environmental Protection Agency to monitor potential pathways for significant population exposures from routine and/or accidental releases of radioactivity from major sources in the United States (U.S. EPA, 1988). This program provides for radiochemical analysis of finished water at five public water supplies located near and on the Oak Ridge Reservation. In this effort, quarterly samples are taken by staff from the Tennessee Department of Environment and Conservation. Although tritium, gross beta, and strontium-90 have generally been measured at higher levels at the Gallaher Water Treatment Plant than the four other systems monitored in the program, there was an exception this year at the Oak Ridge Y-12 site where one sample exhibited a higher tritium value than expected. However, all the results received since the monitoring began in 1996 have been well below regulatory criteria.

Introduction

Radioactive contaminants released on the Oak Ridge Reservation (ORR) enter local streams and are transported to the Clinch River. While monitoring of the river and local water treatment facilities has indicated that concentrations of radioactive pollutants are below regulatory standards, a concern that area water supplies could be impacted by ORR pollutants remains. In 1996, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the Division) began participation in the EPA's Environmental Radiation Ambient Monitoring System, which is now called RadNet. This program provides radiological monitoring of finished water at public water supplies near nuclear facilities throughout the United States. The RadNet program is designed to:

- monitor pathways for significant population exposure from routine and/or accidental releases of radioactivity
- provide data indicating additional sampling needs or other actions required to ensure public health and environmental quality
- serve as a reference for data comparisons (U.S. EPA, 1988)

The RadNet program also provides a mechanism to evaluate the impact of DOE activities on area water systems and to validate DOE monitoring in accordance with the Tennessee Oversight Agreement (TDEC, 2006).

Methods and Materials

In the Oak Ridge RadNet drinking water program, EPA provides radiochemical analysis of finished drinking water samples taken quarterly by Division staff at five public water supplies located on and in the vicinity of the ORR. The samples are collected using procedures and supplies prescribed in the *Environmental Radiation Ambient Monitoring System (ERAMS) Manual* (U.S. EPA, 1988). The samples are analyzed at the Environmental Protection Agency's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama. The analytical frequencies and parameters are provided in Table 1.

Table 1: RadNet Drinking Water Analyses

ANALYSIS	FREQUENCY
Tritium	Quarterly
Gamma Scan	Annually on composite samples
Gross Alpha	Annually on composite samples
Gross Beta	Annually on composite samples
Iodine-131	Annually on one individual sample/sampling site
Radium-226	Annually on samples with gross alpha >2 pCi/L
Radium-228	Annually on samples with Radium-226 between 3-5 pCi/L
Strontium-90	Annually on composite samples
Plutonium-238, Plutonium-239, Plutonium-240	Annually on samples with gross alpha >2 pCi/L
Uranium-234, Uranium-235, Uranium-238	Annually on samples with gross alpha >2 pCi/L

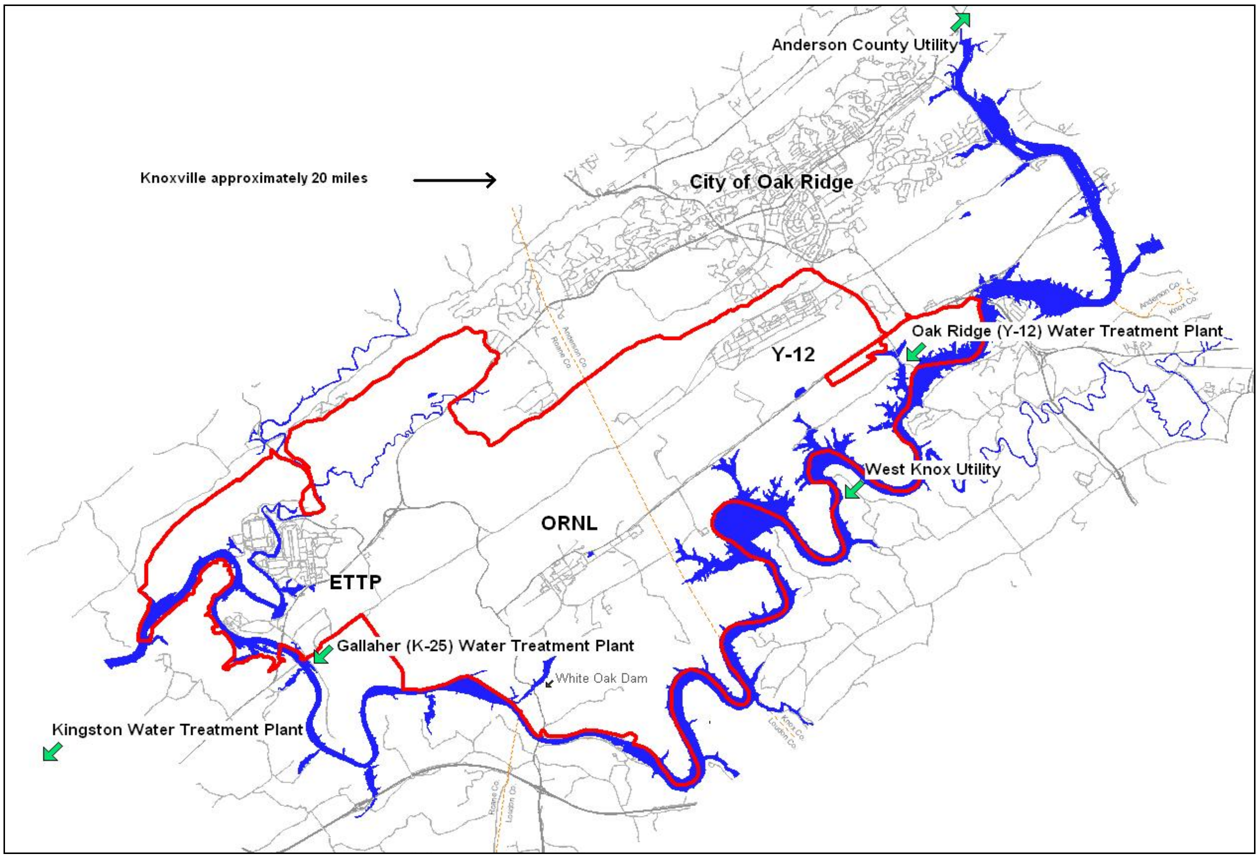

Figure 1: Approximate locations of the intakes for public water systems monitored in association with EPA's RadNet drinking water program

The five locations sampled in the Oak Ridge area for the program are the Kingston Water Treatment Plant, the Gallaher (K-25) Water Treatment Plant, the West Knox Utility, the City of Oak Ridge Water Treatment Facility (formerly the DOE Water Treatment Plant at Y-12), and the

Anderson County Utility. Figure 1 depicts the approximate locations of the raw water intakes associated with these facilities.

Results and Discussion

A large proportion of the radioactive contaminants that are transported off the ORR in surface water enter the Clinch River by way of White Oak Creek, which drains the Oak Ridge National Laboratory complex and associated waste disposal areas in Bethel and Melton Valleys. When contaminants carried by White Oak Creek and other ORR streams enter the Clinch River, their concentrations are significantly lowered by the dilution provided by the waters of the river. With exceptions, contaminant levels are further reduced in finished drinking water by conventional water treatment practices used by area utilities. Consequently, the levels of radioactive contaminants measured in the Clinch River and at area water supplies are far below the concentrations measured in White Oak Creek and many of the other streams on the ORR.

Since the Gallaher (K-25) Water Treatment Plant is the closest water supply downstream of White Oak Creek (approximately 6.5 river miles), this facility would be expected to exhibit the highest concentrations of radioactive contaminants of the five utilities monitored in the program. Conversely, the Anderson County facility (located upstream of the reservation) would be expected to be the least vulnerable of the facilities to ORR pollutants. Based on the data collected since the Oak Ridge ERAMS program (RadNet) began in July of 1996, the above appears to be the case with one exception. In 2007, the fourth quarter sample taken at the Oak Ridge/Y-12 site showed 960 pCi/L of tritium. This sample is being re-analyzed as background results would be expected at this site, which has its intake upstream of the ORR. Other than the noted exception, gross beta, strontium-90, and tritium have all been reported at higher levels in samples taken from the Gallaher (K-25) Water Treatment Plant than at the other facilities monitored in the program. However, the results for the Gallaher facility, as well as for the other sites, have all remained well below applicable drinking water standards. A brief summary of the results received since the Oak Ridge program began is provided below.

Gross alpha, gross beta, and strontium-90 analyses have been performed annually on a composite of the quarterly samples taken from each facility starting in 1997.

- Gross alpha results have all been below 2.0 pCi/L, compared to a drinking water standard of 15 pCi/L.
- The highest gross beta result for the annual composite analysis was reported for the Gallaher facility, with a concentration of 3.86 pCi/L. The average concentration for gross beta results above detection limits at the Gallaher facility since the program’s inception was 3.21 pCi/L. The drinking water standard for beta emitters depends on the specific radionuclides present even though radionuclide specific analysis is generally not required at gross beta levels below 50 pCi/L.
- Of the 49 yearly composite samples analyzed for strontium-90 since 1997, the only results reported above detection limits were for samples taken at the Gallaher facility, with the exception of one result reported for the Oak Ridge Water Treatment Plant at Y-12. This result for the Oak Ridge facility (0.46 pCi/L) was only slightly above the minimum detectable activity (0.41 pCi/L) for the analysis. Consequently, whether this is an actual detection is uncertain. For the Gallaher facility, six of the ten samples analyzed

since 1997 for strontium-90 had low, but detectable, amounts of the strontium-90. The average result was 0.50 pCi/L and the data ranged from undetected to 0.99 pCi/L. The drinking water standard for strontium-90 is 8 pCi/L.

NAREL has performed analysis for iodine-131 each year since 1996 on one sample from each facility. The radionuclide was only reported to be detected in one of the samples analyzed. This result, 0.3 pCi/L, was from a sample taken upstream of the reservation, making the validity of the measurement suspect. The standard for iodine-131 is 3.0 pCi/L.

NAREL performs tritium analysis on each of the quarterly samples taken at the facilities in the program. Tritium is not readily removed by conventional treatment processes and is one of the most prevalent contaminants discharged by White Oak Creek into the Clinch River. Of the 225 tritium results reported for the five Oak Ridge Treatment Plants, only 29 were above detection limits. From the sample results above detection limits, 24 were from samples taken at the Gallaher (K-25) facility and four were reported for the Kingston facility, farther downstream. One sample from the Oak Ridge Y-12 sampling location in 2007 showed 960 pCi/L of tritium. However, the intake for this water treatment plant is upstream of the Oak Ridge Reservation and should have only background levels of tritium. The sample is consequently being re-analyzed to determine if the initial result was correct. Verification sample results were not available at the time of this report. The results for tritium at the Gallaher facility ranged from undetected to 1000 pCi/L and averaged 416 pCi/L for sample results above the detection limits. The drinking water standard for tritium is 20,000 pCi/L.

Only iodine-131 and tritium results have been received from NAREL for 2007 sampling. These data are similar to the results received in past years, with the exception of the high tritium value found at the Oak Ridge Y-12 sampling location for the fourth quarter 2007 sample. It was the only one of the 20 results received for tritium in 2007 that was above detection limits. All the 2007 iodine-131 results were below detection limits.

Conclusion

Radioactive contaminants migrate from the ORR to the Clinch River, which serves as a raw water source for area public drinking water supplies. The impact of these contaminants is diminished by the dilution provided by waters of the Clinch River. Contaminant concentrations are further reduced in finished drinking water by conventional water treatment practices employed by area utilities. RadNet/ERAMS results over the last nine years have all been well below drinking water criteria. Gross beta, strontium-90, and tritium, while below drinking water standards, have all been reported at higher levels in samples taken from the Gallaher (K-25) Water Treatment Plant than at the other facilities monitored in the program, with the exception of the fourth quarter 2007 tritium result at the Oak Ridge Y-12 sampling location, which is being re-analyzed. The Gallaher plant is the closest facility downstream of White Oak Creek, the major pathway for radiological pollutants entering the Clinch River from the ORR.

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GROUNDWATER MONITORING

Oak Ridge Reservation and Vicinity Independent Sampling Report

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Abstract

Groundwater is one primary mode of contaminant migration on the Oak Ridge Reservation (ORR). To a great extent surface water contamination on the reservation begins as contaminated groundwater. Understanding this movement of groundwater within the ORR is to understand the transportation of contaminants from the ORR to outlying areas.

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the Division) conducts independent groundwater sampling at springs, wells, and integrated surface sampling sites on or near the Oak Ridge Reservation (ORR). In calendar year 2007, groundwater-sampling projects included fifty-seven springs/seeps, and wells, and four surface water sites, and one soil sample for a total of sixty-two sites. The groundwater section successfully conducted sampling on all sixty-two sites in 2007.

Exit pathway springs in the peripheral areas of the ORR are monitored for the purpose of maintaining a close observation of the terminal boundaries of the various contaminant plumes originating within the reservation and to assure, insofar as possible, that ORR-sourced contaminants do not escape and become a potential threat to the environment outside the reservation. Domestic water wells are sampled to gauge any potential impact from DOE activities, past and present, to the groundwater resource in the surrounding area. Samples are analyzed for radiochemicals, organic solvents, metals, inorganics, and nutrients. Parameters for analysis are chosen on a case-by-case basis dependent on expected and potential contaminants known or on suspected contaminants at the sites being monitored.

Calendar year 2007 began with sampling as per the Division's Environmental Monitoring Plan (EMP). After reviewing the 2006 Remediation Effectiveness Report (DOE/OR/01-2337&D1 and D2), specifically analytical data from Melton Valley Picket wells, extensive sampling of residential wells across the Clinch River/Watts Bar Reservoir was begun.

The offsite volatile plume from the Y-12 plant beneath Union Valley continues to appear, to some extent, mitigated by the pump-and-treat program initiated in 1998 – 1999. The Division's monitoring of Cattail Spring, near Scarboro Road, was sampled four times in the first six months of 2007 and showed no detections for volatiles during that time. Another potential explanation for the apparent improvement at Cattail Spring is the disturbance that the ground around the spring has suffered as various land-clearing activities have been performed in the area. Bootlegger Spring, which appears to represent the terminus of Y-12's Chestnut Ridge Security Pit plume, continued to show a significant volatile signature in 2007 as it has in the past few years. However, springs and surface water in and around Bear Creek to the west of the Y-12 Complex tended to show an increase in alpha and beta particle emitting radiochemicals.

Overall, the program has maintained this significant increase in sampling and reconnaissance activities. However, due to a reallocation of priorities, groundwater monitoring was focused on the Melton Valley area on and offsite for the second half of the year.

Introduction

This chapter provides a status/review of the Division's Environmental Monitoring & Compliance Program's Groundwater Section's findings. The Groundwater Section's staff sampled thirty-one exit pathway springs and four surface water sources (Figure 1, Table 1). These findings are based on sampling performed during calendar year 2007 (CY2007).

The Tennessee Oversight Agreement (TOA), the Division's agreement with the Department of Energy (DOE), specifies that the State prepare a report of sampling results. The TOA also mentions the reporting of findings based on the State's analytical results. With respect to the TOA's requirements and the following definitions, this chapter attempts to integrate results and findings as an independent comprehensive groundwater monitoring report.

- To monitor is to measure (gauge, calculate, determine, assess, quantify, evaluate, appraise, etc.) some aspect of groundwater;
- To sample is to extract some portion of a larger system of groundwater for testing.

It is the State's duty to provide independent oversight of the DOE groundwater monitoring program. The State is not limited in this duty and "independent monitoring," "supplemental monitoring" and other specific actions have proven to be a most effective means of addressing concerns and inadequacies observed in DOE's monitoring programs. At times in the past the State's performance of this function has led to quantitative and qualitative improvements in DOE's monitoring and surveillance of contaminated groundwater on the ORR.

At this time the State, through its Oversight Division, and the Division, through its groundwater monitoring program performs the vast majority of said monitoring in two significant areas, offsite monitoring and true exit pathway monitoring.

Exit Pathway Monitoring

Effective monitoring of contaminants being transported by groundwater is largely a process of identifying and sampling the pathways by which the groundwater leaves the contaminated areas. Thus, a significant portion of the Division's groundwater sampling has been directed toward identifying and monitoring exit pathways on the ORR.

Given the nature of groundwater flow on the ORR, very effective monitoring may be conducted by sampling springs and seeps on and around the reservation. Springs and seeps represent convergent points where groundwaters emerge on the ORR and often represent the interface between contaminated groundwater and surface water affected by that contamination.

Table 1: Sampling Locations (springs and seeps)			
Site	**Station**	**Station Type**	**Sample Events**
X-10	4537 Zone2	MW	1
X-10	4537 Zone3	MW	1
X-10	4538 Zone2	MW	1
X-10	4538 Zone3	MW	1
X-10	4539 Zone2	MW	1
X-10	4539 Zone4	MW	1
X-10	4539 Zone5	MW	1
X-10	4539 Zone8	MW	1
X-10	4541 Zone2	MW	1
X-10	4541 Zone5	MW	1
X-10	4541 Zone6	MW	1
X-10	4542 Zone4	MW	1
X-11	4542 Zone5	MW	1
Y-12	GW-629	MW	1
OFF	UA-1	MW	5
OFF	UA-2	MW	6
K25	UNW-094	MW	1
K25	UNW-095	MW	1
K25	UNW-107	MW	1
OFF	Dead Horse Spring	RW	1
OFF	Rose Bailey Spring	RW	2
OFF	RWA-22	RW	1
OFF	RWA-29	RW	1
OFF	RWA-56	RW	5
OFF	RWA-58	RW	3
OFF	RWA-63	RW	6
OFF	RWA-65	RW	6
OFF	RWA-68	RW	1
OFF	RWA-74	RW	3
OFF	RWA-75	RW	1
OFF	RWA-76	RW	3
OFF	RWA-77	RW	1
OFF	RWA-78	RW	2
OFF	RWA-79	RW	1
K-25	21-002 Spring	SP	2
X-10	Angel Spring	SP	1
Y-12	Beaver Spring	SP	1
Y-12	Bootlegger Spring	SP	6
Y-12	Cabin Spring	SP	1
Y-12	Cattail Spring	SP	4
Y-12	Cephus Spring	SP	1
K-25	Cress Spring	SP	1
K-25	Cross Spring	SP	1

Table 1: Sampling Locations (springs and seeps) continued			
K-25	Doug's Drip Spring	SP	1
K-25	Fern Spring	SP	1
X-10	Gerry's Spring	SP	1
Y-12	Mt. Vernon Mossy Rock Sp.	SP	1
K-25	PCO Seep	SP	2
OFF	RCB Spring	SP	1
K-25	Regina Loves Bobby Spring	SP	5
K-25	Rip Rap Spring	SP	1
Y-12	SNS-1	SP	2
Y-12	SNS-2	SP	1
Y-12	SNS-4	SP	2
Y-12	SNS-7	SP	1
Y-12	SS-5	SP	3
Y-12	SS-6	SP	3
Y-12	SS-7	SP	2
Y-12	SS-8	SP	2
X-10	Sycamore Spring	SP	1
K-25	Tom's Seep	SP	2
K-25	Treehole Spring	SP	1
X-10	Tull Spring	SP	1
K-25	USGS 10-895 Spring	SP	7
K-25	USGS 8-900	SP	1
Y-12	West Railroad Spring	SP	1
K-25	Wetland Spring	SP	1
Y-12	BCK 10.1	SW	1
Y-12	BCK 4.55 Weir	SW	2
Y-12	BCK 9.6	SW	1
Y-12	New Weir	SW	3

Note: MW = Monitoring Well
RW =Residential Well
SW = Surface Water
SP = Spring
SO = Soil

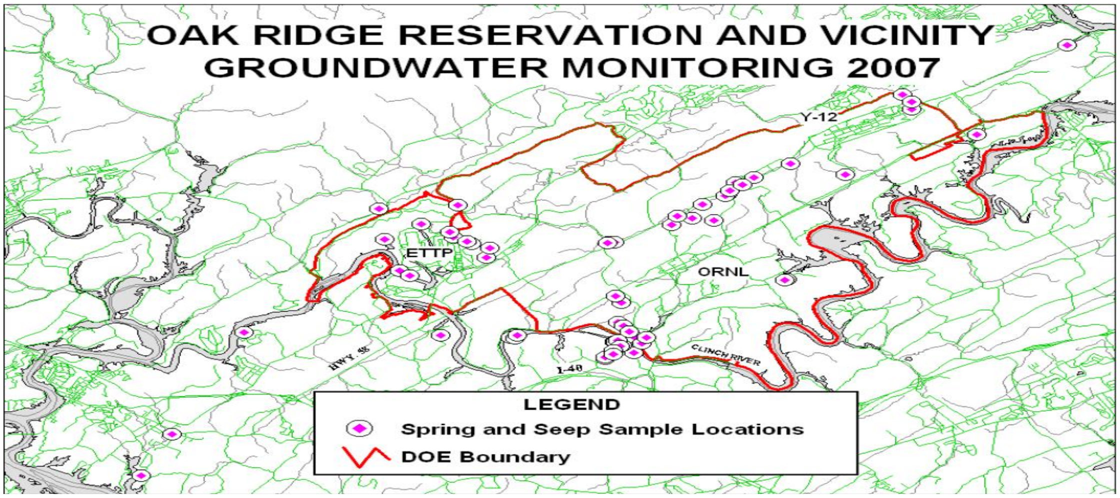

Figure 1: Oak Ridge Reservation and vicinity showing 2007 spring monitoring locations

The Division has been very effective in discovering contaminated and previously unmonitored new springs and seeps. Such discoveries have contributed greatly to the understanding of contaminant movement on the ORR and doubtless there are significant discoveries remaining to be made. 2007 saw a continuance in the amount of resources the Division applied toward reconnaissance for new groundwater monitoring points.

A bedrock assumption of ORR groundwater hydrology has always been that the Clinch River acts as a hydrologic barrier to the movement of contaminants offsite. Testing this hypothesis will require the identification and sampling of the groundwater inputs into the Clinch River. Such activities will be needed to provide assurance that the Clinch is the barrier it is hypothesized to be.

Monitoring Known Contaminated Groundwater

Significant areas of the ORR are underlain by contaminated groundwater and the DOE performs extensive sampling of wells within these areas. Review and comments on annual reports regarding this monitoring is a task performed by the Division as part of its TOA responsibilities.

While DOE's monitoring programs are substantial with respect to the number of monitored wells and sites, there are questions as to the effectiveness of the program. This can be attributed, in part, to the challenge of monitoring in East Tennessee's complex hydrogeologic setting. A larger part can be attributed to well emplacement and sampling points having been established utilizing a groundwater/geologic conceptual model based on questionable assumptions. DOE surveillance data does help to draw plume maps showing the nature and extent of contaminated groundwater. However, there is a tendency for such maps to consistently show best-case scenarios and to assume plumes do not exist where there is no monitoring, even when logic and experience would indicate extensive contamination to exist in an area.

ETTP, the largest portion of which is underlain by the soluble Ordovician carbonates of the Chickamauga Super Group and Knox Group, demonstrates this conundrum. Despite being underlain by demonstrably dissolutionally enhanced fractured carbonates, a dearth of monitoring wells that penetrate said bedrock makes any and all attempts at characterization of contaminant plumes academic. The monitoring points to properly characterize the full nature and extent of contamination in bedrock simply do not exist. This problem was outlined in the 1991 *Tiger Team Assessment of the Oak Ridge K-25 Site* and in a DOE ES&H audit in 2000, and has not been adequately addressed to date.

All rock units underlying the ORR qualify as aquifer by definition. Although some units are poor producers for domestic water supply they still produce a limited quantity of water sufficient to be defined as an aquifer. Some have referred to them as aquitards which, by definition, produce little to no water. Furthermore, all rock units that underlay the ORR and East Tennessee are vulnerable to contamination and plumes that can spread rapidly. This concern is echoed in DOE's position to control, through deed restrictions or notices, many areas of groundwater use in the environs about the ORR. It is inevitable that long-term monitoring of groundwaters in and around the ORR will be necessary to protect the people and environment of East Tennessee from the legacy of DOE operations.

Methods and Materials

The State's Department of Health's Environmental Laboratory conducts the analysis of the water samples for radionuclides, volatile organic compounds, selected metals, nutrients, and inorganic parameters. The Division's spring sampling activities typically include the parameters found in Table 2.

Table 2: Parameters

Nutrient, Metal & General Inorganic Analysis	**Radiological Analysis**	**List of TCL* Volatiles**	**List of TAL ** Semivolatiles**
Metals	Typically	Acetone	Acenaphthene
Arsenic	Gross Alpha	Benzene	Acenaphthylene
Barium	Gross Beta	Bromodichloromethane	Anthracene
Beryllium	Gamma Emitters	Bromoform	Benzo(a)pyrene
Cadmium		Bromomethane	Benzo(a)anthracene
Calcium	**If suspected then**	2-Butanone (MEK)	Benzo(b)fluoranthene
Chromium	**isotopes of:**	Carbon Disulfide	Benzo(g,h,I)perylene
Cobalt	Strontium	Carbon Tetrachloride	Benzo(k)fluoranthene
Copper	Technetium	Vinyl Acetate	Benzoic acid
Iron	Uranium	Chlorobenzene	Benzyl alcohol
Lead	Radium	Chloroethane	Bis(2-chloroethoxy)methane
Magnesium	Tritium	Chloroform	Bis(2-chloroethyl)ether
Manganese		Chloromethane	Bis(2-chloroisopropyl)ether
Mercury		Dibromochloromethane	Bis(2-ethylhexyl)phthalate
Nickel		1,1-Dichloroethane	4-bromophenylphenylether
Potassium		1,2-Dichloroethane	Butylbenzylphthalate
Selenium		1,1-Dichloroethene	4-chloroaniline
Sodium		Cis-1,2-Dichloroethene	4-chloro-3-methyl phenol
Thallium		Trans-1,2-Dichloroethene	2-chloronaphthalene
Vanadium		1,2-Dichloropropane	4-chlorophenylphenylether
Zinc		Cis-1,3-Dichloropropene	Chrysene
		Trans-1,3-Dichloropene	Di-n-butylphthalate
Nutrients		Ethylbenzene	Di-n-octylphthalate
Nitrite		Methylene Chloride	Dibenzo(a,h)anthracene
Nitrate		4-Methyl-2-Pentatone (MIBK)	Dibenzofuran
Total Nitrate+Nitrite		Styrene	3,3'-dichlorobenzidine
		2-Hexanone	2,4-dichlorophenol
General Inorganics		1,1,2,2-Tetrachloroethane	Diethylphthalate
pH		Tetrachloroethene	2,4-dimethylphenol

Table 2: Parameters (continued)

Nutrient, Metal & General Inorganic Analysis	Radiological Analysis	List of TCL* Volatiles	List of TAL ** Semivolatiles
Total Alkalinity		1,1,1-Trichloroethane	4,6-dinitro-2-methylphenol
Boron		1,1,2-Trichloroethane	2,4-dinitrophenol
Total Residue		Trichloroethene	2,4-dinitrotoluene
Suspended Residue		Vinyl Chloride	2,6-dinitrotoluene
Dissolved Residue		o-Xylene	Fluoranthene
Sulfate		m & p-Xylene	Fluorene
Chloride			Hexachlorobenzene
			Hexachlorobutadiene
			Hexachlorocyclopentadiene
			Hexachloroethane
			Indeno(1,2,3-cd)pyrene
			Isophorone
			2-methylnaphthalene
			2-methylphenol
			4-methylphenol
			N-nitosodiphenylamine
			N-nitroso-n-dipropylamine
			Napthalene
			2-nitroaniline
			3-nitroaniline
			4-nitroaniline
			Nitrobenzene
			2-nitrophenol
			4-nitrophenol
			Pentachlorophenol
			Phenanthrene
			Phenol
			Pyrene
			1,2,4-trichlorobenzene
			2,4,5-trichlorphenol
			2,4,6-trichlorphenol
		*TCL (Target Compound List)	**TAL (Target Analyte List)

Finding New Springs

Springs are normally found by walking along creeks and valleys and are often found emerging in streambeds. Specific vegetation such as watercress, willow and sycamore trees is a common indicator of groundwater resurgence, i.e. springs. Careful use of temperature and specific conductivity measurements help delineate groundwater resurgences and even separate different resurgences occurring within the same spring. In the areas of contaminant plumes, orange staining caused by iron-related bacteria breaking down organic compounds also helps identify locations to sample. Smells or odors that may be sweet or stringent may contribute to the ability of locating a spring. However, if odors are noticed, steps must be taken to insure the health and safety of samplers and others by notifying appropriate health and safety personnel.

Field Sampling
A sampling team locates the spring and collects the prescribed number of samples. The personnel wear disposable vinyl gloves while collecting samples. Sample labels (tags) and analysis-request/chain-of-custody forms are completed. Samples are either transported in coolers to the division's office for temporary storage, or they are taken directly to the Knoxville Basin Laboratory. Duplicate samples, trip blanks, and field blanks are taken as directed by the sampling plan.

Data Storage
Analytical results are stored in regular files in the DOE-O office, and the results are entered in a computer database. Eventually this data will be placed onto DOE's Oak Ridge Environmental Information System (OREIS) database. Copies of the lab analyses are provided to DOE upon request.

Analysis
Data generated is analyzed as received and integrated into the sampling program. Both sampling and analysis are dynamic in that results can and do modify the locations and frequencies of sampling.

In the past, analysis has been conducted on a fairly standard set of potential contaminants consisting of radiochemicals, organic solvents, metal and organic constituents. Analytes chosen were determined by process and historic knowledge of the different sites.

Late in 2006, the Division became aware of a new contaminant of concern, 1,4-Dioxane, associated with the organic solvents that are common contaminants in ORR groundwater. Analytic limitations and a relatively recent realization of 1,4-Dioxane's potential as a carcinogen had precluded it as an analyte in the Division's groundwater investigations. 1,4-Dioxane was added to the analyte list for several springs, monitoring wells and residential wells.

Dioxane has properties that render it far easier for transport in the groundwater than the more familiar volatile organic solvents. (In other parts of the nation, where Dioxane has been sampled for the extent of contamination in groundwater, it has been found that the contaminated groundwater plumes commonly double in size.)

Results and Discussion

Groundwater in General
Groundwater is one of the primary and initial modes of contaminant migration within the ORR. To a great extent, surface water contamination on the ORR begins as contaminated groundwater from various disposal trenches, land-farms, and areas where contaminants were, apparently, simply spilled. It then emerges either in springs and seeps or as direct recharge into streambeds.

Understanding the nature and movement of groundwater within the ORR is to understand the initial movement of contaminants from the ORR.

Geology on the ORR consists of Ordovician clastic and carbonate geologic units thrust-faulted into place. This resulted in a geologic strike that is dominantly directed toward the Northeast. The bedding of these rocks predominantly dips towards the southeast at angles between twenty and forty-five degrees. The geologic structure controls the movement of groundwater with the along-strike component being predominant, and cross-strike irregularities, although important, less frequent within particular rock units. To date, sampling has not shown contaminants to have moved off the reservation via groundwater flow by crossing the regional northeasterly strike of the inclined bedrock. However contaminants in groundwater can be shown to have moved along the regional strike and past the reservation boundaries in several locations (e.g. VOCs in Union Valley northeast of Y-12 and strontium in Bethel Valley southwest of ORNL).

Groundwater movement within the ORR is thus demonstrably dominated by flow along remnant structures within the regolith above the bedrock. Additionally, the turbulent rapid water flows through the bedrock along dissolution-enhanced fractures in the karst units and along fractures within the clastic rock.

It has been doctrine that the Clinch River, which surrounds the west and south sides of the Oak Ridge Reservation, forms a hydrogeologic barrier to the movement of contaminated groundwater off the Oak Ridge Reservation. While the Clinch River does appear to be a barrier for contaminant transport, it has not been proven that it is an absolute barrier. Springs can be located issuing along the bank of the Clinch that support this theory. However, 2007 reconnaissance activities have still failed to locate a significant number of springs and seeps of sufficient volume to completely support the belief that the Clinch is a totally effective hydrologic barrier.

Use of the side-scanning sonar in the Clinch River in 2006 have shown a number of potential “targets” that may represent spring orifices. Determination of their hydrologic input, if any, will be challenging and important in establishing the effectiveness of the Clinch as a barrier to contaminant transport.

Data suggesting that the Clinch River may not act as an impenetrable barrier for contaminant migration by groundwater does exist. It has been recognized that cavities below the base of the river are commonly encountered when bedrock wells emplaced in the vicinity penetrate to elevations beneath the bottom of the Clinch River. The actual base flow elevation of the region’s groundwater is not known, so a potential exists for contaminant migration beneath the Clinch River.

The ORR and its environs are underlain by karst and fractured clastic aquifers. Particularly in the areas underlain by karst aquifers conduits may exist that have base levels below the Clinch River. (There is a continued specific concern among Division staff that pressures exerted during injection projects involved in waste disposal could have had enough force to underflow the Clinch River.) Thus, critical locations where monitoring needs to take place both on and off DOE property are areas that may potentially be affected by the injections performed by the Hydrofracture project that took place at ORNL.

Also of concern for the presence of offsite contaminant transport are the banks of the Clinch River and Poplar Creek in and about the ETTP area. Contaminated seeps and springs have been identified on TVA property, and will be discussed in detail in the ETTP section of this report.

Significant areas to the east and north of the ORR are not bounded by the Clinch River. Indeed, it has been determined that plumes do cross the ORR boundary and impact groundwaters offsite and along the geologic strike. In particular, plumes have been demonstrated to exist in Union Valley, east of the Y-12 plant and within Chestnut Ridge, east of the Security Pits. Significantly, both these plumes are within well-developed dissolution-enhanced turbulent conduit aquifers hosted by soluble rock karst aquifers, namely the Maynardville Limestone Formation and the dolomites of the Knox Group.

More problematic is the area north of K-25 bounded by dolomites of the Ordovician Knox Group. While the Knox Dolomites form Blackoak Ridge and any direct contaminant migration from the historic K-25 Site (ETTP) would not be expected through the ridge itself, the question remains as to the potential that some waste may have been disposed on the ridge itself and may affect ground-waters to the north of ETTP.

Sampling results from calendar year 2007 tended to show few changes from 2006 sampling. The improvements noted in Union Valley in 2007, as the plume seemed to respond to the installation of a pump-and-treat system, became more problematic as surface disturbances to the sampling area raise a question regarding the effectiveness of monitoring efforts. Did the surface disturbances impede detections of contaminants? Continued monitoring should answer this question.

The plume originating in the Security Pits on Chestnut Ridge continued to impact its apparent offsite terminus at Bootlegger Spring in the UT Arboretum.

Gross alpha and gross beta levels in springs of lower to middle Bear Creek Valley showed a tendency to slightly increase, suggesting an impact from the waste disposal practices at the EMWMF.

ETTP showed one problem area as an organic solvent plume was tracked by the Division offsite on the east side of the plant area. In 2007, problems were noted and sporadic detections of the radiochemical tritium were seen offsite in Regina Loves Bobby Spring, located on the northern scarp of Blackoak Ridge. It is fully expected by Division groundwater staff that most areas within the boundary of ETTP would show contaminated groundwater with the proper emplacement of wells, sampling and analysis.

Offsite residential well and spring monitoring continues at a much different level than in 2006. The monitoring of seven springs and seeps represents the entirety of the offsite spring monitoring accomplished in 2007. Rose Bailey Spring is the division’s most distal monitoring point. Rose Bailey, a large spring located approximately seven miles southwest of the ETTP, appears to represent a groundwater emergence from the region to the southwest of ETTP. Monitoring at this point provides assurance to the presence or absence of contaminants originating at ETTP within a significant area near the plant. Calendar year 2007 monitoring of Rose Bailey spring showed an absence of any DOE related contaminants.

The Division's Groundwater Program responded to documented reports of contamination in the Melton Valley Picket Wells (March 2007) by dramatically increasing the frequency of sampling and analysis of offsite residential wells located across the Clinch River from the affected locations, and by actively seeking residential wells in the area which are not included in our sampling regime. It should be noted that these residential wells are those located closest to known contamination on the Oak Ridge Reservation. Accordingly, the residential well project's scope was changed to focus on the wells across from Melton Valley. A total of thirteen residential wells were sampled in 2007.

Exit Pathway Springs in General

In general terms, DOE compliance monitoring showed heavily contaminated groundwater near historic disposals, spills and releases on the ORR. As DOE performs extensive monitoring in and near the highly contaminated areas on the ORR and, as such monitoring is resource-intensive, the Division's groundwater program has concentrated on the identification and monitoring of potential and actual exit pathways on and off the reservation.

This program has and continues to add significant value to efforts to monitor groundwater impacts of current and legacy DOE operations on and off the ORR. 2007 saw a continuation of the significant improvements adopted in 2005 and continued in 2006.

Groundwater remains the major modality by which contaminants are initially transported from disposal sites on the ORR. The Division's groundwater monitoring program has identified several points of concern, continues to monitor known exit pathway points and has identified and sampled what appears to be a regional groundwater emergence southwest of the ETTP (Rose Bailey Spring).

Exit Pathway Springs at ETTP (K-25)

Division groundwater monitoring in and around ETTP continued to show contamination reaching several offsite areas, see Figure 2. In particular, TDEC sampling showed volatile organic solvents at spring USGS 10-895 north of the main plant area and at PCO Seep on the bank of the Clinch River west of the plant. Spring 21-002, which is known to drain the K-1070-A Burial Ground, did show increasing concentrations of contaminants in the latter part of 2007.

USGS 10-895 Spring, located just offsite along the bank of Poplar Creek near Blair Road, showed trichloroethylene (TCE) at levels near and just above the 5 µg/L maximum contaminant level (MCL). PCO Seep, located on the bank of the Clinch River on TVA-controlled property, showed levels as high as 18.20 ppb TCE. The source of the contamination in PCO seep is not known but could be from an area known as the "bottle smasher". Speculation on the source of contamination in spring 10-895 abounds. One theory is that potential spoil areas on Blackoak Ridge have wastes disposed within.

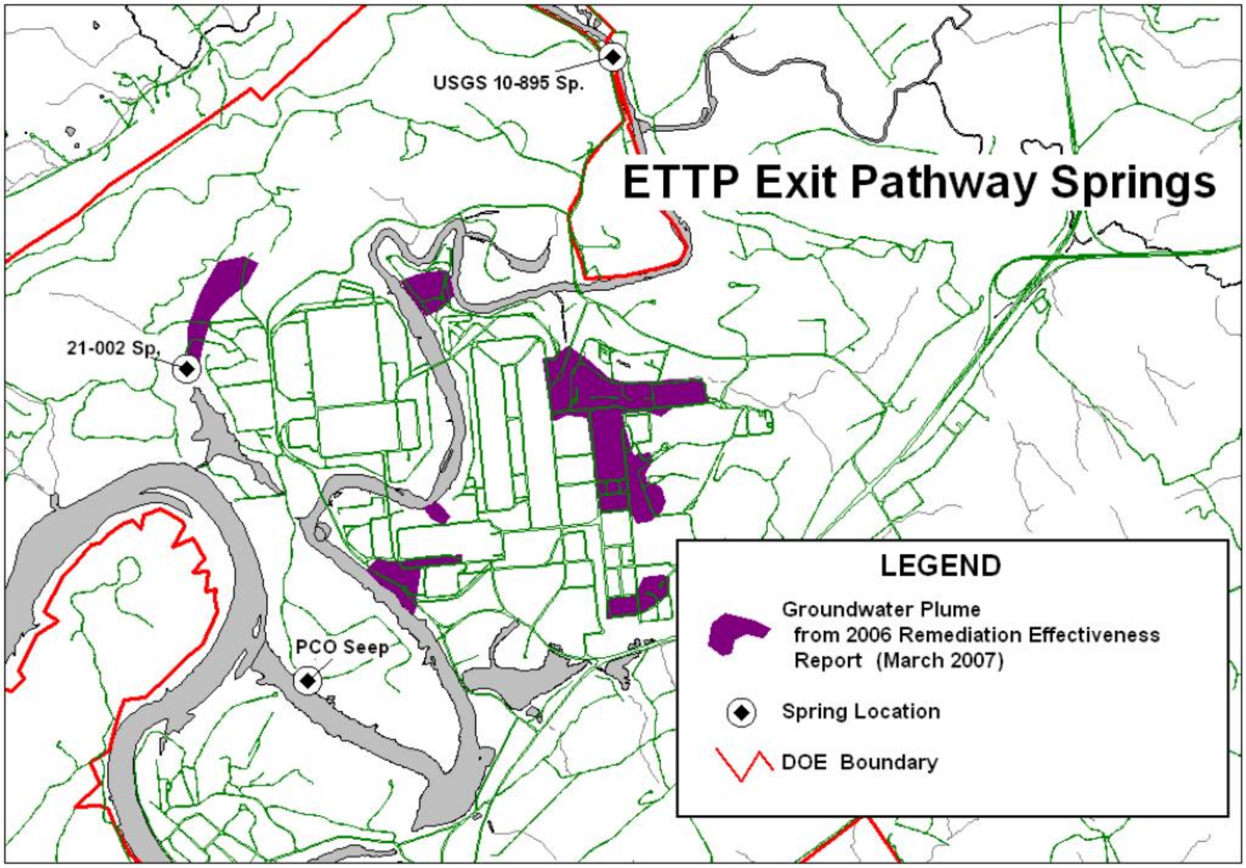

Figure 2: Map of K-25 area showing plumes in relation to spring locations which were not near mapped plumes except Spring 21-002. To achieve effective monitoring, plumes will have to be better understood in relation to impacted springs.

Another possibility is that karst conduit transport of volatile contaminants is occurring from the K-1070-A Burial Ground which is located along the geologic strike (approximately 2.2 km southwest). The third possibility could be that a completely unknown source, such as spillage along the nearby railroad tracks, may account for contaminants found in the 10-895 spring water. The above information has been given to DOE for inclusion in the ETTP investigations and cleanup.

Conversely, plume and degradation models generated in 2005 by DOE contractors in the main plant area and from the K-1070-A Burial Ground consistently showed plumes either smaller than previously mapped or at decreasing concentrations as in the case of Spring 21-002 (known to drain the K-1070-A Burial Ground).The plumes shown on Figure 2 are taken from DOE's 2006 Remediation Effectiveness Report (2006 RER).

Regina Loves Bobby Spring, located on the scarp of Blackoak Ridge, north and across the ridge from the ETTP main plant area, continued to show sporadic results for technetium-99 in 2007. The results are very low and pose no known threat to health from consumption of the water. The potential that any contamination has managed to be transported from the historic K-25 site into groundwaters occurring on the opposite side of Blackoak Ridge is a cause for concern. However, it seems likely that the technetium-99 noted in this spring maybe derived by a mode other than groundwater transport.

ETTP represents a major challenge in the effort to provide adequate groundwater monitoring. The complex contaminants present are a mixture of radiochemicals, volatiles, semi-volatiles and metals emplaced within a complex geology of folded and faulted, dissolutionally-enhanced, fractured, carbonate rock, as well as a few fractured clastic rocks. (Overlaying this geologic structure is a complex; though mostly inactive, industrial site whose operation greatly affects contaminant collection, transport and identification, etc.

Complicating proper characterization is a dearth of wells penetrating bedrock, particularly wells that would cover the southern portions of the plant site. The information from these wells is then used to attempt to model plumes. The Division has taken the position of needing additional monitoring points at ETTP to DOE and its contractors several times. Given the complexities of the ETTP site and the mix of contaminants present, the Division has consistently maintained that modeling is inappropriate and that it is not a replacement for physical monitoring. Sampling results support the contention that the plumes at ETTP need to be monitored and mapped rather than modeled; that contaminated groundwater at the ETTP is not well characterized and not contained within the boundaries.

Exit Pathway Springs at Y-12

Exit pathway monitoring at Y-12 consists of four separate areas of interest (Figure 3). The groundwater plumes designated in the figure are taken from DOE's 2006 Remediation Effectiveness Report.

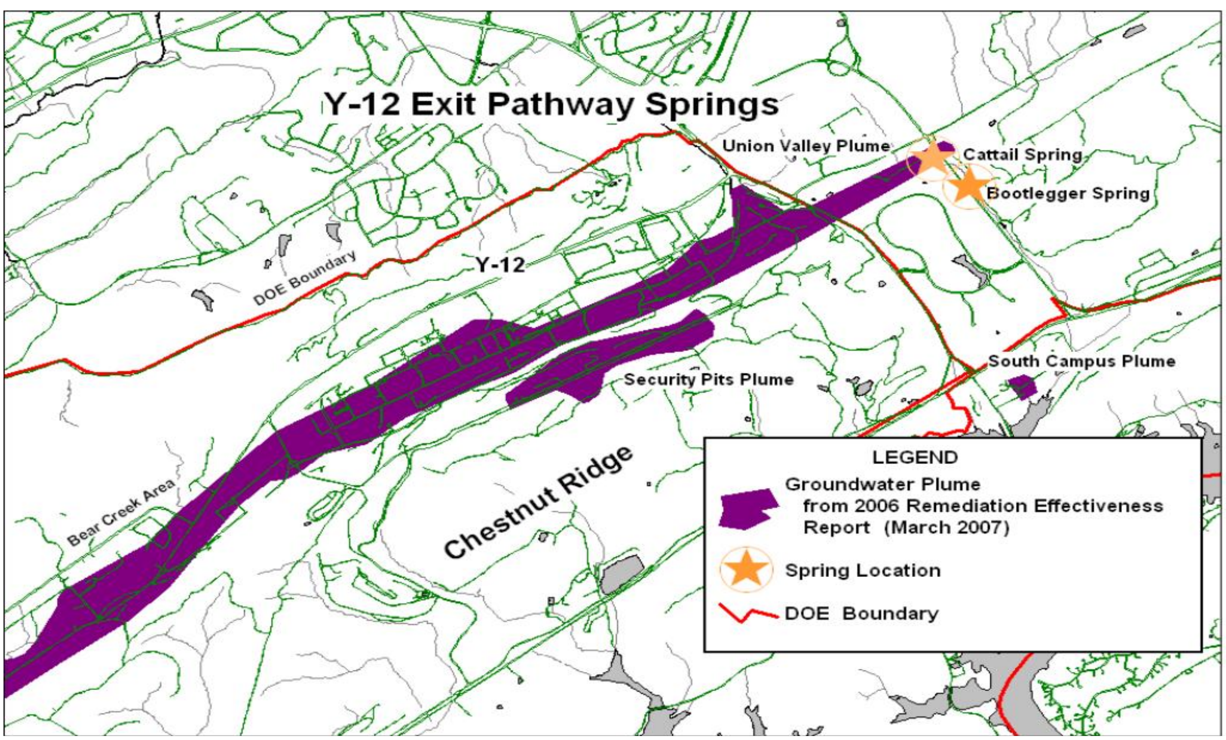

Figure 3: Portion of exit pathway monitoring at Y-12

1. The Union Valley plume, originating at or about the site of the closed New Hope Pond and emanating eastward through the karst conduits of the Maynardville Limestone Formation, apparently has been reemerging at Cattail Spring. This has been, and is, a significant monitoring point for the Division's program.

   Cattail Spring, which had intermittent showings of the organic solvent carbon tetrachloride in 2004, was notable because of the absence of the contaminant in 2005 thru 2007. Monitoring showed no detectable values in 2007. It is suggested that the pump-and-treat system, established some years previously within the eastern portion of Y-12, has mitigated the extent of the organic solvent plume. However, it is possible that landscaping activities, which have occurred involving the Division's monitoring point, have interfered with sampling results. A significant question exists as to whether the same waters are being monitored or as to whether the monitored spring maybe impacted by an influx of surface waters.

   While this apparent mitigation is commendable, it suggests the need for further monitoring and access to wells in the area to judge the extent of plume retreat. Further, it opens up a serious question regarding a differing set of volatiles that is known to exist under a capped municipal landfill located to the northeast of Cattail Spring in Union Valley (currently a driving range is located on the capped landfill). These contaminants are suspected of impacting groundwater in portions of Union Valley.

2. The Security Pits Plume originates on Chestnut Ridge and moves east, emerging at Bootlegger Spring on the UT Arboretum.

   Bootlegger Spring, in the University of Tennessee Arboretum, has shown through past sampling that organic solvents associated with the Security Pits disposal area on Chestnut Ridge near Y-12 flow through the dissolutioned conduit aquifers that are known to exist within the Ordovician-aged Knox Dolomites composing Chestnut Ridge and exit at Bootlegger Spring within the UT Arboretum.

   Sampling during the two extremely wet years of 2003 and 2004 showed organic solvents only appearing during low flow conditions late in those years, whereas, in previous years of sampling, the spring showed consistent, if low, concentrations of organic solvents. 2007 showed a return to a more consistent output of Security Pits-related organic solvent concentrations.

3. Various small springs and seeps, located down slope of the burial grounds that are located on the south slope of Chestnut Ridge, were monitored in 2007 as a check on potential contaminant migration from said burial grounds. No significant impact was noted in 2007.

4. Springs and surface waters of Bear Creek, west of the main plant area and emerging from the well-developed karst aquifer of the Maynardville Limestone Formation were also monitored in 2007.

Exit pathway monitoring in Bear Creek consists of a number of a series of large springs located on the north-facing scarp of Chestnut Ridge and certain surface-water locations in Bear Creek itself. Surface-water sites are integrated into groundwater monitoring, as Bear Creek is a surface expression of the well-developed subsurface karst conduit drainage within the Maynardville Limestone Formation.

A number of contaminated sites exist in Bear Creek. Unless removed, the valley contains significant amounts of depleted uranium, organic solvents, and nitrous contaminants derived from nitric acid. These wastes were emplaced in unlined burials within the various fractured clastic units that underlie the majority of Bear Creek Valley. The exception is the strip immediately in front of and to the north of Chestnut Ridge, which is underlain by the previously mentioned Maynardville Limestone Formation. Waste emplaced in these fractured clastic units tends to drain toward and into the surface/subsurface karst system of Bear Creek within and on the Maynardville Limestone Formation.

2007 was the third complete year of sampling conducted from the finish of significant remedial projects within Bear Creek Valley. The most notable being the remediation of the Bone Yard Burn Yard (BYBY). The BYBY had been a significant source of gross alpha contamination seen in springs in Bear Creek Valley. With its closure, 2005 saw a decrease in gross alpha concentrations in the creek's and spring's waters. 2007 however, has seen the trend of a gradual increase in both gross alpha and gross beta levels seen in the creek and associated springs.

Exit Pathway Springs at ORNL and Melton Valley Picket Wells

Division sampling of exit pathway springs for ORNL and Melton Valley was of limited extent in 2007. Reconnaissance of areas underlain by the Maynardville Limestone Formation in the western portions of Melton Valley failed to find the expected springs. Neither did further reconnaissance in 2007 of the eastern portions of areas underlain by the Maynardville and areas to the east of the main campus locate any potential sampling points.

The Division did continue to sample Raccoon Creek Spring (Gerry's Spring) and Sycamore Spring in Raccoon Valley (Figure 4). Sycamore Spring continued to show the radiochemical strontium-90 in approximately the same order of frequency and magnitude as in 2006, namely 12.10 pCi/L. As can be seen by DOE's groundwater plume boundaries in Figure 4, which are taken from the 2006 RER, DOE has not consistently identified or acknowledged the migration of contaminants to these springs.

A significant portion of the Division's offsite residential well-monitoring program is based on historic contaminants projects such as the Hydrofracture located in Melton Valley and serve, to some extent, as exit pathway monitoring for ORNL. Rather, it is expected they serve to show that no exit pathway exists to domestic wells located on the opposite side of the Clinch River from the ORR. These wells will be discussed in detail below in the section on residential wells.

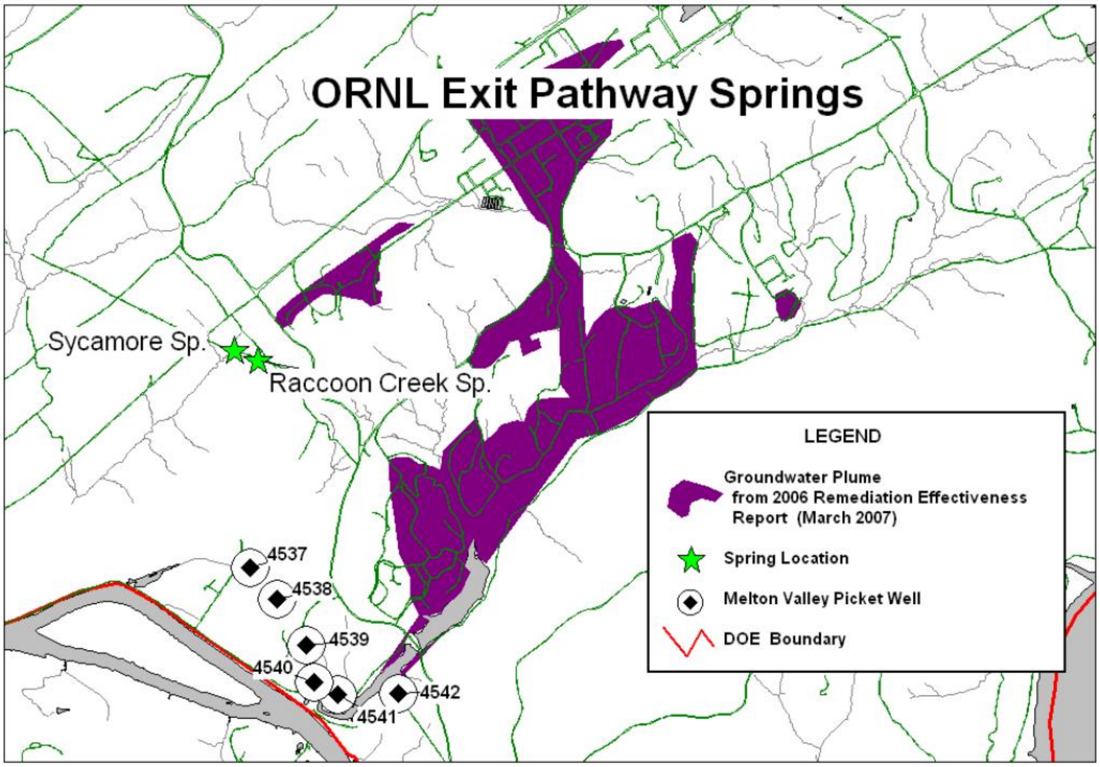

Figure 4: Oak Ridge National Laboratory (ORNL or X-10)

Picket Wells at Melton Valley

Data from the 2006 RER, the Oak Ridge Environmental Information System (OREIS) and DOE, for the Melton Valley exit pathway wells indicate significant radiochemical, heavy metal, fluoride, and volatile organic solvent contamination at depths of 350-500 feet below the ground surface. Additionally, detected radiochemicals such as strontium-90, cesium-137, and cobalt-60 are indicative of contaminants emplaced during the Hydrofracture Project (1959-1984) at depths of 900-1100 feet below the ground surface.

In 2004 and 2005 a series of six picket wells were installed by the DOE across the western terminus of Melton Valley adjacent to the bank of the Clinch River for the purpose of meeting exit pathway monitoring requirements (Figures 4 and 5).

Analytical results published in the 2007 Remediation Effectiveness Report (RER) by DOE, which were reviewed by Division (TDEC/DOE-O) groundwater staff (spring 2007), showed significant radiochemical contamination in Westbay picket wells located along the Clinch River at the southwestern terminus of Melton Valley within the ORR. Average results as high as 936.33 pCi/L gross alpha and 1059 pCi/L gross beta were reported. Further, the contamination was seen in the picket wells at depths well below the base of the Clinch River (300 ft-500 ft below ground surface).

These wells consist of six five-hundred-feet-deep wells equipped with the Westbay multiport sampling system whereby different depth zones can be isolated and sampled. DOE's documented results showed considerable radiochemical contamination at depths significantly below the bottom of the adjacent Clinch River. One zone, 4540-02, at 375 feet below ground surface,

showed a maximum gross alpha result of 2,800 pCi/L. and a maximum gross beta analysis of 2,070 pCi/L. Numerous other zones sampled also showed various radiochemical contaminants.
A review of data entered in the Oak Ridge Environmental Information System (OREIS) showed radio-isotopes characteristic of the Hydrofracture “deep” well injections such as cobalt-60 and strontium-90 had also been detected in the Melton Valley picket wells. Such contaminants in the picket wells strongly suggested that contaminants from the Hydrofracture (1950-1985) injections had been transported as far as the ORR side of the Clinch River.

Split-sampling of the Melton Valley picket wells conducted by the Division Groundwater Program in early 2008 confirmed the presence of the gross alpha emitter uranium in wet chemical analysis by the State Analytical Laboratory. Results showed concentrations far in excess of drinking water limits (MCLs) to be present in zone two of well 4540 (4540-02) where DOE had shown the highest concentrations of gross alpha contamination (89.7 pCi/L in 2007). The MCL for alpha activity is 15 pCi/L. Chromium, 100 ug/L, lead, 21 ug/L and fluoride 5.5 ug/L, were also shown to be present at or above their respective limits which are 100, 15 and 4 respectively.

Of further note is that alkalinity measured as field pH was commonly elevated above 8.5 in the various zones of the Melton Valley picket wells with pH observed as high as 9.5. It should be further noted that directly across the Clinch River from the contaminated picket wells is a cluster of domestic and USGS observation wells showing anomalous elevated alkalinity as well as (in the case of two wells) significant radiochemical, heavy metal, fluoride and volatile organic solvent contamination. These offsite wells are discussed in some detail in the next section.

The demonstrated presence of such significant radiochemical, heavy metal, fluoride, and volatile contamination at significant depths at the DOE boundary is a discovery of the first significance. This could be indicative of contaminant movement from the Melton Valley disposal areas. As the wells are titled picket wells they were thought to be the last line of monitoring for a considerable time.

A further problem is observed with these exit pathway wells completed at depths of five hundred feet when it is known that millions of curies in radiochemicals, as well as other wastes, were disposed of in the Hydrofracture projects at depths of 900-1100 feet below the ground surface. Reason would suggest that any realistic attempt at an installation of exit pathway monitoring wells would be emplaced at the depths to intercept possible contamination.

Aptly demonstrated however, is that the Melton Valley exit pathway wells are indeed monitoring an already-developed plume, not an existing pathway. This suggests that proper exit pathway monitoring must be moved west and across the Clinch River.

Offsite Residential Well and Spring Monitoring
Division monitoring of offsite residential water sources (springs and wells) in 2007 represented a continuation of efforts to monitor potential impacts to groundwater used offsite as a source of drinking water. Criteria used for choosing residential wells and offsite springs to be included in the Division’s sampling and analysis program is dependent on the potential of DOE operations, past or present, to affect the groundwater that supplies the well or spring.

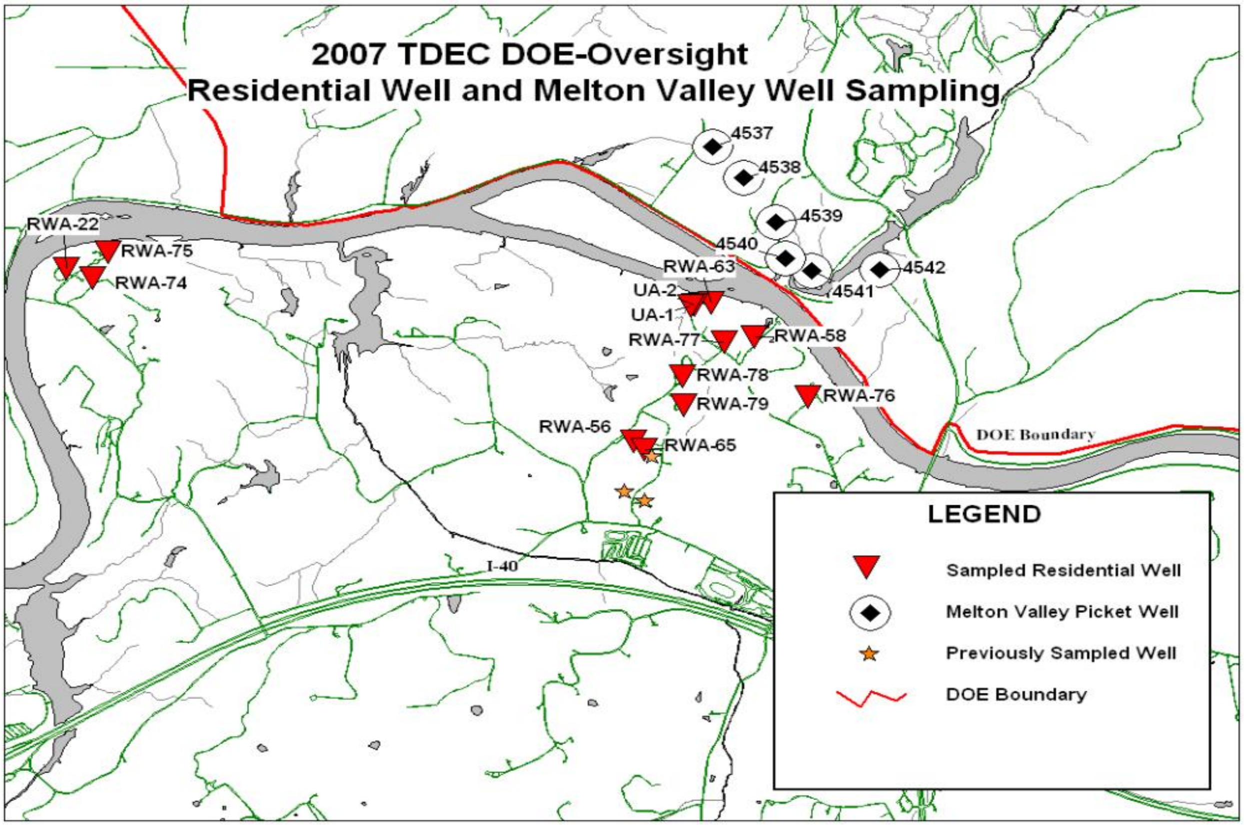

Figure 5: Melton Valley Picket Wells and Residential Well Sampling Area

It should be noted that there are multiple pathways other than the direct migration of contaminants by groundwater movement that must be considered in any rational plan for the monitoring of offsite groundwater that is used or potentially might be utilized for consumption.

The Division's offsite program has concentrated on areas, Figure 5, that have the potential of a direct effect on groundwater offsite. Monitoring has been implemented in wells located directly across the Clinch River from Melton Valley and the Hydrofracture project (which injected significant amounts of radiochemical waste beneath Melton Valley). Additional wells located southwest of the ETTP have been monitored. It is important to recognize that any well in the vicinity may be also impacted by releases that could range from air deposition or contaminated sediments being accessed by wells which are emplaced in alluvial material.

Offsite wells, and in some cases springs, are also generally privately owned and thus the Division is limited to requests for sampling or requesting permission to sample. It is the Division's practice to sample any reasonable site upon request at least once, and to make requests of property owners to sample wells that are located in areas of particular interest.
Results obtained from offsite sampling in 2007 saw three contaminated springs and three contaminated wells: Bootlegger spring (located in the UT arboretum, and discussed in the section on Y-12) USGS 10-895 spring and PCO Seep (located east and west of ETTP and discussed in the ETTP Section). The contaminated wells are all located in what is referred to the Jones Island area directly across the river from the Melton Valley disposal area on the ORR. Also in the Jones

Island area are a number of wells with anomalous water quality parameters, in particular elevated alkalinity.

Two of the contaminated wells are USGS wells installed in the mid-1980s for groundwater observation and are fortunately not used for domestic water supply, as they show consistently elevated levels of uranium, lead and arsenic, as well as an array of radiochemical, metallic, and volatile organic solvent constituents at lesser concentrations. One residential well in the area has shown fluoride concentrations above that considered acceptable for drinking water, and approximately five wells (inclusive of two of the contaminated wells) in the vicinity have shown elevated alkalinity.

The Jones Island area and results of sampling of both the domestic and USGS wells are discussed in detail below.

Another spring, Regina Loves Bobby (located to the north of ETTP and discussed in detail in the ETTP Section), showed a very small amount volatile organic solvents in one sampling event and has shown sporadic tritium in previous years. Speculation as to a possible explanation of this result varies from an air source related to TSCA incinerator operations, to an unknown source of contamination buried on Blackoak Ridge, to the inherent statistical potential associated with radiochemical analysis.

A significant spring, designated Rose Bailey Spring, which feeds the Rose Bailey Lake impoundment and is located approximately seven miles southwest of ETTP, was sampled quarterly in 2007. Rose Bailey is significant as it is a large spring by East Tennessee standards, observed to be producing as much as 150 gallons per minute (gpm) during the drought conditions that existed in September 2005. Rose Bailey Spring also lays along a geologic synclinal structure and within the carbonate Ordovician-age Chickamauga Supergroup, giving ample reason to expect that Rose Bailey Spring represents a regional emergence of groundwater.

While no DOE-related contamination could be identified in samples obtained from Rose Bailey or from two other springs in the area (Love and Dead Horse Spring), Rose Bailey will remain a pivotal part of Division offsite monitoring of groundwater due to its geologic setting and volume of water produced.

Residential Wells

The Division's Groundwater Program responded to documented reports of contamination in the Melton Valley Picket Wells (2006 RER and 2007 RER) by dramatically increasing the frequency of sampling and analysis of offsite residential wells located across the Clinch River from the affected locations, and by actively seeking residential wells in the area which are not included in our sampling regime.

The various residential drinking water wells discussed in this section are all located directly across the Clinch River from Melton Valley. Domestic water in this area (referred to as the Jones Island Area) is supplied by residential wells that are the closest known domestic water wells to contaminated areas on the Oak Ridge Reservation (ORR).

Four of the domestic wells in the area showed elevated field pH (alkalinity). One of the domestic wells saw field pH measurements as high as 10.71 with another showing pH as high as 10.41, which is in excess of the EPA's secondary drinking water limit of 8.5 pH. Elevated alkalinity has been confirmed with multiple field measurements and by subsequent laboratory analysis.

Specific conductivities in this set of domestic and USGS wells are also elevated, showing between 0.500 and 2.600 milli-siemens per centimeter (mS/cm). The highest specific conductivity of 2.610 mS/cm was detected at a domestic well, followed by the UA-2 USGS well that showed 1.655 mS/cm.

One of the domestic wells showed an exceedence of the secondary MCL for fluoride of 2 mg/L with 3.9 mg/L. Another domestic well showed, in one analysis, tritium at levels that, while far below any expected impact regarding health and safety (MCL 20,000 pCi/L), are at levels (493 pCi/L) too high to be accounted for by atmospheric tritium. This is suggestive of the tritium contamination located across the Clinch River in Melton Valley.

A table containing a list of the wells sampled is included as Table 3.

USGS Wells UA-1 and UA-2

Two USGS wells located in the Jones Island Area exceeded MCLs for uranium, lead, arsenic, and fluoride as well as the presence of a number of volatile organic compounds and other toxic metals below their respective drinking water limits. Of note and concern is the proximal location of one of the domestic water wells to the two contaminated USGS wells. The domestic well in question is located within approximately 500 feet of the USGS wells.

USGS UA-1 and UA-2 are wells installed in the mid-1980s by the USGS on behalf of the DOE for the purpose of observing and recording groundwater heads at shallow and intermediate depths. Located adjacent to the river and across, but somewhat downstream, from the mouth of White Oak Creek on the ORR, the two wells can be referred to as paired wells being within approximately twenty feet of each other. UA-1 is completed approximately 60 feet below ground surface and UA-2 at approximately 170 feet.

Table 3: Type of Well Sampling Locations and Dates Sampled

Station	Date	Location Type	Station	Date	Location Type
4537 Zone2	07/26/07	MW	21-002 Spring	03/05/07	SP
4537 Zone3	07/26/07	MW	21-002 Spring	06/07/07	SP
4538 Zone2	07/31/07	MW	Angel Spring	04/11/07	SP
4538 Zone3	07/31/07	MW	Beaver Spring	02/26/07	SP
4539 Zone2	08/01/07	MW	Bootlegger Spring	01/11/07	SP
4539 Zone4	08/02/07	MW	Bootlegger Spring	02/22/07	SP
4539 Zone5	08/02/07	MW	Bootlegger Spring	03/27/07	SP
4539 Zone8	08/06/07	MW	Bootlegger Spring	05/15/07	SP
4541 Zone2	08/07/07	MW	Bootlegger Spring	06/13/07	SP
4541 Zone5	08/07/07	MW	Bootlegger Spring	07/19/07	SP
4541 Zone6	08/07/07	MW	Cabin Spring	03/21/07	SP
4542 Zone4	08/09/07	MW	Cattail Spring	02/22/07	SP
4542 Zone5	08/09/07	MW	Cattail Spring	03/27/07	SP

Table 3: Type of Well Sampling Locations and Dates Sampled (continued)					
Station	**Date**	**Location Type**	**Station**	**Date**	**Location Type**
GW-629	01/09/07	MW	Cattail Spring	05/15/07	SP
UA-1	06/25/07	MW	Cattail Spring	07/19/07	SP
UA-1	08/01/07	MW	Cephus Spring	03/21/07	SP
UA-1	08/29/07	MW	Cress Spring	08/23/07	SP
UA-1	10/18/07	MW	Cross Spring	02/08/07	SP
UA-1	12/18/07	MW	Doug's Drip Spring	03/05/07	SP
UA-2	06/19/07	MW	Fern Spring	03/05/07	SP
UA-2	06/25/07	MW	Gerry's Spring	03/27/07	SP
UA-2	08/01/07	MW	Mt. Vernon Mossy Rock Sp.	03/21/07	SP
UA-2	08/29/07	MW	PCO Seep	03/15/07	SP
UA-2	10/17/07	MW	PCO Seep	12/10/07	SP
UA-2	12/18/07	MW	RCB Spring	03/28/07	SP
UNW-094	06/18/07	MW	Regina Loves Bobby Spring	02/22/07	SP
UNW-095	06/18/07	MW	Regina Loves Bobby Spring	03/05/07	SP
UNW-107	06/18/07	MW	Regina Loves Bobby Spring	06/13/07	SP
Dead Horse Sp.	10/30/07	RW	Regina Loves Bobby Spring	06/27/07	SP
Rose Bailey Sp.	03/29/07	RW	Regina Loves Bobby Spring	07/19/07	SP
Rose Bailey Sp.	06/27/07	RW	Rip Rap Spring	03/20/07	SP
RWA-22	10/29/07	RW	SNS-1	02/08/07	SP
RWA-29	10/30/07	RW	SNS-1	08/23/07	SP
RWA-56	06/19/07	RW	SNS-2	02/08/07	SP
RWA-56	07/31/07	RW	SNS-4	02/08/07	SP
RWA-56	08/28/07	RW	SNS-4	08/23/07	SP
RWA-56	10/03/07	RW	SNS-7	02/08/07	SP
RWA-56	11/29/07	RW	SS-5	01/30/07	SP
RWA-58	08/28/07	RW	SS-5	06/04/07	SP
RWA-58	10/03/07	RW	SS-5	08/16/07	SP
RWA-58	11/15/07	RW	SS-6	01/30/07	SP
RWA-63	06/19/07	RW	SS-6	06/04/07	SP
RWA-63	06/25/07	RW	SS-6	08/16/07	SP
RWA-63	07/25/07	RW	SS-7	01/30/07	SP
RWA-63	08/28/07	RW	SS-7	06/04/07	SP
RWA-63	10/03/07	RW	SS-8	05/31/07	SP
RWA-63	11/15/07	RW	SS-8	08/16/07	SP
RWA-65	06/19/07	RW	Sycamore Spring	03/27/07	SP
RWA-65	07/31/07	RW	Tom’s Seep	01/22/07	SP
RWA-65	08/28/07	RW	Tom’s Seep	06/18/07	SP
RWA-65	10/03/07	RW	Treehole Spring	03/15/07	SP
RWA-65	11/15/07	RW	Tull Spring	04/11/07	SP
RWA-65	11/29/07	RW	USGS 10-895 Spring	01/11/07	SP
RWA-68	08/28/07	RW	USGS 10-895 Spring	02/22/07	SP
RWA-74	03/29/07	RW	USGS 10-895 Spring	03/27/07	SP
RWA-74	06/19/07	RW	USGS 10-895 Spring	04/23/07	SP
RWA-74	10/11/07	RW	USGS 10-895 Spring	05/15/07	SP
RWA-75	10/29/07	RW	USGS 10-895 Spring	06/13/07	SP
RWA-76	08/28/07	RW	USGS 10-895 Spring	10/11/07	SP

Table 3: Type of Well Sampling Locations and Dates Sampled (continued)					
Station	**Date**	**Location Type**	**Station**	**Date**	**Location Type**
RWA-76	10/03/07	RW	USGS 8-900	03/22/07	SP
RWA-76	11/15/07	RW	West Railroad Spring	03/21/07	SP
RWA-77	08/28/07	RW	Wetland Spring	03/28/07	SP
RWA-78	10/29/07	RW			
RWA-78	11/29/07	RW	UA1/UA2	12/4/2007	SO
RWA-79	11/29/07	RW			
BCK 10.1	02/26/07	SW			
BCK 4.55 Weir	01/30/07	SW			
BCK 4.55 Weir	05/31/07	SW			
BCK 9.6	02/26/07	SW			
New Weir	01/30/07	SW			
New Weir	06/04/07	SW			
New Weir	08/16/07	SW			

Note: MW = Monitoring Well
RW =Residential Well
SW = Surface Water
SP = Spring
SO = Soil

One of the two USGS observation wells, UA-2, has shown anomalously elevated field pH (alkalinity). The pH was detected as high as11.13 and therefore the supervisor required the use of eye protection and gloves to protect personnel from the potential caustic effect of contact with this well's water.

Water from UA-2 showed elevated salinity (1.655 mS/cm), and an uneven distribution of various contaminants. Uranium, lead, arsenic, antimony, and fluoride have been detected above safe drinking water standards (maximum contaminant levels -MCLs) in one of the USGS wells, while the other USGS well showed lead, arsenic, and fluoride above MCLs (Table 4). Present in the USGS wells, but shown to be below the MCLs, were strontium-90, gross beta activity, toluene, acetone, PCE, and TCE.

Both USGS wells belong to the DOE and are in considerably less than optimal condition. Well casings show extensive rust and, in the case of the deeper well, UA-2, the casing has been perforated above the grout and ground level by the action of corrosion. Both wells are grouted above ground level within an oversized exterior casing. While the grout is also observed to be in poor condition, showing some fracturing and crumbling, it appears that the actual seal formed by the grout is intact for both wells.

Uranium, arsenic, lead, fluoride, aluminum, barium, lithium, boron, antimony, copper, zinc, cobalt, vanadium, molybdenum, thallium, strontium-90, gross beta, toluene, acetone, PCE, TCE, dichlorobenzene, xylene, benzaldehyde, phenol, , and nitrate have been shown by analysis to be present in one or the other of these two wells (Table 4). UA-2 has consistently shown highly elevated field pH measuring as high as 11.3, while UA-1 consistently shows a more normal groundwater pH between 7.5 and 8.

Table 4 also illustrates the levels of arsenic, lead, fluoride, and antimony (116 µg/L, 110 µg/L, 5.3mg/L, and 6 µg/L respectively) at or above EPA's MCLs (10 µg/L, 15 µg/L, 4mg/L, and 6 µg/L respectively) in USGS well UA-2. This well, not used for domestic water consumption, shows in repeated analyses levels of arsenic, lead, fluoride and antimony above their MCLs shown in BOLD in Table 4.

Uranium and lead in the USGS well designated UA-1 showed extremely high analytical results for samples taken in the month of December 2007 (Table 4). Levels as high as 3312 µg/L for uranium and 5160 µg/L for lead were detected in the water of UA-1. It should be noted that MCLs for uranium and lead are 30 µg/L and 15 µg/L respectively. Arsenic was also shown to be above the MCL of 10 µg/L in the December 2007 analysis with results for arsenic at 22.8 µg/L.

Table 4: Significant Detections and MCL Exceedences in USGS Wells UA-1 and UA-2

Location	Date Collected	Parameter	Result	Units	Rad Error	Method Limit	EPA MCL
UA-1	06/25/07	Tetrachloroethene	0.94	µg/L	N/A	2.00	5
UA-1	08/29/07	Tetrachloroethene	3.32	µg/L	N/A	0.25	5
UA-1	08/29/07	Vanadium	49	µg/L	N/A	2.00	
UA-1	10/18/07	Gross Alpha coppt	0.26	µg/L	0.11	0.21	15
UA-1	**10/18/07**	**Lead**	**35**	µg/L	N/A	1.00	**15**
UA-1	10/18/07	Sodium	14.7	mg/L	N/A	0.10	
UA-1	10/18/07	Strontium	646	µg/L	N/A	5.00	
UA-1	**10/18/07**	**Tetrachloroethene**	**5.66**	µg/L	N/A	0.25	**5**
UA-1	10/18/07	Uranium	24	µg/L	N/A	20.00	30
UA-1	**12/18/07**	**Arsenic**	**22.8**	µg/L	N/A	1.00	**10**
UA-1	12/18/07	Barium	603	µg/L	N/A	100.00	2000
UA-1	12/18/07	Chloroethane	5.85	µg/L	N/A	0.088	
UA-1	12/18/07	Cobalt	26	µg/L	N/A	2.00	
UA-1	**12/18/07**	**Lead**	**5160**	µg/L	N/A	1.00	**15**
UA-1	12/18/07	Lithium	25	µg/L	N/A	0.00	
UA-1	12/18/07	Tetrachloroethene	1.38	µg/L	N/A	0.050	5
UA-1	**12/18/07**	**Uranium**	**3312**	µg/L	N/A	20.00	**30**
UA-2	06/25/07	Tetrachloroethene	1.40	µg/L	N/A	2.00	5
UA-2	08/29/07	Acetone	41.00	µg/L	N/A	2.30	
UA-2	**08/29/07**	**Arsenic**	**115**	µg/L	N/A	1.00	**10**
UA-2	**08/29/07**	**Lead**	**109**	µg/L	N/A	1.00	**15**
UA-2	08/29/07	Toluene	1.15	µg/L	N/A	0.062	1000
UA-2	**10/17/07**	**Antimony**	**6**	µg/L	N/A	3.00	**6**
UA-2	**10/17/07**	**Arsenic**	**130**	µg/L	N/A	1.00	**10**
UA-2	10/17/07	Benzaldehyde	11	µg/L	N/A	6.000	
UA-2	10/17/07	Boron	550	µg/L	N/A	200.00	
UA-2	**10/17/07**	**Fluoride**	**5.3**	mg/L	N/A	0.06	**4**
UA-2	10/17/07	Gross Alpha coppt	0.44	µg/L	0.12	0.22	15
UA-2	**10/17/07**	**Lead**	**93**	µg/L	N/A	1.00	**15**
UA-2	10/17/07	Lithium	14	µg/L	N/A	0.00	
UA-2	10/17/07	Phenol	27.8	µg/L	N/A	0.200	
UA-2	12/18/07	1,4-Dichlorobenzene	0.4	µg/L	N/A	0.080	
UA-2	**12/18/07**	**Arsenic**	**47.6**	µg/L	N/A	1.00	**10**
UA-2	12/18/07	Boron	260	mg/L	N/A	90.00	
UA-2	12/18/07	Chloroethane	6.52	µg/L	N/A	0.088	

Table 4: Significant Detections and MCL Exceedences continued							
UA-2	12/18/07	Fluoride	2.50	mg/L	N/A	0.06	4
UA-2	**12/18/07**	**Lead**	**27.9**	µg/L	N/A	1.00	**15**
UA-2	12/18/07	Lithium	85	µg/L	N/A	0.00	
UA-2	12/18/07	pH	10.60	units	N/A	N/A	
UA-2	12/18/07	Sulfate	73.00	mg/L	N/A	2.00	
UA-2	12/18/07	Tetrachloroethene	1.25	µg/L	N/A	0.050	5

Notes: **BOLD** result greater than MCL; MCL maximum contaminant level; coppt co precipitation method; µg/L micrograms per liter; mg/L milligrams per liter; N/A Not Applicable

Significant results were also seen in UA-1 for aluminum with 3970 ppb which exceeded the EPA's Secondary Maximum Contaminant Level (SMCL) for aluminum (50 to 200 µg/L), with barium 603 µg/L, lithium 25 µg/L, cobalt 26 µg/L and vanadium 13 µg/L also being present.

While adjacent well UA-2 has consistently shown lead arsenic and fluoride above the MCLs for drinking water, December 2007 results for UA-1 were anomalous in that previous results had only shown traces of most of the above listed contaminants with only fluoride being at or above the drinking water MCL. December results were in stark contrast as analysis for uranium and lead showed values far in excess of drinking water standards. A further anomaly was observed regarding the reported numbers for uranium in that reported results for gross alpha and co-precipitated alpha did not indicate the presence of any significant alpha-emitting radionuclide such as uranium. This analysis was performed with both filtered and unfiltered aliquots.

Due to the noted potential significance and the anomalies, it was requested that the State Environmental Laboratory (Laboratory) use archived samples and run duplicates on the metal analysis. This duplicate analysis confirmed the presence of uranium, lead, and arsenic in well UA-l at or above the original reported levels. The uranium and lead analyses were 6126 µg/L and 6670 µg/L respectively. Analysis for uranium was performed on two separate ICP setups and the lead analysis was performed by both ICP and graphite furnace.

It was then requested that archived samples for metals analysis be used for gross and co-precipitated alpha, and that archived, radiochemical samples be used to perform digested metals analysis. This "cross sample" analysis confirmed the presence of uranium, both by wet chemistry and the detected emission of alpha particle radiation. The results of these analyses will be reported in the division's 2008 Environmental Monitoring Report.

Further, the methodology that showed alpha particles in this sample strongly suggests that the uranium present in the sample, and by implication other metals detected in said sample, were in the form of suspended solids, possibly in the form of colloids.
It is suggested that the initial acidification of the radiochemical samples caused the suspended solids to precipitate, and that separation is most likely responsible for the initial failure to detect alpha radiation from the radiochemical sample. In contrast the sample for metals has a much more rigorous digestion process before filtration in that it is both acidified and heated. It is suggested that suspended solids were forced into solution by this process resulting in a more accurate rendering of concentrations for uranium than were shown by the radiochemical analysis.

Composite soil samples were collected by Division groundwater staff on 12/4/07, from the area around and about the two USGS wells, UA-1 and UA-2, and analyzed for metallic constituents by the Laboratory.

EPA Region 9 has published on their website preliminary remediation goals (PRGs) for groundwater (http://epa.gov/region09/waste/sfund/prg/#prgtable). Metals analysis has shown two contaminants, uranium and thallium, that exceed EPA Region 9 PRGs (preliminary remediation goals). Eleven other metals of varying toxicity showed up in concentrations below their respective PRGs. Even though the Oak Ridge Reservation is located in EPA Region 4, the EPA Region 4 observes the use of Region 9 PRGs.

Uranium concentrations of 31 mg/kg and thallium concentrations of 72.5 mg/kg (residential PRGs of 16 mg/kg {ingestion of uranium} and 5.2 mg/kg {combined thallium}) were reported from the soil composite samples obtained in the area. Other metallic contaminants reported in the sample, but below their PRGs, were arsenic barium, beryllium, boron, cadmium, cobalt, copper, lead, and vanadium.

Conclusions

In general, other than Melton Valley and the Jones Island area, the same groundwater successes and concerns identified in previous years can be applied to 2007.

Offsite and Melton Valley

Three wells, two USGS observation wells and one domestic well located directly across the Clinch River from DOE's legacy disposal areas in Melton Valley, are contaminated. Five wells, one of the USGS wells and four domestic wells clustered on the west side of the Clinch River in the same area, show elevated alkalinity (pH). Three wells in the area, one a USGS well, show elevated salinity.

The most significant contaminant concentrations observed were for uranium, lead, arsenic, and fluoride and were found in one or the other of the two USGS wells which are not used for drinking water. One domestic well showed fluoride at or just above the 4 ppm drinking water limit.

The Melton Valley Picket wells, located on the ORR just to the East of the Clinch River and directly across from the impacted USGS and domestic wells, show significant radiochemical, heavy metal, volatile organic and inorganic contamination. Further, the Melton Valley Picket wells show that this contamination exists at considerable depths (400-500 feet below the ground surface). The presence of specific radionuclides strontium-90, cesium-137, and cobalt-60 indicate that wastes injected during the Hydrofracture project are, at least in part, responsible for the contamination seen at depth.

Proximity, geographic distribution, elevated alkalinity (characteristic of Hydrofracture impacted wells), the varied list of contaminants detected, and the single DOE analysis that showed the characteristic legacy radiochemical strontium-90 in the one of the offsite wells suggest that contaminants and alkalinity observed on the west side of the Clinch River in the Jones Island Area may have migrated by one or more mechanisms from the legacy wastes disposal projects in DOE's Melton Valley on the western side of the Clinch River.

Conversely, several factors argue for caution before assigning culpability. First, there is a lack of replication of that radiochemical strontium analysis. Secondly, the other contaminants seen are found outside of the DOE complex. And, thirdly, it is difficult to postulate a groundwater flow regime that would transport contaminants under such a significant river as the Clinch

It is generally accepted that contaminants emplaced by the Hydrofracture project are present at depth on the DOE side of the Clinch and adjacent to the river. Certain depths shown by the Melton Valley Picket wells contain significant concentrations of radiochemical and heavy metal contamination. It is known that the two USGS wells directly across from Melton Valley contain significant concentrations of similar contaminants.

The Melton Valley Picket Well Data, on its own merit, suggest that groundwater resources across the Clinch River are at risk and wells that are completed below the base of the Clinch River are particularly at risk of inducing the flow of contaminated groundwater beneath and across the river. Combined with the identification of contaminated wells opposite the Melton Valley disposal areas and the identification of a number of wells in the area with anomalous water parameters, in particular alkalinity, the Division expects to increase monitoring and to ask DOE to increase monitoring offsite as well.

ETTP

ETTP continues to show contaminated springs and seeps along its eastern and western peripheries.

Y-12

The Union Valley plume from Y-12 continues to show abatement as seen by analysis at its former terminal point of Cattail Spring. Just where the plume terminates has not been established but it is obvious that the Y-12 pump and treatment program has had a welcome measure of success.

The plume originating at the Y-12 Security Pits and emerging at Bootlegger Spring in the UT Arboretum continues to show sporadic results in analysis and appears to be governed by ambient conditions.

Groundwater in and along Bear Creek tended to show a worrisome increase in results for gross alpha in 2006 most likely in relation to remedial activities and the storage of wastes in the EMWMF.

General

Insuring the effective monitoring and surveillance of groundwater plumes is the goal of the Division’s groundwater monitoring program as well as being one of the basic tenants of the Division’s oversight mission.

Given the seriousness and amounts of waste emplaced within the complex hydrogeology of the ORR, effectiveness becomes the key aspect of any monitoring program because current waste in the groundwater will remain for years, decades or even longer. The eventual maturation of plumes and the effectiveness of remediation efforts have been and are problematic.

Groundwater contamination remains one of the most serious environmental problems on the Oak Ridge Reservation. The complexities and sheer quantities of the contaminants, the simple fact that contaminants were disposed of by one means of burial or another, combined with the complex hydrogeologic subsurface environment, creates a monitoring problem for which the word challenging is an understatement.

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Contaminated Groundwater Discharges from the ORNL 7000 Area into White Oak Creek and Tracing Studies on Chestnut Ridge

Principal Author: Sid Jones

Abstract

Groundwater discharging into White Oak Creek from the 7000 area of Oak Ridge National Laboratory is known to be contaminated with volatile organic compounds. A sampling project was proposed in the 2006 DOE Oversight Division Environmental Monitoring Plan to better define discrete discharges of contaminated groundwater into White Oak Creek and its tributaries near the 7000 area. Sampling was first performed in late 2006, and further sampling was carried out early in 2008. At least three such contaminated discharges were located or confirmed. A spring previously reported to have been contaminated, a seep on the south bank of White Oak Creek, and a discharge from a steam line sump pump were found to be contaminated with the solvent trichloroethene and its decomposition products. The distribution of these discharges relative to flow paths inferred from local gradients and geology indicates that multiple sources of these compounds may be present in the 7000 area, and that multiple plumes of contamination may be migrating toward the creek.

Tracing studies using fluorescent dyes to better delineate groundwater flow paths in small watersheds around the Y-12 plant landfills and southeast to the headwaters of White Oak Creek were proposed in the 2007 DOE Oversight Environmental Monitoring Plan. However, due to a shortage of staff with tracing expertise and budget limitations resulting from added sampling in higher priority monitoring projects, no tracing studies were conducted in 2007.

Introduction

Two groundwater monitoring studies in the area along Chestnut Ridge and Bethel Valley between the Y-12 plant and the Oak Ridge National Laboratory were proposed by the Waste Management Section of the DOE Oversight Division in the division's 2006 and 2007 Environmental Monitoring Plans. Tracing studies proposed in 2007 around the Y-12 landfills were not carried out due to a shortage of staff with tracing expertise and budget limitations resulting from added sampling in higher priority monitoring projects. Sampling for volatile organic compounds in the White Oak Creek watershed in Bethel Valley south of the creek's headwaters on Chestnut Ridge, proposed in 2006, was completed in two stages in late 2006 and in early 2008.

Recent sampling in White Oak Creek (WOC) and its tributaries has confirmed that volatile organic compounds (VOCs) are migrating from the 7000 area at Oak Ridge National Laboratory (ORNL) to the creek (Bechtel Jacobs Corporation, 2005). This prior investigation was conducted using a 200 foot sampling interval along the creek channel, and did not have sufficient resolution to locate suspected discrete discharge points for contaminated groundwater. The previous sampling did implicate one tributary spring and a creek reach of less than 750 feet as being the major sources of contaminated groundwater discharge into the creek. In addition, a source area for the plume discharging at the contaminated spring was at least partially defined by drilling. Since more than one source of VOCs was suspected of being present in the ORNL 7000 area, further investigation to better delineate the discharge points of contaminated groundwater was undertaken in December of 2006 and in January of 2008.

The general area of interest was the reach of WOC between the culvert under Bethel Valley Road and the point where it flows under White Oak Avenue near the Hollifield Accelerator. Just north of Bethel Valley Road, the base flow of the WOC sinks in a small swallow hole. Anecdotal evidence suggests that base flow emerges near the ORNL swan pond, roughly along geologic strike with the swallow hole. The flow is presumed to be diverted to subsurface flow paths in the Benbolt or Rockdell limestone, and, during baseflow conditions, the creek remains dry downstream until reaching the confluence with a tributary fed by seeps and drains from the ORNL 7000 area. The stream channel north and east of White Oak Avenue that typically carries baseflow, as well as tributaries to the south and east, were the targets of this investigation. Flow estimates and specific conductance measurements along this reach of creek and in the two main tributaries to the east and south (see Figure 1) revealed no significant loss of water to the subsurface.

The objective of this project was to better delineate discrete discharges of contaminated groundwater along the reach of WOC identified by Bechtel Jacobs Corporation (2005). The stream was sampled for VOCs at intervals of about 50 feet in the area of the Heavy Ion Research Facility. Springs, tributary streams, and a sump discharge for the 7000 area steam line that act as in-feeders to the creek along the reach were also sampled. Sampling in December 2006 was conducted for screening, both to better identify any discrete discharge points such as seeps or drains and to determine stream reaches having no apparent influx of contaminated water. After reviewing data from the first sampling event, re-sampling was carried out in January 2008 to better define discrete discharges of contamination.

Methods

The reach of White Oak Creek (WOC) identified in the *Engineering Study Report for Groundwater Actions in Bethel Valley* (Bechtel Jacobs Corporation, 2005) as having low concentrations of volatile organic compounds was sampled for volatiles. Springs, tributaries, and a sump were also sampled. In an effort to maximize the influence of springs and seeps on water chemistry while minimizing loss of volatiles from the creek to the atmosphere, the monitoring was conducted at a time when streams were at base flow, but temperatures cool. Field parameters were recorded, and stream or spring discharge was estimated. Standard operating procedures for sample collection and analysis, as given by USEPA (1991) and the Tennessee Department of Health Laboratory Services (1999) were used. Sampling locations are displayed in Figures 1 and 2.

Results

Results for the thirteen samples (seven in 2006 and six in 2008) are given in Tables 1 and 2. Samples from upstream locations in White Oak Creek (see Figure 1, locations 3 and 7 and Figure 2, location 5) and in the eastern orifice of the primary spring feeding this reach of the creek (see Figure 1, location 6) were uncontaminated. Volatile organics found in other samples were limited to trichloroethene and its breakdown products, primarily cis-1, 2 dichloroethene.

Figure 1: Locations for December 2006 sampling event in the ORNL 7000 area. Map scale: 1” = 240’.

Table 1. Sampling Results for December, 2006			
Number	**Site Description**	**Trichloroethene (ppb)**	**Dichloroethene (ppb)**
1	White Oak Creek	2.46	3.24
2	Heavy Ion Facility Seep	3.02	6.76
3	White Oak Creek	0	0
4	Spring Fed Tributary	2.02	1.76
5	West Spring	27.0	16.7
6	East Spring	0	0
7	Discharge below outfall 234	0	0

Figure 2: Locations for January 2008 sampling event in the ORNL 7000 area. Map scale: 1" = 240'.

Table 2. Sampling Results for January, 2008			
Number	**Site Description**	**Trichloroethene (ppb)**	**Dichloroethene (ppb)**
1	White Oak Creek	1.51	2.43
2	Heavy Ion Facility Seep	50.2	50.4 (cis1,2); 1.2 (trans1,2)
3	White Oak Creek	0.69	1.81
4	Spring Fed Tributary	1.01	2.03
5	White Oak Creek	0	0
6	Steam line sump discharge	96.0	197.0(cis1,2); 4.1 (trans1,2)

A sample from the western spring orifice (Figure 1, location 5) confirms previous reports identifying this spring as a discharge point for contaminated groundwater south of WOC and White Oak Avenue. Samples from a small groundwater discharge in a bend of WOC adjacent to the ORNL Heavy Ion Research facility (Figures 1and 2, location 2) indicated VOC levels up to about 0.1 parts per million (or 100 ppb). In addition to these natural discharge points, a pumped discharge from a sump associated with the steam line just south of White Oak Avenue (Figure 2, location 6) was found to be contaminated with the same suite of volatile organics.

VOC concentrations in the tributary downstream of the spring (Figures 1 and 2, location 4 were much less than those in the sump discharge or at the Heavy Ion Research seep. Groundwater flow paths in Oak Ridge carbonates and shales are often confined within a narrow stratagraphic zone, and the contaminated spring, seep and sump lie in somewhat different strata. Given these sampling results, it appears possible that unidentified sources of TCE contamination may be present in the ORNL 7000 area.

Conclusions

Analytical results for water samples taken form White Oak Creek and its tributaries show that volatile organic compounds, principally trichloroethene and its breakdown products, are migrating to the creek from one or more sources near the 7000 area of Oak Ridge National Laboratory via groundwater. Contaminated groundwater discharges to surface streams at a minimum of two discrete discharge points. Given the geology of the site and the location of the contaminated discharges, it appears that multiple sources of contamination may impact groundwater in this area. Alternatively, bifurcation of an otherwise strata-bound plume may be caused or enhanced by sump pumps and/or other anthropogenic features in the area.

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RADIOLOGICAL MONITORING

Ambient Gamma Radiation Monitoring of the Uranium Hexafluoride (UF_6) Cylinder Yards at the East Tennessee Technology Park

Principle Author: Robert Storms

Abstract

The Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division), in cooperation with the Department of Energy and Bechtel Jacobs Company, is conducting a radiation dose rate survey of the East Tennessee Technology Park's uranium hexafluoride (UF_6) cylinder storage yards. Dose rate measurements are taken at the perimeter fence lines using Landauer® Luxel® optically stimulated luminescence (aluminum oxide) dosimeters. Monitoring of ambient gamma levels at the UF_6 cylinder storage yards began in April 1999 and has continued to date. The data gathered is being used to determine if areas monitored have exceeded state and/or federal regulatory limits for exposure to members of the public. This data is also being used to determine if environmental concerns are warranted and what, if any, remedial actions are necessary before this property is free-released and/or prior to occupation by companies during the planned reindustrialization of the East Tennessee Technology Park site. All cylinders were removed prior to 2007. Dosimeters remained for one quarter in 2007 to confirm the potential dose was below 100 mrem/yr (the State and federal exposure limit). All potential doses for the quarter were below 8 mrem with the exception of one (11 mrem). This specific location data, along with its corresponding radiological data, will be incorporated into the MapInfo computer program. This will allow the user the ability to locate an individual monitoring point and view its radiological history. A radiological walkover of the perimeter did not find any elevated levels above background.

Introduction

During the development and operation of the gaseous diffusion uranium enrichment process, containers, support equipment, and support facilities were designed, constructed, and used to store, transport, and process depleted UF_6. After a significant inventory was produced, outdoor storage facilities (i.e., cylinder yards) evolved. The goal of the DOE-Oversight UF_6 cylinder yard dose assessment program is to evaluate the level at which the public is protected from radiation doses emitted from the cylinder yards. This is especially important since DOE's mission is the continual transformation of ETTP into a commercial industrial park. As of December of 2006, all cylinders have been removed and shipped to Portsmouth Ohio for final disposition.

Materials and Methods

Dosimeters measure the dose from exposure to gamma radiation over time. The division's cylinder yard monitoring is performed using aluminum oxide dosimeters. These are obtained from Landauer®, Inc., in Glenwood, Illinois. Aluminum oxide dosimeters with a minimum reporting value of 1 mrem are generally placed in areas where exposures are expected to be significantly higher than background (the naturally occurring dose). The dosimeters are collected by division staff and shipped to Landauer® for processing. To account for exposures that may be received in transit or storage, control dosimeters are included in each shipment from the Landauer® Company. The control dosimeters are stored in a shielded container at the division office, and returned to Landauer® with the field-deployed dosimeters for processing. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division offices is subtracted from the exposure reported for the field-deployed dosimeters by Landauer®. Annually, the quarterly exposures (minus the exposure obtained from the control dosimeter) are summed for each location. The resultant annual dose is compared to the State and DOE primary dose limit for members of the public (100 mrem/yr exposure).

Discussion and Results

At the close of 2006, only the K-1066 E, J and L yards had been active. All UF6 cylinders were shipped to Portsmith Ohio by December of 2006. The division's Ambient Gamma Radiation Monitoring Program continued the monitoring of the cylinder yards for an additional quarter in 2007. All dosimeters were below 8 mrems for the quarter, with the exception of one at the K-1066 E yard, which was 11 mrems. A radiological survey with a sodium iodide was conducted around the perimeter of the former UF-6 cylinder yards and no elevated readings were detected. At present, there are no further concerns with the former cylinder yards. Once the radiological barriers are removed by DOE, the division will perform a complete walkover of the sites since vacated by the cylinders removal.

Conclusions

The data show potential doses at the three cylinder yards to be within normal to acceptable ranges of background after the removal of the cylinders. All of the dosimeters were below 8 mrems with the exception of one (11 mrem). In addition, a radiological survey of the perimeter of the cylinder yards, confirmed no elevated readings above normal background. The division will conduct a survey of the area vacated by the removal of the cylinders, once DOE removes the radiological barriers (ropes). The purpose of this project was to monitor the potential dose to the public from the UF6 cylinders. The division will continue to monitor the area under the walkover survey program to insure the area is free from contamination once DOE confirms the yards are no longer a radiological hazard and removes the barrier ropes.

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Facility Survey and Infrastructure Reduction Program

Principal Author: David Thomasson

Abstract

Like other Department of Energy (DOE) research facilities across the nation, the Oak Ridge Reservation released large quantities of hazardous chemicals and radiological contamination into the surrounding environment during nearly five decades of nuclear weapons research and development. Since most of this contamination was released directly from operational buildings, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the Division) developed a Facility Survey Program to document the full histories of facilities on the reservation. The survey program examines each facility's physical condition, process history, inventory of hazardous chemical and radioactive materials, relative level of contamination, past contaminant release history and, present-day potential for release of contaminants to the environment under varying conditions ranging from catastrophic (i.e. earthquake) to normal everyday working situations. This broad-based assessment supports the objectives of Section 1.2.3 of the *Tennessee Oversight Agreement*, which was designed to inform local citizens and governments of the historic and present-day character of all operations on the reservation. This information is also essential for local emergency planning purposes. Since 1994 the Division's survey team has characterized 185 facilities and found that thirty-eight percent have either released contaminants, or pose a relatively high potential for release of contaminants to the environment. In many cases, this high potential-for-release is related to legacy contamination that escaped facilities through degraded infrastructures over decades of continual industrial use (e.g. leaking underground waste lines, substandard sumps and tanks, or unfiltered ventilation ductwork). Since the inception of the program, DOE corrective actions (including demolitions) have removed twenty-six facilities from the Division's list of high Potential Environmental Release (PER) facilities. In 2007, one facility from this list (K-1401-L3) was removed through demolition.

Beginning in 2002, the Facility Survey Program staff also began focusing some of its effort on the oversight of facilities slated for demolition at ORNL and Y-12. This activity was in response to formal, accelerated infrastructure reduction (demolition) programs at each of those sites. During 2007, staff made 99 oversight visits to keep abreast of facility status.

Introduction

The Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the Division), in cooperation with the Department of Energy (DOE) and its contractors, conducts a Facility Survey Program (FSP) on the Oak Ridge Reservation (ORR). The program provides a comprehensive, independent assessment of active and inactive facilities on the reservation based on their 1) physical condition, 2) inventories of radiological materials and hazardous chemicals, 3) levels of contamination, and 4) operational history. The ultimate goal of the program is to fulfill the commitments agreed to by the State of Tennessee and the Department of Energy in Section 1.2.3 of the *Tennessee Oversight Agreement*, which states that "*Tennessee will pursue the initiatives in attachments A, C, E, F, and G. The general intent of these action items is to continue Tennessee's: (1) environmental monitoring, oversight and environmental restoration programs; (2) emergency preparedness programs; and (3) delivery of a better understanding to the local governments and the public of past and present operations at the ORR and potential impacts on human health and/or the environment by the ORR.*" **The overall**

objective of the Facility Survey Program is to provide a detailed assessment of all potential hazards affecting, or in any way associated with, facilities on the Oak Ridge Reservation. To this end, the program evaluates facilities' potential for release of contaminants to the environment under varying environmental conditions ranging from catastrophic (i.e. tornado, earthquake) to normal everyday working situations. This information is also incorporated into local emergency preparedness planning.

Methods, Materials and Evaluating the Potential for Environmental Release (PER)
Survey program staff take a historical research approach to evaluating each facility. Prior to commencing fieldwork they examine engineering documents, past contaminant release information, hazard-screening documents, drain databases, and radiological and chemical inventory data. They then perform a walk-through of the facility with the facility manager to gather additional information and to validate information acquired from previously reviewed documents. During the field visit, calibrated radiation survey instruments are used to estimate radiation contamination and dose levels in and around each facility. At the end of the document review and walk-through process, a final report is produced and information is entered into the Division's Potential for Environmental Release (PER) database. This database helps the team characterize conditions at each facility based on its physical condition and potential for release of contaminants to the environment.

The PER database is composed of ten categories that relate directly to the contents and condition of the operational infrastructure within and around each facility (Table 1). Each category is assigned a score from 0 to 5 (5 reflects the greatest potential for release) for each of the ten categories (Table 1). As facilities are scored, totaled, and compared with each other, a relative ranking emerges. Special circumstances, such as legacy releases and professional judgment also influence category scoring. Scores are not intended to reflect human health risk. Rather, their sole purpose is to help characterize facilities based on the conditions in and around them. This information is used within the Division for information, comparison, and review purposes only.

Table 1: Categories to be Scored

1.	Sanitary lines, drains, septic systems
2.	Process tanks, lines, and pumps
3.	Liquid low-level waste tanks, lines, sumps, and pumps
4.	Floor drains and sumps
5.	Transferable radiological contamination
6.	Transferable hazardous materials contamination
7.	Ventilation ducts and exit pathways to create outdoor air pollution
8.	Ventilation ducts and indoor air/building contamination threat
9.	Radiation exposure rates inside the facility escalated
10.	Radiation exposure rates outside the facility escalated

The final facility survey report notifies DOE of the Division's findings so that DOE has the opportunity to respond and formulate corrective actions. When the division receives written confirmation from DOE of corrective actions taken at a specific facility, the ranking for that facility is modified accordingly in the PER database. The ten categories that are scored and the scoring criteria for each category are presented below in Tables 1 and 2. Table 3 provides a program summary.

Table 2: Potential Environmental Release Scoring Guidelines

Score	Score is based on observations in the field and the historic and present-day threat of contaminant release to the environment/building and/or ecological receptors.
0	**No potential**: no quantities of radiological or hazardous substances present.
1	**Low potential**: minimal quantities present, possibility of an insignificant release, very small probability of significant release, modern maintained containment.
2	**Medium-low potential**: quantities of radiological or hazardous substances present, structures stable in the near- to long-term, structures have integrity but are not state-of-the-art, adequate maintenance.
3	**Medium-high potential**: structures unstable, in disrepair, containment failure clearly dependent on time, integrity bad, maintenance lacking, containment exists for the short-term only.
4	**High potential**: quantities of radiological or hazardous substances present. Containment for any period of time is questionable; migration to environment has not started.
5	**Release:** radiological or hazardous substance containment definitely breached, environmental/interior pollution from structures detected, radiological and/or hazardous substances in inappropriate places like sumps/drains/floors, release in progress, or radiological exposure rates above Nuclear Regulatory Commission (NRC) guidance.
Note: A score of 0 or 1 designates a low Potential Environmental Release rank; a score of 2 or 3 designates a moderate rank; a score of 4 or 5 designates a high rank.	

Discussion and Results

The Facility Survey Program entered its fourteenth year in January 2007. As in previous years, inter-agency staff cooperation was excellent; this facilitated the flow of information related to corrective actions, changes in facility status or mission, decommissioning and decontamination activities, and onsite professional activities.

In accordance with past Division policy, an individual survey conducted on a facility at ETTP that has been leased to private industry might only address those portions of the facility that are leased. Consequently, some older reports may not include adjacent areas in the same facility or related facilities. These adjacent areas and related facilities may be contaminated and/or exhibit infrastructure problems that are not reflected in the report. Therefore, when reviewing these reports, it is important to look for the phrase “leased area of the facility.” This phrase indicates that the survey report covers only the leased area of the facility specifically, and is not intended to assess the entire facility or related facility problems (such as drain lines) that may exist outside of the leased area.

Since program staff is continually in the process of evaluating DOE corrective actions taken to address facility concerns, any current ranking may not reflect the most recent corrective actions. Since the inception of the FSP, corrective actions (including demolition) have removed twenty-seven facilities (X3525, X7823-A, X7827, X7819, X3505, Y9404-3, Y9208, Y9620-2, Y9616-3, Y9959, Y9959-2, Y9736, Y9720-8, K1025-A, K1025-B, K1015, K1004-E, K1004-A, K1004-B, K1098-F, K1200-C, X7055, Y9738, X7700, X7700C, X7701, K1401-L3) from the Division’s list of “high” Potential Environmental Release facilities.

Table 3: Facility Survey Program Summary

	Totals	High PER Facilities	Removed High PER	Facilities Resurveyed	Demolition Visits
A. Facilities surveyed 1994	15	9	0	0	0
B. Facilities surveyed 1995	35	11	0	0	0
C. Facilities surveyed 1996	34	9	0	0	0
D. Facilities surveyed 1997	23	8	0	0	0
E. Facilities surveyed 1998	8	3	1	2	0
F. Facilities surveyed 1999	14	3	0	0	0
G. Facilities surveyed 2000	14	5	3	0	0
H. Facilities surveyed 2001	17	8	1	1	0
I. Facilities surveyed 2002	8	5	5	0	90
J. Facilities surveyed 2003	4	4	0	0	236
K. Facilities surveyed 2004	0	0	2	1	463
L. Facilities surveyed 2005	4	2	7	0	380
M. Facilities surveyed 2006	2	2	7	4	123
N. Facilities surveyed 2007	7	7	1	0	99
O. Totals	**185**	**71**	**27**	**8**	**1391**

Description of the 55 Highest Scoring Facilities (1994-07)

The PER database attempts to reflect the overall condition of a facility and the potential for environmental release. However, it is not the total score of the ten categories that is always the best indicator of potential for environmental release. Rather, what appears to be the most accurate indicator is the number of categories for which a facility scores a four or five (Table 1). Of the 185 facilities scored since 1994, 71 stood out with one or more categories scoring a four or five (Table 4). Twenty six of these facilities have been removed through corrective actions or demolition. The following 55 high-scoring facilities are arranged in descending order of total numbers of fours and fives in the PER database.

At **Y-12**, fifteen facilities had at least one category score of 4 or 5: 9731, 9204-3, 9201-4, 9401-2, 9213, 9743-2, 9203, 9769, 9201-3, 9616-3, 9210, 9224, 9211 and, 9207.

Facility Y9731 is the oldest facility in the Y-12 complex. It originally housed the pilot project for the prototype calutron, and the original production facilities for stabilized metallic isotopes, which were used in nuclear medicine. It received four category scores of 5, two category scores of 4, with a total score of 37. Most of the facility (outside the office area) today is not receiving preventative
maintenance. Process tanks and lines have leaked radiological and hazardous materials throughout the building. Asbestos-containing pipe insulation is peeling and flaking, as is lead-bearing interior and exterior paint. The exhaust fans for the building are not HEPA filtered, and therefore pose a direct pathway to the environment.

Facility Y9204-3 (Beta 3) is one of the original isotope enrichment facilities at Y-12. It received two category scores of 5, three category scores of 4, with a total score of 33. This 250,000 sq. ft. facility is now inactive and locked. The largest concerns are leaking PCB-contaminated mineral oil (Z-oil), and radiological contamination. The building has not been sampled above eight feet for radiological contamination, even though the probability of finding it is great. The building historically and presently vents directly to the environment without HEPA filtration.

Table 4: Potential for Environmental Release for High-Scoring Facilities

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
	DRAIN	TANKS	TANKS	SUMPS	TRANSF	TRANSF	VENT TO	VENT	INT. EXP.	O. EXP.	NUMBER	SURVEY
	LINES	LINES	LINES	DRAINS	RAD.	HAZ.	OUTSIDE	INSIDE	RAD.	RAD.	OF	YEAR
BUILDING	SANI.	PROC.	LLLW	FLOOR	CONT.	CONT.	AIR	SYSTEM	SURVEY	SURVEY	4 and 5's	
X3550	5	5	3	5	4	5	5	5	5	5	9	2006
X3026	2	3	5	4	5	5	5	5	5	5	8	2005
X3029	0	4	4	5	5	5	1	4	5	5	8	2007
X3033	1	4	4	4	4	5	3	2	5	5	7	2007
X3028	0	4	4	3	4	4	4	5	5	3	7	1997
X3517	3	5	5	2	5	3	4	2	5	5	6	2005
Y9731	4	5	1	4	3	5	5	5	3	2	6	2003
K1037-C	0	0	0	0	5	5	5	5	5	4	6	1998
X3030	1	5	5	5	4	5	1	1	1	3	5	2007
X3031	1	4	4	4	4	5	1	1	1	2	5	2007
X3118	1	4	4	4	4	5	1	1	1	2	5	2007
X3033A	0	4	4	4	4	5	3	3	2	2	5	2007
Y9401-2	1	4	1	4	1	5	4	4	1	0	5	2001
Y9204-3	3	5	2	3	4	5	4	4	2	1	5	2000
X3019-B	2	2	5	3	2	3	4	4	4	4	5	1995
K633	3	5	1	4	5	5	2	5	4	5	5	2002
X3032	0	4	4	4	2	5	3	3	2	2	4	2007
Y9201-4	2	5	0	2	2	4	5	5	2	1	4	1998
X3005	2	3	3	2	3	5	3	5	5	4	4	2006
K1004-J	5	5	0	4	3	0	0	0	1	1	3	2000
Y9203	4	2	0	4	2	4	2	2	2	0.5	3	1995
X2545	0	3	5	0	4	2	3	0	0	4	3	1995
K1200-C	1	3	0	1	3	5	2	4	3	4	3	1995
Y9769	1	1	0	4	4	2	1	2	4	2	3	1995
X3020	0	0	5	5	5	0	2	0	0	1	3	1997
X3108	0	0	5	5	5	0	2	2	2	2	3	1997
X3091	0	0	5	5	5	1	2	2	3	2	3	1997
Y9743-2	0	3	0	5	3	5	2	2	2	1	2	2001
X3592	0	3	3	2	4	4	3	3	3	2	2	2001
X3504	1	3	0	4	5	0	2	1	2	2	2	2001
X2531	1	1	2	1	5	2	2	1	2	4	2	2001
Y9213	3	1	5	3	3	5	1	1	1	1	2	2000
X3001	3	1	2	3	3	2	4	4	3	3	2	1995
K1200-S	2	3	0	3	3	2	3	4	2.5	4	2	1995
X7706	4	3	0	4	2	0	2	2	2	2	2	1996
X7707	4	0	0	4	2	3	2	2	0	0	2	1996
Y9959	0	0	0	0	1	4	0	0	1	0	1	2003

Table 4: Potential for Environmental Release for High-Scoring Facilities (cont'd)

	1	2	3	4	5	6	7	8	9	10		
	DRAIN	TANKS	TANKS	SUMPS	TRANSF	TRANSF	VENT TO	VENT	INT. EXP.	O. EXP.	NUMBER	SURVEY
	LINES	LINES	LINES	DRAINS	RAD.	HAZ.	OUTSIDE	INSIDE	RAD.	RAD.	OF	YEAR
BUILDING	SANI.	PROC.	LLLW	FLOOR	CONT.	CONT.	AIR	SYSTEM	SURVEY	SURVEY	4 and 5's	
X3085	1	4	3	3	3	2	1	2	3	3	1	1994
X7602	0	2	0	2	4	2	1	3	2	1	1	1997
K1220-N	0	2	0	0	3	2	2	4	2	3	1	1995
X3002	0	2	0	2	3	1	2	3	4	1	1	1996
Y9210	1	0	0	4	1	1	1	2	1	0	1	1995
Y9224	1	0	0	4	1	1	1	2	1	0	1	1995
Y9211	1	0	0	4	1	1	1	2	1	0	1	1995
Y9207	2	0	0	1	1	4	3	1	1	0	1	1995
X7700-B	0	0	0	0	3	0	2	0	0	4	1	1996
Y9201-3	2	1	0	2	3	5	2	2	2	1	1	1999
*K1401-L3	1	0	0	1	4	2	1	2	3	1	1	1997
*X7055	0	0	0	4	0	1	1	1	0	0	0	1997
*Y9736	0	0	0	0	0	4	2	3	0	0	0	2003
*Y9738	2	0	0	4	2	4	1	1	2	1	0	2002
*X7819	0	0	0	0	0	0	0	0	0	0	0	1994
*X3505	0	0	0	0	0	0	0	0	0	0	0	2000
*Y9620-2	0	0	0	0	0	0	0	0	0	0	0	1994
*Y9208	0	0	0	0	0	0	0	0	0	0	0	1995
*Y9404-3	0	0	0	0	0	0	0	0	0	0	0	1994
*K1025-A	0	0	0	0	0	0	0	0	0	0	0	1995
*K1025-B	0	0	0	0	0	0	0	0	0	0	0	1996
*Y9616-3	0	0	0	0	0	0	0	0	0	0	0	2002
*Y9959-2	0	0	0	0	1	4	0	0	1	0	1	2003
*Y9959	0	0	0	0	0	0	0	0	0	0	0	2003
*Y9736	0	0	0	0	0	0	0	0	0	0	0	2003
*9720-8	0	0	0	0	0	0	0	0	0	0	0	2005
*K1004-B	0	0	0	0	0	0	0	0	0	0	0	2001
*K1004-A	0	0	0	0	0	0	0	0	0	0	0	2001
*K1015	0	0	0	0	0	0	0	0	0	0	0	2002
*K1004-E	0	0	0	0	0	0	0	0	0	0	0	2002

* Denotes demolished facility

Facility Y9201-4 (Alpha 4) is also one of the original Y-12 uranium enrichment buildings. It received three category scores of 5, one category score of 4, with a total score of 28. The containment integrity of the original process system is weak. This has resulted in breaches that have deposited contaminants in unwanted places throughout the building. Evidence suggests that open (non-filtered) exhaust fans have also released contaminants from the interior of the building to the environment for decades. PCBs, asbestos insulation, and chipping/flaking lead-based paint are also found deposited throughout the building.

Facility Y9401-2 (Plating Shop) received four category scores of 4, one category score of 5, with a total score of 25. All of these scores relate to a variety of chemical contamination issues.
Facility Y9213 (Criticality Experiment Facility) received two category scores of 5, with a total score of 24. This facility was built in 1951 and contains two underground neutralization tanks and an underground pit. The tanks and pit present a very high potential for radiological and chemical soil contamination. The areas around the tanks have not been sampled for contamination. The facility also exhibits extensive flaking of exterior lead-based paint.

Facility Y9743-2 (Animal Quarters) received two category scores of 5, with a total score of 20. These scores reflect the uncertainty associated with the lack of radiological and chemical sampling surveys, the complete lack of institutional and process knowledge and, the fact that there are interior tanks and bottles with unknown contents. The probability of biological and chemical contamination is high. There is also a total lack of facility maintenance.

Facility Y9203 (Instrumentation, Characterization Department and Manufacturing Technology Development Center) has three category scores of 4 with a total score of 22.5. Despite much work that has been done to re-route process drains from terminating in the storm sewer system, these drains now go to the sanitary sewer system. This termination still presents a potential pathway to the environment and the public.

Facility Y9769 (Analytical Services Organization) has three category scores of 4 with a total score of 21. The primary hazards associated with this facility are related to the wide variety of toxic materials maintained in the laboratory and the building's drain destination. Exit drains go to the Oak Ridge Sewage Treatment Facility and therefore represent a pathway for contaminants to the city's effluent and/or sludge. Also, the sub-basement area is posted as a contamination area and confined space. Failure of containment could cause a release to East Fork Poplar Creek or to the atmosphere.

Facility Y9201-3 (Alpha 3) received one category score of 5, with a total score of 20. This facility is not receiving any maintenance on its exterior painted surface. Lead-based paint is chipping and is being spread extensively around the building.

Facilities Y9210, Y9211, Y9224 (ORNL Biology) each had one category score of 4 with a total score of 11 for each facility. The original concern regarding each of these facilities was the questionable terminal destinations of their exit drains, which in some cases historically went to the storm sewer system. Written confirmation from the DOE contractor has since shown the correct terminations and corrective actions taken on some of these drains, but there are still undefined and/or inappropriate drain terminations (i.e. lab drains that terminate at the sanitary sewer).

Facility Y9207 (Biology Complex) received one category score of 4, with a total score of 13. In this facility the sinks in a radiological area drain directly to the Oak Ridge sewer system, and thus represent a potential pathway for radiological materials to the city sewage and sludge.

At **ETTP,** five facilities had at least one category score of four or five: K1037-C, K633, K1200-S, K1004-J, and K1220-N.

Facility K1037-C (Nickel Smelter House) received five category scores of 5, one category score of 4, with a total score of 29. This is an old facility in general disrepair. It has numerous roof leaks and is heavily contaminated, both radiologically and chemically. Large scrubber-type vessels located on the east end of the second floor of the barrier production area contain internal radioactive contamination. Discarded contaminated equipment is stored in the building. The facility is posted as a PCB hazard. No corrective actions have been completed at this facility.

Facility K633 received five category scores of 5, and two category scores of 4 with a total score of 33. There is extensive radiological contamination throughout the building, and extensive peeling of exterior and interior paint, which contain PCBs, asbestos, and lead. External soil contamination suggests radiological material has moved to the environment.

Facility K1200-S (Centrifuge Preparation Laboratory, South Bay) received two category scores of 4 with a total score of 26.5. The high score is primarily attributable to the uncertainty of radiological contamination associated with the ventilation system. The interior ductwork and portions of the roof where air is exhausted have not been surveyed for contamination. The potential for airborne release appears great. Equipment inside the facility contains uranium hexafluoride and other hazardous chemicals, and there are numerous radiologically-contaminated storage areas. Confined space entry requirements prevented the Division from performing a survey of the pits below the centrifuges. The greatest release potential for contaminants would be during decontamination and decommissioning activities. *Equipment removal and cleanup is ongoing at this facility. It is expected that the facility will in the future be removed from the division's "high rankers" list.*

Facility K1004-J received two category scores of 5, one category score of 4, with a total of 19. This facility was constructed in 1948 and was originally used for uranium recovery from spent fuel solutions and centrifuge research. It originally included a hot cell, reinforced concrete vaults, a 750-gallon "hot" tank, a 5,500-gallon underground low-level liquid waste tank, and a laboratory. The facility was ranked high in the PER database because of the insufficient knowledge concerning facility infrastructure. First, there is considerable uncertainty over the location and number of active storage vaults under the facility. It is also unknown whether any of these vaults contain radioactive materials or contamination. There is considerable uncertainty over drainpipe connections and their contribution of radiological and chemical contaminants to general area contamination. No corrective actions have been completed at this facility.

Facility K1220-N (Centrifuge Plant Demonstration Facility, North) received one category score of 4 with a total score of 18. The interior ductwork has not been surveyed for radiological contamination and the score reflects a high degree of uncertainty concerning the presence of radionuclides. Uranium residuals are present inside the centrifuge systems. After the centrifuge systems are removed and the criticality and security concerns are addressed, this facility is a candidate for reuse. No corrective actions have been conducted at this facility.

At **ORNL,** twenty-eight facilities had at least one category score of four or five: 3550, 3026, 3029, 3033, 3028, 3517, 3030, 3031, 3118, 3033A, 3019-B, 3032, 7720, 7700B, 2545, 3020, 3108, 3091, 3592, 3504, 3001, 7706, 7707, 2531, 3002, 3085, 7602, and 3517.
Facility X3550 received eight category scores of five, one category score of 4, with a total score of 47. The greatest issue with this facility is radiological contamination. The entire building is a

contamination zone. At the time of the survey, four windows were found open to the environment, which created a direct pathway for contamination to the environment and wildlife. Floor, laboratory, sink and hood drains, which are plumbed to sanitary, storm, and process-collection systems, have contributed to soil and groundwater contamination over time. Radiological contamination was found in the soil directly under a gutter downspout. Contamination was also found in the soil in front of and adjacent to a portable trailer that was used as an analytical laboratory for the building. Excessive flaking and peeling of old lead-based paint from interior and exterior walls has occurred over many years.

Facility X3026 received seven category scores of five, one category score of 4, with a total score of 44. These scores reflect the fact that the physical integrity of this building is severely compromised. The entire facility is a radiological contamination zone, and it contains two banks of four-each contaminated hot cells. Roof holes and broken windows allow the free flow of rainwater and wildlife in and out, and the potential for environmental release of contaminants along this pathway is great. The high level of moisture in the building (from rainwater intrusion) has resulted in mold levels so high that the building is now a designated respirator area. The liquid low-level waste line to which the building is attached has leaked and contributed to soil contamination at the northwest corner of the facility.

Facility X3029 (Radioisotope Production Area/Source Development Lab) received five category scores of 5, three category scores of 4, with a total score of 38. This entire hot cell facility is a posted radiological contamination zone that also contains interior, posted radiation areas. During operation, radiological contamination migrated from hot cells and found its way into floor drains and lines. There is a very high probability that this contamination migrated from drain lines and contributed to soil and ground water contamination. The facility also exhibits old, broken floor tiles (asbestos containing) and extensive peeling of lead-based interior and exterior paint. During its operation, 3029 handled Co-60, Cs-137, Sr-90, Ir-192, C-14, Tc-99, I-131, as well as other radioisotopes. The facility was shutdown in the late 1960s.

Facility X3033 (Krypton and Tritium Facility) received three category scores of 5, four category scores of 4, with a total score of 37. This is another surplus Isotope Circle facility. It was placed in standby mode in the 1990s. The facility also includes a five-foot tall cinder block containment structure that houses four, charcoal-filled stainless steel tanks used for permanent storage of Kr-85. Radiation dose rates are still relatively high around and above the top edge of the wall of this structure. During its operational history, this facility processed C-14, Kr-85, H-3 and probably other radioisotopes. The entire facility is a posted radiological contamination zone, and there is a high probability that the facility has contributed to soil and groundwater contamination via leaky process and low level wastewater collection lines. In a man-hole type of sump near the S.W. corner of the bldg. radiological dose rates approach 10 mR/hr. from Cs-137 contamination.

Facility X3517 received five category scores of five, one category score of 4, with a total score of 39. Despite these relatively high scores, the physical condition of this facility is good, and much effort has gone into decontamination and cleanup work inside the facility. Still, breaches in containment/process systems in the facility resulted in low levels of radiological contamination being distributed throughout. The liquid low level waste system has contributed radiological contamination to the soil and groundwater outside the building.

Facility X3505 (Low Intensity Test Reactor) received three category scores of five, one category score of 4, with a total score of 35. The primary issues with this facility are activation products associated with the reactor, reactor infrastructure, and reactor shielding materials. Radioactive contamination also exists throughout the facility. A leaky roof on the eastern half of the facility has caused excessive, interior mold and mildew buildup. Another concern is the large quantities of flaking and peeling lead-based, PCB-containing paint on the interior and exterior of the building.

Facility X3028 received two category scores of five, five category scores of 4, with a total score of 36. The primary issue with this facility was the relatively large quantity of radiological contamination distributed throughout the building. It also shows extensive peeling and chipping of interior wall paint that is supposed to serve as containment for plutonium contamination. Ongoing corrective actions are occurring at this facility.

Facility X3030 (Radioisotope Production Lab.) received four category scores of 5, one category score of 4, with a total score of 31. This surplus, Isotope Circle facility processed a wide range of radioisotopes during its 50-year operational history, including Co-56, Co-57, Au-198, Fe-55, Np-234, Se-75, Sr-90, Sn-119m, U-237, P-33, and Ir-192. All operations were stopped in the late 1990s. The facility contains “High Contamination” as well as “High Radiation” areas. As with most other Isotope Circle processing facilities, there is a very high probability that 3030 contributed radiological contamination to soil and groundwater via exfiltration from leaky wastewater and process lines. And like many other of these nonoperational surplus facilities, it also exhibits extensive peeling of exterior lead-based paint that is moving into the environment.

Facility X3031 (Radioisotope Production Lab.) received four category scores of 4, one category score of 5, with a total score of 27. This facility was built in 1950 as part of the Isotopes Program and was deactivated in 1997. During its active history, it processed a wide variety of radioisotopes. Today it contains fixed and removable radiological contamination located in “High Contamination” and “Radiation Areas.” Leaky process and low-level waste water collection lines have contributed to soil and groundwater contamination.

Facility X3118 (Radioisotope Production Lab.) received four category scores of 4, one category score of 5, with a total score of 27. The primary issues with this building are: a leaky roof, a leaky process waste water line that has contributed to soil and groundwater contamination and, flaking and peeling lead-based paint throughout the facility.

Facility X3033-A (Actinide Fabrication Facility) received four category scores of 4, one category score of 5, with a total score of 31. This facility contributed to soil and groundwater contamination via leaky process and liquid low level waste lines. Most of the remaining radiological contamination is present in small, fixed hot spots of alpha-emitting transuranics: plutonium, americium, and curium.

Facility X3019-B (High Level Radiation Analytical Laboratory) at ORNL has four category scores of 4, one category score of 5, with a total score of 33. The primary concern with this facility is the very high levels of radiological contamination. The eight hot cells in this facility are “Very High Radiation Areas” and contain many different radionuclides from past operations. The in-cell steam pipes, the off-gas ventilation system, and the ventilation ductwork on the roof are also radiologically contaminated. Also, the laboratory off-gas ductwork located above the hot cells contains perchlorates six times above the maximum recommended by the ORNL Perchloric Acid Committee. Perchlorates are shock sensitive and have the potential to react violently when disturbed. Signage identifying this hazard is posted, and the situation was recently upgraded from an “Off-normal” to an “Unusual Occurrence.”

Facility X3032 (Radioisotope Production Lab. E) received three category scores of 4, one category score of 5, with a total of 29. These scores are primarily related to the fact that leaky process and liquid low level waste lines contributed to soil and ground water contamination. Also, lead-based paint that was used as wall covering thought out the facility is peeling and flaking excessively.

Facility X3001 (Graphite Reactor) at ORNL has two category scores of 4, with a total score of 28. The primary concern with this facility is that there is considerable radiological contamination. The air exhaust shaft that vented the reactor pile is contaminated with cesium-137, strontium-90, and fission products. This is a source releasable to the outside environment if a fire or other event occurred in the ventilation system. Several corrective actions, such as the plugging of drains that went to the sewer system, were recently implemented at this facility.

Facilities X7706, 7720, 7700B (Cooling House, Civil Defense Bunker, Below-ground Outside Source Storage Area) are all part of the Tower Shielding Complex. A survey of this group of facilities resulted in five category scores of 4. The primary issues at this complex of facilities are soil contamination, uncovered activated and contaminated concrete rubble, and drain lines that have direct connections to the environment.

Facility X2545 (Coal Yard Runoff Collection Basins) at ORNL has one category score of 5, two category scores of 4, with a total score of 21. Orphaned, 2- and 6-inch diameter, cast iron Low-Level Liquid Waste (LLLW) lines run through the facility property, and a LLLW line box is posted as a radiation area. The area has been chained off and is overgrown with vegetation. Due to the radiological postings, the cast iron LLLW lines are assumed to be degraded and leaking to the environment. ORNL Environmental Restoration staff has been notified of these lines and their condition, but TDEC has not received written confirmation concerning planned corrective actions.

Facility X3504 (Geosciences Lab) received one category score of 5, one score of 4, with a total of 20. The entire building is a posted contamination area. There is also underground and soil contamination outside of the building.

Facility X2531 (Radiological Waste Evaporator Facility) received one category score of 5, one score of 4, with a total score of 21. This ranking includes #2537 (Evaporator Pit) and #2568 (HEPA filter bldg.). Even though this is a relatively clean, modern facility, it earned these scores because of several areas of transferable radiological contamination and high radiological dose rates surrounding the evaporator pit.

Facility X3592 (Coal Conversion Facility) received two category scores of 4, with a total score of 27. Its original mission was to explore the potential for utilizing liquefied coal as an alternative fuel source. But in later years the facility performed lithium isotope separation using massive quantities of mercury. The scores were given for transferable radiological contamination and mercury contamination found in the drains.

Facility X3002 (HEPA Filter House for the Graphite Reactor) has one category score of 4, with a total score of 18. The primary hazards associated with this building are related to the high level of airborne and other radiological contamination in the roughing filter room, the HEPA filter bank, and the ventilation system. Several corrective actions that were recommended by the Division were implemented at this facility.

Facility X3020 (Radiological stack for bldg. 3019A-B) received three category scores of 5, with a total score of 18. All of the major concerns noted for this facility were related to legacy features that are not part of the present-day operational infrastructure. There is an antiquated, contaminated drain line that was part of the ORNL LLLW system. This line leaked and contributed to surface and subsurface contamination of the general area from the 1940's through the 1970's. It was capped in the late 1970's, but is possibly still contributing contamination. There is also a contaminated, above-grade, single-walled concrete sump box attached to the floor drain system.

Facilities X3108 and 3091 (HEPA filter houses for buildings 3019A-B and Radiological Stack 3020) each received three category scores of 5; #3108 received a total score of 23, and #3091 received a total score of 25. These two facilities are physically connected to the #3020 stack. And like the #3020 stack situation described above, all major concerns noted with these facilities are related to their non-operational infrastructure. Associated with both facilities is a contaminated drain system that went to the LLLW system. This line leaked and contributed to general-area surface and subsurface contamination from the 1940's through the 1970's. It was capped in the late 1970's, but is possibly still contributing to contamination. Both facilities also contain significant levels of radiological contamination, considerable contaminated aboveground ductwork, and contaminated lower-level HEPA filter pits. Both facilities are non-state-of-the-art structures that are adequately maintained.

Facility X3085 (Oak Ridge Research Reactor Pumphouse) received one category score of 4, with a total score of 25. This score was based on the possibility for underground leakage of contaminated water from the 10,000-gallon decay tank, and from the underground valve sump tank located in the front of the building. Two empty, but internally contaminated, above-ground tanks are still tied to underground piping adjacent to the building. Several recommended corrective actions, such as the plugging of floor drains, have been completed at this facility.

Facility X7602 (Integrated Process Development Lab.) received one category score of 4, with a total score of 17. The primary concern with this building was the extensive transferable radiological contamination throughout the facility.

Conclusion

The historic release of chemical and radiological materials from buildings and other facilities on the Department of Energy's Oak Ridge Reservation has led to elevated levels of contaminants in regional terrestrial and aquatic ecosystems. In an effort to understand more about the sources of these contaminants, the Division investigates the historic and present-day potential for release of contaminants from facilities through its Facility Survey Program. During its fourteen-year history the program has examined 185 facilities and found that thirty-eight percent (71) have either contributed to or pose a relatively high potential for release of some contaminant to the environment. These facilities are termed “high rankers” in the program’s Potential for Environmental Release database.

In many cases legacy contamination from degraded facility infrastructure, such as underground waste lines, substandard sumps and tanks, or ventilation ductwork, is generating high scores in the database, and this will continue until antiquated facilities are fully remediated. This is particularly the case at Oak Ridge National Laboratory where many facilities were connected to an aging, leaky underground low-level liquid waste line system. Inactive facilities that are no longer receiving adequate exterior or interior maintenance are also driving high scores. On many buildings, peeling lead-based paint is extensive, and leaky roofs are not uncommon. These conditions will only worsen as time passes, if not remediated. On the other hand, formal infrastructure reduction programs that began at Y-12 and ORNL in 2002 and at ETTP in 2003 are alleviating some of these problem areas.

When facility concerns are noted by the Division, they are relayed to the Department of Energy via the Facility Survey Report so that corrective actions can be formulated. To date, many corrective actions and demolitions have occurred. A total of twenty-seven facilities have been removed from the division’s list of high Potential Environmental Release facilities. Those concerns that have not been corrected to the extent that the Division has reduced the Potential Environmental Release score to less than a “4” are reflected in this report. The rankings are changed when written documentation is received by the Division from DOE. Since the evaluation of corrective actions is an ongoing, time-consuming process, present scores may in some cases not reflect the most recently completed corrective actions.

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Haul Road Radiological Surveys

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Abstract

The Oak Ridge Reservation (ORR) was placed on the National Priorities List (NPL) in 1989, which is generated by the Environmental Protection Agency (EPA). In an effort to identify portions of the ORR that had not been environmentally impacted by past Federal (Department of Energy – DOE) activities, Footprint Reduction was instituted. Its mission was to determine which land parcels could be conditionally released from Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) requirements. CERCLA 120-(h) was used as the guideline by the footprint team for the footprint investigations.

The haul road segment of the project began in 2005 as an oversight of the transport/hauling of radioactive materials on haul roads on the Oak Ridge Reservation. This oversight activity was generated due to a response to a spill (May, 2005) of radioactive materials on a portion of Bear Creek Valley Road. After this spill occurred, haul roads were built in order for the radioactive materials to be transported to the new Environmental Management Waste Management Facility (EMWMF) waste cell in Bear Creek Valley without traveling on public roads. In 2007, the Division conducted weekly walkover surveys of Reeves Road and the new haul road. In October 2007, TDEC was informed by DOE contractors that Reeves Road was not currently being used for waste transport, therefore, no further surveys were performed on this section for the remainder of 2007. With this change, TDEC began a weekly schedule for portion surveys on the new haul road. This project will expand as more haul roads are utilized and/or areas of potential for radioactive contamination and transport are identified.

Introduction

The Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the Division), with the cooperation of the U.S. Department of Energy (DOE) and its contractors, conduct periodic walkover surveys of radiological waste haul roads located within the ORR to evaluate the potential for spills and/or leakage of radioactive materials during transport. This program is in response to a radioactive spill that occurred on Bear Creek Valley Road. As a result of this spill, Bear Creek Valley Road was repaved and designated as a secure road, inaccessible to the general public. The Division, in an effort to protect the environment and the citizens of the State of Tennessee, has decided to survey radioactive material haul/transport roads on the ORR. As of 2007, there are two haul roads being surveyed weekly. They are Reeves Road (ORNL to EMWMF) and the new haul road (ETTP to EMWMF). Walkover surveys are also conducted on an “as needed” basis on other roads within the ORR. Any areas exceeding 200dpm/100cm^2 removable beta, 1000dpm/100cm^2 total beta, 20dpm/100cm^2 removable alpha, and 100dpm/100cm^2 total alpha would require remediation. These values are conservative for these contaminants.

Haul road surveys were conducted on a regular basis during 2007. After being informed that Reeves Road was not currently being used for waste transport; no further surveys were performed on this section for the remainder of 2007. Surveys were conducted using the Ludlum Model 2221 Scaler Ratemeter with the Model 44-10 2X2” NaI Gamma Scintillator. Normal background with this instrument on the Oak Ridge Reservation is 7,000-8,000 cpm. All readings during 2007 surveys were less than 9,000 cpm and most averaged within the range of normal background for this area. Visual inspections were conducted. No areas of concern were noted and no soil staining or vegetation stress was noted.

A field log is produced for each walkover survey and a copy is placed in the files at the Division's office. If any anomalous data is collected during the walkover survey, the information is directed to the TDEC Radiological Monitoring and Oversight Manager and corresponding DOE officials are contacted.

Methods and Materials

Procedures employed during the project are consistent with those contained in the Division's Work Plan for the Walkover Survey Program for field radiological surveys. The area is researched prior to surveying in order to know what type of radioisotopes will be most common to the area. The Walkover Surveys are conducted using a physical approach. Background material in the vicinity is evaluated prior to the survey by conducting a drive through of the area. A walkover survey of the area is then conducted with the use of the Division's radiological detection instruments. The instruments available for use are provided in Table 1.

Table 1: Division of DOE Oversight Portable Radiation Detection Equipment

Radiological Detection Instruments	Radiological Detection Probes	Radioactivity Measured
Ludlum Model 2221 Scaler Ratemeter	Ludlum Model 44-10 2x2" NaI Gamma Scintillator	Gamma (cpm)
Ludlum Model 3 Survey Meter	Ludlum Model 44-9 Pancake G-M Detector	Alpha, Beta, Gamma (cpm)
Ludlum Model 3 Survey Meter	Ludlum Model 43-65 50 cm^2 Alpha Scintillator	Alpha (cpm)
Bicron Micro Rem	Internal 1x1" NaI Gamma Scintillator	Tissue Dose Equivalent, Gamma (μRem/hr)
Bubble Technology Industries Microspec-2	E-Probe With 2x2" NaI Gamma Scintillator	Gamma Spectroscopy (Isotope Identification)

The instrument of choice for most of the road surveys is the Ludlum Model 2221 Scaler Ratemeter with the Model 44-10 2X2" NaI Gamma Scintillator. Other radiological instruments are on hand as necessary.

Two staff members conduct the haul road walkover survey. The staff members visually split the road into halves lengthwise and each staff member surveys one-half of the road by walking in a serpentine motion from side to side along the portion of road they are surveying. The NaI probes are held approximately six to twelve inches above the ground's surface.

Areas with staining of soil or stressed vegetation are noted with the Division's global positioning system device for sampling at a later date. When an area of concern is noted, staff conducts a thorough walkover of the area using the GPS to locate the area of concern with latitude and longitude coordinates. A field log is generated on each trip with the State's findings. The walkover surveys also allow visual inspection of the roads for erosion and trash/garbage/debris that may be on or alongside the haul road. When the surveyors observe instances such as this, they are noted in the field log and surveyed if possible. Areas of concern, as well as other points, are logged to show coverage. A map of the area is printed out with points of interest or concerns plotted. A report is generated with the State's findings. Concerns are brought to the attention of the Federal Facility Agreement (FFA) and/or the Tennessee Oversight Agreement (TOA) project managers for resolution.

Results and Discussion

The objective of this oversight activity is the detection of radionuclides that may have been leaked and/or spilled on radiological transport/haul roads on the ORR. The 2007 objective consisted of bi-monthly surveys of Reeves Road and the new haul road, until such time that Reeves Road was not utilized. At this time, a weekly survey of portions of the haul road was conducted. The Division generates a field log for each site during the walkover survey. The purpose of the oversight activity is to determine the presence of any radionuclides located on the transport/haul roads.

One location on the south end (ORNL side) of Reeves Road was found to contain elevated gamma readings. This reading was collected prior to current haul road activity. The pertinent TOA manager was contacted and the area has subsequently been corded off and marked as a radiological contamination area. To date, this has been the only area found that required FFA/TOA project manager attention. Future work will consist of continuing the walkover surveys until the haul roads are no longer in use.

Conclusions

The continued use of the radioactive material transport/haul roads will require the State's continued walkover surveys in order to adequately determine the potential presence or lack of any radionuclides. The 2008 plan will be to further investigate the ORR haul roads and evaluate the potential for new pathways for any radionuclides to reach public roads from the ORR.

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Ambient Radiation Monitoring on the Oak Ridge Reservation Using Environmental Dosimetry

Principal Author: Robert Storms

Abstract

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division began monitoring ambient radiation levels on the Oak Ridge Reservation in 1995. The program provides conservative estimates of the dose to members of the public from exposure to gamma and neutron radiation attributable to Department of Energy activities on the reservation and establishes baseline values for measuring the need and effectiveness of remedial activities. In this effort, environmental dosimeters have been placed at selected locations on and near the reservation. Results from the dosimeters are compared to background values and the State dose limit for members of the public. In 2007, the doses reported for locations monitored off the reservation were all at levels below the primary dose limit. There was however, an overall increase, compared to the previous year, in the potential of doses reported.

Introduction

Radiation is emitted by various radionuclides that have been produced, stored, and disposed of on the Oak Ridge Reservation (ORR). As a consequence of past activities, both radioactive and toxic wastes contaminate many of the ORR facilities and the surrounding environment. In order to assess the risks posed by radioactive contaminants, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division began monitoring ambient radiation levels on and in the vicinity of the ORR in 1995. In this effort, environmental dosimeters are used to measure the external radiation dose at selected monitoring stations. The program provides:

- conservative estimates of the potential dose to members of the public from exposure to gamma radiation,
- baseline values used to assess the need and effectiveness of remedial actions,
- information necessary to establish trends in gamma radiation emissions, and
- information relative to the unplanned release of radioactive contaminants on the ORR.

Methods and Materials

The dosimeters used in the program are obtained from Landauer, Inc., of Glenwood, Illinois. Each dosimeter uses an aluminum oxide photon detector to measure the dose from gamma radiation (minimum reporting value = 1 mrem). At locations where a potential for the release of neutron radiation exists, the dosimeters also contain an allyl diglycol carbonate based neutron detector (minimum reporting value = 10 mrem). Dosimeters are collected quarterly and sent to Landauer for processing.

To account for exposures received in transit, control dosimeters are provided with each shipment of dosimeters received from the Landauer Company. These dosimeters are stored in a lead container at the Division office during the monitoring period and returned to Landauer for processing with the associated field deployed dosimeters. The vender subtracts the result for the control dosimeter (which should reflect exposures received in transport/storage) from the dose for the field-deployed dosimeters prior to reporting the data.*

As the quarterly data are received from the vendor, staff review the results and compile a quarterly report, which is distributed to DOE and other interested parties. At the end of the year, the quarterly results are summed for each location and the resultant annual dose compared to background values and the State's primary dose limit for members of the public (100 mrem/year above background concentrations and medical applications). Each year, a report of the results and findings are compiled and presented in the Division's annual Environmental Monitoring Report.

Monitoring stations in the program have been broken into six categories. These include background locations (including residential), ORNL sites, Y-12 locations, ETTP locations, the EMWMF and the SNS.

Results and Discussion

It is important to note that the Atomic Energy Act exempts DOE from outside regulation of radiological materials at its facilities, but requires DOE to manage these materials in a manner protective of the public health and the environment. Since access to the reservation has in the past been predominately restricted to employees of DOE or their contractors, locations within the fenced areas of the reservation have traditionally been viewed as inaccessible to the general public. With the reindustrialization and revitalization of portions of the reservation, there has been an influx of workers employed by businesses not directly associated with DOE operations. These individuals are considered members of the general public, several of the sites within the boundaries of the ORR become areas which may pose a risk to these individuals of exceeding the 100 mrem/yr dose limit established by DOE. This program includes monitoring the fence line of ETTP leases and CROET facilities in the vicinity of suspect areas.

State regulations define a member of the public as *any* individual, except those receiving an occupational dose of radiation. In the State regulations, an occupational dose refers to the radiation dose received by an individual employed to perform duties that involve exposures to radiation. The regulations go on to limit the dose to members of the public to 100 mrem/year (above background and medical applications) and the release of radiation to unrestricted areas to a dose of two mrem in any one-hour period. In this context, a restricted area is defined as an area with access limited for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

**Note:* Prior to 2005, control dosimeters were stored unshielded at the Division office during the monitoring period, which, in effect, incorporated background exposures for the monitoring interval into the control dose subtracted from the field dosimeter results. To comply with associated protocol in ANSI N545-1975, staff began, in 2005, to store the control dosimeters in a lead container during the monitoring period. Since the lead container shields the control dosimeter from background radiation, a background measurement is no longer included in the control dose or subtracted from the dose reported for the monitored sites. To evaluate the data, the doses from several background locations (areas that should be unaffected by DOE operations) are included in the data set (e.g., TDEC offices, Norris Dam, Fort Loudoun Dam).

The dose of radiation an individual receives at any given location is dependent on the intensity and the duration of the exposure. For example, an individual standing at a site where the dose rate is one mrem/hour would receive a dose of two mrem, if he stayed at the same spot for two hours. If he or she were exposed to the same level of radiation for eight hours a day for the approximately 220 working days in a year (1,760 hours), the individual would receive a dose of 1,760 mrem in that year. It is important to note that the doses reported in the Division's Ambient Radiation Monitoring Programs are based on the exposure an individual would receive if he or she remained at the monitoring station twenty-four hours a day for one year (8,760 hours). Since this is very unlikely to be the actual case, the doses reported should be viewed as conservative estimates of the maximum dose an individual would receive at each location.

The monitoring locations and associated results for the program can be roughly organized into three categories: (1) stations located off the ORR; (2) sites on the ORR that are, potentially accessible to the public; and (3) locations within restricted areas of the reservation. When reviewing the data, it is important to note that the doses reported for the program include background radiation associated with the site, which would not be included in assessing the dose limit. From these three categories the data is further broken down and reported by locations: (1) offsite, (2) East Tennessee Technology Park, (3) the Oak Ridge National Laboratory, (4) Spallation Neutron Source, (5) Y-12, and (6) the Environmental Monitoring Waste Management Facility

Stations off the ORR

The doses reported for monitoring stations off the reservation (e.g., residential areas) were all well below the 100 mrem dose limit for members of the public. The highest reported levels were found at the Emory Valley Greenway at 69 mrem/yr. 2006 data at this location were estimated at 64 mrem/yr.

ETTP

The doses reported from ETTP and vicinity sites were all below the 100 mrem/yr dose limits for members of the public with one exception, a dosimeter on the west end of Bear Creek Road monitoring potential doses from Energy Solutions. This dosimeter across the street from the facility measured 142 mrem/yr. This is up from 2006 numbers of 108 mrem/yr. This facility is regulated by the Division of Radiological Health (DRH) in Knoxville. The results of this divisions monitoring have been shared with DRH. Other sites monitored under this project include the TSCA Incinerator and the K-27 building.

ORNL

At ORNL there were nine locations that exceeded the 100 mrem/yr dose limits. Seven of these sites are not accessible to the general public and are located within secure areas. The Molten Salt Reactor Experiment exhibited 829 mrem potential dose for 2007. This is up from 2006 numbers of 717 mrem. Other locations include the White Oak Creek Weir at Lagoon Rd (226 mrem/yr), down from the previous year of 263 mrem/yr and the confluence of White Oak Creek and Melton Branch (827 mrem/yr) up from 2006 numbers of 782 mrem/yr. Also worth mentioning is a hot spot on Haw Ridge, discovered during a walkover survey by Division staff in 1996. Numbers here were 218 mrem/yr, similar to the previous year findings of 208 mrem/yr. The fifth area was at the Solid Waste Storage Area 5. The dosimeter placed here received 418 mrem/yr. This is due to the storage tanks located in the area. The highest number received anywhere in the program was at a tulip poplar tree within the cesium forest (24,235 mrem/yr). The previous year's dose was 16,109 mrem/yr. The 33% change is most likely due to repositioning of the dosimeter. The seventh spot mentioned for this section was the cesium forest satellite plot, located near the tulip poplar tree. The dose here was 589 mrem/yr, up from 2006 numbers of 522 mrem/yr. Both of these sites appear to be associated with a 1962 study that injected a group of trees at the location with 360 millicuries of cesium-137 to investigate the isotope's behavior in a forest ecosystem (Witkamp, 1964).

This brings us to the final two areas within ORNL that exhibited potential elevated doses. These two areas are new to the program and are the north and south side of Central Ave. These two sites were read at an estimated 274 mrem/yr. and 102 mrem/yr. respectively. These two areas will continue to be observed and are potentially accessible to the public. However, the likelihood that someone would remain in these spots for 24 hours a day is unrealistic.

Spallation Neutron Source

With the opening of the SNS for research, the Division extended the dosimeter program to cover the site. Currently 16 dosimeters are spread throughout the facility to monitor the potential release of gamma radiation or neutrons. The highest estimated yearly dose from a location within the site, was 48 mrem/yr at the beam tunnel berm.

Y-12

Currently, outside of the EMWMF facility we have dosimeters at three locations within the Y-12 complex. These are the Uranium Oxide Storage Vaults, the Walk-In Pits and the East Perimeter Air Monitoring Station. There were no potential doses above 100 mrem/yr in 2006 or 2007. The Division will continue to monitor for other potential areas for deployment of dosimeters.

Environmental Management Waste Management Facility (EMWMF)

In 2007 the dosimeter program expanded to monitor two locations within the EMWMF complex, the waste cell and the contact water ponds. Dosimeters have been placed around the boundary, on the fence, of each facility. Estimated potential doses do not exceed the 100 mrem/yr dose limit at either facility for 2007.

The dose measurements taken at the K-1420 Decontamination and Uranium Recovery Facility at ETTP have historically exhibited results above the primary dose limit. One of the more contaminated facilities at the site, the building was constructed in 1954 to house decontamination and uranium recovery operations, including the disassembly and chemical decontamination of gaseous diffusion equipment. In 1999, DOE's Reindustrialization Program contracted with a private firm to decontaminate the facility, in exchange for the use of space in the building after the project was completed. The effort was abandoned following a contract dispute and the facility was subsequently scheduled for demolition. This demolition was completed in October 2006 and all debris was removed from the site during December 2006. The dose reported for 2006 (410 mrem) was above the primary dose limit, but that dose is based on the first two quarters of data. The potential yearly dose was estimated at 547 mrem/yr. The building was in the process of being demolished during the third quarter and the dosimeter was lost during the demolition. The fourth quarter dose readings were reported at below the laboratory's minimum detectable quantity of 1 mrem after the building was removed. The dose readings for 2007 were 15 mrem/yr. Again, this is after demolition of the building and removal of the debris.

The situation at ORNL is somewhat different. Land adjacent to the main campus has been deeded to organizations outside of DOE; buildings have been constructed using private funds; and facilities are now occupied by non-DOE contractors (ORAU, 2003). Access to the site is controlled for security purposes, but admittance is allowed with the appropriate visitor's pass. Within the access controlled area, sites have been designated as radiation areas for safety, but the doses measured at the boundary of some of these areas have exceeded the primary dose limit and approached the State's limit for the dose to an unrestricted area.

Conclusion

Overall, the radiation doses measured in the Environmental Dosimetry Program increased in 2007. Off site and background locations were slightly increased as well. However, doses at several locations dropped due to remediation and removal actions. Worthy of mention is the demolition and removal of debris of the K-1420 building.

2007 Results for TDEC monitoring on the Oak Ridge Reservation using Environmental Dosimetry

Station # (Dosimeter)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly & neutron dosimeters are reported semi-annually*	Type of Radiation	Dose Reported for 2007 in mrem *M = Below Minimum Detectable Quantity* 1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	2007 Total Dose **	2006 Total Dose **
	Off Site							
9 (OSL)	Norris Dam Air Monitoring Station (Background)	Gamma	3	11	6	8	28	22*
61 (OSL)	Outer & Illinois Ave	Gamma	2	10	5	Absent	23*	7
62 (OSL)	East Pawley	Gamma	6	10	8	8	32	13*
63 (OSL)	Key Springs Road	Gamma	1	5	4	3	13	9
64 (OSL)	Cedar Hill Greenway	Gamma	2	7	5	6	20	16
65 (OSL)	California Ave	Gamma	M	10	2	5	17	7
66 (OSL)	Emory Valley Greenway	Gamma	23	19	15	12	69	64*
67 (OSL)	West Vanderbilt	Gamma	8	12	12	10	42	30
70 (OSL)	Scarboro Perimeter Air Monitoring Station	Gamma	4	12	14	9	39	31
80 (OSL)	Elza Gate	Gamma	Absent	Absent	3	8	22*	13
86 (OSL)	Loudoun Dam Air Monitoring Station (Background)	Gamma	4	10	5	7	26	15
86a (Neutron)	Loudoun Dam Air Monitoring Station (Background)	Gamma	2	9	6	8	25	19
		Neutron	M	M	M	M		
91 (OSL)	DOE-Oversight Office filing cabinet	Gamma	M	8	M	6	14	10

East Tennessee Technology Park

11 (OSL)	Grassy Creek Embayment on the Clinch River	Gamma	8	10	8	9	35	28*
15 (OSL)	K-1070-A Burial Ground	Gamma	1	10	4	8	23	19
16 (OSL)	K-901 Pond	Gamma	1	6	2	5	14	19
18 (OSL)	TSCA on fence across from Tank Farm	Gamma	8	14	11	10	43	32
21 (OSL)	White Wing Scrap Yard	Gamma	10	18	10	14	52	47
42 (OSL)	K-1401 Building (East Side)	Gamma	3	9	5	7	24	14
43 (OSL)	K-1401 Building (West Side)	Gamma	10	14	Absent	11	47*	39
44 (OSL)	K-25 Building	Gamma	M	8	2	8	18	7
45 (OSL)	K-770 Scrap Yard	Gamma	M	7	2	4	13	4*
47 (OSL)	Bear Creek Road ~ 2800 feet from Clinch River	Gamma	36	36	37	33	142	108
48 (OSL)	K-1420 Building	Gamma	2	8	2	3	15	547*

East Tennessee Technology Park Continued

57	(OSL)	UF_6 Cylinder Storage Yard K-895	Gamma	Absent	9	8	NA	34*	11
58	(OSL)	K-25 Portal 5	Gamma	New	New	New	8	32*	NA
72	(OSL)	ETTP Visitors' Overlook	Gamma	10	Absent	10	14	45*	36
78	(OSL)	ED3 Quarry at Blair Road	Gamma	3	7	6	4	20	9
79	(OSL)	ED1 on pole	Gamma	3	10	7	9	29	32
155	(OSL)	K-27 Building (NW Corner)	Gamma	New	3	3	6	16*	NA
156	(OSL)	K-27 Building (North Side)	Gamma	New	M	1	6	9*	NA
157	(OSL)	K-27 Building (NE Corner)	Gamma	New	3	6	6	20*	NA
158	(OSL)	K-27 Building (SE Corner)	Gamma	New	2	4	3	12*	NA
159	(OSL)	K-27 Building (South Side)	Gamma	New	M	3	2	7*	NA
160	(OSL)	K-27 Building (SW Corner)	Gamma	New	M	4	4	11*	NA
161	(OSL)	TSCA Incinerator (East Side)	Gamma	New	6	7	8	28*	NA
162	(OSL)	TSCA Incinerator (South Side)	Gamma	New	5	7	9	28*	NA
163	(OSL)	TSCA Incinerator (West Side)	Gamma	New	M	3	2	7*	NA

Oak Ridge National Laboratory

20	(OSL)	Freels Bend Entrance	Gamma	5	14	11	9	39	22
22	(OSL)	High Flux Isotope Reactor	Gamma	5	15	8	10	38	33
22a	(OSL)	High Flux Isotope Reactor (duplicate)	Gamma	9	13	12	11	45	36
23	(OSL)	SWSA 5 (South 7828)	Gamma	5	11	6	6	28	41
24	(OSL)	Building X-7819	Gamma	11	15	15	12	53	46
25	(OSL)	Molten Salt Reactor Experiment	Gamma	147	213	244	225	829	717
26	(OSL)	Cesium Fields	Gamma	8	15	12	8	43	29
27	(OSL)	White Oak Creek Weir @ Lagoon Rd	Gamma	53	61	59	53	226	263
28	(OSL)	White Oak Dam @ SR 95	Gamma	6	8	7	6	27	19
30	(OSL)	X-3513 Impoundment	Gamma	6	11	8	10	35	25
31	(OSL)	Cesium Forest boundary	Gamma	19	25	21	23	88	77
31a	(OSL)	Cesium Forest boundary (duplicate)	Gamma	23	25	22	20	90	82
32	(OSL)	Cesium Forest on tree	Gamma	8,606	8,344	4,058	3,227	24,235	16,109
33	(OSL)	Cesium Forest Satellite Plot	Gamma	127	135	182	145	589	522

Oak Ridge National Laboratory (Cont.)

34 (OSL)	SWSA 6 on fence @ SR 95	Gamma	6	13	10	8	37	32
35 (OSL)	Confluence of White Oak Ck & Melton Branch	Gamma	180	197	282	168	827	782
41 (OSL)	North Tank Farm/ Gunnite tanks	Gamma	16	17	17	13	63	58
46 (OSL)	Homogeneous Reactor Experiment Site	Gamma	3	7	4	5	19	28
55 (OSL)	SWSA 5 TRU Waste Trench	Gamma	15	20	20	16	71	77
56 (OSL)	Old Hydrofracture Pond	Gamma	19	24	26	22	91	84
		Gamma	14	27	25	21	87	98
56a (Neutron)	Old Hydrofracture Pond (duplicate)	Neutron	M	M	M	M		
68 (OSL)	White Oak Creek @ Coffer Dam	Gamma	M	5	2	4	11	M
69 (OSL)	Graphite Reactor	Gamma	6	12	11	12	41	38
75 (OSL)	Hot spot on Haw Ridge	Gamma	48	50	70	50	218	208
81 (OSL)	ORNL Visitors' Center	Gamma	4	12	10	5	31	25
		Gamma	89	107	117	105	418	345
87 (Neutron)	SWSA 5 near storage tank area	Neutron	M	M	M	M		
		Gamma	New	New	77	60	274*	NA
166 (Neutron)	Central Ave (North Side)	Neutron	New	New	M	M		
167 (OSL)	Central Ave (South Side)	Gamma	New	New	28	23	102*	NA
84 (OSL)	Tower Shielding Facility @ gate	Gamma	New	New	9	8	34*	NA
85 (OSL)	Tower Shielding Facility @ bunker rubble	Gamma	New	New	8	5	26*	NA

Spallation Neutron Source

		Gamma	M	4	M	2	6	NA
12 (Neutron)	Target Bldg (East Side)	Neutron	Absent	M	M	M		
		Gamma	2	11	M	7	20	NA
17 (Neutron)	Beamdump Bldg 8520	Neutron	M	M	M	M		
		Gamma	M	4	3	4	11	NA
51 (Neutron)	Target Bldg 8702 (South Side)	Neutron	M	M	M	M		
		Gamma	M	7	4	4	15	NA
53 (Neutron)	Central Exhaust Facility	Neutron	M	M	M	M		
		Gamma	M	7	4	2	13	NA
53a (Neutron)	SNS Target Bldg	Neutron	M	M	M	M		

Spallation Neutron Source (Cont.)

73 (OSL)	Water Tower (overlook) North Side	Gamma	M	8	4	5	17	8*
74 (OSL)	Cooling Tower 8913 (South Side)	Gamma	1	7	3	5	16	7
93 (Neutron)	Ring Bldg Perimeter Fence	Gamma	M	9	4	9	22	NA
		Neutron	New	New	M	M		
97 (Neutron)	LINAC Beam Tunnel Berm (East)	Gamma	6	12	8	8	34	NA
		Neutron	New	M	M	M		
98 (Neutron)	LINAC Beam Tunnel Berm	Gamma	New	15	11	10	48*	NA
		Neutron	New	M	M	M		
99 (Neutron)	LINAC Beam Tunnel Berm	Gamma	5	10	4	8	27	NA
		Neutron	New	M	M	M		
100 (Neutron)	LINAC Beam Tunnel Berm	Gamma	New	14	6	12	43*	NA
		Neutron	New	M	M	M		
101 (Neutron)	LINAC Beam Tunnel Berm (West)	Gamma	4	11	6	10	31	NA
		Neutron	New	M	M	M		
102 (Neutron)	LINAC Beam Tunnel Berm	Gamma	New	12	10	7	39*	NA
		Neutron	New	M	M	M		
103 (Neutron)	LINAC Beam Tunnel Berm	Gamma	4	9	5	7	25	NA
		Neutron	New	M	M	M		
104 (Neutron)	SNS Administrative Building	Gamma	New	6	M	5	15*	NA
		Neutron	New	M	M	M		

Y-12

38 (OSL)	Uranium Oxide Storage Vaults	Gamma	4	9	6	6	25	16
39 (OSL)	Walk In Pits (Back side)	Gamma	5	11	7	8	31	18
71 (OSL)	East Perimeter Air Monitoring Station	Gamma	5	13	4	7	29	20

90	(OSL)	Waste Cell Perimeter Fence @ gate	Gamma	6	11	4	7	28	23
92	(OSL)	Contact Water Ponds Fence @ gate	Gamma	New	15	18	14	63*	NA
105	(OSL)	Contact Water Ponds Fence (NW Corner)	Gamma	New	6	14	11	40*	NA
106	(OSL)	Contact Water Ponds Fence (North Side)	Gamma	New	8	11	11	40*	NA
107	(OSL)	Contact Water Ponds Fence (North Side)	Gamma	New	8	14	13	47*	NA
108	(OSL)	Contact Water Ponds Fence (North Side)	Gamma	New	8	14	13	47*	NA
109	(OSL)	Contact Water Ponds Fence (North Side)	Gamma	New	8	14	8	40*	NA
110	(OSL)	Contact Water Ponds Fence (NE Corner)	Gamma	New	6	17	13	48*	NA
111	(OSL)	Contact Water Ponds Fence (East Side)	Gamma	New	7	11	12	40*	NA
112	(OSL)	Contact Water Ponds Fence (SE Corner)	Gamma	New	8	13	13	45*	NA
113	(OSL)	Contact Water Ponds Fence (South Side)	Gamma	New	4	16	13	44*	NA
114	(OSL)	Contact Water Ponds Fence (South Side)	Gamma	New	10	16	12	51*	NA
115	(OSL)	Contact Water Ponds Fence (South Side)	Gamma	New	9	10	11	40*	NA
116	(OSL)	Contact Water Ponds Fence (South Side)	Gamma	New	7	13	10	40*	NA
117	(OSL)	Contact Water Ponds Fence (SW Corner)	Gamma	New	M	13	11	32*	NA
118	(OSL)	Waste Cell Perimeter Fence (SE Corner)	Gamma	New	7	12	12	40*	NA
119	(OSL)	Waste Cell Perimeter Fence (South Side)	Gamma	New	6	15	10	40*	NA
120	(OSL)	Waste Cell Perimeter Fence (South Side)	Gamma	New	8	15	10	44*	NA
121	(OSL)	Waste Cell Perimeter Fence (South Side)	Gamma	New	4	15	13	43*	NA
122	(OSL)	Waste Cell Perimeter Fence (South Side)	Gamma	New	8	9	8	33*	NA
123	(OSL)	Waste Cell Perimeter Fence (South Side)	Gamma	New	6	13	11	40*	NA
124	(OSL)	Waste Cell Perimeter Fence (South Side)	Gamma	New	4	16	11	40*	NA
125	(OSL)	Waste Cell Perimeter Fence (South Side)	Gamma	New	8	15	14	49*	NA
126	(OSL)	Waste Cell Perimeter Fence (South Side)	Gamma	New	10	11	12	44*	NA
127	(OSL)	Waste Cell Perimeter Fence (South Side)	Gamma	New	7	16	16	52*	NA
128	(OSL)	Waste Cell Perimeter Fence (South Side)	Gamma	New	9	14	9	43*	NA
129	(OSL)	Waste Cell Perimeter Fence (SW Corner)	Gamma	New	7	17	11	47*	NA
130	(OSL)	Waste Cell Perimeter Fence (West Side)	Gamma	New	5	15	12	43*	NA
131	(OSL)	Waste Cell Perimeter Fence (West Side)	Gamma	New	7	8	11	35*	NA
132	(OSL)	Waste Cell Perimeter Fence (West Side)	Gamma	New	8	18	14	53*	NA
133	(OSL)	Waste Cell Perimeter Fence (West Side)	Gamma	New	8	16	10	45*	NA

EMWMF (Cont.)

134 (OSL)	Waste Cell Perimeter Fence (West Side)	Gamma	New	M	17	13	40*	NA
135 (OSL)	Waste Cell Perimeter Fence (West Side)	Gamma	New	6	15	12	44*	NA
136 (OSL)	Waste Cell Perimeter Fence (NW Corner)	Gamma	New	10	15	11	48*	NA
137 (OSL)	Waste Cell Perimeter Fence (North Side)	Gamma	New	7	21	18	61*	NA
138 (OSL)	Waste Cell Perimeter Fence (North Side)	Gamma	New	9	19	13	55*	NA
139 (OSL)	Waste Cell Perimeter Fence (North Side)	Gamma	New	7	19	11	49*	NA
140 (OSL)	Waste Cell Perimeter Fence (North Side)	Gamma	New	2	9	8	25*	NA
141 (OSL)	Waste Cell Perimeter Fence (North Side)	Gamma	New	4	14	10	37*	NA
142 (OSL)	Waste Cell Perimeter Fence (North Side)	Gamma	New	10	19	13	56*	NA
143 (OSL)	Waste Cell Perimeter Fence (North Side)	Gamma	New	8	19	14	55*	NA
144 (OSL)	Waste Cell Perimeter Fence (North Side)	Gamma	New	9	20	12	55*	NA
145 (OSL)	Waste Cell Perimeter Fence (North Side)	Gamma	New	6	19	14	52*	NA
146 (OSL)	Waste Cell Perimeter Fence (North Side)	Gamma	New	11	16	11	51*	NA
147 (OSL)	Waste Cell Perimeter Fence (NE Corner)	Gamma	New	6	17	9	43*	NA
148 (OSL)	Waste Cell Perimeter Fence (East Side)	Gamma	New	6	14	11	40*	NA
149 (OSL)	Waste Cell Perimeter Fence (East Side)	Gamma	New	6	17	11	45*	NA
150 (OSL)	Waste Cell Perimeter Fence (East Side)	Gamma	New	8	17	13	51*	NA
151 (OSL)	Waste Cell Perimeter Fence (East Side)	Gamma	New	6	15	11	43*	NA
152 (OSL)	Waste Cell Perimeter Fence (East Side)	Gamma	New	4	12	12	37*	NA
153 (OSL)	Waste Cell Perimeter Fence (East Side)	Gamma	New	5	14	12	40*	NA
154 (OSL)	Waste Cell Perimeter Fence (East Side)	Gamma	New	5	14	13	43*	NA

Notes: Two types of dosimeters are used in the program, optically stimulated luminescent dosimeters (OSLs) and neutron dosimeters. The OSLs measure the dose from gamma radiation, which is considered sufficient for most of the monitoring stations. The neutron dosimeters, which have been placed at selected locations, measure the dose from neutrons in addition to the gamma radiation. At the locations where the neutron dosimeters have been deployed, the total dose is the sum of the doses reported for neutrons and the dose reported for gamma radiation. The primary dose limit for members of the public specified in both DOE Orders and 10 CFR Part 20 (Standards for Protection Against Radiation) is 100 mrem total effective dose equivalent exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

M = Below minimum detectable quantity (1 mrem for gamma, 10 mrem for thermal neutrons)

NA = Not applicable due to the dosimeter placement location changing from the 2006 location.

Absent = The dosimeter was not found at the time of collection.

New- Location was not in service during the quarter or the dosimeter was changed to a Neutron.

*The dose reported for this station is based on an estimated total yearly dose (less than four quarters of data were reported for this station).

** A control dosimeter is provided with each batch of dosimeters received from the vendor. The control dosimeters are used to identify the portion of the dose reported during processing due to radiation exposures received in storage and transit. The dose reported for the control dosimeter is subtracted from the dose reported for each field-deployed dosimeter. Beginning in 2005, background derived from the dose at the Division's offices is no longer subtracted from the results for the individual sites. As a consequence, data reported for 2005 can be expected to be slightly higher than in past years (up to ~15 mrem/quarter). The change is most notable at locations that were near or below the background measurement.

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Real Time Ambient Gamma Monitoring of the Oak Ridge Reservation

Principal Authors: Natalie Pheasant, Gary Riner, Howard Crabtree

Abstract

In 2007, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division placed gamma exposure rate monitors at seven locations (shown in Figure 1):

- Background location (Fort Loudoun Dam),
- ORNL Truck Monitor Station (7000 Area),
- On the fence near the front gate at Oak Ridge National Laboratory's Molten Salt Reactor,
- Weigh-in station at the Environmental Management Waste Management Facility in Bear Creek Valley, near the Y-12 National Security Complex,
- Weigh-in station at the ETTP haul road scale (located at Portal 6 on the haul road connecting ETTP and the Environmental Management Waste Management Facility),
- TRU Processing Facility at ORNL, and
- Oak Ridge National Laboratory's Corehole 8 area.

Measurements collected from these sites ranged from background levels to 802 μrem/hour. All results, were below limits specified by State and Nuclear Regulatory Commission regulations, requiring their licensees to conduct operations in such a manner that assures external potential dose in any unrestricted area does not exceed 2.0 millirem (2,000 μrem) in any one-hour period.

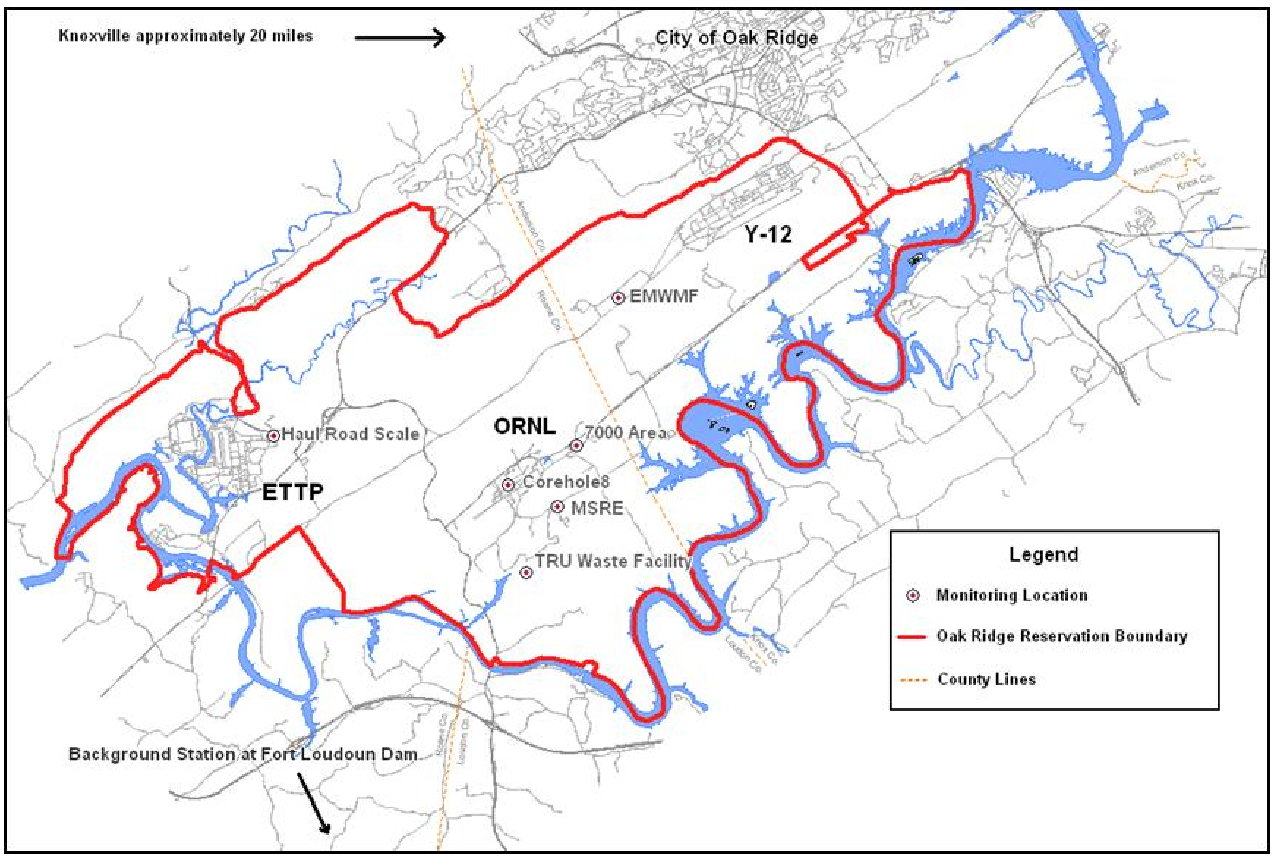

Figure 1: 2007 Placement of exposure rate monitors on the Oak Ridge Reservation.

Introduction

The Tennessee Department of Environment and Conservation (TDEC) DOE Oversight Division (the Division) has deployed continuously-recording exposure-rate monitors on the Oak Ridge Reservation (ORR) since 1996. While the environmental dosimeters used in the Division's ambient radiation monitoring program provide the cumulative dose over the time period monitored, the results cannot account for the specific time, duration, and magnitude of fluctuations in the dose rates. Consequently, when using dosimeters alone, a series of small releases cannot be distinguished from a single large release. The continuous-exposure-rate monitors can record gamma radiation levels at short intervals (e.g., one minute), providing an exposure-rate profile that can be correlated with activities or changing conditions at a site. The instruments have primarily been used to record exposure rates during remedial activities and to supplement the integrated-dose rates provided by the Division's environmental dosimetry program.

Methods and Materials

In 2007, exposure-rate monitors were placed at seven locations. The monitors used in the program are manufactured by Genitron Instruments and marketed under the trade name GammaTRACER. Each unit contains two Geiger-Mueller tubes, a microprocessor-controlled data-logger, and lithium batteries. All units are sealed in a weather resistant case to protect the internal components. The instruments can be programmed to measure gamma exposure rates from 1 μrem/hour to 1 rem/hour at predetermined intervals (one minute to two hours). The results reported are the average of the measurements recorded by the two Geiger-Mueller detectors, but data from each detector can be accessed if needed. Information recorded by the data-loggers is downloaded to a computer using an infrared transceiver and associated software. Monitoring in the program focuses on the measurement of exposure rates under conditions where gamma emissions can be expected to fluctuate substantially over relatively short periods and/or where there is a potential for an unplanned release of gamma-emitting radionuclides to the environment. Candidate monitoring locations include remedial activities, waste disposal operations, pre- and post-operational investigations, and emergency response activities.

Results recorded by the monitors are evaluated by comparing the data to background measurements and State radiological standards.

Results and Discussion

The amount of radiation an individual can be exposed to is restricted by state and federal regulations. The primary dose limit for members of the public specified by these regulations is a total effective dose equivalent* of 100 mrem in a year. Since there are no agreed upon levels where exposures to radiation constitute zero risk, radiological facilities are also required to maintain exposures as low as reasonably achievable (ALARA). Table 1 provides some of the more commonly encountered dose limits.

The unit used to express the limits (rem) refers to the dose of radiation an individual receives: also stated, the radiation absorbed by the individual. For alpha and neutron radiation, the measured

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* Dose equivalent is the product of the absorbed dose in tissue and a quality factor. Total Effective Dose Equivalent means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). The deep-dose equivalent refers to the dose equivalent in tissue at 1 cm derived from external (penetrating) radiation. Dose contributions from background radiation and medical applications are not included in the dose calculation.

quantity of exposure, roentgen (R), is multiplied by a quality factor to derive the dose. For gamma radiation, the roentgen and the rem are generally considered equivalent. The more familiar unit, rem, is used in this report to avoid confusion. It is important to note that the monitors used in this program only account for the doses attributable to external exposures from gamma radiation. Any dose contribution from alpha, beta, or neutron radiation would be in addition to the measurements reported.

Table 1: Commonly encountered dose limits for exposures to radiation

Dose Limit	**Application**
5,000 mrem/year	Maximum annual dose for radiation workers
100 mrem/year	Maximum dose to a member of the general public
25 mrem/year	Limit required by State regulations for free release of facilities that have been decommissioned
2 mrem in any one hour period	The State limit for the maximum dose in an unrestricted area in any one hour period

Fort Loudoun Dam Background Station

Background exposure rates fluctuate over time due to various phenomena that alter the quantity of radionuclides in the environment and/or the intensity of radiation being emitted by these radionuclides. For example, the gamma exposure rate above soils saturated with water after a rain are expected to be lower than the rate over dry soils because the moisture shields radiation released by terrestrial radionuclides. To better assess exposure rates measured on the reservation and the influence that natural conditions have on these rates, Division staff maintains one gamma monitor at Fort Loudoun Dam in Loudon County to collect background information. From January 1, 2007 through December 31, 2007, exposure rates averaged 9.6 μrem/hour and ranged from 8 to 18 μrem/hour.

On average, individuals in the United States receive a dose of approximately 300 mrem/year from naturally occurring radiation. Most of this dose is from internal exposures received as a result of breathing radon and associated daughter radionuclides.

The ORNL Truck Monitor (7000 Area)

Trucks haul waste from ORNL to the Y-12 Industrial Landfill, a facility permitted by TDEC's Division of Solid Waste Management with the provision that the facility shall not dispose of radioactive wastes. Wastes trucks are screened before leaving the ORNL site at a radiation monitor in the 7000 area. Trucks are screened again at the Y-12 Industrial Landfill prior to disposal at the facility.

On July 16, 2007, staff placed a gamma monitor at the ORNL Truck Monitor to measure gamma activity before the trucks leave the ORNL Site. The monitor was programmed to increase the frequency of measurements recorded from fifteen-minute intervals to one-minute intervals, if exposure levels exceeded 20 μrem/hour. To date, all results have been similar to background measurements. During the monitored period (July 16, 2007 to December 31, 2007), the measurements ranged from 4 to15μrem/hour and averaged 6.4 μrem/hour (Figure 2).

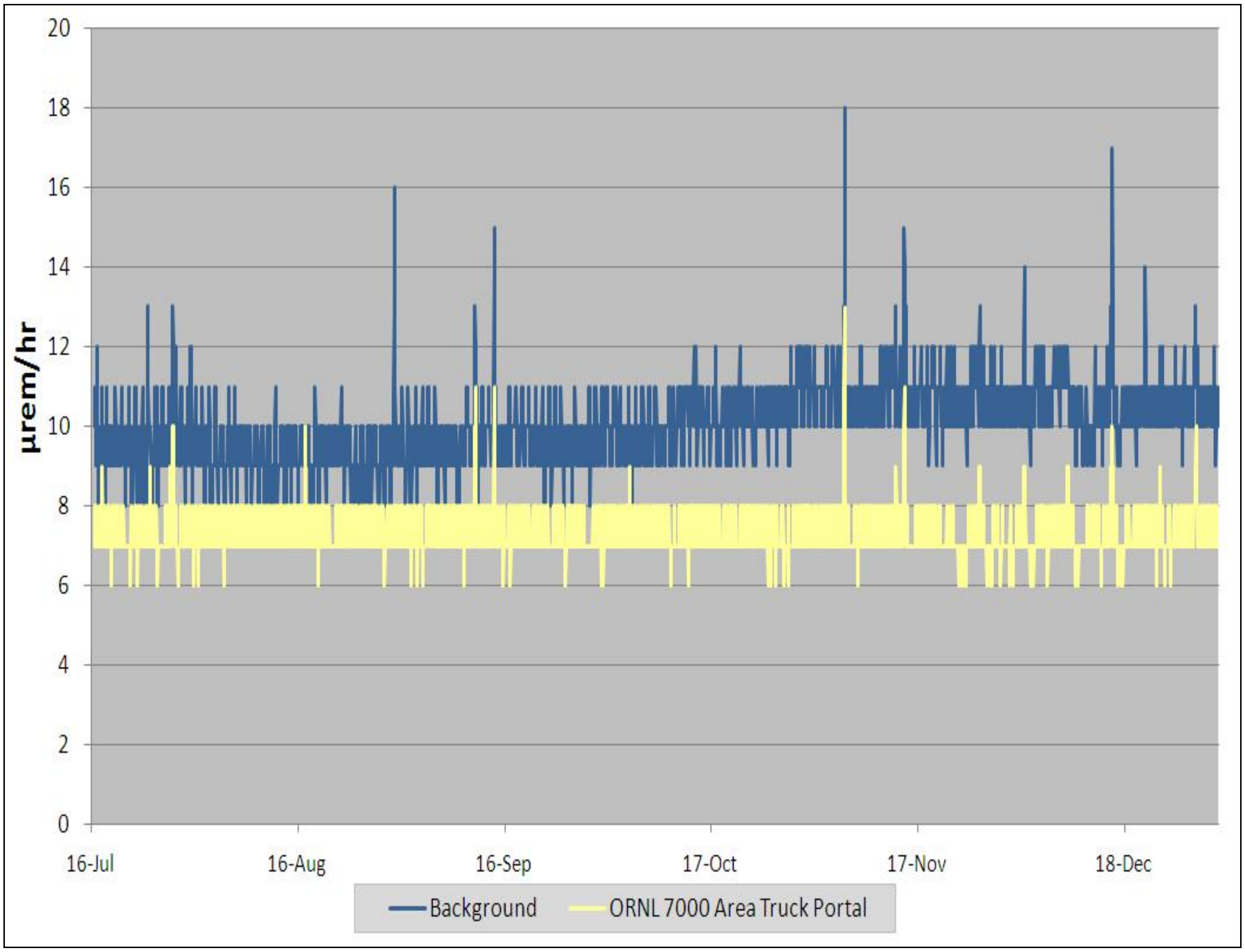

Figure 2: 2006/2007 Gamma exposure rates measured at the entrance to the ORNL 7000 Area Truck Monitor and the background station at Fort Loudoun Dam

The State dose limit to an unrestricted area is 2 mrem (2,000 µrem for gamma) in any one-hour period. The State dose limit for members of the public is 100 mrem in a year.

The Molten Salt Reactor Experiment (MSRE)

The concept of a molten salt reactor was first explored at ORNL in association with a 1950s campaign to design a nuclear powered airplane. After interest in an atomic airplane subsided, the Molten Salt Reactor was constructed to evaluate the feasibility of applying the technology to commercial power applications. The concept called for circulating uranium fluoride (the fuel) dissolved in a molten salt mixture through the reactor vessel. The Molten Salt Reactor achieved criticality (a chain reaction resulting in a release of radiation) in 1965 and was used for research until 1969.

When the reactor was put into shutdown mode, the molten fuel salts and flush salts were transferred to drain tanks and allowed to solidify. In 1994, an investigation of the MSRE discovered elevated levels of uranium hexafluoride and fluorine gases throughout the off-gas piping connected to the drain tanks. Among other problems, uranium had migrated through the system to the auxiliary charcoal bed, creating criticality concerns. Actions were taken to stabilize the facility and a CERCLA Record of Decision was issued in July 1998, requiring the removal, treatment, and safe disposition of the fuel and the flushing of salts from the drain tanks.

During 2007 (Figure 3), staff recorded gamma exposure rates with a monitor placed near the gate where the trucks containing radioactive materials (fuel removed from the drain tanks) exit the MSRE and transport it to a storage area.

During the 2007 sampling period, the average rate was 19.7μrem/hour with a minimum of 9 μrem/hour and a maximum of 128 μrem/hour. The increase is attributed to radioactive material stored inside the boundary fence near the monitor. The highest rate (128 μrem/hour) occurred on February 22, 2007.

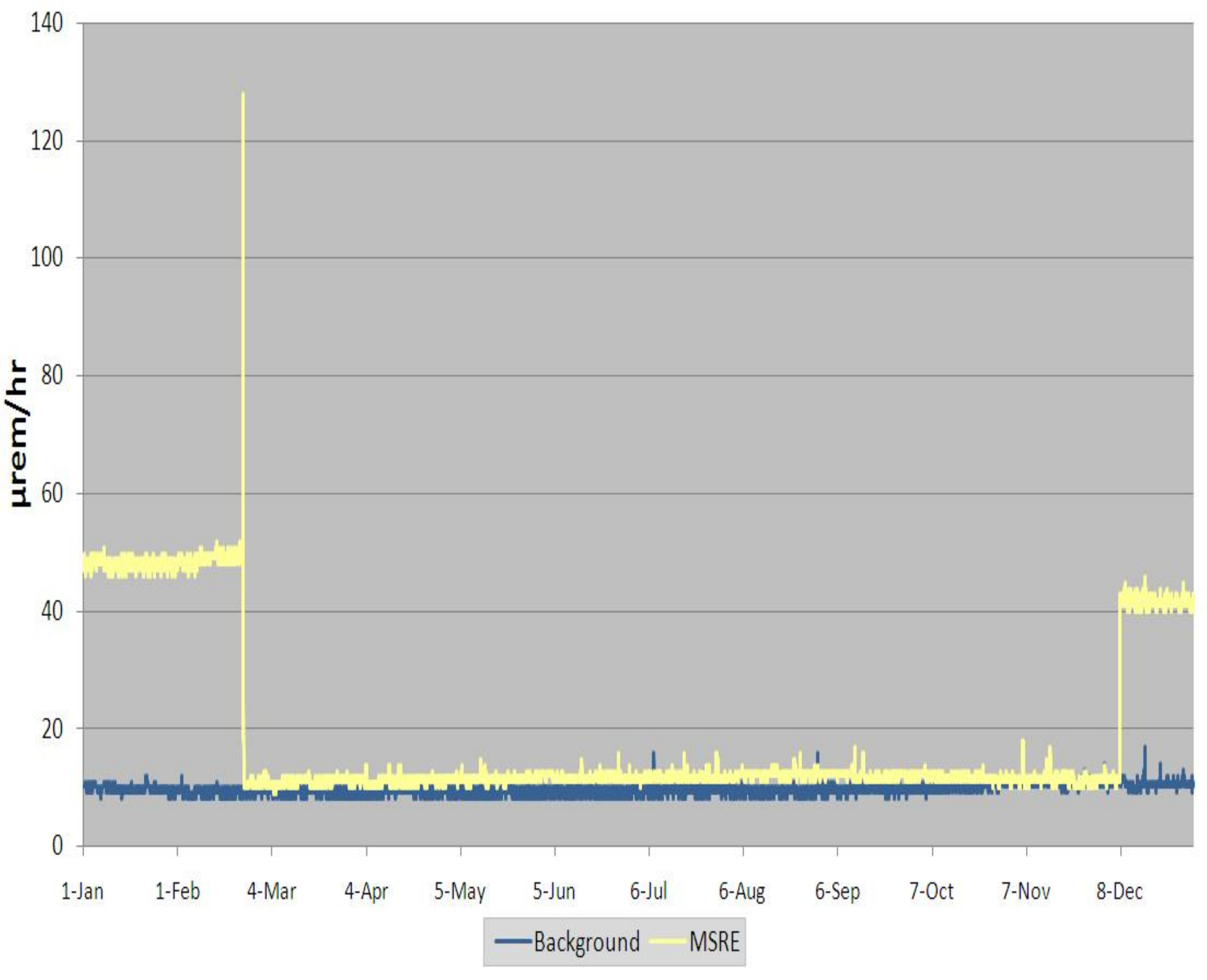

Figure 3: 2007 Gamma exposure rates measured at the gate of MSRE and at the background station at Fort Loudun Dam

The State dose limit to an unrestricted area is 2 mrem (2,000 μrem for gamma) in any one-hour period. The State dose limit for members of the public is 100 mrem in a year.

The Environmental Management Waste Management Facility (EMWMF)

The EMWMF was constructed in Bear Creek Valley (near the Y-12 Plant) to dispose of wastes generated by CERCLA activities on the ORR. The EMWMF relies on a waste profile provided by a generator to characterize waste disposed of in the facility. This profile is based on an average of the contaminants in a waste lot. Since the size of waste lots can vary from a single package to many truckloads of waste, the averages reported are not necessarily representative of each load of waste transported to the facility. That is, some loads may have highly contaminated wastes, while other loads may contain very little contamination.

To attain an understanding of the variability in radioactive waste disposed of at the EMWMF, a gamma monitor was secured at the facility's check-in station on August 27, 2002. Each truck transporting waste for disposal is required to stop at this location while the vehicle/waste is weighed and the driver processes the associated manifest. In 2007, the monitor was programmed to record measurements at fifteen-minute intervals at exposure rates below 40 μrem/hour and at one-minute intervals at exposure levels above 40 μrem/hour.

When waste containing gamma emitters are not near the weigh station, the data reflects exposure levels similar to background measurements. As the trucks carrying gamma emitters pull onto the scale, the exposure levels increase, peak as the waste moves past the monitor, then abruptly decline as the trucks leave the area. While relatively high measurements can be observed in the data, the durations of the elevated readings are only a few minutes. This, coupled with the monitor's inability to read alpha and beta emissions, results in relatively low average values when compared to the maximum exposures measured.

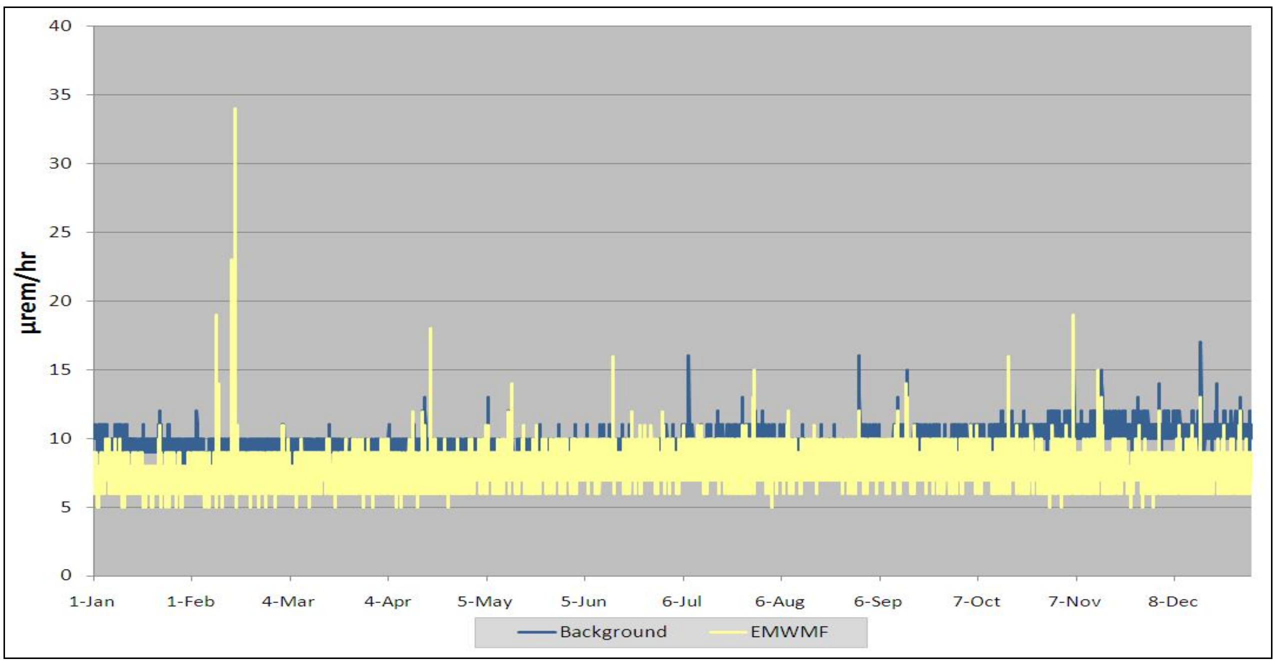

Figure 4: 2007 Results of gamma exposure rate monitoring at the weigh-in station for the Environmental Management Waste Management Facility and at the background station

The State dose limit to an unrestricted area is 2 mrem (2,000 μrem for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

In 2007, the measurements taken at the EMWMF averaged 7.8 μrem/hour. The maximum value, recorded was 134 μrem/hour and the minimum was 5μrem/hour (Figure 4).

The ETTP Haul Road Scale

A dedicated haul road from ETTP to the EMWMF is used to transport wastes generated by CERCLA activities at ETTP. Trucks departing ETTP cross a scale located near Portal 6. Trucks crossing this scale are not weighed at the scale at the EMWMF. Beginning on January 30, 2007, a gamma instrument was placed at the scale.

Trucks carrying gamma emitters pull onto the scale and the exposure levels increase. Peak levels are reached as the waste moves past the monitor, followed by an abrupt decline as the trucks leave the area. While higher measurements can be observed in the data, the duration of the elevated readings is only a few minutes. This, coupled with the monitor's inability to read alpha and beta emissions, results in relatively low average values when compared to the maximum exposures measured. This is especially significant at this site as contaminants found at the ETTP site are mostly alpha emitters with some beta emitters. None of this radiation is recorded on the exposure rate monitors, which are used to measure only gamma radiation. Rates during the monitoring period ranged from four to 15 μrem/hour with an average of 6.4 μrem/hour (Figure 5).

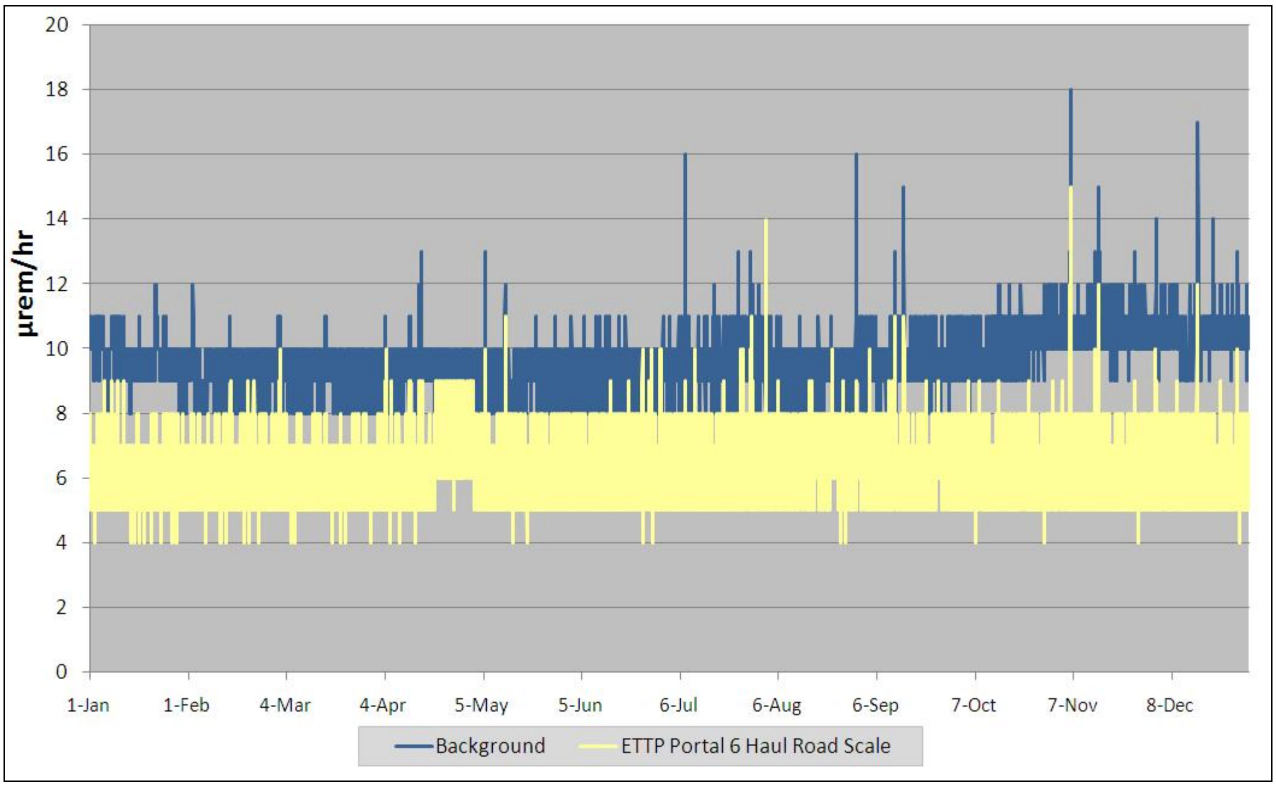

Figure 5: 2007 Results of gamma exposure rate monitoring at the ETTP haul road scale and at the background station

The State dose limit to an unrestricted area is 2 mrem (2,000 μrem for gamma) in any one-hour period. The State dose limit for members of the public is 100 mrem in a year.

The TRU Waste Processing Facility at ORNL

Beginning February 28, 2007, a gamma monitor was placed near the contact-handled TRU waste receiving area. The monitor was mounted on an exterior wall just outside of a storage/staging area. Most of the readings can be attributed to stored waste. Gamma exposure rates increase as more materials are received and stored during the sampling period and decrease as wastes are moved to other locations (some within the staging/storage area but further from the exposure-rate monitor). Rates during the monitoring period ranged from 25 to 802 μrem/hour with an average of 117.7 μrem/hour (Figure 6).

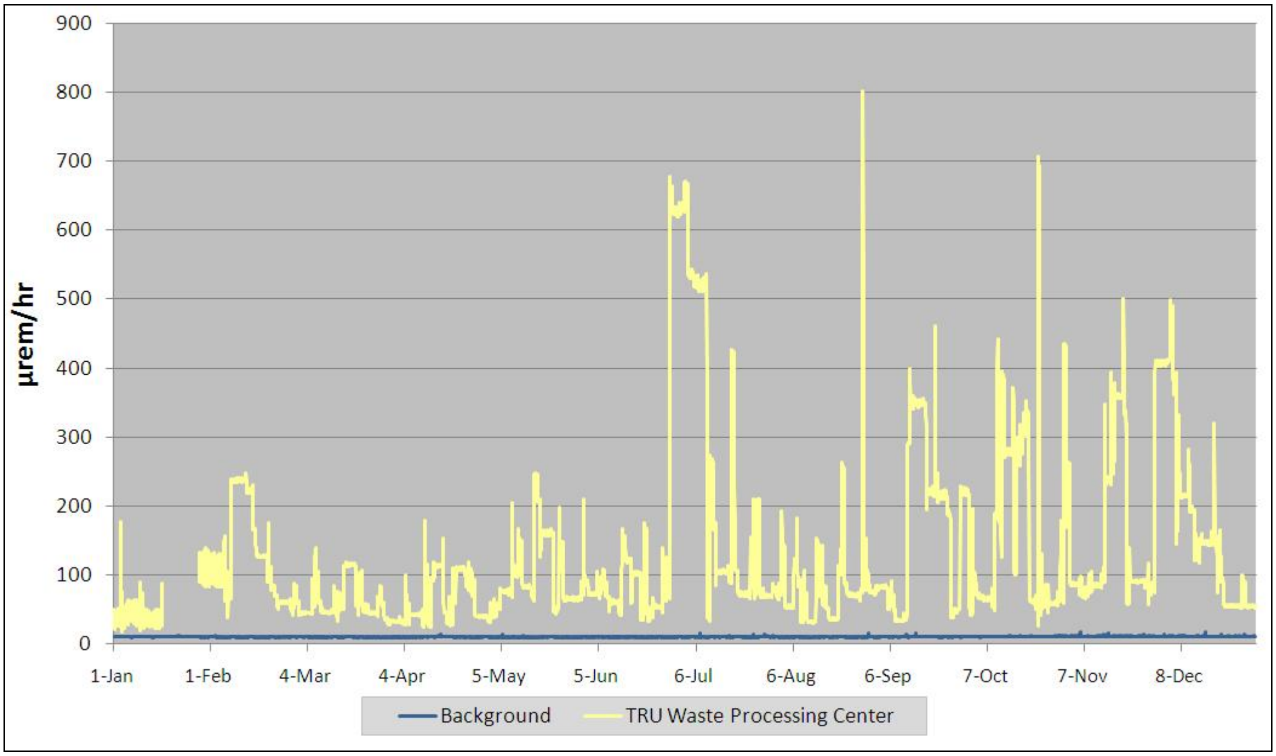

Figure 6: 2007 Results of gamma exposure rate monitoring at the TRU Waste Processing Facility and at the background station

The State dose limit to an unrestricted area is 2 mrem (2,000 μrem for gamma) in any one-hour period. The State dose limit for members of the public is 100 mrem in a year.

Corehole 8 at ORNL

Monitoring at Corehole 8 at ORNL continued from January 1, 1970 until July 16, 2007. Previous remediation of the North Tank Farm area (gunite tanks) exposed soil with much higher contamination levels than expected. Work was halted and characterization of the remaining contaminated area was initiated. Readings increased during invasive sampling but returned to pre-investigation levels after the sampling was completed. The site was relatively inactive during this sampling period with rates ranging from 15 to 21 μrem/hour with an average of 17.2 μrem/hour (Figure 7).

Conclusion

The use of continuously-recording gamma-exposure monitors has proven to be a flexible and reliable method for monitoring gamma radiation on the reservation. Based on the data collected in 2007, the following conclusions were reached.

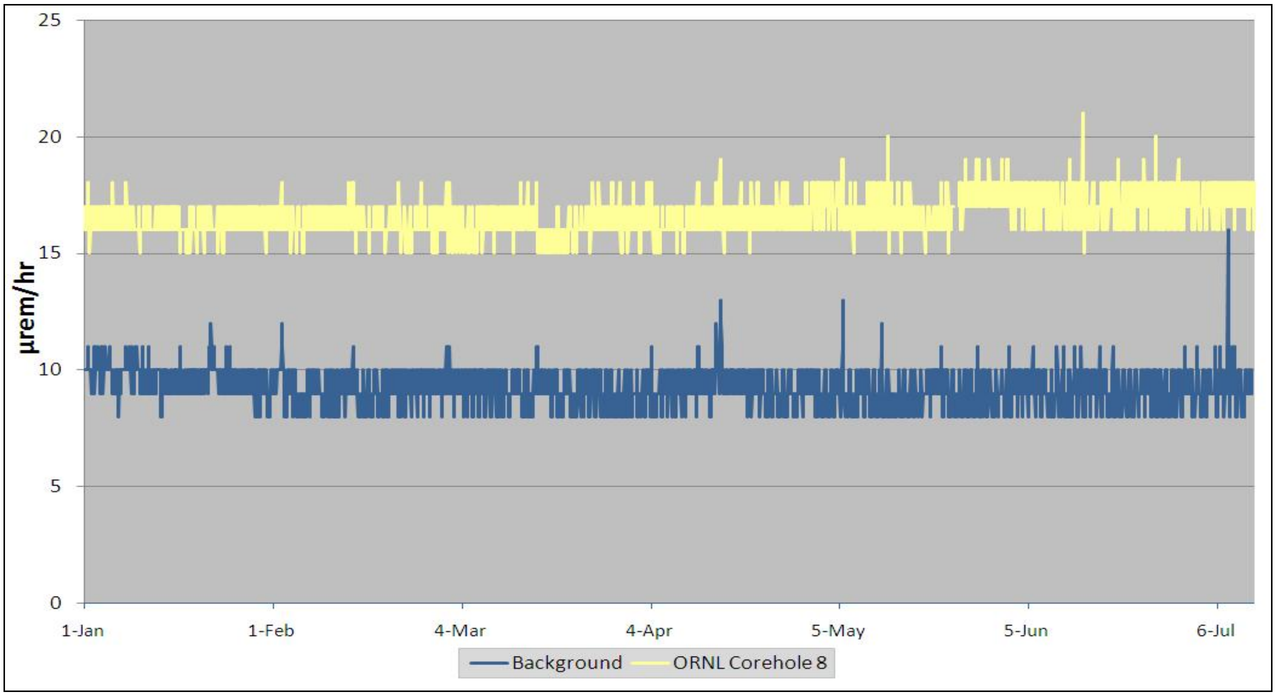

Figure 7: 2007 Results of gamma exposure rate monitoring at the ORNL Core Hole 8 and at the background station

The State dose limit to an unrestricted area is 2 mrem (2,000 µrem for gamma) in any one-hour period. The State dose limit for members of the public is 100 mrem in a year.

- Gamma levels at the ORNL Truck Monitor (7000 area) were consistent with background measurements.
- Measurements taken at the MSRE were not indicative of any releases during the period. Increases in the exposure levels measured during the year have been attributed to a contaminated salt probe stored near the monitor.
- Measurements taken at the EMWMF ranged from 5 to 34 µrem/hour and averaged 7.8 µrem/hour. The highest value in the previous year was 8928 µrem/hour, and represents approximately 446% of the State maximum dose to an unrestricted area in any one-hour period (2,000 µrem/hour). The highest measurements recorded were during the delivery of wastes from the remediation of the Homogeneous Reactor Experiment.
- Measurements taken at the ETTP Haul Road Scale are consistent with detectable low gamma levels slightly above background measurements.
- Measurements taken at the TRU Waste processing facility increased as waste was received and the volume of stored waste increased. Rates are expected to be variable in future sampling as materials with high contamination levels are received, stored, and processed.
- Gamma levels at Corehole 8 at ORNL were consistent with background measurements for the area. Future remediation would likely increase readings with a return to near background levels after completion of the remediation project. A gamma monitor would need to be located at the site when remediation begins.

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Surplus Material Verification

Principle Author: John McCall

Abstract

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division's Radiological Monitoring and Oversight Program conducted random radiological monitoring of surplus material offered for sale to the public. A total of 13 inspection visits were conducted at the Oak Ridge Reservation (ORR) facilities. No sales were conducted at the ETTP facility. Four items were observed that required further evaluation. All four of these items had measurable radioactivity.

Introduction

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the Division), in cooperation with the U.S. Department of Energy (DOE) and its contractors, conducts random radiological surveys of surplus materials that are destined for sale to the public on the Oak Ridge Reservation (ORR). In addition to performing the surveys, the Division reviews the procedures used for release of materials under DOE radiological regulations. Some materials, such as scrap metal, may be sold to the public under annual sales contracts, whereas other materials are staged at various sites around the ORR awaiting public auction/sale. The Division, as part of its larger radiological monitoring role on the reservation, conducts these surveys to help ensure that no potentially contaminated materials reach the public. In the event that radiological activity is detected, the Division immediately reports the finding to the responsible supervisory personnel of the surplus sales program and follows their response to the notification to see that appropriate steps (removal of items from sale, resurveys, etc.) are taken to protect the public.

Methods and Materials

Staff members make random surveys of items that are arranged in sales lots by using standard survey instruments. Inspections are scheduled just prior to sales after the material has been staged. Items range from furniture and equipment (shop, laboratory and computer) to vehicles and construction materials. Particular attention is paid to items originating from shops and laboratories. Where radiological release tags are attached, radiation clearance information is compared to procedural requirements. If any contamination is detected during the on-site survey, the surplus materials manager for the facility is notified immediately.

Results and Discussion

A total of 13 inspections were conducted at ORNL and Y-12. No sales were held at ETTP. Low levels of radiological contamination were discovered on four items during the DOE-O surveys. Four observations requiring further evaluation were made at the Y-12 surplus sales facility. In an inspection on January 18, 2007, radiation above background levels was detected on two chairs. A further evaluation by Y-12 radiation protection service personnel determined that radiation was present and the chairs were removed from the sale. In an inspection on May 8, 2007, contamination was detected on one chair. Y-12 radiation protection service personnel surveyed the chair and determined that radiological contamination was present. The isotopes present were determined to be enriched uranium and depleted uranium. The chair was removed from the sales inventory. In inspection on October 31, 2007, contamination was detected on a large floor safe.

Y-12 radiation protection service personnel surveyed the safe and determined that radiological contamination was present. The item was removed from the sales inventory.

Conclusion

Hundreds of surplus materials items were sold through ORNL or Y-12 surplus sales organizations in separate sales events. The facilities have performed a good job of preventing radiological contamination from reaching the public by surveying their surplus material sales. Minor radiological contamination was detected in only four items. All four of the items were removed from the auction list. The items were returned to their owners at Y-12 for determining the proper disposition.

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SURFACE WATER MONITORING

Monitoring of Liquid Effluents at the Environmental Management Waste Management Facility

Principal Author: Howard Crabtree

Abstract
The availability of the Environmental Management Waste Management Facility (EMWMF) has expedited remedial activities, but the water-rich environment of the region has presented challenges to the containment of contaminants in the facility. State monitoring of liquid effluents at the site began sporadically in 2005 and was developed into a program in 2006. The intent of the program is to help ensure that any leaks from EMWMF are identified quickly (for associated damage control) and to verify that effluents released from EMWMF and associated contaminant control mechanisms are consistent with criteria agreed upon by parties to the Federal Facility Agreement (i.e. the Department of Energy, the Environmental Protection Agency, and the State). Based on the current regulations, radionuclides can be released from EMWMF to North Tributary 5, provided the quantities do not exceed concentrations that would be equivalent to an annual average dose of 25 mrem/year. State data for 2007 indicate the levels of radionuclides released from the facility were below the agreed upon dose limit.

Introduction
The Tennessee Oversight Agreement requires the State to provide monitoring as necessary to verify Department of Energy (DOE) data and assess the effectiveness of DOE contaminant control measures on the Oak Ridge Reservation (ORR). To this end, the Tennessee Department of Environment and Conservation's Division of DOE Oversight (the Division) began a program in 2006 to monitor waste streams at the Environmental Management Waste Management Facility. EMWMF is a waste disposal facility exclusively dedicated to the disposal of wastes generated by remedial activities on the ORR and related sites within the State of Tennessee. The facility is operated under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986.

The availability of EMWMF has expedited remedial activities on the reservation, but new challenges to containing of contaminants have arisen that would not be expected in more arid areas. On at least two occasions the pooled water has overflowed its containment during heavy rains, releasing effluents to the environment and, on at least one occasion, washing out the berms that contained the effluents. On another occasion, the pooled liquids were released intentionally during heavy rains to avoid damage similar to that previously experienced at the facility. In this case, the 400,000 gallons of effluents released by-passed the sediment basin, resulting in a fine of $300,000 levied against the operator.

Under the current agreement between FFA parties, the effluents that pool in the waste cell are periodically pumped to one of four holding ponds and sampled. If the sample has levels of radioactivity above DOE's Derived Concentration Guides (DCGs) (concentrations of radionuclides equivalent to a dose 100 mrem/year), the effluent is treated as leachate and sent for treatment at the Oak Ridge National Laboratory (ORNL) Process Waste Treatment Facility. If the result is below the DCGs, the effluent is pumped into an unlined channel that leads to the sediment basin. In the sediment basin, the effluents mix with any stormwater that has been collected from the facility grounds and the mixture is released through a weir into a second channel that discharges to NT-5. Effluents released through the weir are sampled by DOE contractors both monthly and each time a holding pond is emptied into the basin.

Methods and Materials

The EMWMF effluent monitoring program was started to help ensure that any accidental releases at the facility can be identified as soon as possible (to limit the spread of the contamination), and to verify that effluents from the facility and associated contaminant control mechanisms are consistent with criteria agreed upon by the State, EPA, and DOE. Current State monitoring locations are depicted in Figure 1 and descriptions of the sampling points follow the figure.

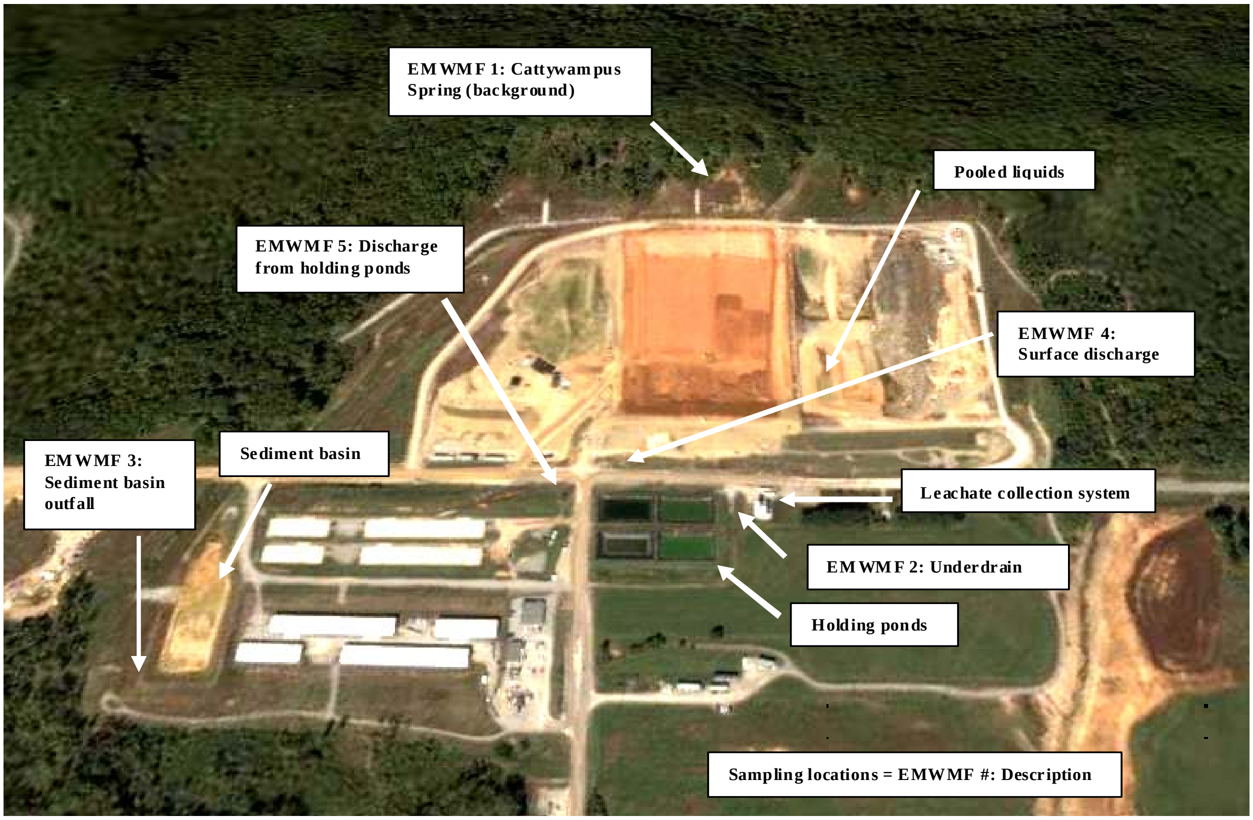

Figure 1: Sampling locations and other locations of interest at the Environmental Management Waste Management Facility

- EMWMF 1: This is the background location. Cattywampus Spring is located upslope of the facility at the headwaters of NT-4. The majority of the NT-4 channel was filled and associated waters diverted to NT-5 to accommodate construction of EMWMF. Samples are taken periodically at this site in conjunction with the EMWMF 2 location (the under-drain). Due to low flow at this site, samples are generally collected after periods of rain when flow is slightly increased.

- EMWMF 2: This location captures discharge from the underdrain beneath the facility. A sample is taken at this site on the same day as the EMWMF 1 location. Should the liner leak, contaminants in the underdrain are likely to provide the first indication. Taking the background sample on the same day helps assure a background measurement taken under similar conditions is available for comparison.
- EMWMF 3: This location is at the weir below the sediment basin, at the outfall leading to NT-5. Samples are collected at this location when (1) water has been released from the holding ponds, has collected in the sediment basin, and is draining at the outfall, (2) a precipitation event has pushed large quantities of water through the sediment basin and (3), there is a large sediment load due to either a rain event or a release from a holding pond. At one point, suspended solids were a recurrent problem at this location. The problem appears to have been mostly rectified as cleared areas have been re-vegetated. Staff generally visit the EMWMF site at least twice weekly for other routine sampling. Water conditions at the site are observed at these times and samples are collected as merited; usually for one of the three reasons noted above.
- EMWMF 4: This location is at a pipe that receives pumped storm water runoff from waste cells that are designated as inactive as well as water from another hose that releases water that would be leachate if there were waste in the cell where the water is coming from.
- EMWMF 5: This is an unlined ditch where the water from the holding ponds is released and then used to transfer these effluents to the sediment basin. The effluents in the holding ponds consist of liquids and suspended materials that accumulate at the lower end of an active cell, over a protective layer of largely impervious soil.

  Effluent samples can only be taken at this location when water is being pumped from the holding ponds to the ditch leading to the sediment basin. Staff members are not present at the site daily, so samples are not collected every time water from one of the holding ponds is released. When a sample is taken at this site, a corresponding sample is often collected a day or two later when this water has reached the sediment basin outfall (EMWMF 3).
- Other sites are sampled as conditions merit.

The samples are collected in a relatively conservative fashion, following basic EPA procedures (*General Field Sampling Guidelines*, SOP No. 2001). The media sampled include effluents, surface water, stormwater, and occasionally groundwater and sediments.

The analytical parameters vary based on the media being sampled, previous findings, and the particular wastes being disposed of at the time. Gross analysis is used to screen for alpha and beta emitters, with more specific analyses performed in response to elevated results. Samples are not filtered prior to analysis. Since monitoring for all radionuclides disposed of in the facility would be cost prohibitive, efforts focus on isotope-specific analyses of the more mobile species (e.g. tritium and technetium-99), contaminants previously detected in effluents (e.g. uranium isotopes and strontium-90), and radionuclides that would not be evident in gross measurements (e.g. tritium). Gamma spectrometry is used to identify gamma emitters (e.g. cesium-137).

In general, concentrations of contaminants fluctuate as site conditions change. The weather (precipitation), operational activities (pumping of effluents from the holding ponds), and contaminants in the waste being disposed of at the site, each effect contaminant concentrations. Consequently, samples are taken as conditions merit (rather than on a fixed schedule) with the intent to monitor waste streams under different conditions in order to characterize and delineate contaminant releases.

Results and Discussion

When sampling at the EMWMF began in 2005, it seemed apparent that the dynamics inherent to the hydrology, waste streams, and operations of the EMWMF could make a large difference in the sampling results, and that better information relative to how the different components interact would be valuable in trying to assess conditions at the site. Since monitoring staff visit the site two to three times weekly in association with other programs, it was decided to keep the program flexible enough to take advantage of sample opportunities observed during routine visits, as well as provide comprehensive sampling of the facility in general.

Under the new procedure, the mixture of stormwater and drainage from the waste that pools at the bottom of the waste cells was to be stored in the four holding ponds. If the results of samples taken from these effluents were below DOE's Derived Concentration Guides, the effluents could be released to the sediment basin. Releases from the sediment basin are limited to an annual average concentration of radionuclides equivalent to a dose of 25 mrem/year. Samples are taken by DOE contractors both from the outfall of the basin each month and each time the contents from a holding pond are released to the sediment basin. The sum of fractions[1] is calculated for each sampling event and the results averaged at the end of the year to determine compliance.

Background Data (EMWMF 1): The background results are compared to the results from samples collected at the other monitoring locations in the program to identify any contaminants that may be a consequence of EMWMF activities. Fluctuations in the data at all sampling locations at EMWMF can be expected due to changing conditions at the location (e.g., high suspended solids due to storms). The background samples are collected at Cattywampus Spring (EMWMF 1) on the ridge above the facility at the headwaters of NT-4. On 01/12/05, iodine-129 was measured at 2.6 pCi/L. Detectable amounts of iodine-129 would not be expected at the background location and the analysis of the isotope is difficult, so the result is considered suspect until corroborating data are received. However, the EMWMF has reported iodine-129 as detected in their groundwater data, which would appear to support the possibility of its presence at the site. Only one sample was taken at the background site in 2007, despite an effort to collect background samples quarterly, due to an inability to collect water at the spring because of draught and low water conditions. To remedy this problem, staff plan to obtain quarterly samples from a well upslope of the waste cells (and not far from the original sampling point at the spring).

The under-drain (EMWMF 2): Prior to the construction of EMWMF, FFA parties agreed on a contingency plan to be implemented if the water table rose to within ten feet of the liner (the

[1] The sum of fractions is a method used to determine compliance when more than one radionuclide is present in a waste stream. To calculate a sum of fractions, divide the concentration of each nuclide present by its limit, then add the results. If the results are above one, the waste exceeds the limit and the facility would be out of compliance.

fundamental barrier that prevents contaminants from leaking out of the facility into the groundwater). The intent of the contingency plan was to avoid the liner being damaged by hydrostatic pressures caused by the water table rising to levels above the liner. In 2003, State geologists taking water level measurements near the filled NT-4 channel noted the water table had risen into the 10 foot buffer below the facility; DOE was advised and the contingency plan implemented. The continued rise of the water table subsequently led to the construction of a drain running north to south underneath the facility to lower the water table that had risen to the facility's liner in some areas. The water exiting the drain basically consists of groundwater draining from beneath the EMWMF waste cells, which should not be contaminated if there are no leaks from the facility. No anomalous results were found, and the data was very similar to that collected at the background station (Table 1).

Table 1: Liquid effluent sampling results at EMWMF 1 and EMWMF 2 (pCi/L)

Location	Collection Date	Gross Alpha	Gross Beta	H-3	Tc-99	I-129
EMWMF 1- background	01/12/05	-1.1	4.0	187	0.0	2.6
EMWMF 1- background	03/01/05	-1.0	2.4			
EMWMF 1- background	03/23/05	0.3	2.6			
EMWMF 1- background	04/20/05	0.1	2.0			
EMWMF 1- background	09/26/05	-0.5	2.8	-283	0.4	
EMWMF 1- background	01/23/06	-0.5	2.9			
EMWMF 1- background	11/16/06	-0.6	3.9			0.5
EMWMF 1- background	04/04/07	0.00	2.4			
EMWMF 2- underdrain	01/12/05	-2.8	2.5	186	1.8	
EMWMF 2- underdrain	04/20/05	-0.3	2.0	0	-0.6	
EMWMF 2- underdrain	09/26/05	-1.0	2.9	-42.2	2.7	
EMWMF 2- underdrain	01/23/06	-0.1	0.9			
EMWMF 2- underdrain	11/16/06	5.5	1.8	158	0	
EMWMF 2- underdrain	4/4/2007	0.5	0.6			
EMWMF 2- underdrain	7/6/2007	0.5	1.2	163		
EMWMF 2- underdrain	10/5/2007	-0.3	0.2	0	0.00	

Drainage ditch receiving effluents from inactive waste cells (EMWMF 4): Effluents are occasionally pumped from inactive waste cells at the site to a drainage ditch at the EMWMF 4 sampling point. The opportunity to sample at this location has been limited to instances when staff actually observed EMWMF personnel pumping effluents from the cells, resulting in limited available data. More recently water from a hose that releases water that would be leachate if there were waste in the cell where the water is coming from began to also be released at this site. Unlike the water pumped directly from the inactive waste cells, this water appears clear and free of sediments. Only one sample was collected at this site in 2007, but the gross alpha and gross beta results were at or below background levels.

Effluents from the holding ponds (EMWMF 5) and the sediment basin outfall (EMWMF 3): FFA parties have agreed that concentrations of radionuclides released from the sediment basin outfall (EMWMF 3) to the receiving stream (NT-5) are not to exceed an annual average concentration equivalent to 25 mrem in a year, which is based on provisions specified in DOE Order 5400.5. To help ensure that releases are below this limit, DOE has placed a cap on concentrations of radionuclides in the four holding ponds (EMWMF 5) that can be released to the sediment basin. This limit is set by DOE's Derived Concentration Guides, which provide the concentration of specific radionuclides equivalent to 100 mrem/year dose (see Table 2).

As previously noted, the holding ponds contain a mixture of storm water and drainage from the waste that pools over a nearly impermeable layer of soils in the active cells. These effluents require removal from the waste cells to prevent them from overflowing containment and being released to the environment (which has occurred in the past). Any radioactive material naturally occurring in the stormwater component of the effluent would be expected to be very low, so the only significant contributor to the radioactive contamination released from the facility can be assumed to originate in the drainage from the waste that is captured in the pools inside the active waste cells.

Table 2: Derived Concentration Guides (DCGs) for select isotopes

Isotope	Derived Concentration Guide (100 mrem/year)	¼ of DCG (25 mrem/year)
H-3	2,000,000 pCi/L	500,000 pCi/L
Sr-90	1,000 pCi/L	250 pCi/L
Tc-99	100,000 pCi/L	25,000 pCi/L
U-234	500 pCi/L	125 pCi/L
U-235	600 pCi/L	150 pCi/L
U-238	600 pCi/L	150 pCi/L

The drainage from the waste is mixed with significant amounts of stormwater both in the active cells, due to a general lack of stormwater controls, and in the sediment pond. This basically increases the volume of contaminated materials, while lowering the concentrations of radionuclides in the effluents by dilution. Since the concentrations of the effluents are lowered, larger volumes of more contaminated wastes can be released to the environment without exceeding limits.

Based on the data collected in this project, the principal alpha emitters are the uranium isotopes. The principal beta emitters are strontium-90, yettrium-90, tritium, and technitium-99. Yettrium-90 is not shown in the tables, but is a daughter product of strontium-90 that would be in secular equilibrium, so it can be assumed to be present in concentrations equal to the concentrations of strontium-90. The largest values were reported for the effluents released from the holding ponds, which contain effluents from the pooled water in the active cells.

Table 3 shows the results of the 2007 effluent sampling at the sediment basin outfall (EMWMF 3). All the results are well below the DCGs corresponding to 25mrem/year, but many are also noticeably higher than background levels.

Table 3: Liquid effluent sampling results at EMWMF 3: sediment basin outfall (pCi/L)

Location	Collection Date	Gross Alpha	Gross Beta	H-3	Tc-99	Sr-90
EMWMF 3*	01/16/07	10	403	164	11.5	
EMWMF 3*	01/22/07	1.1	242	164	3.86	
EMWMF 3	04/04/07	1	27.6			
EMWMF 3*	04/27/07	34.6	605			
EMWMF 3	06/15/07	3	59.8	0		
EMWMF 3*	10/10/07	9.5	223	168	24.09	48
EMWMF 3	10/19/07	13.9	151.1	0		
EMWMF 3*	10/24/07	3.8	32.6	0		
EMWMF 3*	11/16/07	7.1	94.8			
EMWMF 3	11/26/07	2	30.9			
EMWMF 3*	12/14/07	12	151	0	20.27	

*Sample collected due to water being pumped from the holding ponds

Samples are also occasionally collected at the sediment basin outfall and analyzed for suspended solids. While the suspended solids problem appeared to have been mostly rectified by re-vegetating bare areas, on two occasions when suspended solids did appear to be an issue and samples were collected, the resulting values were above the 110 mg/L limit. This information was referred to the Division's Environmental Restoration Program.

Table 4: Liquid effluent sampling results at discharge from the holding ponds (pCi/L)

Location	Collection Date	Gross Alpha	Gross Beta	H-3	Tc-99	Sr-90
EMWMF 5	02/12/07	204	1561	984	46.1	836
EMWMF 5	05/07/07	49.2	1240	335		317
EMWMF 5	05/21/07	75	616	494		
EMWMF 5	06/25/07	47.3	1172	654		
EMWMF 5	08/01/07	16.7	467	327	13.77	
EMWMF 5	10/10/07	15.4	449	337	8.67	109
EMWMF 5	11/13/07	30	424	171	16.83	85
EMWMF 5	12/12/07	31	320	0	40.3	81
EMWMF 5	12/17/07	33	400	0	21.82	86

Table 4 shows the results of the 2007 effluent sampling at the discharge from the holding ponds (EMWMF 5). Many of the individual results were noticeably higher than background levels and the effects of dilution can be seen when compared with corresponding samples collected at the EMWMF 3 location. While the 2007 results were below the DCG limits corresponding to a dose of 100 mrem per year, they were over the DCGs corresponding to a dose of 25mrem/year, even with the limited number of samples taken and analyses run. However, the limit for effluents being released at the discharge from the holding ponds is 100 mrem/year, not 25mrem/year as it is at the sediment basin outfall.

Conclusion

Despite the problems noted at EMWMF, the data collected by Division staff in 2007 does not indicate that limits agreed upon by FFA parties were exceeded, with the exception of the levels of suspended solids released at the weir on two occasions when samples were taken. Better storm water controls would rectify some of the previously noted issues at EMWMF. It would also insure that dilution was not used as a means to release effluents with higher concentrations of contamination to the environment and would lead to a lower volume of contaminated effluents.

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Rain Event Surface Water Monitoring

Principle Author: Randy Hoffmeister

Abstract

The DOE Oversight Division conducted surface water sampling at stream sites on the Oak Ridge Reservation (ORR) in 2007. Samples were collected during the fourth quarter following a qualifying rain event. Most results were consistent with results from a non-contaminated site following a heavy rain. Exceptions were elevated radiological results from Melton Branch and elevated chromium results from Mitchell Branch. These results were likely due to remedial activities taking place near the stream.

Introduction

Heavy rains may lead to point and non-point source contaminant releases to streams on Oak Ridge Reservation (ORR). These rain events, defined as 1" of rain in a 24-hour period or 2" of rain in a 72-hour period, could cause the displacement of contamination at greater levels than a rain event of lesser magnitude. Additionally, a heavy rain event may cause the release of an unidentified contaminant or one that has previously been of little concern.

A surface water sampling program has been established to assess the degree of impact, if any, caused by these rain events. Select locations on five streams originating on the ORR will be sampled quarterly if a heavy rain event occurs in that quarter. Mill Branch serves as the reference stream under ideal conditions. Table 1 shows locations that have been selected for sampling.

Table 1. Sample Locations

Site	Location
EFK 23.4	East Fork Poplar Creek at Y-12 entrance
WCK 3.0	White Oak Creek at Lagoon Road
MEK 0.1	Melton Branch Weir
MIK 0.1	Mitchell Branch Weir
BCK 4.5	Bear Creek Weir at Hwy. 95
MBK 1.6	Mill Branch

Methods and Materials

A single heavy rain in the fourth quarter was the only qualifying event in 2007. On October 24, 2007 surface water samples were collected and analyzed for the following parameters.

Inorganics: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, zinc, nitrogen (NO^2 & NO^3), ammonia, nitrogen (total Kjeldahl), total phosphates
Other tests: E. coli, Enterococcus, dissolved residue, suspended residue, and total hardness
Radionuclides: Gross alpha, gross beta, gamma radionuclides

Results

Results of the microbiological analysis of the samples were as expected for samples taken following a rain event. High levels of *E. coli* and *Enterococcus* were observed at all sites and with the exception of *Enterococcus* at EFK 23.4, all levels exceeded reference conditions. The results are shown in Table 2.

Table 2. Results of Microbiological Analysis 10/24/07

Site	*E. Coli*	*Enterococcus*
	cfu/100ml	cfu/100ml
EFK 23.4	249	343
WCK 3.0	1203	1553
MEK 0.1	488	>2419
MIK 0.1	1986	2419
BCK 4.5	1414	>2419
MBK 1.6	179	1046

Results of the routine parameters were also as expected for samples taken following a rain event. All levels exceeded reference conditions. The results are shown in Table 3.

Table 3. Results of Routine Parameters Analysis 10/24/07

Site	Hardness (mg/l)	Residue, dissolved (mg/l)	Residue, suspended (mg/l)
EFK 23.4	164	191	<10
WCK 3.0	166	286	<10
MEK 0.1	199	251	<10
MIK 0.1	228	343	<10
BCK 4.5	225	246	<10
MBK 1.6	152	175	<10

The results for nutrient analysis were also as expected for samples taken following a rain event. All levels met or exceeded reference conditions. The results are shown in Table 4.

Table 4. Results of Nutrient Analysis 10/24/07

Site	Ammonia	NO^2 & NO^3	Total Kjeldahl	Phosphorus
	(mg/l)	(mg/l)	(mg/l)	(mg/l)
EFK 23.4	<0.1	2.2	<0.5	0.07
WCK 3.0	<0.1	1.7	<0.5	0.2
MEK 0.1	<0.1	0.22	<0.5	0.17
MIK 0.1	<0.1	0.73	<0.5	<0.07
BCK 4.5	<0.1	1.5	<0.5	<0.07
MBK 1.6	<0.1	<0.10	<0.5	<0.07

The results for metal analysis were also as expected for samples taken following a rain event. The elevated level of chromium at MIK 0.1 is related to the CERCLA clean-up activities in the vicinity of the stream. The results are shown in Table 5.

Table 5. Results of Metals Analysis 10/24/07

Site	Hg (ug/l)	As (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Fe (ug/l)	Pb (ug/l)	Mn (ug/l)	Zn (ug/l)
EFK 23.4	<0.2	<1	<1	<1	3	163	<1	50	23
WCK 3.0	<0.2	<1	<1	<1	5	235	<1	31	28
MEK 0.1	<0.2	<1	<1	<1	1	376	<1	111	8
MIK 0.1	<0.2	<1	<1	23	5	354	<1	232	18
BCK 4.5	<0.2	<1	<1	<1	<1	234	<1	65	4
MBK 1.6	<0.2	<1	<1	<1	<1	289	<1	57	4

The results of the gross alpha, gross beta and gamma radionuclide scan are shown in Table 6. With the exception of gross beta at MEK 0.1, the results are similar to those seen at these sites during non-rain event conditions.

Table 6. Results of Gross Alpha/Beta and Gamma Radionuclide Analysis 10/24/07

Site	Gross Alpha (pCi/l ± Error)	Gross Beta (pCi/l ± Error)	Cs-137 (pCi/l ± Error)
EFK 23.4	17.4 ± 4.2	7.0 ± 2.7	ND
WCK 3.0	3.9 ± 3.2	95.0 ± 7.7	ND
MEK 0.1	1.8 ± 2.2	909 ± 23	ND
MIK 0.1	82 ± 12	87.1 ± 7.9	ND
BCK 4.5	39.8 ± 6.8	25.0 ± 4.4	ND
MBK 1.6	0.0 ± 1.2	1.0 ± 1.5	ND

ND – indicates that the analyte was analyzed for but not detected.

Sr-89 and Sr-90 are also analyzed at MEK 0.1 (Table 7). Analysis is conducted due to historical evidence of contamination at this site. Observed levels are typical.

Table 7. Strontium Results from MEK 0.1

Sr-89 (pCi/l ± Error)	Sr-90 (pCi/l ± Error)
39 ± 59	204 ± 67

Conclusion

Overall, the results indicate that, with the exception of Melton Branch and Mitchell Branch, there appears to be no significant movement of contaminants into the sampled streams due to the heavy rainfall event. The Melton Branch sampling results are not conclusive at this point, but they do appear to indicate that remedial activities are having a beneficial effect on levels of contaminants entering the stream. The chromium results on Mitchell Branch indicate there has been at least a short term insult to the stream. Continued sampling at this site will assist in determining the effectiveness of remedial activities.

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Ambient Sediment Monitoring Project

Principle Author: John (Tab) Peryam

Abstract

Sediment analysis is a good way to assess what contaminants have been present in a water body in the past. These contaminants are often incorporated into the clay and organic matter fraction of sediment through mechanisms such as cation exchange capacity and organic functional groups. Sediment samples from several Clinch River and tributary sites were analyzed for metals, extractable organics, and radiological parameters. Since there are no federal or state sediment cleanup levels, the data are compared to soil background levels, EPA Region 4 sediment screening levels and consensus-based sediment quality guidelines. Where contaminants are found in sediments, the levels are at low concentrations that do not pose a threat to human health.

Introduction

Sediment is an important part of aquatic ecosystems. Many aquatic organisms depend on sediment for habitat, sustenance, and reproduction. Sediment is also a depository for contaminants such as metals, radionuclides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and agricultural chemicals. Concentrations of contaminants can be much higher than that in the water column. Some sediment contaminants may be directly toxic to benthic organisms or may bioaccumulate in the food chain, creating health risks for wildlife and humans. Sediment analysis is an important aspect of environmental quality and impact assessment for rivers, streams, and lakes. The Tennessee Department of Environment and Conservation's DOE Oversight Division (TDEC/DOE-O) conducts sediment monitoring for 25 sites (Table 1 and Figures 1a-1f). There are ten sites on the Clinch River and 15 sites on tributaries of the Clinch. Clinch River Mile (CRM) 52.6 (site 2) is a background site and is located upstream of the Oak Ridge Reservation (ORR). Two of the tributary sites (White Creek and Clear Creek) are located upstream of the ORR and serve as background sites. Sampling was conducted in 2007 during April and May. Data are available online at EPA's STORET database (http://www.epa.gov/storet/dbtop.html). Click on "browse or download modernized STORET data". Then, under "query options", select "STORET regular results, regular results by project". On the next page, under "step 1", select TDEC DOE as the organization and select "SEDIMENT" as the project in "step 2".

Methods and Materials

Sediment samples were taken during April and May using the methods described in the 2007 Ambient Sediment Monitoring Plan. River sediment samples were taken with a petite ponar dredge; stream samples were taken with stainless steel spoons. The Tennessee State Laboratories processed the samples, according to EPA-approved methods.

Table 1: Sampling Sites

Site	Description	Latitude	Longitude	CRM*	Figure
2	Clinch River Mile (CRM) 52.6	36°03'46"N	84°11'49"W	52.6	1.4
3	CRM 35.5	35°56'39"N	84°14'21"W	35.5	1.3
4	Grubb Islands	35°53'52"N	84°22'24"W	17.9	1.2
5	Brashear's Island	35°55'13"N	84°26'02"W	10.1	1.1
6	CRM 48.7	36°01'28"N	84°10'02"W	48.7	1.4
7	CRM 41.2	35°58'30"N	84°12'30"W	41.2	1.3
8	Scarboro Creek. M 0.1	35°58'59"N	84°13'00"W	41.2	1.3
9	Kerr Hollow Branch. M 0.1	35°58'45"N	84°13'37"W	41.2	1.3
10	McCoy Branch. M 0.1	35°57'57"N	84°14'54"W	37.5	1.3
12	E. Fork Walker Branch. M 0.1	35°57'22"N	84°15'58"W	33.2	1.3
13	Bearden Creek Mile 0.1	35°56'05"N	84°17'01"W	31.8	1.3
18	Raccoon Creek Mile 0.1	35°54'12"N	84°21'05"W	19.5	1.2
20	Grassy Creek Mile 0.1	35°54'36"N	84°22'55"W	14.55	1.2
22	Unnamed Stream M 0.1	35°54'29"N	84°23'25"W	14.45	1.2
23	Ernie's Creek. M 0.1	36°02'19"N	84°12'47"W	51.1	1.4
24	White Creek. M 0.1	36°20'47"N	83°53'42"W	102.4	1.6
25	Clear Creek. M 0.1	36°12'49"N	84°03'33"W	77.7	1.5
27	CRM 7.0	35°53'37"N	84°27'46"W	7.0	1.1
28	CRM 4.0	35°53'29"N	84°29'55"W	4.0	1.1
29	CRM 0.0	35°51'52"N	84°32'01"W	0.0	1.1
32	Jones Island	35°54'03"N	84°21'02"W	19.7	1.2
33	Poplar Creek Mile (PCM) 1.0	36°01'03"N	84°14'21"W	12.0	1.1
36	PCM 2.2	35°55'50"N	84°24'19"W	12.0	1.1
37	PCM 3.5	35°56'25"N	84°24'02"W	12.0	1.1
38	PCM 5.5	35°54'04"N	84°21'58"W	12.0	1.1

*For tributaries, this refers to the location of the mouth of the stream.

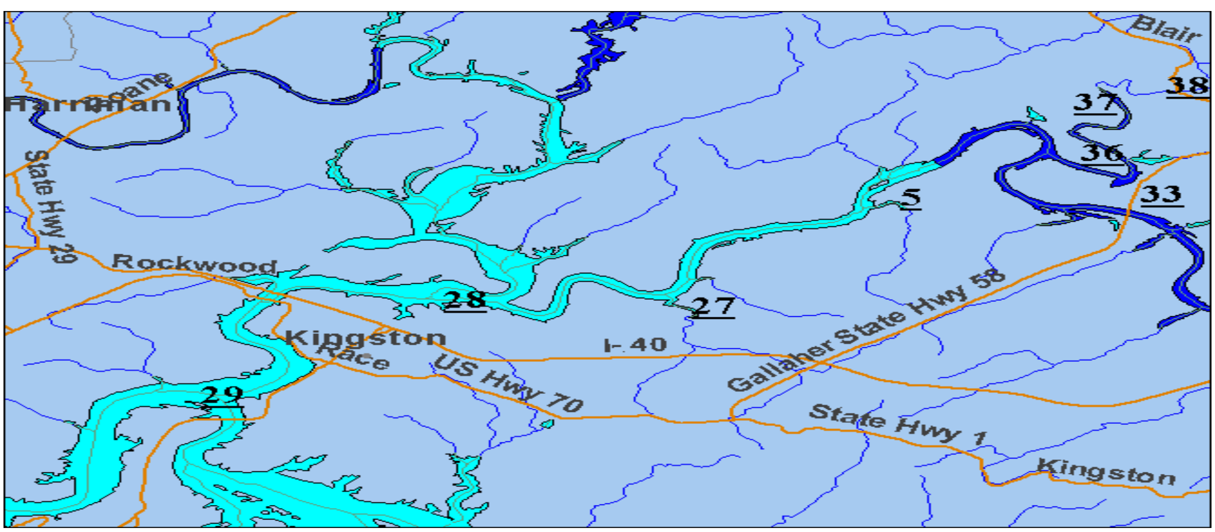

Figure 1a: Sediment Sampling Sites 5, 27, 28, 29, 33, 36, 37, 38

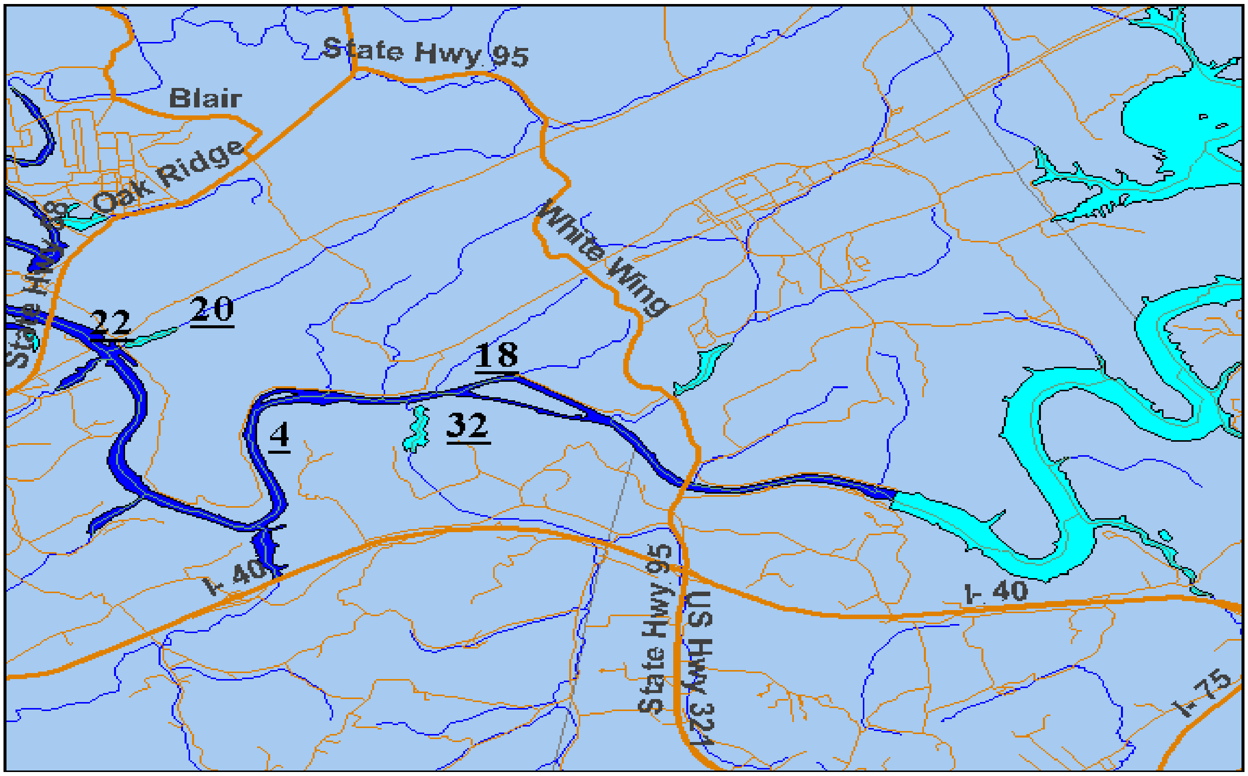

Figure 1b: Sediment Sampling Sites 4, 18, 20, 22, 32

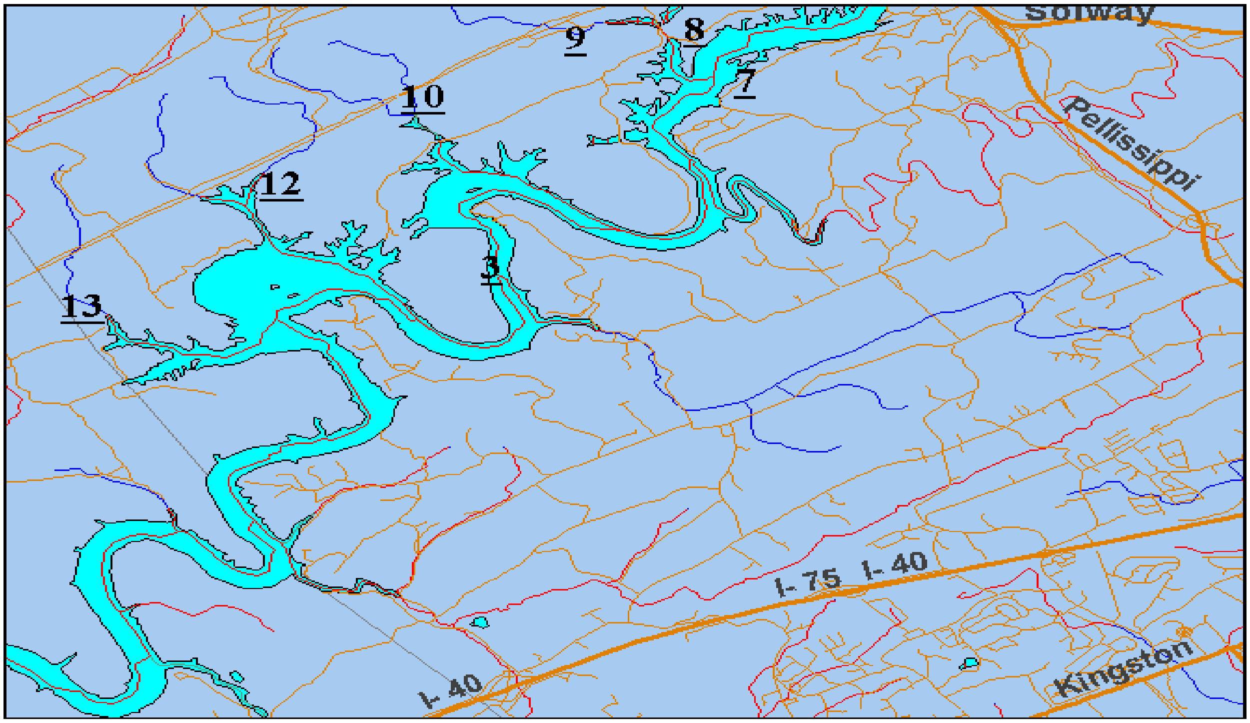

Figure 1c: Sediment Sampling Sites 3, 7, 8, 9, 10, 12, 13

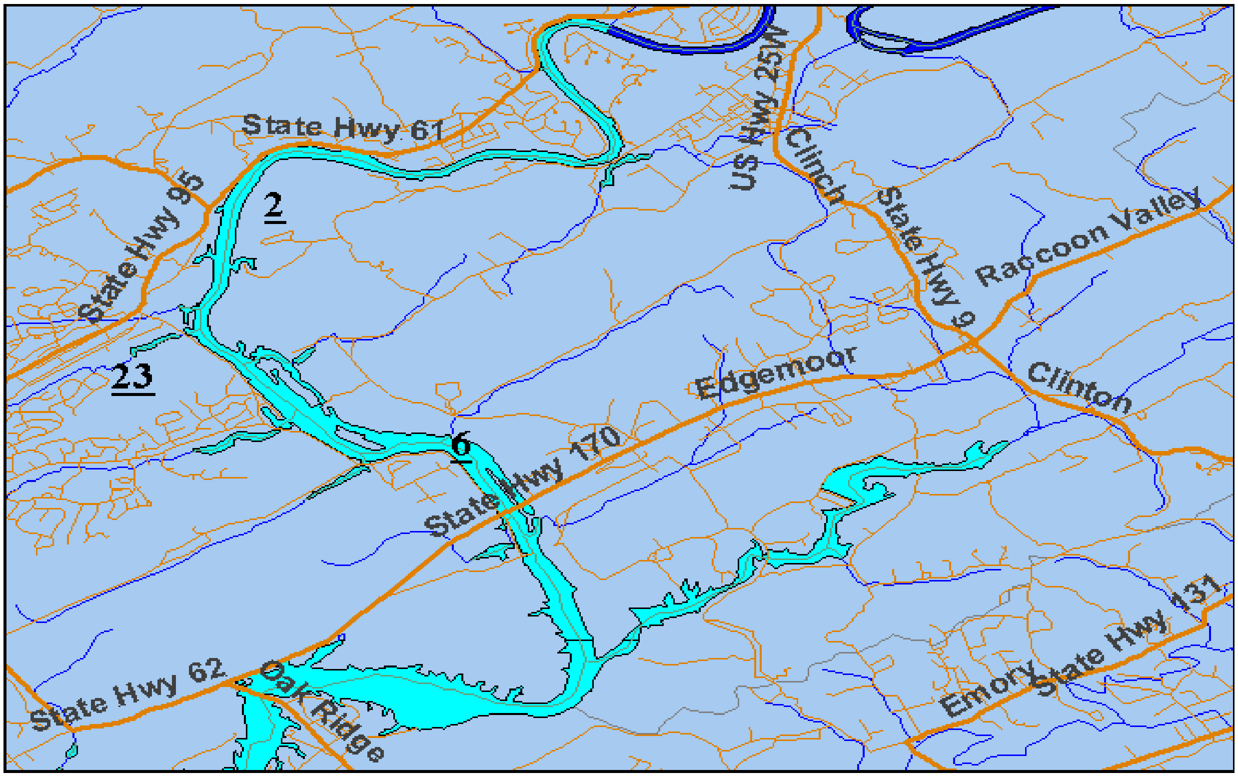

Figure 1d: Sediment Sampling Sites 2, 6, 23

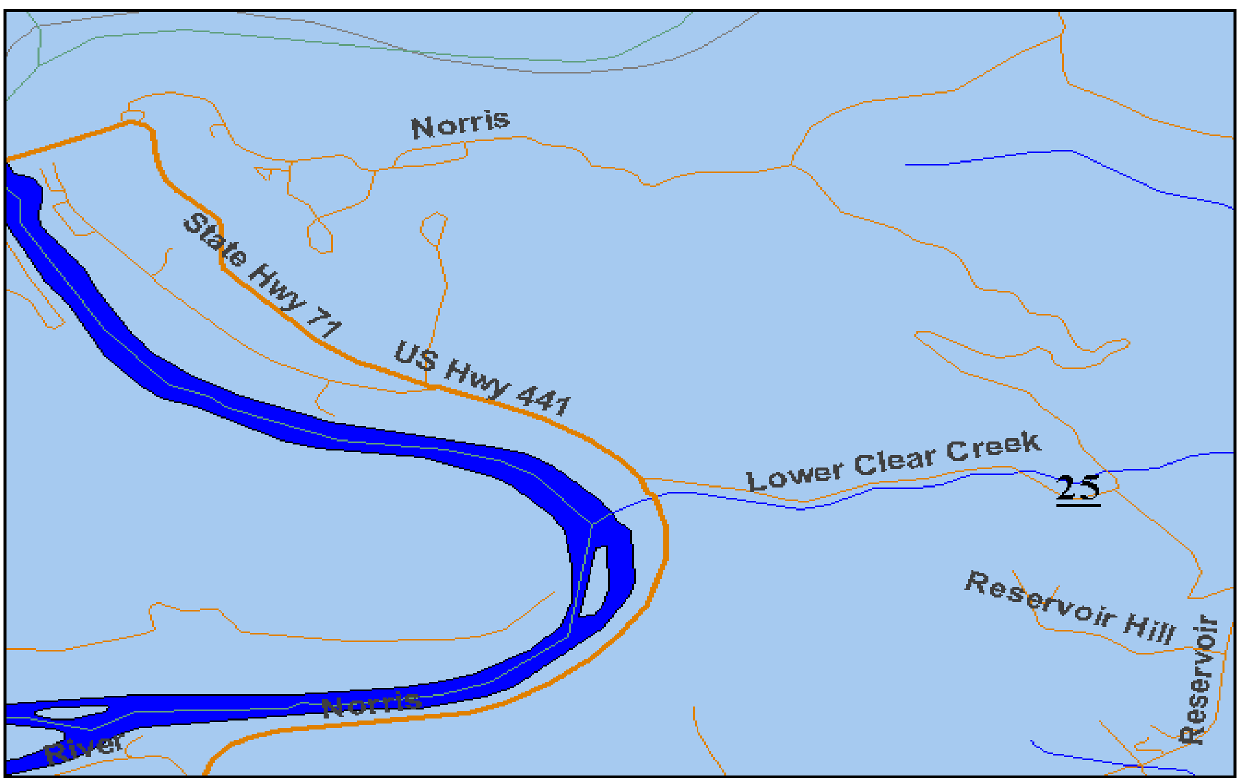

Figure 1e: Sediment Sampling Site 25

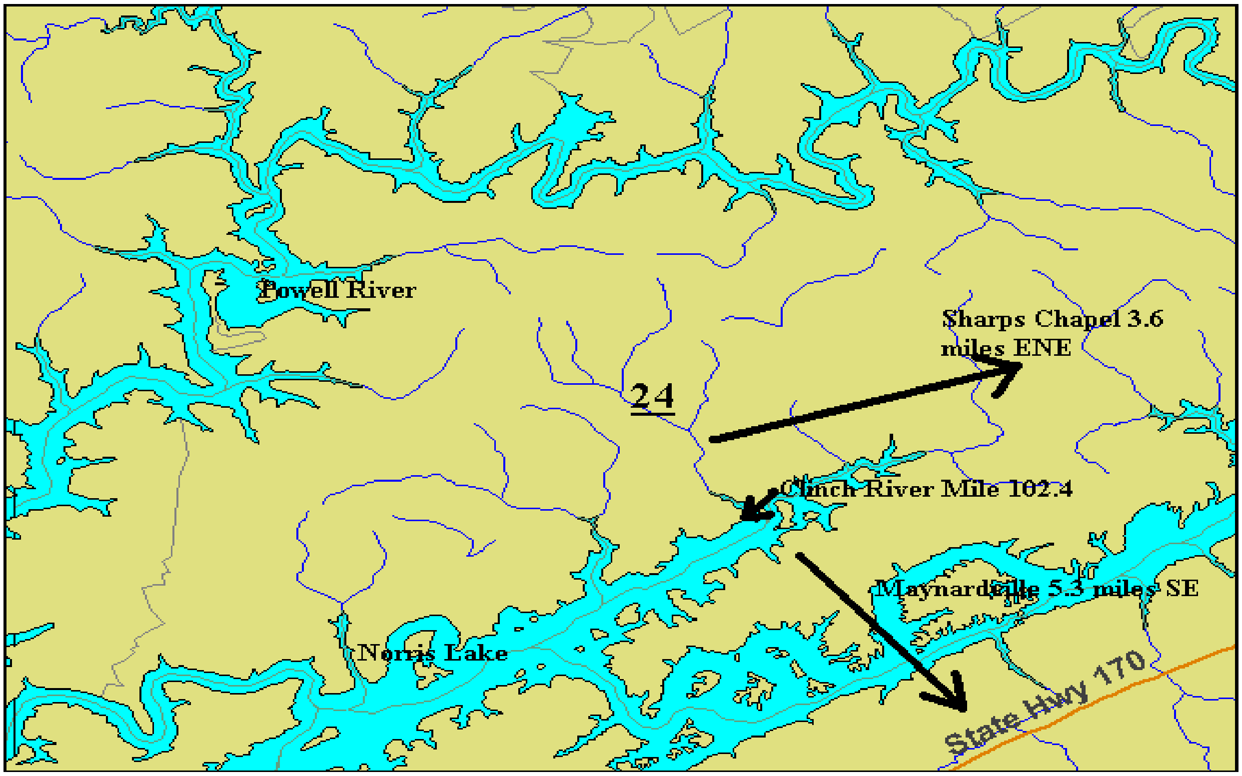

Figure 1f: Sediment Sampling Site 24

Results and Discussion

Metals Analyses

Arsenic at McCoy Branch has been historically elevated either due to the remediated Filled Coal Ash Pond upstream or due to the naturally high background soil values (55.1 ppm) for arsenic in the stream's headwaters (DOE 1993b). The arsenic value (see Figure 2) at McCoy Branch (38.1 ppm) was greater than the Probable Effects Concentration (PEC) for arsenic (McDonald *et al.* 2000). Concentrations of a metal or chemical above the probable effects concentration (PEC) indicate that conditions adverse to sediment-dwelling biota are present in the sediment, and toxicity is expected to occur frequently. The threshold effects concentrations (TECs) are concentrations below which adverse effects are not expected to occur (Ingersoll *et al.* 2000). There is no clear temporal trend in the 13 years of arsenic data collected at McCoy Branch. The arsenic data for all of the other sites was below the PEC.

The only other metal found above the PEC was mercury (Table 2). Sediment samples taken in Poplar Creek all had values greater than the PEC for mercury (1.1 ppm) (Figure 4). Mercury values ranged from 2.85 to 4.56 ppm and increased in an upstream direction. These mercury values are a result of contamination from Y-12 via East Fork Poplar Creek. Mercury samples taken at river miles 7.0 and 0.0 were above soil background levels (0.506 ppm) for mercury (DOE 1993b) (Figure 3). For the purpose of river sediment comparisons, the estimate of the 95th percentile for ORR overall background soil data on pages G-54 to G-56 (of DOE 1993b) was used as background. The mercury levels in all of the Clinch River sediment samples taken below Poplar Creek exceed the EPA Region 4 sediment screening value of 0.13 ppm (EPA 1995). Mercury concentrations do not show any clear temporal trends at any of the sites sampled.

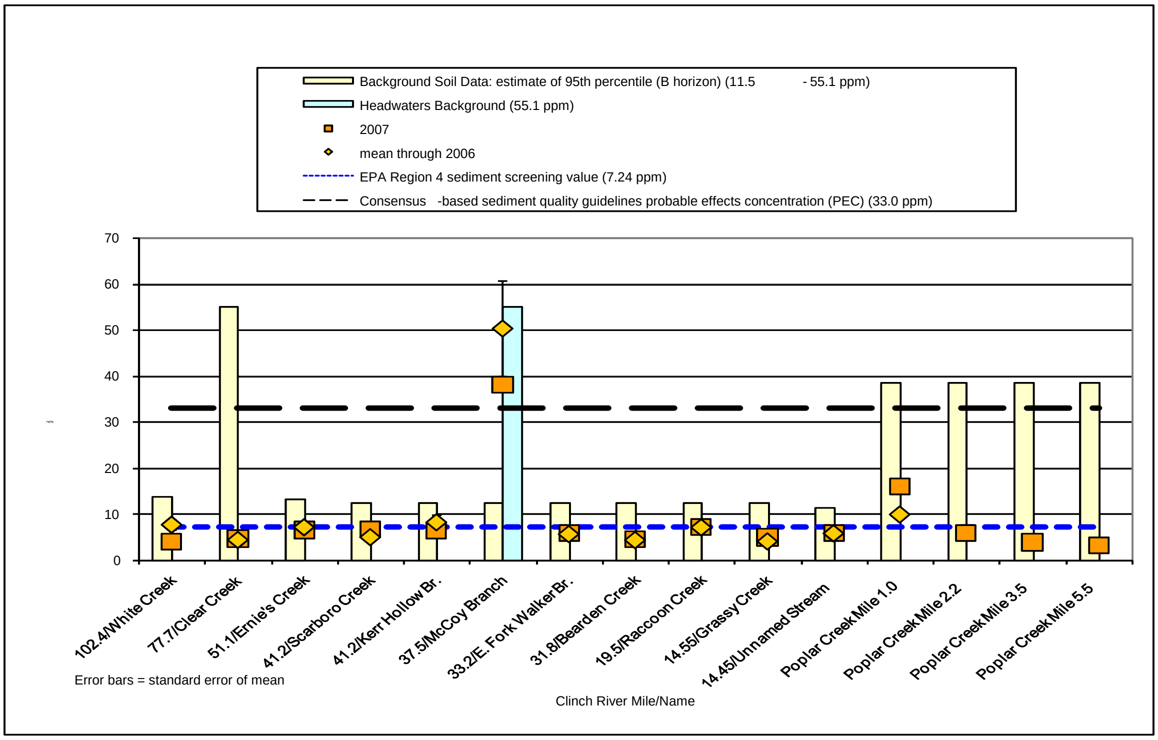

Figure 2: Arsenic in Clinch River Tributary Sediments

Clinch River Mile (CRM) 35.5 had the highest values for Cadmium (1.1 ppm) and Copper (50 ppm) (Table 2); metals at CRM 35.5 are discussed further in the toxicity section of this report. The maximum value for lead (53 ppm) in Table 2 was from Ernie's Creek. Poplar Creek Mile (PCM) 2.2 had the highest value for nickel (33 ppm); the Poplar Creek sampling sites are covered in more detail in the toxicity section.

Table 2: Summary of Metals Data

Parameter	Units	Min.	Max.	Mean	Std. Dev.	Range	Count	PRG*	TEC**	PEC***
Aluminum	mg/kg	1340	19600	7419	4362	18260	25	1.00E+06		
Arsenic	mg/kg	1.6	38.1	7.0	7.3	36.5	25	15.9	9.79	33
Cadmium	mg/kg	0	1.1	0.2	0.4	1.1	25		0.99	4.98
Chromium	mg/kg	5	29	15	6	24	25		43.4	111
Copper	mg/kg	4	50	15	11	46	25	1.00E+06	31.6	149
Iron	mg/kg	4430	30100	17337	7540	25670	25	1.00E+06		
Lead	mg/kg	5	53	24.4	12.3	48	25		35.8	128
Magnesium	mg/kg	481	5250	1588.6	974.0	4769	25			
Manganese	mg/kg	251	4760	1267.8	1022.3	4509	25	9.72E+05		
Mercury	mg/kg	0	4.56	0.68	1.32	4.56	25	1.04E+04	0.18	1.06
Nickel	mg/kg	3	33	15.2	8.0	30	25		22.7	48.6
Total Organic Carbon	%	0.34	6.02	2.218	1.560	5.68	25			
Total Solids	%	19.4	78.7	59.17	14.35	59.3	25			
Zinc	mg/kg	19.3	116	60.4	31.0	96.7	25		121	459
Particle size - gravel	%	0	28.69	5.4	9.1	28.69	25			
Particle size - sand	%	2.62	70.7	36.9	20.8	68.08	25			
Particle size - silt	%	4.71	73.2	40.0	16.5	68.49	25			
Particle size - clay	%	3.09	44.7	17.41	11.1	41.6	25			

*PRG - DOE Preliminary Remediation Goals, Total Soil Risk 1E-6 or HI=1
**Consensus Based Sediment Quality Criteria, Threshold Effects Concentration (McDonald *et al.* 2000)
***Consensus Based Sediment Quality Criteria, Probable Effects Concentration (McDonald *et al.* 2000)

Note: Shaded values indicate levels greater than TEC or PEC.

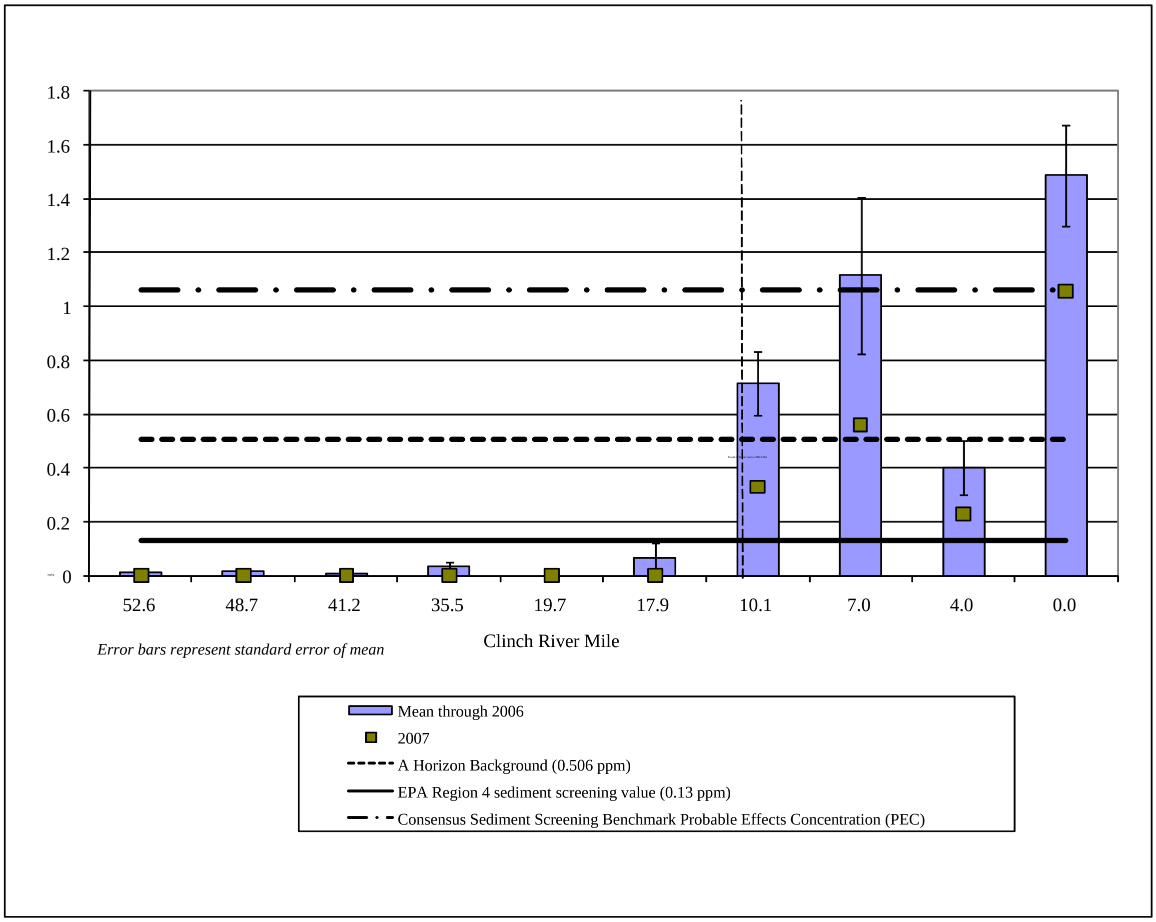

Figure 3: Mercury in Clinch River Sediment Grab Samples (2007)

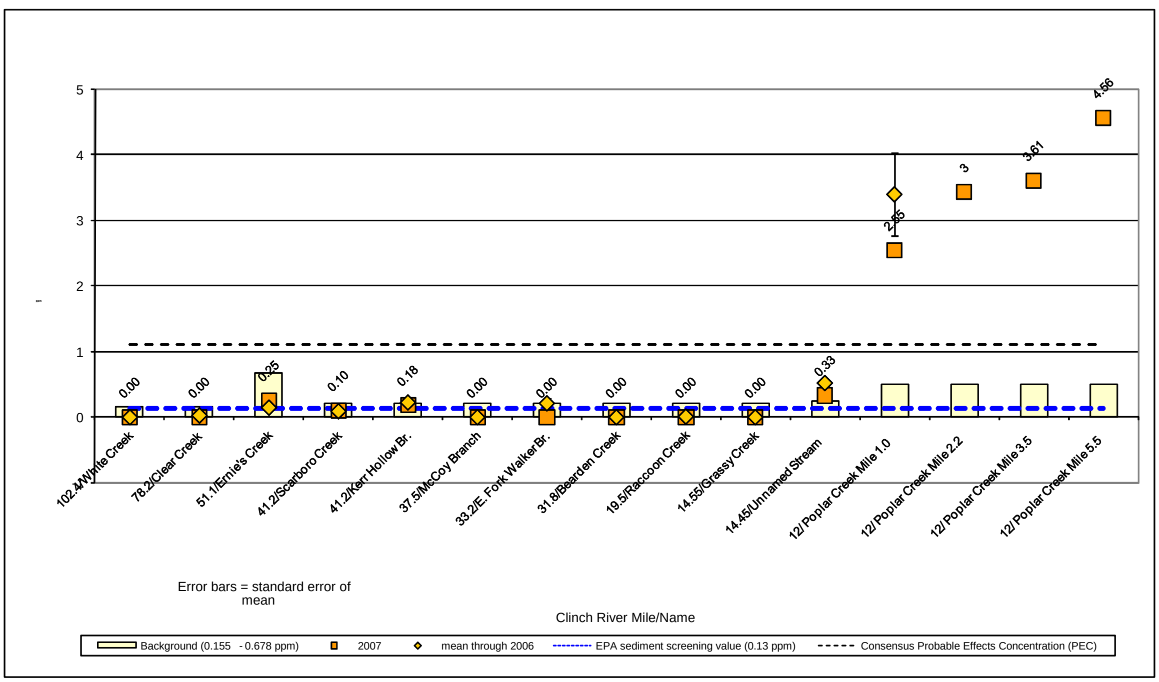

Figure 4: Mercury in Clinch River Tributary Sediments

Organics Analyses

Table 3: Summary of organics data

Parameter	Units	Minimum	Maximum	Mean	Std. Dev.	Range	Count	PRG*	TEC**	PEC***
Aldrin	ppb	0	0	0	0	0	25	3750		
alpha-BHC	ppb	0	0	0	0	0	25			
cis-Chlordane	ppb	0	0	0	0	0	25	62,400	3.24	17.6
beta-BHC	ppb	0	0	0	0	0	25			
Chlordane	ppb	0	0	0	0	0	25	62,400	3.24	17.6
DDD	ppb	0	0	0	0	0	25	336,000	5.28	572
DDE	ppb	0	0	0	0	0	25	237,000	5.28	572
DDT	ppb	0	0	0	0	0	25	109,000	5.28	572
delta-BHC	ppb	0	0	0	0	0	25			
Dieldrin	ppb	0	0	0	0	0	25	3940	1.9	61.8
alpha-Endosulfan	ppb	0	0	0	0	0	25	1.68.E+08		
beta-Endosulfan	ppb	0	0	0	0	0	25	1.68.E+08		
Endosulfan Sulfate	ppb	0	0	0	0	0	25			
Endrin	ppb	0	0	0	0	0	25	502,000	2.22	207
Endrin Aldehyde	ppb	0	0	0	0	0	25			
Endrin Ketone	ppb	0	0	0	0	0	25			
gamma-BHC (Lindane)	ppb	0	0	0	0	0	25		2.37	4.99
gamma-Chlordane	ppb	0	0	0	0	0	25	62,400	3.24	17.6
Heptachlor	ppb	0	0	0	0	0	25	16,500		
Heptachlor epoxide	ppb	0	0	0	0	0	25	8200	2.47	16
Hexachlorobenzene	ppb	0	0	0	0	0	25	14,900		
Hexachlorocyclopentadiene	ppb	0	0	0	0	0	25	303,000		
Methoxychlor	ppb	0	0	0	0	0	25	1.40.E+08		
Pcb-aroclor 1221	ppb	0	0	0	0	0	25	5870		
Pcb-aroclor 1232	ppb	0	0	0	0	0	25	5870		
Pcb-aroclor 1242	ppb	0	0	0	0	0	25	5870		
Pcb-aroclor 1248	ppb	0	0	0	0	0	25	5870		
Pcb-aroclor 1254	ppb	0	0	0	0	0	25	5870		
Pcb-aroclor 1260	ppb	0	0	0	0	0	25	5870		
Toxaphene	ppb	0	0	0	0	0	25	58,900		
1,2,4-Trichlorobenzene	ppb	0	0	0	0	0	25	1.23.E+07		
2,4,6-Trichlorophenol (TCPh)	ppb	0	0	0	0	0	25	5.43.E+06		
2,4-Dichlorophenol	ppb	0	0	0	0	0	25	1.13.E+08		
2,4-Dimethylphenol	ppb	0	0	0	0	0	25	5.61.E+08		
2,4-Dinitrophenol	ppb	0	0	0	0	0	25	8.35E+07		
2,4-Dinitrotoluene	ppb	0	0	0	0	0	25	22,500		
2-Chloronaphthalene	ppb	0	0	0	0	0	25	1.00E+09		
2-Chlorophenol	ppb	0	0	0	0	0	25	1.40E+08		
2-Nitrophenol	ppb	0	0	0	0	0	25			
Dinitro-o-cresol	ppb	0	0	0	0	0	25	4.18E+06		
4-Bromophenyl phenyl ether	ppb	0	0	0	0	0	25			
4-Chloro-3-methylphenol	ppb	0	0	0	0	0	25			
Chlorophenyl-4 phenyl ether	ppb	0	0	0	0	0	25			
4-Nitrophenol	ppb	0	0	0	0	0	25	3.34E+08		
Acenaphthene	ppb	0	0	0	0	0	25	1.19E+08		
Acenaphthylene	ppb	0	0	0	0	0	25			
Anthracene	ppb	0	0	0	0	0	25	1.00E+09	57.2	845
Benzo[a]anthracene	ppb	0	809	44	170	809	25	6350	108	1050
Benzo[a]pyrene	ppb	0	928	37	186	928	25	635	150	1450
Benzo[b]fluoranthene	ppb	0	1780	101	365	1780	25	6350		
Benzo[g,h,i]perylene	ppb	0	274	11	55	274	25			
Benzo[k]fluoranthene	ppb	0	431	17	86	431	25	63,500		
bis(2-chloroethoxy) methane	ppb	0	0	0	0	0	25	8.41E+07		
bis(2-chloroethyl) ether	ppb	0	0	0	0	0	25	18,900		
bis(2-ethylhexyl) phthalate (DEHP)	ppb	0	587	40	140	587	25	2.26E+06		
bis(2-chloroisopropyl) ether	ppb	0	0	0	0	0	25	1.00E+09		
Butyl benzyl phthalate	ppb	0	0	0	0	0	25	3.91E+07		
Chrysene	ppb	0	1240	59	251	1240	25	635,000	166	1,290

Table 3: Summary of organics data (continued)

Parameter	Units	Minimum	Maximum	Mean	Std. Dev.	Range	Count	PRG*	TEC**	PEC***
Dibenzo[a,h]anthracene	ppb	0	0	0	0	0	25	635	33	
Diethyl phthalate	ppb	0	0	0	0	0	25	1.00E+09		
Dimethyl phthalate	ppb	0	0	0	0	0	25	1.00E+09		
Dibutyl phthalate	ppb	0	0	0	0	0	25	1.00E+09		
bis(n-octyl) Phthalate	ppb	0	0	0	0	0	25			
Fluoranthene, C1-C4	ppb	0	1910	117	401	1910	25	7.95E+07	423	2230
Fluorene, C1-C3	ppb	0	0	0	0	0	25	1.26E+08	77.4	536
Hexachlorobenzene	ppb	0	0	0	0	0	25	14,900		
Hexachlorobutadiene	ppb	0	0	0	0	0	25	95,200		
Hexachlorocyclopentadiene	ppb	0	0	0	0	0	25	303,000		
Hexachloroethane	ppb	0	0	0	0	0	25	1.51E+06		
Indeno[1,2,3-cd]pyrene	ppb	0	1700	68	340	1700	25	6350		
Isophorone	ppb	0	0	0	0	0	25	6.98E+07		
Naphthalene	ppb	0	0	0	0	0	25	1.61E+07	176	561
nitro-Benzene	ppb	0	0	0	0	0	25	9.04E+06		
n-Nitrosodimethylamine	ppb	0	0	0	0	0	25	768		
n-Nitrosodipropylamine	ppb	0	0	0	0	0	25	5640		
n-Nitrosodiphenylamine	ppb	0	0	0	0	0	25	8.06E+06		
Pentachlorophenol (PCP)	ppb	0	0	0	0	0	25	63,700		
Phenanthrene, C1-C4	ppb	0	626	25	125	626	25		204	1170
Phenol	ppb	0	0	0	0	0	25	1.00E+09		
Pyrene	ppb	0	1060	58	216	1060	25	5.96E+07	195	1520

*PRG - DOE Preliminary Remediation Goals, Total Soil Risk 1E-6 or HI=1
**Consensus Based Sediment Quality Criteria, Threshold Effects Concentration (McDonald *et al.* 2000)
***Consensus Based Sediment Quality Criteria, Probable Effects Concentration (McDonald *et al.* 2000)

No organics parameters exceeded the PECs; the levels found do not present a threat to human health or wildlife. The high (maximum) values (Table 3) for the polycyclic aromatic hydrocarbons (PAHs) such as benzo[a]pyrene, benzo[b]fluoranthene, etc. are from Ernie's Creek. Table 4 lists PAH data for Ernie's Creek and Scarboro Creek. Both streams have a number of PAH values that exceed the TECs but are less than the PECs (shaded areas). Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 chemicals that are primarily associated with the incomplete combustion of coal, oil, gas, garbage, or other substances like tobacco or charbroiled meat. PAHs are usually found as a mixture of several of these compounds. PAHs are found in coal tar, crude oil, creosote, and roofing tar, but a few are used in the manufacture of medicines, dyes, plastics, and pesticides.

Table 4: Polycyclic aromatic hydrocarbons (PAHs) at Ernie's and Scarboro Creeks

Parameter	Units	Ernie's Creek	Scarboro Creek	PRG*	TEC**	PEC***
Benzo[a]anthracene	ppb	809	292	6350	108	1050
Benzo[a]pyrene	ppb	928	201	635	150	1450
Benzo[b]fluoranthene	ppb	1780	424	6350		
Benzo[g,h,i]perylene	ppb	274	non-detect			
Benzo[k]fluoranthene	ppb	431	non-detect	63,500		
Chrysene	ppb	1240	241	635,000	166	1,290
Fluoranthene, C1-C4	ppb	1910	656	7.95E+07	423	2230
Indeno[1,2,3-cd]pyrene	ppb	1700	non-detect	6350		
Phenanthrene, C1-C4	ppb	626	non-detect		204	1170
Pyrene	ppb	1060	235	5.96E+07	195	1520
Total PAHs	ppb	10758	2049		1610	22,800

*PRG - DOE Preliminary Remediation Goals, Total Soil Risk 1E-6 or HI=1
**Consensus Based Sediment Quality Criteria, Threshold Effects Concentration (McDonald *et al.* 2000)
***Consensus Based Sediment Quality Criteria, Probable Effects Concentration (McDonald *et al.* 2000)

The exact origin of the slightly elevated PAH levels at Ernie's Creek and Scarboro Creek is not known; it may be due to runoff from roads and parking lots in Oak Ridge or it may be an influx of contaminants from an old landfill in the area. The most likely cause is coal-tar and asphalt-based pavement sealers used to improve the appearance of parking lots and driveways. Studies done in Austin, Texas provide strong evidence to support the idea that parking lot sealcoats are the major source of PAHs that end up in stream sediments in residential and commercial areas (Mahler *et al.* 2005). Scarboro Creek may have been contaminated by groundwater from an old landfill in Union Valley. Ernie's Creek flows through the city of Oak Ridge and has so many possible avenues of infiltration that it would be impossible to pinpoint one source as the culprit. Ernie's Creek may also have been contaminated by groundwater leakage of an old Oak Ridge landfill on the east side of Oak Ridge. Stormwater drainage from area roads may have also contributed with petroleum products spilled and leaked from vehicles.

Radiological Analyses
The radiological sediment data show no reason for human health concerns; all parameters are well below DOE PRGs. The recreational PRG for Cs-137 is 2580 pCi/g (total soil 1E-06) (DOE 2005). Many of the river sampling sites below Jones Island show Cs-137 above background (DOE 1993b) but Clinch River Mile (CRM) 0.0 has the highest levels (Figure 5). At Clinch River Mile 10.1 Cs-137 activities appear to have decreased over the 13-year span of sediment sampling from 1994 to 2007.

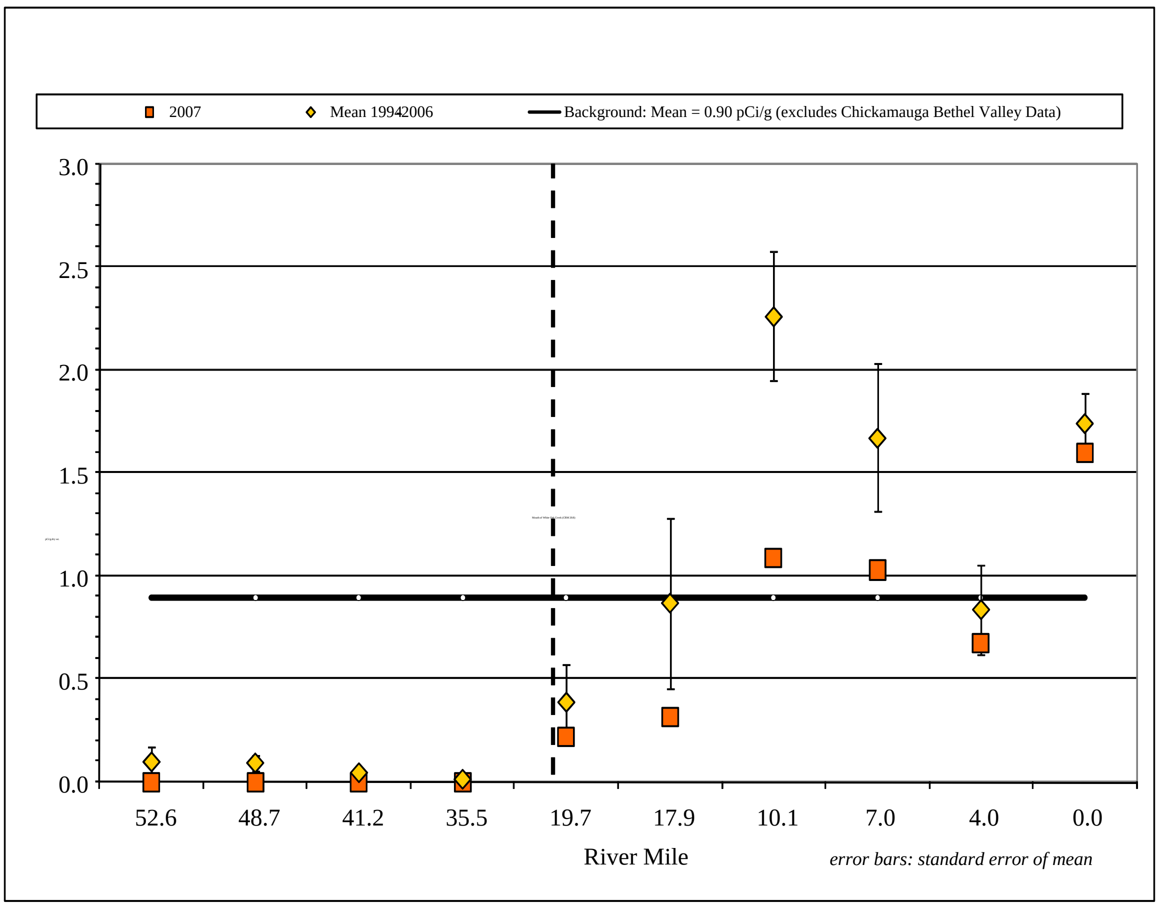

Figure 5: Cesium-137 in Clinch River Sediments

Site 22 (a tributary, mouth at CRM 14.45) has shown significantly higher levels of Cs-137 than all of the other sites (see Figure 6). This stream runs through the K-1515C lagoon that was once used to receive backwash material from filters at the ETTP Water Treatment Plant. It is believed that these water filters concentrated the Cs-137 from suspended river sediments. The K-1515C lagoon is no longer used for the purpose of catching filter backwash material.

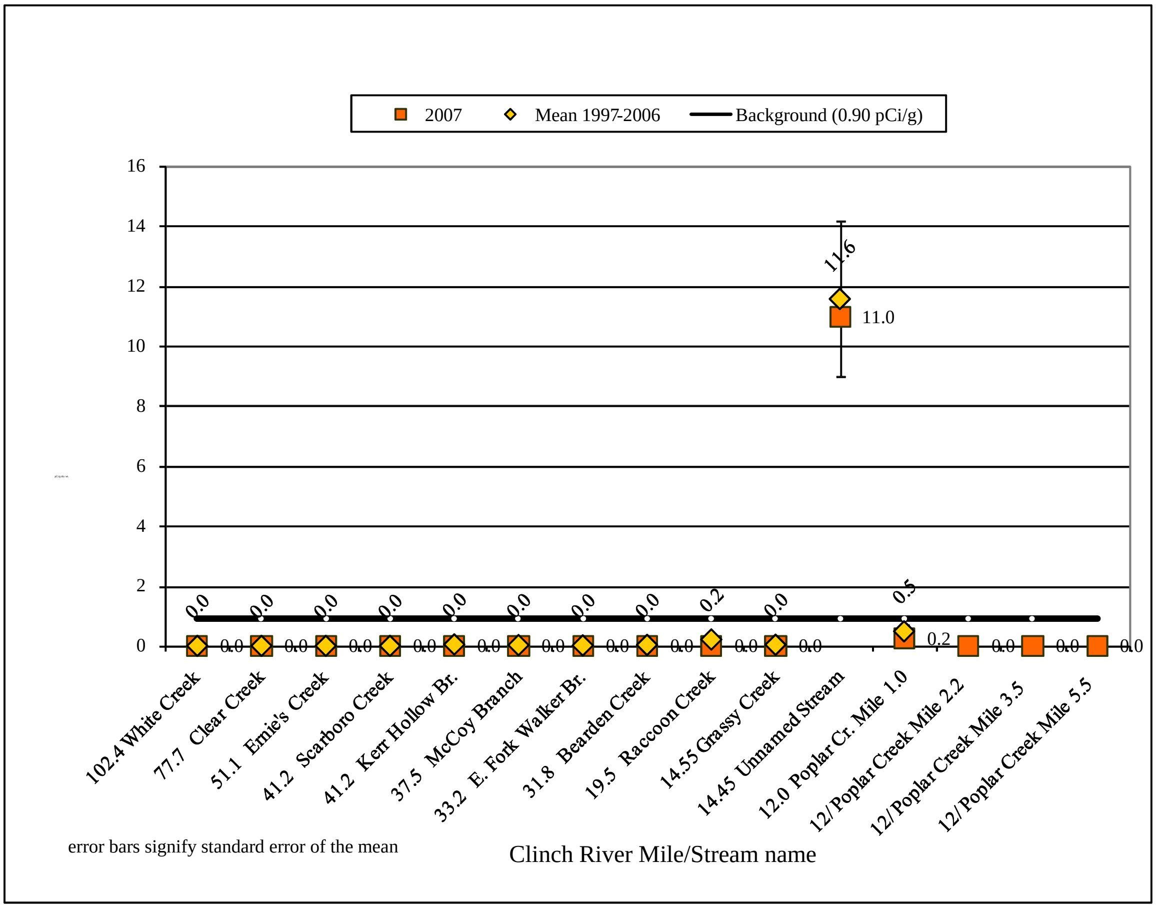

Figure 6: Cs-137 in Clinch River Tributary Sediments

Toxicity Analyses

Ten-day whole-sediment toxicity tests were conducted on selected sites with *Hyallela azteca* by Advent-Environ of Brentwood, Tennessee. Figure 7 shows per cent (%) survival for selected sites on the Clinch River. Sites for toxicity testing were selected based on elevated metals values from the 2007 sediment sample analyses.

Clinch River Mile 35.5 was the only sampling location that demonstrated a detrimental effect to *H. azteca* in terms of significantly reduced survival (t Test at alpha 0.05) (Advent-Environ 2007) as compared to the control. Table 5 lists metals data for the Clinch River sites tested for toxicity. The results from Clinch River Mile 35.5 included five metals that were greater than the TEC but less than the PEC (arsenic, cadmium, copper, lead and nickel). The data for semi-volatile organics and pesticides were all non-detects and radiological data were at background levels. Clinch River Mile 35.5 is upstream of all DOE plants. It is unknown why the metals levels are slightly elevated at this site.

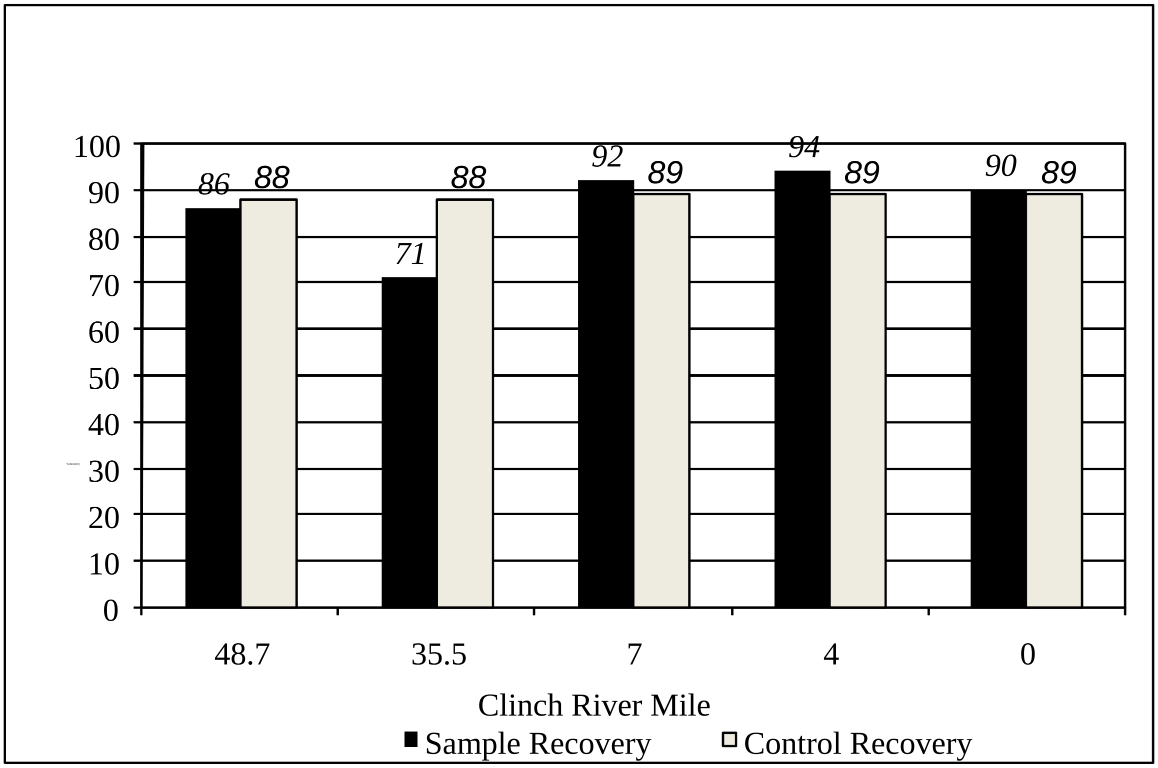

Figure 7: % Survival of *Hyallela azteca* in Clinch River samples

Table 5: Metals data for sites tested for toxicity

	CRM 48.7	CRM 35.5	CRM 7	CRM 4	CRM 0	TEC*	PEC*
Arsenic	3.1	13.0	4.5	1.9	11.6	9.79	33
Cadmium	<0.5	1.1	<0.5	<0.5	0.8	0.99	4.98
Chromium	11	19	12	5	19	43.4	111
Copper	10	50	6	11	41	31.6	149
Lead	16	40	14	11	34	35.8	128
Mercury	<0.1	<0.1	0.561	0.230	1.06	0.18	1.06
Nickel	11	29	8	9	28	22.7	48.6
Zinc	51.6	116	37.6	31.5	114	121	459

* McDonald *et al.* 2000

The three sites on Poplar Creek that were tested for sediment toxicity did not show significant detrimental effects to *H. azteca* as compared to the control; the toxicity test results are shown in Figure 8. All three of these Poplar Creek sites had mercury levels above the PEC (Table 6). At Poplar Creek Mile (PCM) 3.5, nickel is greater than the TEC and less than the PEC. PCM 2.2 values for nickel and cadmium exceeded the TEC and were less than the PEC. Clear Creek Mile (CCM) 0.1 is a background tributary site (shaded areas).

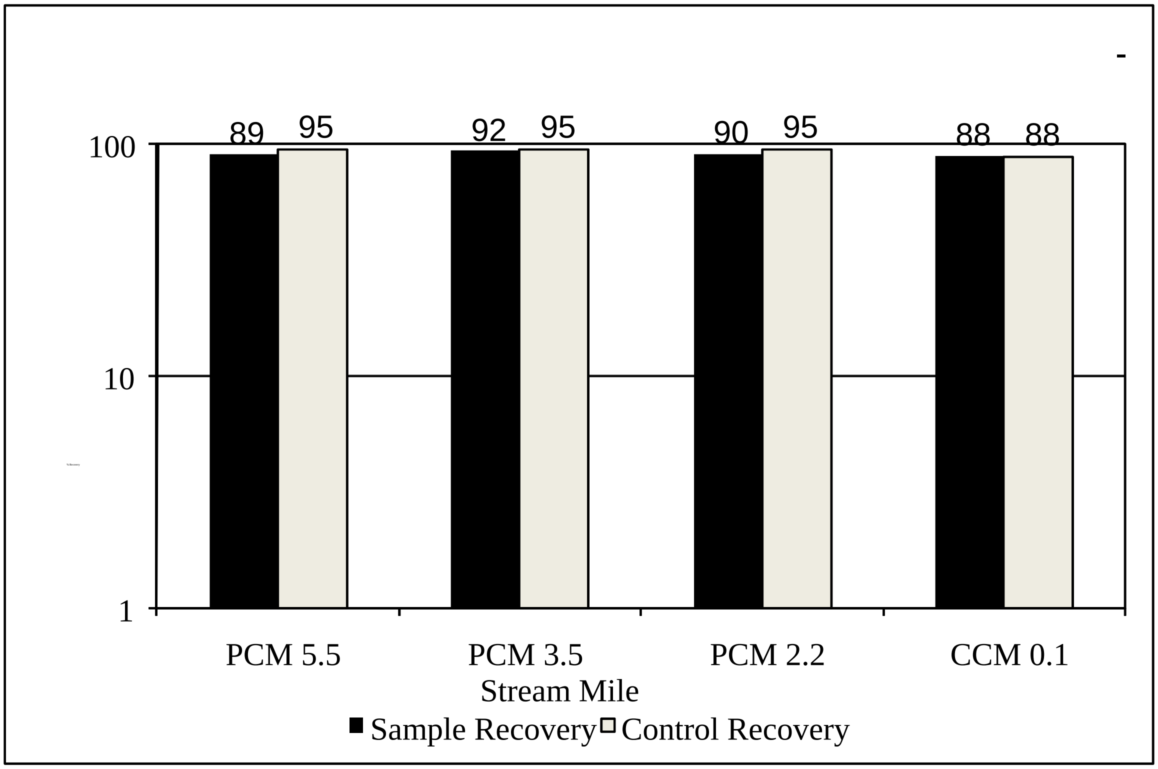

Figure 8: % Survival of *Hyallela azteca* in tributary samples

Table 6: Metals data for Poplar Creek and Clear Creek sites

	PCM 5.5	PCM 3.5	PCM 2.2	CCM 0.1	TEC*	PEC*
Arsenic	3.3	3.9	5.9	4.7	9.79	33
Cadmium	0.7	0.7	1.0	<0.5	0.99	4.98
Chromium	15	14	16	12	43.4	111
Copper	20	18	27	7	31.6	149
Lead	24	19	27	29	35.8	128
Mercury	4.56	3.61	3.43	<0.1	0.18	1.06
Nickel	21	24	33	9	22.7	48.6
Zinc	87.0	80.3	116	34.6	121	459

* McDonald *et al.* 2000

Conclusion

Sediment data from 2007 samplings show no levels of contamination that exceed DOE Preliminary Remediation Goals (PRGs) for recreation and, based on these criteria, do not pose a threat to human health. If, in the future, these sediments are to be used for agricultural or other purposes, analysis should be performed to determine the suitability for these new purposes. The arsenic value at McCoy Branch (38.1 ppm) was greater than the Probable Effects Concentration (PEC) for arsenic (McDonald *et al.* 2000). There is no clear temporal trend in the 13 years of arsenic data collected at McCoy Branch. The arsenic data for all of the other sites was below the PEC.

Mercury levels in the samples taken in the Clinch River below the confluence of Poplar Creek are elevated. Although the levels of mercury are well below the recreational PRG, they are higher than all of the other Clinch River sediment sampling sites. Mercury concentrations do not show any clear temporal trends at any of the sites sampled.

Scarboro Creek and Ernie's Creek continue to show elevated PAH levels. Site 22 (CRM 14.45) has shown considerably higher levels of Cs-137 than all of the other sites. This is believed to be due to the effect of concentrating suspended Cs-137-contaminated sediment particles in river water by filters at the ETTP Water Treatment Plant and disposing of the filter backwash material in the K-1515C lagoon. Cs-137 is found at levels that are above background at most of the sites below the mouth of White Oak Creek. The levels are very low and do not pose a threat to recreation or human health. At Clinch River Mile 10.1 Cs-137 activities appear to have decreased over the 13-year span of sediment sampling from 1994 to 2007. The level of contamination appears to be decreasing over time as a result of the radioactive decay of the Cs-137 and the deposition of fresh sediment on the bottom. Clinch River Mile 35.5 was the only sampling location that demonstrated a detrimental effect to *H. azteca* in terms of significantly reduced survival as compared to the toxicity control.

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Ambient Surface Water Monitoring Program

Principle Author: John (Tab) Peryam

Abstract

The Division conducted surface water sampling at 20 sites on the Clinch River and some tributaries of the Clinch River in 2006 (Table 1 and Figures 1a-f). The samples were analyzed for certain microbiological organisms, metals, nutrients and radiological parameters. Two samples exceeded Tennessee water quality criteria for *E. coli*: Clinch River Mile 52.6 (site 2) and East Fork Walker Branch Mile 0.1 (site 12). The radionuclides lead-212 and lead-214 were found at levels higher than the DOE Preliminary Remediation Goals (recreation), but these isotopes are a naturally occurring part of the environment.

Table 1: Sample Locations

Site	Location	Clinch River Mile*	Map
1	Clinch River Mile (CRM) 78.7	78.7	Figure 1.5
2	CRM 52.6	52.6	Figure 1.4
3	CRM 35.5	35.5	Figure 1.3
4	CRM 17.9	17.9	Figure 1.2
5	CRM 10.1	10.1	Figure 1.1
6	CRM 48.7	48.7	Figure 1.4
7	CRM 41.2	41.2	Figure 1.3
8	Scarboro Creek	41.2	Figure 1.3
9	Kerr Hollow Branch	41.2	Figure 1.3
10	McCoy Branch	37.5	Figure 1.3
12	East Fork of Walker Branch	33.2	Figure 1.3
13	Bearden Creek	31.8	Figure 1.3
18	Raccoon Creek	19.5	Figure 1.2
20	Grassy Creek	14.55	Figure 1.2
22	Unnamed Stream	14.45	Figure 1.2
23	Ernie's Creek	51.1	Figure 1.4
24	White Creek	102.4	Figure 1.6
25	Clear Creek	77.7	Figure 1.5
32	CRM 19.7	19.7	Figure 1.2
33	Poplar Creek Mile 1.0	12.0	Figure 1.2

*For tributaries, refers to location of tributary mouth on the Clinch River.

Introduction

The Division conducts semi-annual surface water sampling to detect possible contamination from DOE sites. There are eight sites on the Clinch River and 12 tributary sites. Contaminants in surface water samples are rarely detected; the data provide an ambient data set for evaluation of possible future contaminant discharges.

Sampling was conducted during April and September/October. Samples were analyzed for *E. coli* and *Enterococcus* bacteria, alpha, beta, and gamma emissions, ammonia, chemical oxygen demand (COD), dissolved residue, NO^3 & NO^2 nitrogen, suspended residue, total hardness, total Kjeldahl nitrogen, total phosphate, arsenic, cadmium, copper, iron, lead, manganese, mercury, chromium, and zinc. Data are available online at EPA's STORET database (http://www.epa.gov/storet/dbtop.html). Click on "browse or download modernized STORET data". Then, under "query options", select "STORET regular results, regular results by project". On the next page, under "step 1", select TDECDOE as the organization and select "WATER" as the project in "step 2".

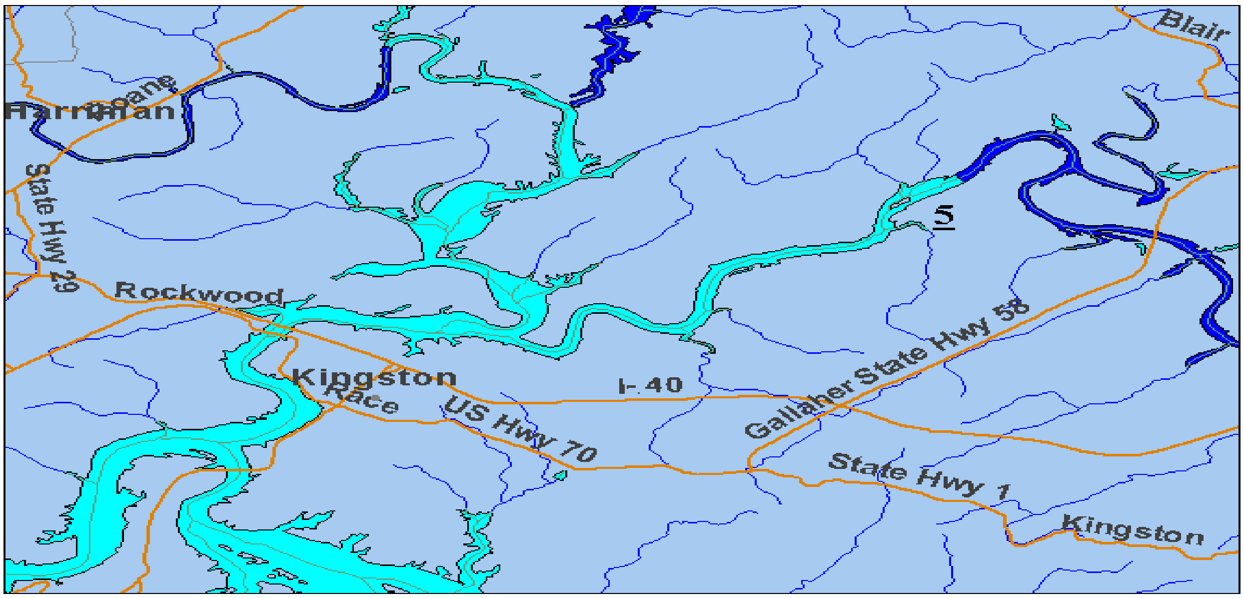

Figure 1a: Surface Water Sampling Site 5

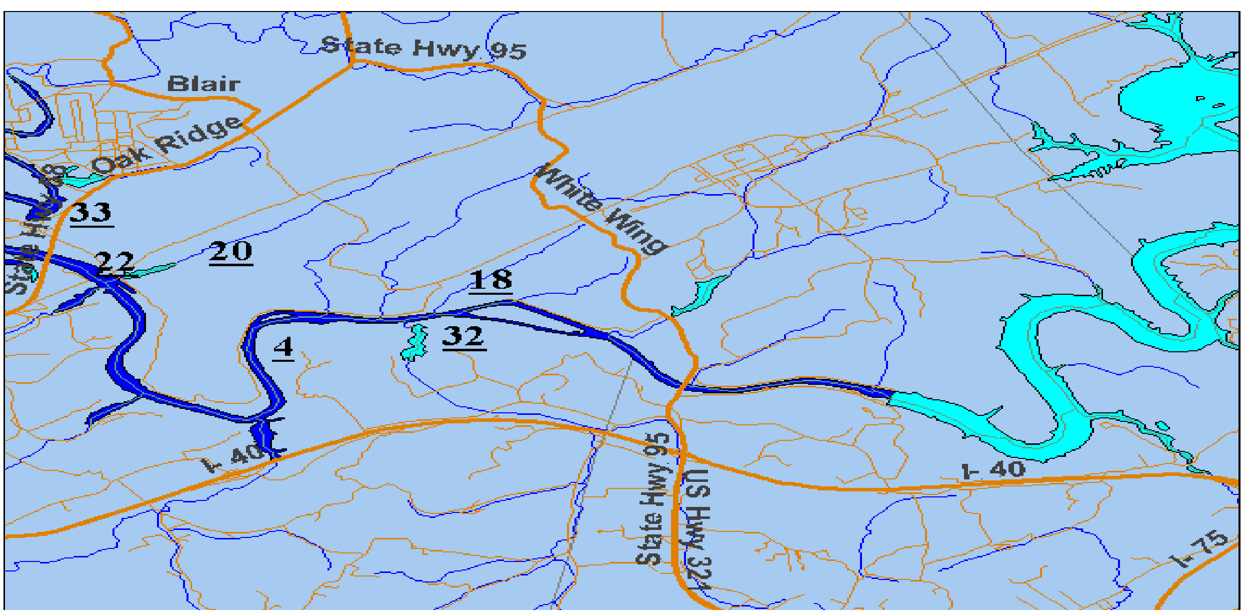

Figure 1b: Surface Water Sampling Sites 4, 18, 20, 22, 32, 33

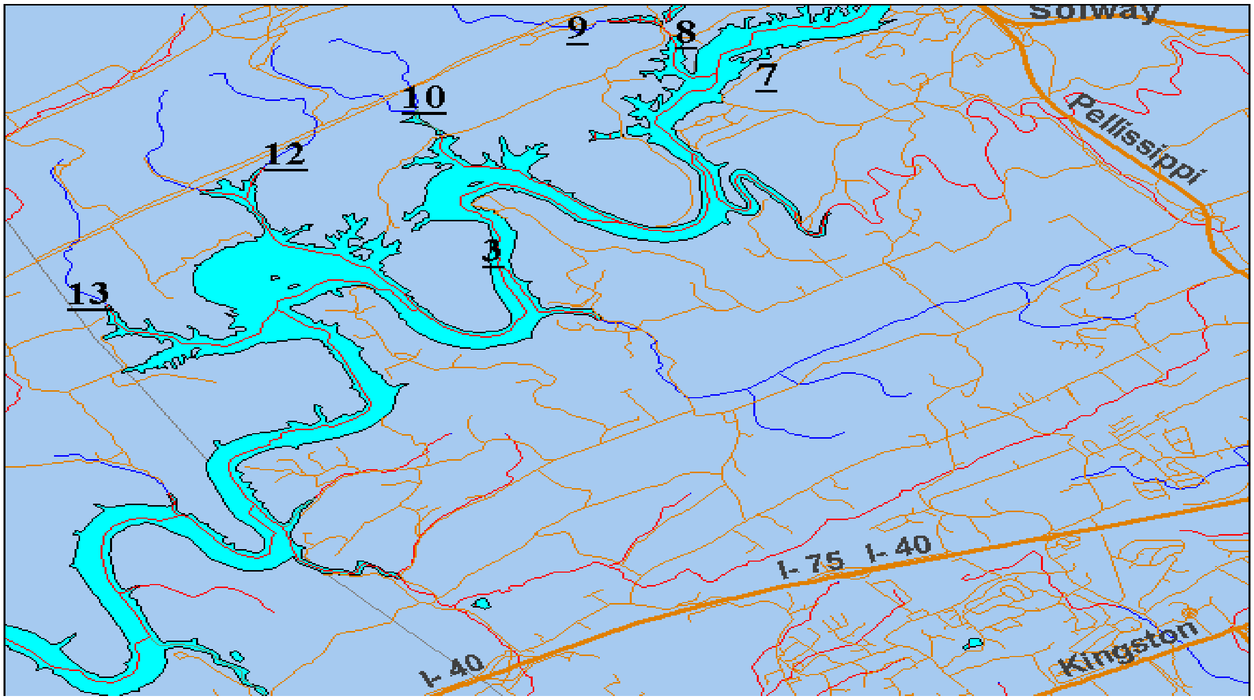

Figure 1c: Surface Water Sampling Sites 3, 7, 8, 9, 10, 12, 13

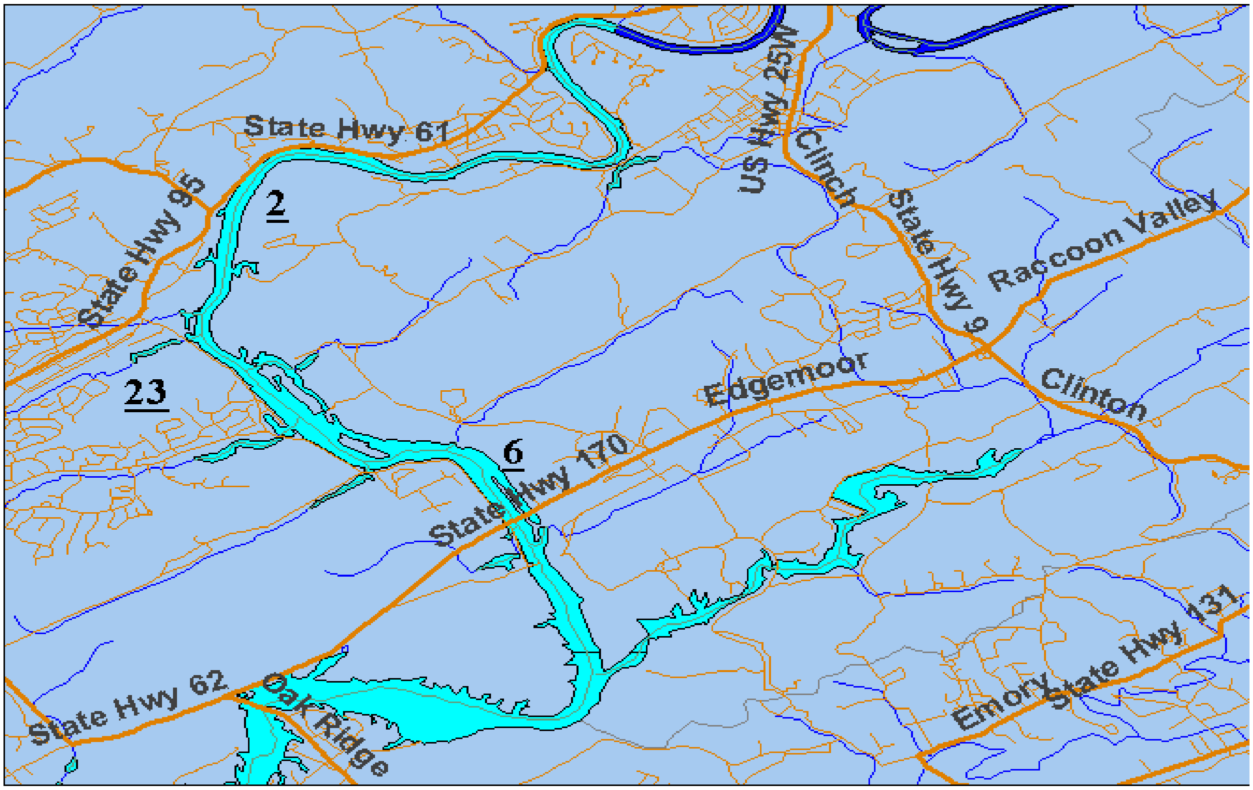

Figure 1d: Surface Water Sampling Sites 2, 6, 23

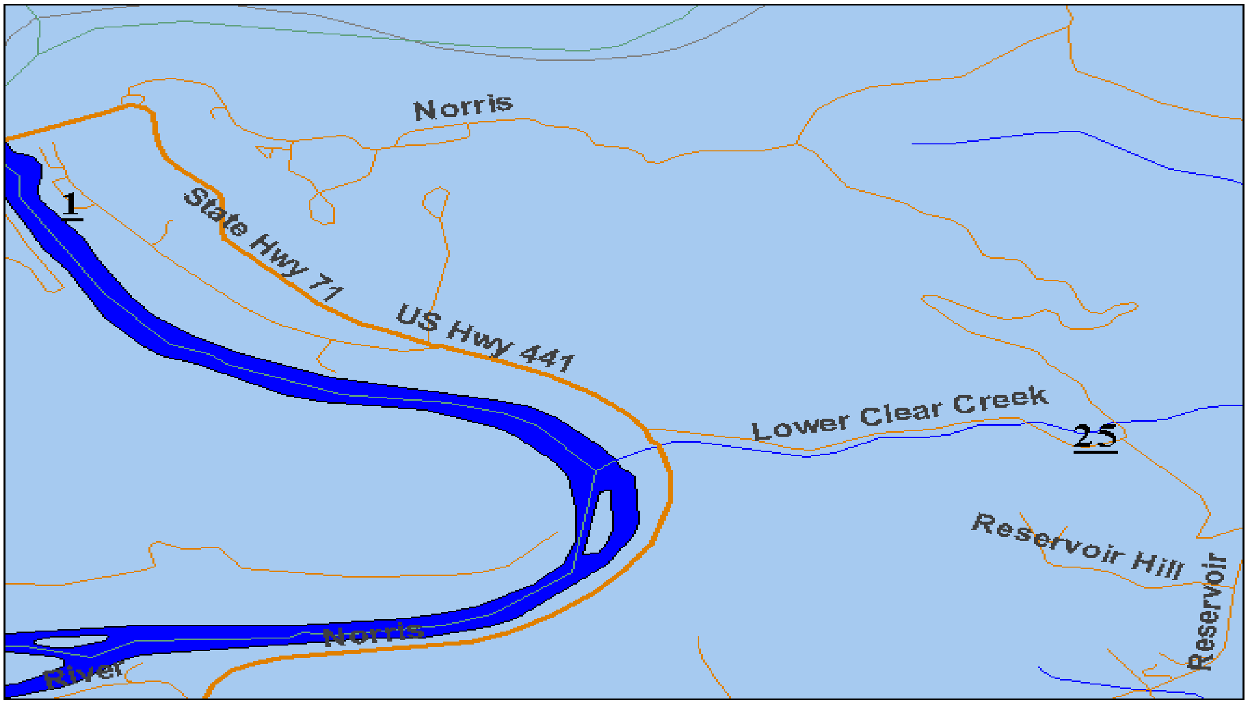

Figure 1e: Surface Water Sampling Sites 1, 25

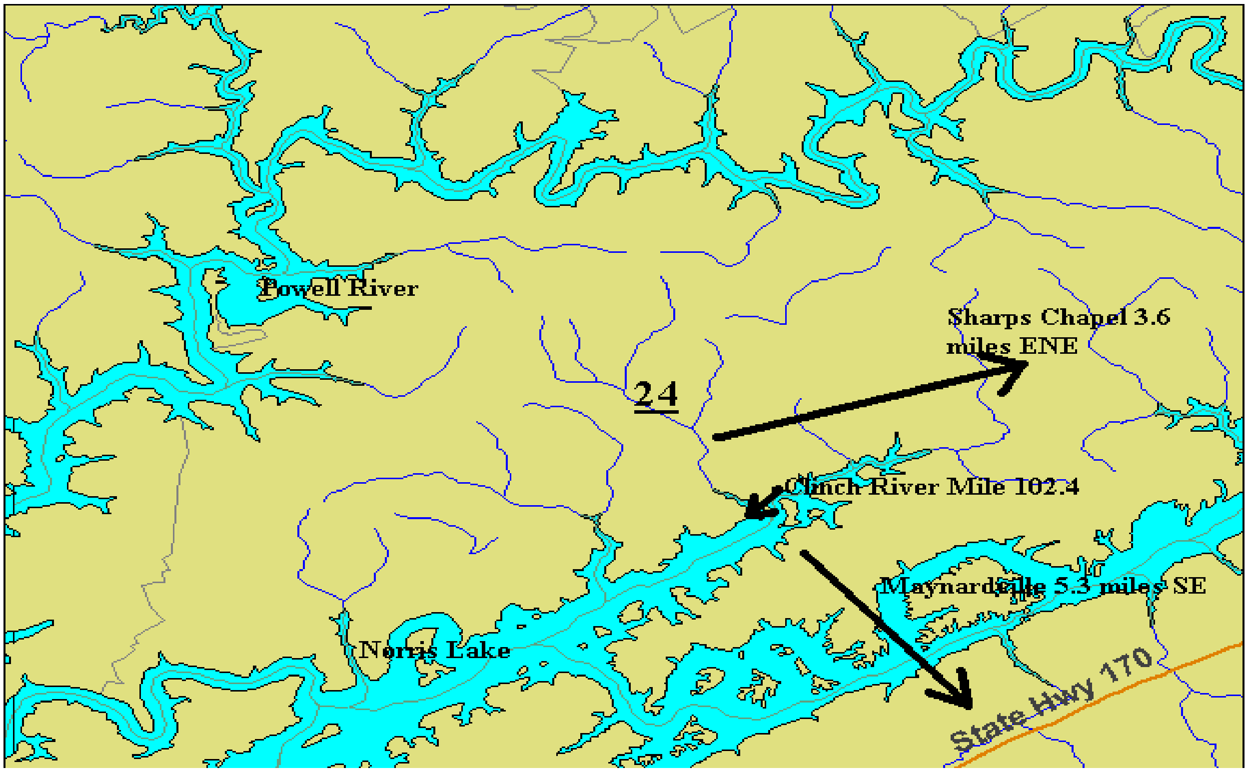

Figure 1f: Surface Water Sampling Site 24

Methods and Materials

Surface water sampling techniques and equipment are designed to minimize effects on the chemical and physical integrity of the sample. A clean pair of new, disposable gloves will be worn each time a different location is sampled and gloves should be donned immediately prior to sampling. When the sample container lid is removed it should be protected from contamination. Samples are collected by direct dipping of the sample container into the stream. If wading, samples are collected on the upstream side to avoid any suspension of sediments. The sampler should be careful not to displace the preservative from a pre-preserved sample container. Tributary sites are sampled far enough upstream to avoid the effects of high river flows. The Tennessee State Department of Health (TDH) Laboratories processed the samples, according to EPA approved methods.

Results and Discussion

The Tennessee Water Quality Criteria (TWQC) for *E. coli* (recreation, organisms only) is 487 cfu/100ml for a single sample for White Creek, Clear Creek (Tier II streams) and the Clinch River (a reservoir). For all of the other tributaries the TWQC is 941 cfu/100ml for a single sample. The East Fork Walker Branch water sample taken on September 28, 2006 had 1203 colony forming units (CFU) per 100ml (see maximum value on Table 2). The mean of the data at this site (1997-2005, 21 samples) is 197 ± 253.7 cfu/100ml. This stream has its mouth at Clinch River Mile (CRM) 33.2 and its headwaters across Bethel Valley Road on the side of Chestnut Ridge in the vicinity of several DOE landfills. In addition, the sample taken at CRM 52.6 (site 2) on September 26, 2006 had an *E. coli* value of 866 cfu/100 ml. A reading this high in the main body of the river is unusual; the mean of the data at this site (1998-2005, 20 samples) is 65.5 ± 216.9 cfu/100ml. These elevated readings could be caused by a number of factors such as leaky sewage systems, animal waste runoff, or laboratory error.

The only radionuclides testing higher than the DOE Preliminary Remediation Goals (PRGs) were lead-212 and lead-214 (DOE 2005) (see Table 3). These are naturally-occurring isotopes in the thorium and radium decay series, respectively. These radionuclides are part of the geology of the area and contribute to the terrestrial component of our background dose.

Conclusion

With the exception of the *E. coli* values at CRM 52.6 and at East Fork Walker Branch, the water analyses were within acceptable ranges of the TWQC for all the parameters that were measured. These *E. coli* values are unusual when past data at these sites is taken into consideration. Lead-212 and lead-214 values exceeded DOE PRGs, but these are naturally occurring radionuclides.

Table 2: Surface Water Data Summary (non-radiological)

Parameter	Units	Min.	Max.	Mean	S.D.	Range	Count	TWQC*
ammonia	mg/L	0	0	0	0	0	38	n.a.
COD	mg/L	0	22	5.8	5.7	22	38	n.a.
dissolved oxygen	mg/L	5.2	11.9	8.8	1.5	6.7	20	5.0[a]
dissolved residue	mg/L	55	237	152.2	43.4	182	38	500[b]
E. coli	CFU/100ml	0	2419	201.0	540.7	2419	38	487[c]/941[d]
Enterococcus	CFU/100ml	0	2419	316.1	643.6	2419	38	n.a.
NO_3 & NO_2	mg/L	0	1.6	0.3	0.4	1.6	38	n.a.
pH		6.4	8.3	7.7	0.4	1.9	20	5.5-9[a]
specific conductivity	µs/cm	137	477	289.3	76.4	340	20	n.a.
suspended residue	mg/L	0	80	3.3	13.7	80	38	n.a.
total hardness	mg/L	87	258	160.2	33.3	171	38	n.a.
total Kjeldahl nitrogen	mg/L	0	1.2	0.1	0.3	1.2	38	n.a.
total phosphate	mg/L	0	0.15	0.02	0.04	0.15	38	n.a.
arsenic	µg/L	0	9	0.5	1.6	9	38	10[e]
cadmium	µg/L	0	0	0	0	0	38	2.0[h]
chromium	µg/L	0	6	0.2	1.0	6	38	16[g]
copper	µg/L	0	4	0.7	1.3	4	38	13[h]
iron	µg/L	0	1140	169.3	227.5	1140	38	n.a.
lead	µg/L	0	2	0.1	0.3	2	38	5[f]/65[a]
manganese	µg/L	8	568	71.4	100.3	560	38	n.a.
mercury	µg/L	0	0	0	0	0	38	0.051[e]
zinc	µg/L	3	16	6.4	2.7	13	38	120[h]

*Tennessee Water Quality Criteria:

[a] Fish and Aquatic Life (FAL), applies to all sites

[b] Industrial Water Supply, applies only to Clinch River Sites

[c] Recreation (organisms only), one time sample for lakes, scenic rivers, tier II, tier III streams

[d] Recreation (organisms only), one time sample for any other water bodies (applies to tributaries other than Clear, White Cr.)

[e] Recreation (organisms only), applies to all sites

[f] This value is for Domestic Water Supply, which applies only to Clinch River Sites.

[g] FAL (Chromium VI)

[h] Fish and Aquatic Life (FAL), applies to all sites. This value is for total hardness of 100mg/L

Table 3: Radiological Surface Water Data Summary

Parameter	Minimum	Maximum	Mean	Standard Deviation	Range	# of samples	PRG[1]
Actinium-228	0	18.4	0.8	3.6	18.4	40	24
Bismuth-212	0	26.7	1.3	5.9	26.7	40	180
Bismuth-214	0	115.8	14.4	21.6	115.8	40	670
Cesium-137	0	0	0.0	0.0	0	40	0.024
Lead-210	0	0	0.0	0.0	0	40	0.005
Lead-212	0	9.9	0.5	2.0	9.9	40	0.17
Lead-214	0	72.1	6.5	14.6	72.1	40	12
Potassium-40	0	0	0.0	0.0	0	40	600*
Radioactivity, alpha	-2	2.6	0.5	1.0	4.6	40	n.a.
Radioactivity, beta	0.2	9.7	2.4	1.9	9.5	40	n.a.
Thallium-208	0	5.9	0.1	0.9	5.9	40	n.a.

Units are pCi/L

[1] DOE Preliminary Remediation Goals (PRGs), Recreational Land Use: Concentration in Water/Ingestion fish/radionuclides at 10-6; last updated 2/27/07

* DOE PRG, Recreational Land Use: Ingestion of water/radionuclides at 10^{-6}; last updated 2/27/07

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ORR Surface Water Monitoring (Physical Parameters)

Principal Author: Gerry Middleton

Abstract

Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for this pollution to impact surface waters on the ORR as well as offsite aquatic systems. The local karst topography and related structural geology influences the fate and transport of contaminants that may further degrade the groundwater and surface water quality of aquatic systems adjacent to the ORR. Therefore, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (TDEC DOE-O, or Division), collected ambient water quality data at seven ORR and one offsite stream locations during 2007. The field data results, collected twice a month, are summarized in Figures 2-9.

Introduction

The Division began to collect ambient, real time water quality monitoring data at eight stream sites dispersed in several watersheds during 2007 (Figure 1). The main watersheds include East Fork Poplar Creek, Bear Creek, and Mitchell Branch. Field data were also collected from Mill Branch, a small reference stream located in the City of Oak Ridge. The EFK 13.8 km monitoring location is offsite of the ORR, yet is approximately ten km downstream from sources of anthropogenic pollution associated with the Y-12 National Security Complex. The project objectives were to create a baseline of water quality monitoring data (physical stream parameters) gathered on a regular basis (every two weeks), and to determine possible water quality impairment issues. Furthermore, this monitoring task was directed toward determining long-term water quality trends, assessing attainment of water quality standards and providing background data for evaluating stream recovery due to toxicity stressors. Table 1 is a list of the field monitoring sites that were selected for data collection during 2007.

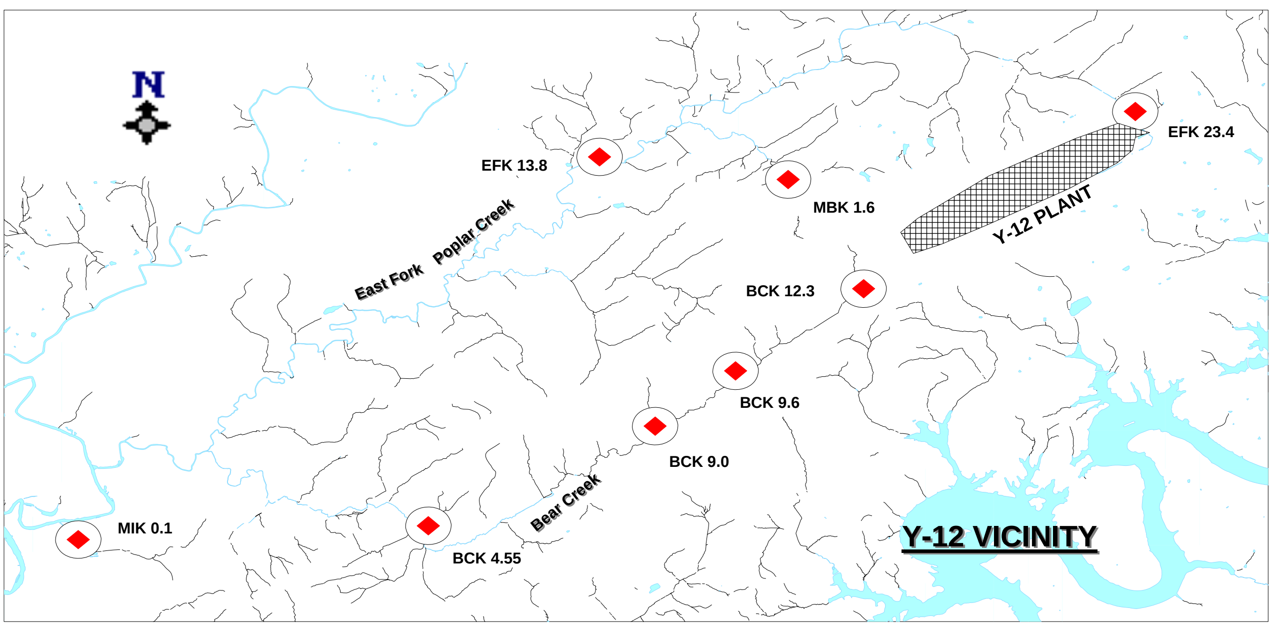

Figure 1: Oak Ridge Reservation –Y-12 Vicinity

Table 1. Sample Locations

Site	Location
EFK 23.4	Station 17 (Y-12 near Scarboro Rd)
EFK 13.8	Oak Ridge Sewage Treatment Plant
BCK 4.55	Bear Creek Weir at Hwy. 95
BCK 9.0	Bear Creek New Weir
BCK 9.6	Bear Creek Monitoring Location
BCK 12.3	Bear Creek Monitoring Location
MIK 0.1	Mitchell Branch Weir
MBK 1.6	Mill Branch (Reference)

Methods and Materials

Parameters collected were temperature, pH, conductivity, dissolved oxygen, and turbidity. The Horiba® U-10 Water Quality Checker instrument is a simultaneous, multi-parameter instrument used for measuring water quality including all these parameters. The instrument consists of a probe unit (with various sensors) attached to a handheld unit (LCD readout & keypad) via a 3-foot cable. Measurements were taken simply by immersing the probe directly into the creek, pond, or river. Parameter readings were recorded from the hand-held unit LCD readout (one parameter at a time is displayed and is initialized using the keypad). The instrument was pre-calibrated prior to each field departure, and the information recorded in a Division laboratory logbook. During each stream examination, the Horiba data was recorded in a field notebook including time, date and weather conditions. One team member recorded the instrument readings and other field notes, while the other person operated the Horiba instrument. Unusual occurrences relating to stream conditions were duly noted.

In case field readings such as pH and conductivity were beyond benchmark ranges, then the following action was taken: (1) wait 24 hours, re-calibrate the Horiba, and collect new physical parameter readings; (2) if readings are still deviant, investigate possible causes (e.g., defective equipment, storm surge/rain events, releases that may have affected pH, etc.); (3) following investigation, report findings to appropriate program(s) within the Division to determine if further action is needed. Field and monitoring methods, and health and safety procedures were followed per the Tennessee Department of Health's *Standard Operating Procedures* (TDH 1999), and the TDEC DOE-O *Health, Safety, and Security Plan* (Thomasson 2006).

Results and Discussion

Field data were collected monthly from the monitoring sites in 2007. Most of the data collected were within normal ranges for surface waters monitored in the ORR vicinity. The mean data for each site are presented in Figures 2-9 on a logarithmic scale. Conductivity numbers (only) are shown at the top of the x-axis for ease of interpretation. There were no data collected during August and December.

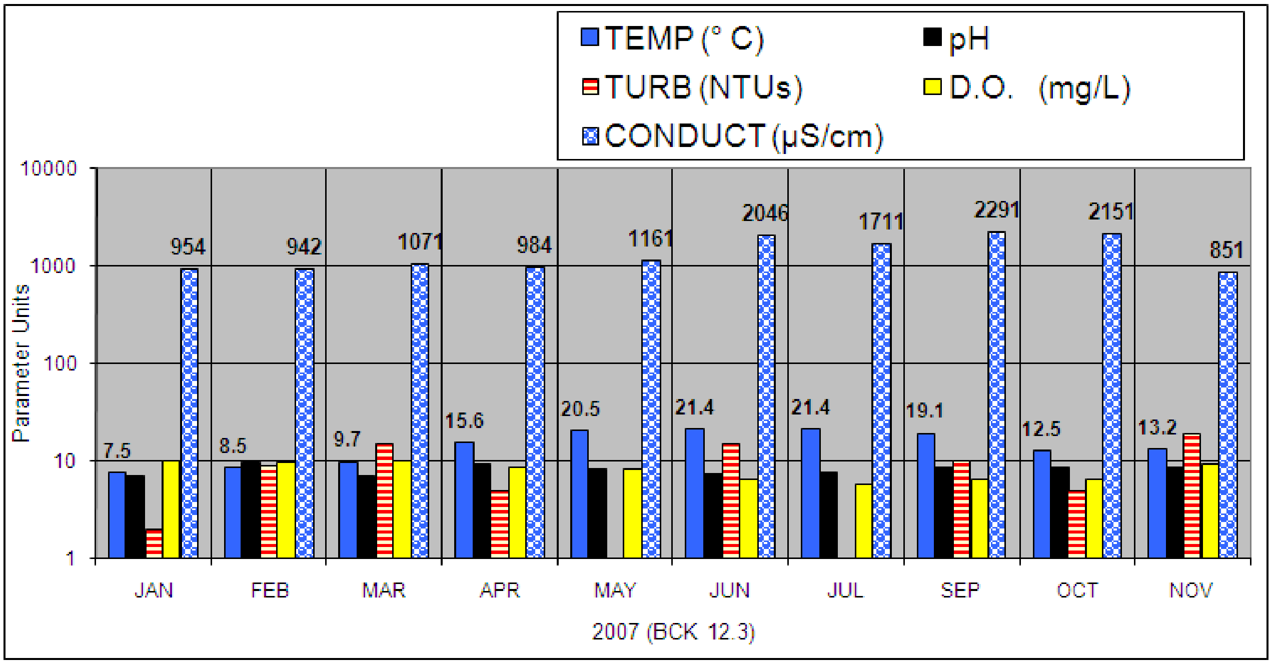

Figure 2: 2007 BCK 12.3 AMBIENT STREAM DATA

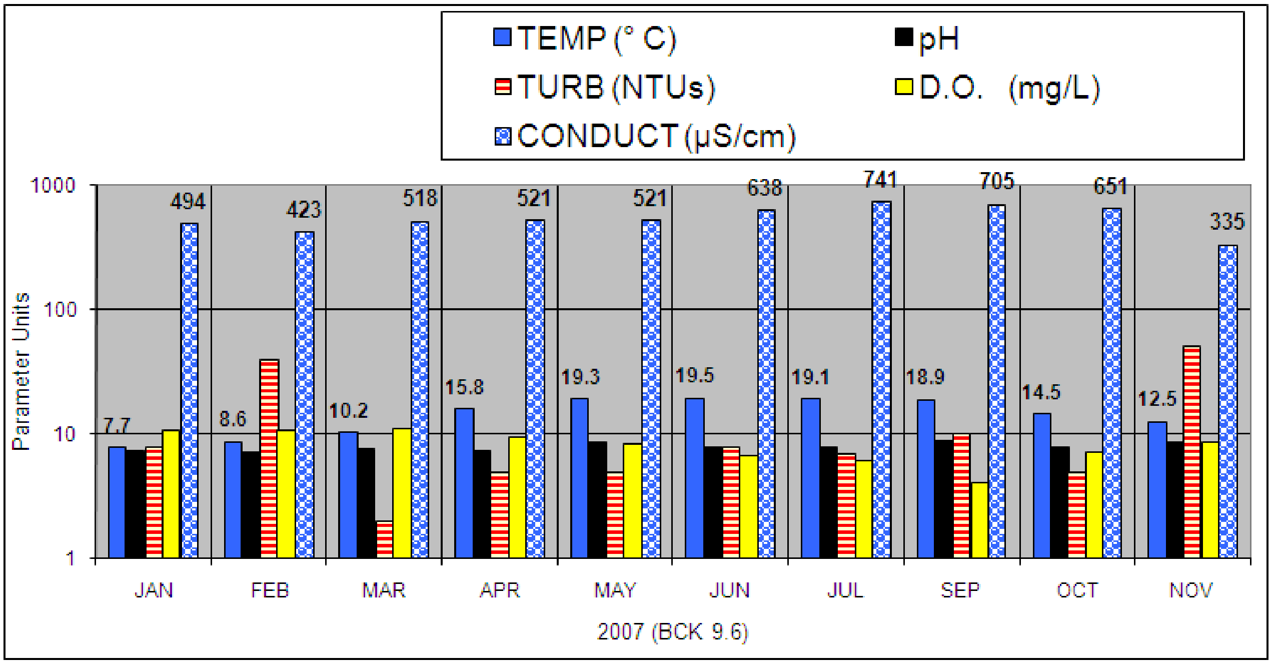

Figure 3: 2007 BCK 9.6 AMBIENT STREAM DATA

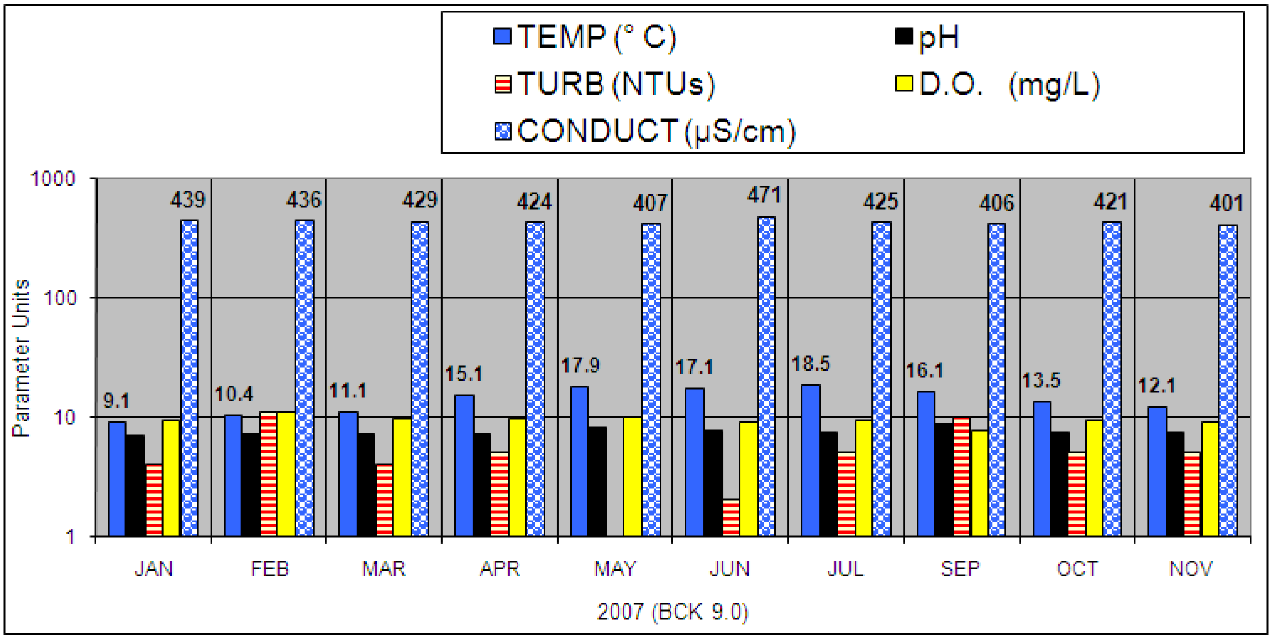

Figure 4: 2007 BCK 9.0 NEW WEIR AMBIENT STREAM DATA

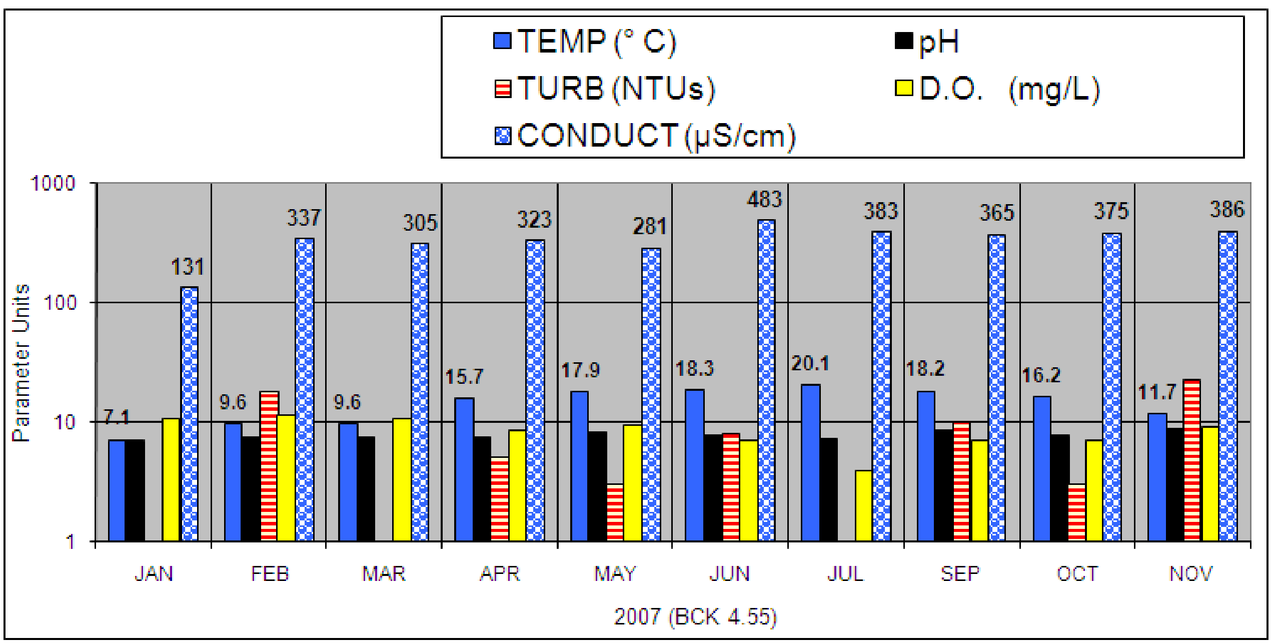

Figure 5: 2007 BCK 4.55 AMBIENT STREAM DATA

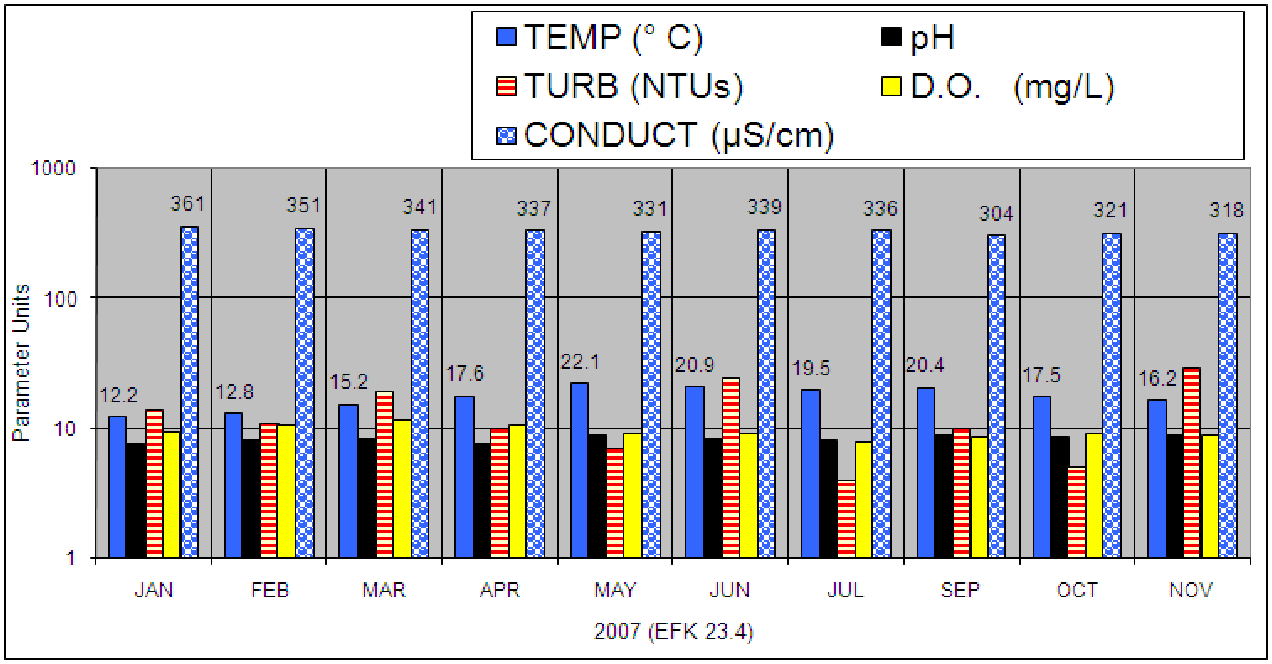

Figure 6: 2007 EFK 23.4 AMBIENT STREAM DATA

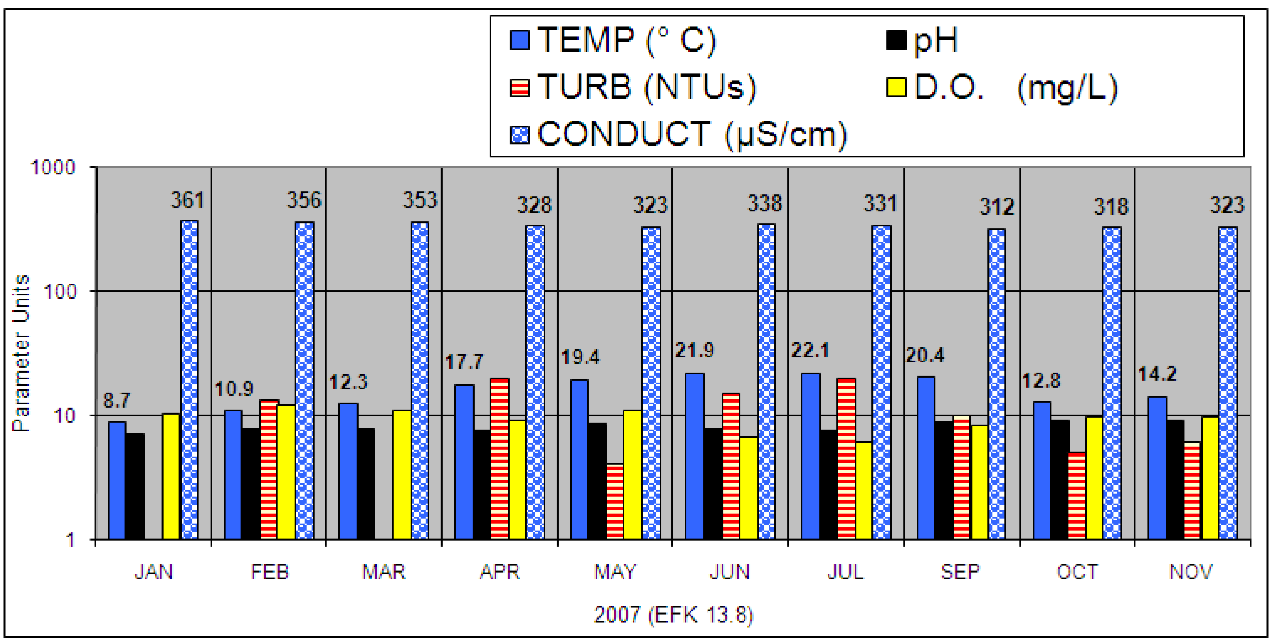

Figure 7: 2007 EFK 13.8 AMBIENT STREAM DATA

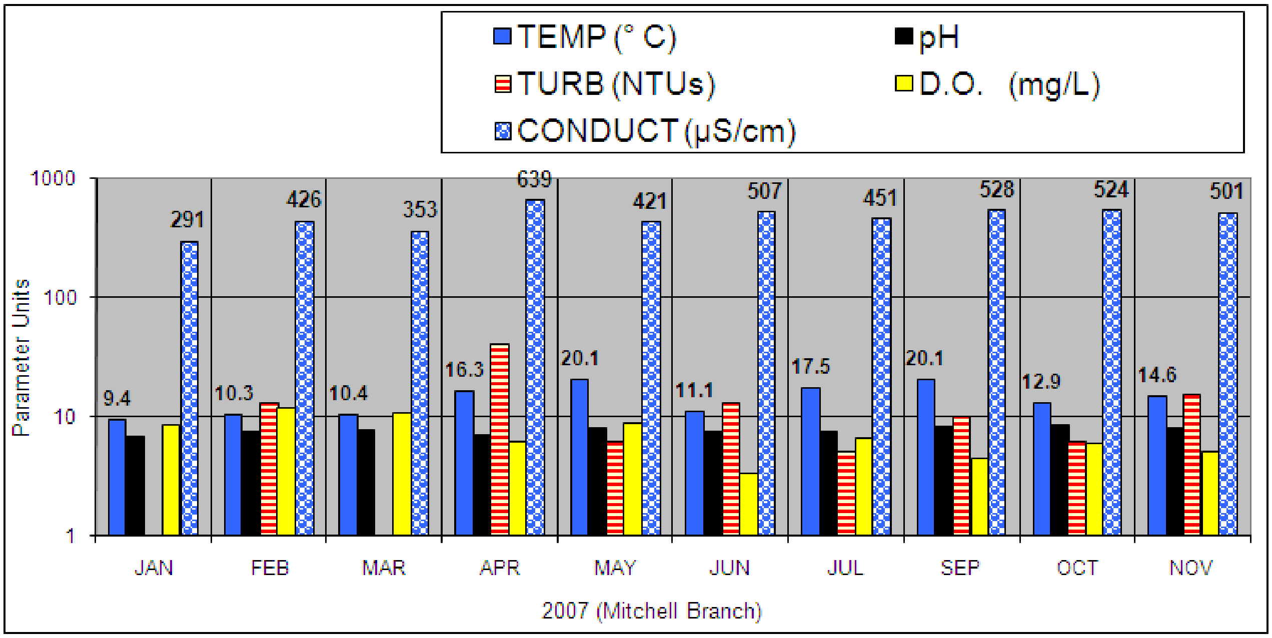

Figure 8: 2007 MITCHELL BRANCH AMBIENT STREAM DATA

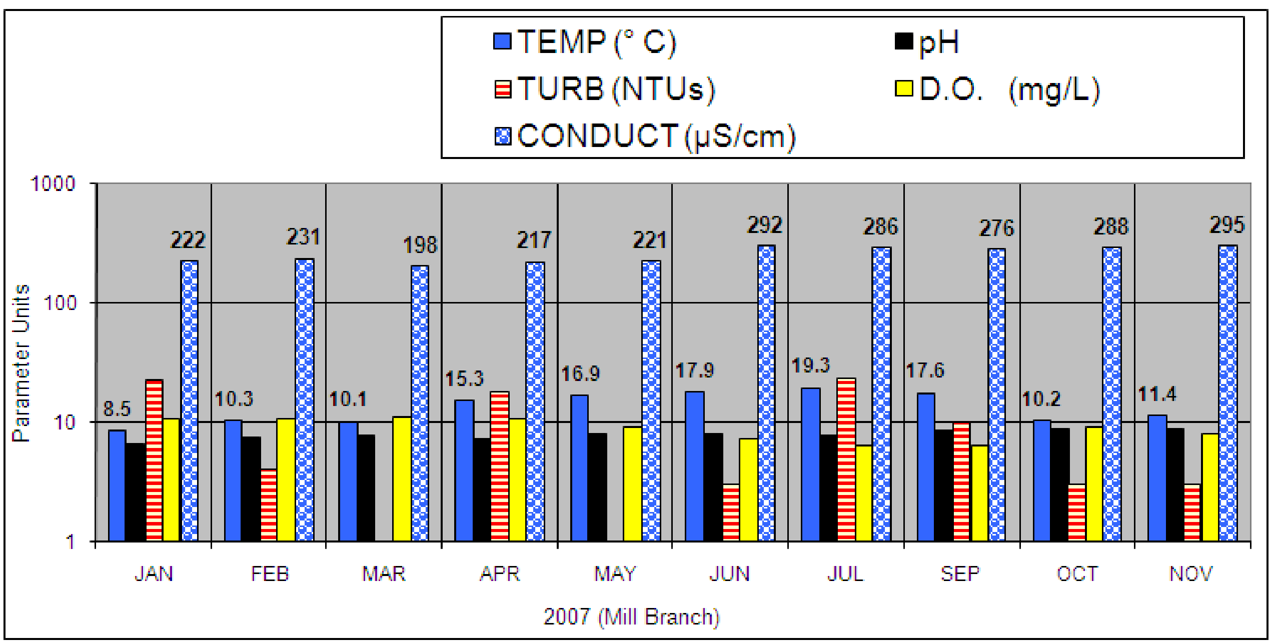

Figure 9: 2007 MILL BRANCH 1.6 AMBIENT STREAM DATA

Conclusion

The data met all State water quality criteria for the parameters observed at the seven monitoring stations on the reservation. However, consistently high conductivity readings observed at Bear Creek km 12.3 (BCK 12.3) suggests degraded water quality as a result of high nutrient levels in the aquatic system. BCK 12.3 is located downstream and west of the capped S-3 Ponds site and the Y-12 West End water treatment facility.

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Standard Operating Procedures. Tennessee Department of Health Laboratory Services. Nashville, Tennessee. 1999.

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Underwater Survey

Principal Author: Donald F. Gilmore

Introduction

Historical operations on the Oak Ridge Reservation (ORR) may have resulted in the disposal of used equipment and materials into Poplar Creek and the Clinch River. Although no firm documentation exists to support this, there is extensive anecdotal evidence and personal communication to warrant a survey of these two bodies of water to identify possible contaminated material. New technology now allows the use of relatively inexpensive equipment, side scan sonar, to be used to possibly identify underwater structures.

Surveys conducted in 2006 on the Clinch River from river miles 12 to 14 revealed only one anomalous structure located on the right descending bank at approximately CRM 13. This structure appeared to be a piece of concrete culvert. Surveys of Poplar Creek revealed a group of anomalous structures located at approximately PCM 1.9. Although there has not been a definitive identification of these, based on historical photographs, it appears that these structures are concrete culverts associated with a causeway constructed at that location circa 1945-1950. Additional survey was planned for 2007. However, this project was not completed in 2007 due to changing priorities.

References

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Hydrographic Survey Manual. Department of the Army, U.S. Army Corps of Engineers, Washington D.C., 20314-1000, 2004.

Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing, E 1391-90, American Society for Testing and Materials, Philadelphia, PA, 1990.

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EMWMF Storm Water Sampling

Principal Author: Donald F. Gilmore

Introduction

Heavy rainfall events have the capability of transporting significant quantities of sediment into nearby bodies of water. This mass transport can, in turn, impact the quality of the receiving waters. Due to the extensive area of disturbed soils at the Environmental Management Waste Management Facility (EMWMF), sampling of the receiving waters for total residue would aid in determining the extent of their impact from the EMWMF.

To assess the degree of surface water impact caused by these rain events, samplings of NT4 (north tributary 4 of Bear Creek), NT5 (north tributary 5 of Bear Creek), and Bear Creek were to be conducted following heavy rain events to determine the quantity of sediment being displaced. Two locations on Bear Creek were to be sampled to determine the quantity of sediment deposited (above and below the intersections at NT4 and NT5). One sample was to be collected on NT4 and one sample was to be collected on NT5 to determine the quantity of material coming off the EMWMF.

In order to compare the relative contribution of the sediment load coming off the EMWMF, samples also were to be taken at Kerr Hollow Branch and the unnamed tributary just west of Kerr Hollow Branch. These sites are located below the sanitary landfills used by Y-12.

The monitoring was to be conducted within 24 hours following either a 1" rain event in a 24-hour period or a 2" rain event over a 72-hour period. Due to the lack of appreciable rainfall meeting the criteria to sample this project was not completed.

References

Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, U.S. Environmental Protection Agency, Region IV, 960 College Station Road, Athens, Georgia. 1996.

Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing, E 1391-90, American Society for Testing and Materials, Philadelphia, PA, 1990.

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Ambient Trapped Sediment Monitoring Project

Principle Author: John (Tab) Peryam

Abstract

Sediment analysis is a good way to assess what contaminants have been present in a water body in the past. These contaminants are often incorporated into the clay and organic matter fraction of sediment through mechanisms such as cation exchange capacity and organic functional groups. Sediment samples from several Clinch River and tributary sites will be collected with passive sediment traps and analyzed for metals and radiological parameters. The goal of this project is to assess currently transported sediments in streams as compared to grab samples scooped from the bottom of the water body. Sediment traps yield information about what sediment constituents are being transported in the river at the present time as compared to samples obtained by dredge. Samples taken by dredge may have been deposited years ago and give no information about current conditions. Since there are no federal or state sediment cleanup levels, the data are compared to soil background levels, EPA Region 4 sediment screening levels and consensus-based sediment quality guidelines. Where contaminants are found in sediments, the levels are at low concentrations that do not pose a threat to human health.

Introduction

Sediment is an important part of aquatic ecosystems. Many aquatic organisms depend on sediment for habitat, sustenance, and reproduction. Sediment is also a depository for contaminants such as metals, radionuclides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and agricultural chemicals. Concentrations of contaminants can be much higher than that in the water column. Some sediment contaminants may be directly toxic to benthic organisms or may bioaccumulate in the food chain, creating health risks for wildlife and humans. Sediment analysis is an important aspect of environmental quality and impact assessment for rivers, streams, and lakes. This project focuses on the sediments that are currently being transported in the Clinch River and some tributaries.

Methods and Materials

Sediment traps were placed in various locations on the Clinch River, McCoy Branch and Poplar Creek during the fall of 2007. Checks of the sediment traps late in the year showed that an insufficient amount of sediment had accumulated in the traps to run analyses. Therefore the sediment traps will be checked again in the spring of 2008; the samples will be collected for analyses assuming that the traps are still in place and have collected enough sediment (100 g) for analyses.

Table 1: Sampling Sites

Location	Clinch RM	Description
Bull Run Steam Plant	48.7	Just upstream of skimmer wall
McCoy Branch	37.5	in pool at the mouth of the creek
Jones Island	19.7	at downstream end of Jones Island just to right of tail about 20 feet
Clinch River	15	about 40' downstream from power lines
Clinch River	37.2	~75' downstream of inlet where logs have washed up, tied beneath a mimosa
		there are two redbud trees to the right of the mimosa tree; mimosa hangs out
		over the water slightly
Poplar Creek M 0.1	PCM 0.1	cable tied to first set of supports and on downstream piling of old DOE sampling station
Brashear's Island	10.1	near downstream end of island on south side of island.

Conclusion

Although this project was implemented in 2007, an insufficient amount of sediment was collected by the passive sediment traps in order to run metals and radiological analyses in 2007. Spring of 2008 should yield enough sediment to complete the initial data set for this project. Traps deployed again after spring sampling should accumulate a sufficient amount of sediment for analyses in the fall of 2008.

References

Consensus-based Sediment Quality Guidelines: Recommendations for Use & Application, Interim Guidance. PUBL-WT-732 2003. Wisconsin Department of Natural Resources. 2003.

Ecological Screening Values, Ecological Risk Assessment Bulletin No. 2. U.S. Environmental Protection Agency Region IV, Waste Management Division. Atlanta, Georgia. 1995. (superceded by http://www.epa.gov/region04/waste/ots/ecolbul.htm#tbl3).

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Final Report on the Background Soil Characterization Project at the Oak Ridge Reservation, Oak Ridge, Tennessee, DOE/OR/01-1175/V2, U.S. Department of Energy, Oak Ridge, Tennessee. 1993

Ingersoll, C.G., D.D. MacDonald, N. Wang, J.L. Crane, L.J. Field, P.S. Haverland, N.E. Kemble, R.A. Lindskoog, C. Severn, and D.E. Smorong. *Prediction of Toxicity Using Consensus-based Freshwater Sediment Quality Guidelines.* EPA-905/R-00/007. U.S. Environmental Protection Agency, Great Lakes National Program Office. 2000.

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Mahler, B.J., P.C. Van Metre, T.J. Bashara, J.T. Wilson, D.A. Johns. *Parking Lot Sealcoat: An Unrecognized Source of Urban Polycyclic Aromatic Hydrocarbons.* Environmental Science & Technology. 39: 5560-5566. 2005.

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APPENDIX A
LIST OF COMMON ACRONYMS AND ABBREVIATIONS

ASER	Annual Site Environmental Report (written by DOE)
ASTM	American Society for Testing and Materials
BCK	Bear Creek Kilometer (station location)
BFK	Brushy Fork Creek Kilometer (station location)
BJC	Bechtel Jacobs Company
BMAP	Biological Monitoring and Abatement Program
BNFL	British Nuclear Fuels Limited
BOD	biological oxygen demand
BWXT	Y-12 Prime Contractor (current)
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAP	Citizens Advisory Panel (of LOC)
CCR	Consumer Confidence Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	contaminants of concern
COD	chemical oxygen demand
CPM (cpm)	counts per minute
CRM	Clinch River Mile
CROET	Community Reuse Organization of East Tennessee
CWA	Clean Water Act
CYRTF	Coal Yard Runoff Treatment Facility (at ORNL)
D&D	decontamination and decommissioning
DCG	derived concentration guide
DOE	Department of Energy
DOE-O	Department of Energy-Oversight Division (TDEC)
DWS	Division of Water Supply (TDEC)
E. coli	*Escherichia coli*
EAC	Environmental Assistance Center (TDEC)
ED1, ED2, ED3	Economic Development Parcel 1, Parcel 2, and Parcel 3
EFPC	East Fork Poplar Creek
EMC	Environmental Monitoring and Compliance (DOE-O Program)
EMWMF	Environmental Management Waste Management Facility
EPA	Environmental Protection Agency
EPT	*Ephemeroptera, Plecoptera, Trichoptera* (May flies, Stone flies, Caddis flies)
ERAMS	Environmental Radiation Ambient Monitoring System
ET&I	equipment test and inspection
ETTP	East Tennessee Technology Park
FDA	U.S. Food and Drug Administration
FFA	Federal Facility Agreement
FRMAC	Federal Radiation Monitoring and Assessment Center
g	Gram
GHK	Gum Hollow Branch Kilometer (station location)
GIS	Geographic Information Systems
GPS	Global Positioning System
GW	ground water
GWQC	Ground Water Quality Criteria

LIST OF COMMON ACRONYMS AND ABBREVIATIONS CONTINUED

HAP	hazardous air pollutant
HCK	Hinds Creek Kilometer (station location)
IBI	Index of Biotic Integrity
IC	in compliance
"ISCO" Sampler	Automatic Water Sampler
IWQP	Integrated Water Quality Program
K-####	Facility at K-25 (ETTP)
K-25	Oak Ridge Gaseous Diffusion Plant (now called ETTP)
KBL	Knoxville Branch Laboratory
KFO	Knoxville Field Office
l	Liter
LC_{50}	lethal concentration at which 50 % of test organisms die
LMES	Lockheed Martin Energy Systems (past DOE Contractor)
LOC	Local Oversight Committee
LWBR	Lower Watts Bar Reservoir
MACT	Maximum Achievable Control Technologies
MARSSIM	Multi-agency Radiation Survey and Site Investigation Manual
MBK	Mill Branch Kilometer (station location)
MCL	maximum contaminant level (for drinking water)
MDC	minimum detectable concentration
MEK	Melton Branch Kilometer (station location)
µg	Microgram
mg	Milligram
MIK	Mitchell Branch Kilometer (station location)
ml	Milliliter
MMES	Martin Marietta Energy Systems (past DOE Contractor)
µmho	micro mho (mho=1/ohm)
MOU	Memorandum of Understanding
m	Meter
mR	Microroentgen
mrem	1/1000 of a rem – millirem
N, S, E, W	north, south, east, west
NAAQS	National Ambient Air Quality Standards
NAREL	National Air and Radiation Environmental Laboratory
NAT	no acute toxicity
NEPA	National Environmental Policy Act
NESHAPs	National Emissions Standards for HAPs
NIC	not in compliance
NOAEC	no observable adverse effect concentration (to tested organisms)
NOV	Notice of Violation
NPDES	National Pollution Discharge Elimination System
NRWTF	Non-Radiological Waste Treatment Facility (at ORNL)
NT	Northern Tributary of Bear Creek in Bear Creek Valley
OMI	Operations Management International (runs utilities at ETTP under CROET)
OREIS	Oak Ridge Environmental Information System http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html
ORISE	Oak Ridge Institute for Science and Education

LIST OF COMMON ACRONYMS AND ABBREVIATIONS CONTINUED

ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Association
OSL	Optically Stimulated Luminescent (Dosimeter)
OU	operable unit
PACE	Paper, Allied-Industrial, Chemical, and Energy Workers Union
PAM	perimeter air monitor
PCB	polychlorinated Biphenol
pCi	$1x10^{-12}$ curie (picocurie)
PCM	Poplar Creek Mile (station location)
pH	proportion of hydrogen ions (acid vs. base)
PID	Photoionization Detector
PWSID	Potable Water Identification "number"
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PRG	preliminary remediation goals
QA	quality assurance
QC	quality control
R	Roentgen
RBP	Rapid Bioassessment Program
RCRA	Resource Conservation and Recovery Act
REM (rem)	Roentgen equivalent man (unit)
RER	Remediation Effectiveness Report
ROD	Record of Decision
RSE	Remedial Site Evaluation
SLF	sanitary landfill
SNS	Spallation Neutron Source
SOP	standard operating procedure
SPOT	Sample Planning and Oversight Team (TDEC)
SS	surface spring
STP	sewage treatment plant
SW	surface water
TDEC	Tennessee Department of Environment and Conservation
TDS	total dissolved solids
TIE	toxicity identification evaluation
TLD	thermoluminescent dosimeter
TOA	Tennessee Oversight Agreement
TRE	toxicity reduction evaluation
TRM	Tennessee River Mile
TRU	Transuranic
TSCA	Toxic Substance Control Act
TSCAI	Toxic Substance Control Act Incinerator
TSS	total suspended solids
TTHM's	total Trihalomethanes
TVA	Tennessee Valley Authority
TWQC	Tennessee Water Quality Criteria
TWRA	Tennessee Wildlife Resources Agency
US	United States

LIST OF COMMON ACRONYMS AND ABBREVIATIONS CONTINUED

UT-Battelle	University of Tennessee-Battelle (ORNL Prime Contractor)
VOAs	volatile organic analytes
VOC	volatile organic compound
WCK	White Oak Creek Kilometer (station location)
WM	waste management
WOL	White Oak Lake
X-####	Facility at X-10 (ORNL)
X-10	Oak Ridge National Laboratory
Y-####	facility at Y-12
Y-12	Y-12 Plant (Area Office)

APPENDIX B

2007 Semi-Annual Surface Water Sampling Results at Benthic Macroinvertebrate Sampling Sites

APPENDIX B

2007 Semi-Annual Surface Water Sampling Results at Benthic Macroinvertebrate Sampling Sites

East Fork Poplar Creek														
	EFK 25.1		EFK 24.4		EFK 23.4		EFK 13.8		EFK 6.3		HCK 20.6		CCK 1.45	
UNIT	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
CFU/100ml	11	62	19	54	27	34	123	235	86	770	130	38	3	25
CFU/100ml	4	15	9	222	49	111	162	276	219	291	162	68	7	15
mg/L	0.82	1.1	0.18	0.56	0.12	0.41	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
mg/L	172	164	174	160	179	161	199	166	189	170	205	229	145	167
mg/L	1.8	2.4	1.5	2.2	1.5	2.1	1.1	1.6	3.6	3.6	0.47	<0.10	0.41	0.30
mg/L	168	174	158	178	165	178	165	176	193	208	161	196	111	124
mg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
mg/L	33	36	33	37	34	38	30	36	34	38	11	16	33	4
mg/L	0.96	1.1	<0.5	0.65	<0.5	0.56	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
mg/L	0.08	<0.07	0.09	<0.07	0.07	<0.07	0.03	<0.07	0.52	0.55	0.01	<0.07	<0.01	<0.07
µg/L	211	202	207	145	192	120	146	177	126	196	193	215	89	61
µg/L	80	123	71	64	61	50	39	38	21	30	44	45	28	30
µg/L	11	19	9	18	10	16	6	5	12	11	4	3	4	2
µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
µg/L	3	3	3	3	3	2	2	2	2	2	<1	<1	1	<1
µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
µg/L	0.2	0.2	0.3	0.3	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
pCi/L														
pCi/L					8.5									
pCi/L	13.7				11.9						14.5			
pCi/L	30.8	18.2	15.8	15.7	23.2						17.6			
pCi/L	4.3	5.9	3.2	8.6	3.2	5.7	2.8	18.4	4.1	7.7	0.0	0.5	0.3	0.8
pCi/L	3.2	4.2	2.7	5.4	3.4	3.1	1.3	3.7	3.5	4.4	2.4	3.0	0.6	1.0

	Mitchell Branch						Bear Creek					
	MIK 1.43		MIK 0.71		MIK 0.45		BCK 12.3		BCK 9.6		MBK 1.6	
UNIT	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
CFU/100ml	19	13	117	921	1046	2419	4	10	285	1120	27	159
CFU/100ml	10	96	201	1046	135	517	23	55	51	148	41	111
mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
mg/L	96	129	194	266	216	244	456	743	248	396	120	163
mg/L	0.10	<0.10	0.36	0.62	0.28	0.45	51	83.0	13.4	23	0.10	<0.10
mg/L	69	100	198	340	213	296	636	1090	247	472	88	186
mg/L	<10	35	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
mg/L	<0.01	<0.07	0.02	0.24	0.03	0.19	<0.01	<0.07	<0.01	<0.07	0.01	<0.07
µg/L	310	598	270	231	399	259	103	72	246	46	183	157
µg/L	256	164	74	138	96	138	830	890	39	12	42	48
µg/L	4	2	13	17	13	9	9	12	6	6	3	3
µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
µg/L	<1	<1	<1	<1	<1	<1	4	5	<1	<1	<1	<1
µg/L	<1	<1	139	229	101	109	<1	<1	<1	<1	<1	<1
µg/L	N/A	N/A	N/A	223	N/A	87	N/A	N/A	N/A	N/A	N/A	N/A
µg/L	<1	<1	2	3	2	2	<1	<1	<1	<1	<1	<1
µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
pCi/L												
pCi/L				29.8				15.0				32.6
pCi/L			33.1	49.4			11.6	22.2		50.5		43.2
pCi/L	1.1	0.6	60.1	178	65.3	95	79	322	28.5	74	-0.3	3.9
pCi/L	0.6	1.5	73.1	186	55.2	106.3	222	584	46.1	108.7	0.4	3.3

White Oak Creek											
		WCK 6.8		WCK 3.9		WCK 3.4		WCK 2.3		MEK 0.3	
TEST	**UNIT**	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Enterococcus	CFU/100ml	29	14	285	122	197	36	86	58	66	33
E. Coli	CFU/100ml	23	23	308	548	93	84	45	108	236	91
Ammonia	mg/L	<0.1	<0.1	<0.1	0.25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Hardness	mg/L	152	169	164	178	164	155	171	154	184	202
Nitrate and Nitrite	mg/L	<0.10	<0.10	0.89	0.57	2.0	2.7	1.2	2.0	0.27	0.41
Total Dissolved Solids	mg/L	119	159	192	214	201	273	201	274	190	235
Total Suspended Solids	mg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Sulfate	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TKN	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Phosphorus	mg/L	0.02	<0.07	0.12	0.15	0.22	1.0	0.28	0.26	0.69	0.91
Iron	µg/L	76	84	135	86	130	74	118	96	185	72
Manganese	µg/L	13	19	24	12	26	9	45	18	34	19
Zinc	µg/L	5	6	22	22	15	16	12	12	7	5
Arsenic	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cadmium	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium, Total	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Copper	µg/L	<1	<1	4	7	2	5	2	4	1	<1
Lead	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Mercury	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Pb-210	pCi/L										
Pb-214	pCi/L	27.7		30.6		54.0		17.9			
Bi-214	pCi/L	42.8		50.0		94.7		20.7		20.0	
Cs-137				42.4		26.2					
gross alpha	pCi/L	2.1	0.4	4.2	3.5	11.6	11.7	3.5	10.4	4.8	1.2
gross beta	pCi/L	0.9	0.4	117.1	141.2	139.7	98.0	188	103.5	57.1	93.5