MAXEY FLATS
NUCLEAR DISPOSAL SITE
CALENDAR YEAR 2012

SUMMARY REPORT

May 2013

Prepared by:

Commonwealth of Kentucky
Cabinet for Health and Family Services
Department for Public Health
Division of Public Health Protection and Safety
Radiation Health Branch
Radiation/Environmental Monitoring Section

CONTENTS

FIGURES

MFNDS CY2011 SUMMARY REPORT

Introduction

One thousand two hundred ninety four (1,294) water samples were collected during calendar year (CY) 2012 from the environment within 4.5 miles of the Maxey Flats Nuclear Disposal Site (MFNDS). The Radiation/Environmental Monitoring Section (REMS) of the Radiation Health Branch (RHB) performed 3,253 analyses on these samples. An additional 17,266 quality control (QC) analyses were performed to ensure the accuracy and precision of the analytical results. The cited 17,266 QC analyses represent all daily, instrument, and run QC analyses. Data was validated by an independent third party.

Surface water and groundwater samples were collected from the MFNDS and its environs in CY2012. Surface water samples were collected from on-site streams (within the original licensed site area), off-site streams (outside the original licensed area), drains, washes, ditches, and retention basins. Groundwater samples were collected from drinking-water wells and United States Geological Survey (USGS) monitoring wells. Samples were also collected from the public water supply in Hillsboro, Kentucky. Analytical data generated from the MFNDS sampling locations is provided in Appendix 1.

In CY2012, the REMS conducted extended radionuclide analyses on groundwater samples from the USGS monitoring wells outside the restricted area and on samples from select surface water locations and seeps. Extended radionuclide analyses of monitoring-well groundwater, surface water, and seep-water samples provided the RHB with information regarding contaminant migration from the burial trenches following completion of Initial Remedial Phase CERCLA activities.

Data collected during 2012 was used to assess whether the actions implemented during the Initial Remedial Phase under CERCLA at the MFNDS were successful in meeting remedial goals. The details of the assessment of validated data from monitoring wells, seeps, and surface water locations are captured in this document.

Laboratory Considerations

The sample minimum detectable activity (MDA) for tritiated water (HTO) measurements by the REMS laboratory ranged from 0.28 picocuries/milliliter (pCi/ml) for 5.0 ml sample aliquots used in the analysis of all on-site, off-site, drinking wells, some monitoring wells, and soil water samplers to 1.71 pCi/ml for 0.1 ml aliquots used in the analysis of various and monitoring well water samples. The MDA for gross alpha-particle activity concentration is sample volume dependent and was approximately 2.0 pCi/l for 200 ml aliquots, increasing with a decrease in sample aliquot volume. The MDA for gross beta-particle activity concentration is also sample volume dependent, and was approximately 4.0 pCi/l for 200 ml aliquots, increasing with a decrease in sample aliquot volume.

Background & Offsite Monitoring

Mean HTO activity concentration for sample locations ranged from less than the MDA (at background and off-site sampling locations), to 125 pCi/ml at the legal site license boundary (Location 144) in the East Main Drainage Channel. Background and off-site surface-water sample locations included: Rock Lick Road at the first bridge (101), Crane Creek (119) on Hwy 32, Crane Creek on Rawlings Road (121), Rock Lick Creek above its confluence with No-Name Creek (122), Fox Creek off Hwy 158 (130), Fox Creek after confluence with Rock Lick Creek (132), and Fox Creek on Hwy 111 (136). All sampling locations are shown in Figure 6.

HTO activity concentration in groundwater samples from the background drinking-water well, 112, north of the site at Hwy 1895 was below the laboratory reported sample MDAs.

East Main Drain Seep Monitoring

Samples collected from a biomonitoring plot in 1990 established the contamination zone on the East Main Drain Hillside. The plume of HTO activity associated with the seeps on the East Main Drain Hillside was mapped by using data from the biomonitoring network. The biomonitoring plot results indicated that HTO moves through the colluvium on the East Main Drain Hillside to the East Main Drainage Channel above the 800' elevation (above Location 113). REMS personnel have monitored the East Main Drain Hillside seeps since 1990.

Data for the LFS2 seep on the East Main Drain Hillside from January through December 2012 indicates that HTO activity in groundwater continues to migrate from the 40-Series trenches to the East Main Drain Hillside, though the continuing downward trend indicates that the remedy has likely made LFS2 a less preferential path for migration of contamination. Minimum, Maximum, and Average HTO Activity Concentrations at LFS2 are shown in Figure 1. Since this movement is most likely through fractures in the Upper/Lower Farmers Members underlying the East Side of the site, it may have been difficult to mitigate during remediation of the facility. The continually increasing HTO activity concentrations downstream in the drain confirm that the apparent reductions at LFS2 are merely indications of changes in contaminant pathways/media flow rates rather than any mitigation due to the implemented remedy.

The REMS continues to monitor the East Main Drain Hillside for further evidence of radionuclide activity. East Drain seeps USF1N, LFS2, EMR1&2, and EML3&4 were collected during the annual seep sample collection in CY2012 (Figure 6). Elevated HTO activity concentration was detected in samples collected from the Farmers outcrop seeps surrounding the East Main Drain at four (4) of the locations sampled in CY2012.

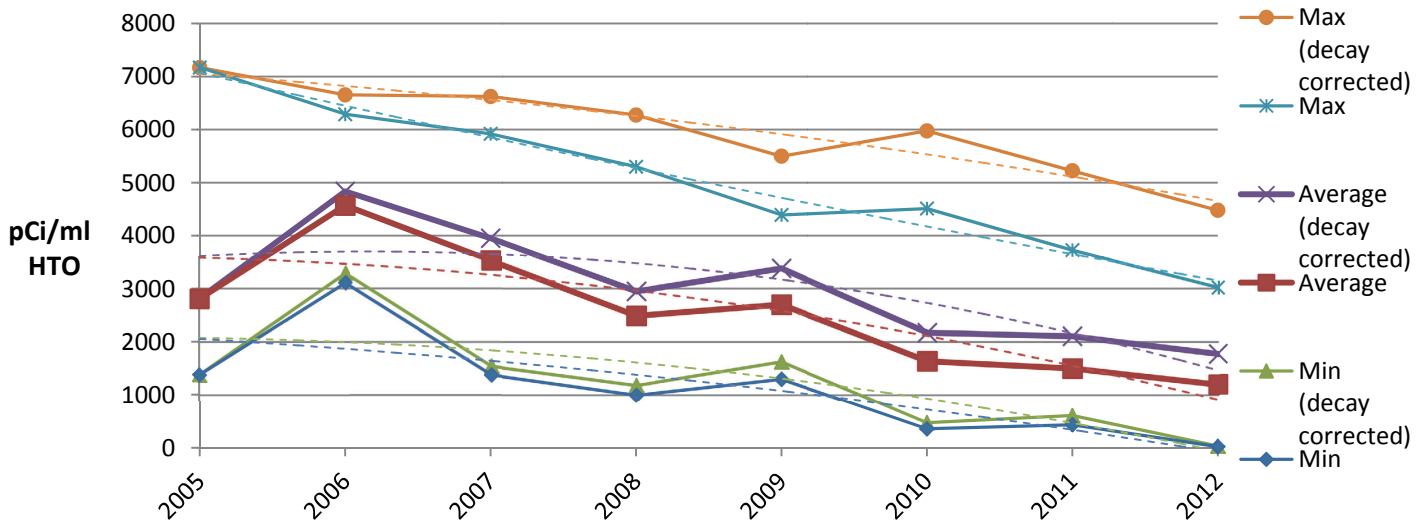

Figure 1. Minimum, Maximum, and Average HTO Activity Concentrations at LFS2

East Main Drain Monitoring

The HTO activity concentration at East Main Drain sampling locations 113 and 144 (Figure 6) is representative of the discharge to surface water of leachate-contaminated groundwater that has migrated through the subsurface from the 40-Series disposal trenches to the East Main Drainage Channel.

The HTO activity concentration in surface water at East Main Drainage Channel locations 113 and 144 remain elevated relative to HTO activity concentration upgradient and upslope at the outlet of the East Main Drainage Retention Pond (EDOUTL) (Figure 6). Based on four (4) samples collected at the EDOUTL in 2012, the average HTO in surface water at EDOUTL was 1.9 pCi/ml as compared to 74 and 175 pCi/ml at locations 144 and 113, respectively. Average HTO activity concentrations at 113 and 144 are shown in Figure 2.

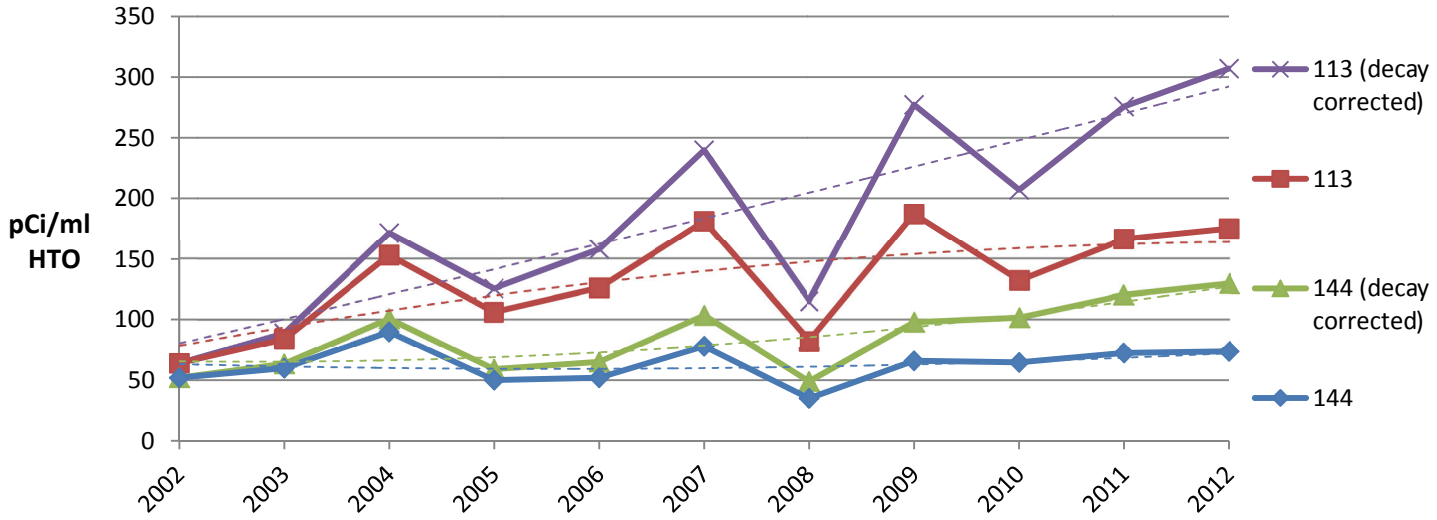

Figure 2. Average HTO Activity Concentrations at 113 & 144

The mean HTO activity concentration for the East Drain ISCO automatic sampler (EDRN) (Figure 6) at 800 feet above mean sea level (MSL) in the East Main Drainage Channel is shown in Figure 3, along with ranges for each year. An automatic sampler composites surface water samples on a daily basis.

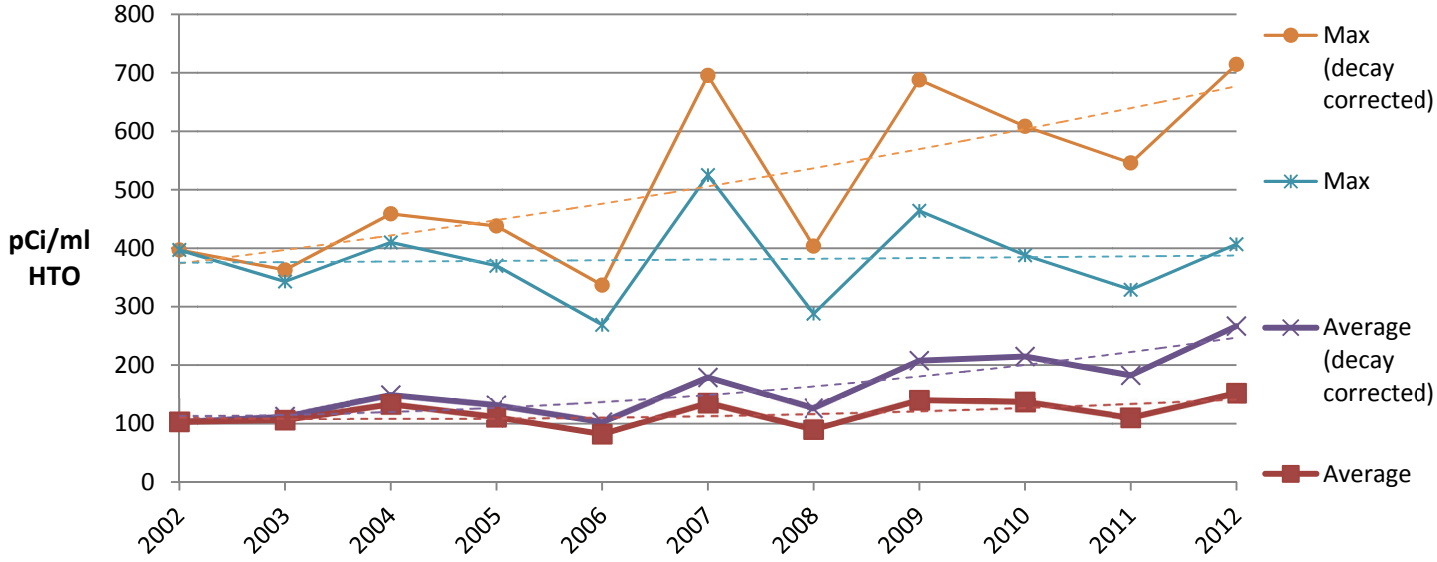

Figure 3. Maximum and Average HTO Activity Concentrations at EDRN

West Hillside Monitoring

During the Initial Remedial Phase of the CERCLA Action, releases of HTO occurred from the Earthen Mound Concrete Bunkers (EMCB) that was constructed for disposition of trench leachate. These HTO releases occurred from 1999 through 2000 and impacted surface water in Wash 107 (Figure 6). The data in previous annual reports demonstrate that by 2004 the average annual level of HTO at location I107 had decreased to less than the MDA. This demonstrates that the releases that occurred during the Initial Remedial Phase of the CERCLA Action are no longer impacting Wash 107. The current data also show that the HTO levels at several sampling points in Wash 107 continue to be impacted by a source of HTO other than the release that occurred during the Initial Remedial Phase of the CERCLA action. The source of HTO impacting Wash 107 is likely the western series trenches. This data establishes releases from the trenches via the fractures in the lower sandstone marker bed to the west hillside colluvium with release to the surface water in Wash 107 are still a major concern for the long-term stability of the site.

Surface water sampling locations in Wash 107 from the middle of the hillside, locations F107 and G107, downgradient/downslope to the dirt road, W7ATRD, have elevated HTO activity concentration compared to levels of HTO activity concentration above the middle of the hillside at locations H107, I107 and J10. The HTO activity concentration in surface water sampling locations from the middle of the hillside in Wash 107 to downslope locations at the bottom of the west hillside indicate that HTO continues to move from the western series disposal trenches to the west hillside via subsurface pathways. This data supports the continuing release of HTO from the disposal site to the west hillside subsequent to the Initial Remedial Phase of the CERCLA Action at the MFNDS. The remedial action at the site has not beneficially impacted the rate of release of HTO from the disposal trenches to the west hillside.

The mean HTO activity concentration for Drip Springs Creek Location 103 (Figure 6) grab-samples and ISCO are displayed in Figure 4. There may be a correlation between the small upward trend in decay corrected HTO activity concentrations at 103 and the significant upward trend in decay corrected HTO activity concentrations at 102, but it is not the primary contributor.

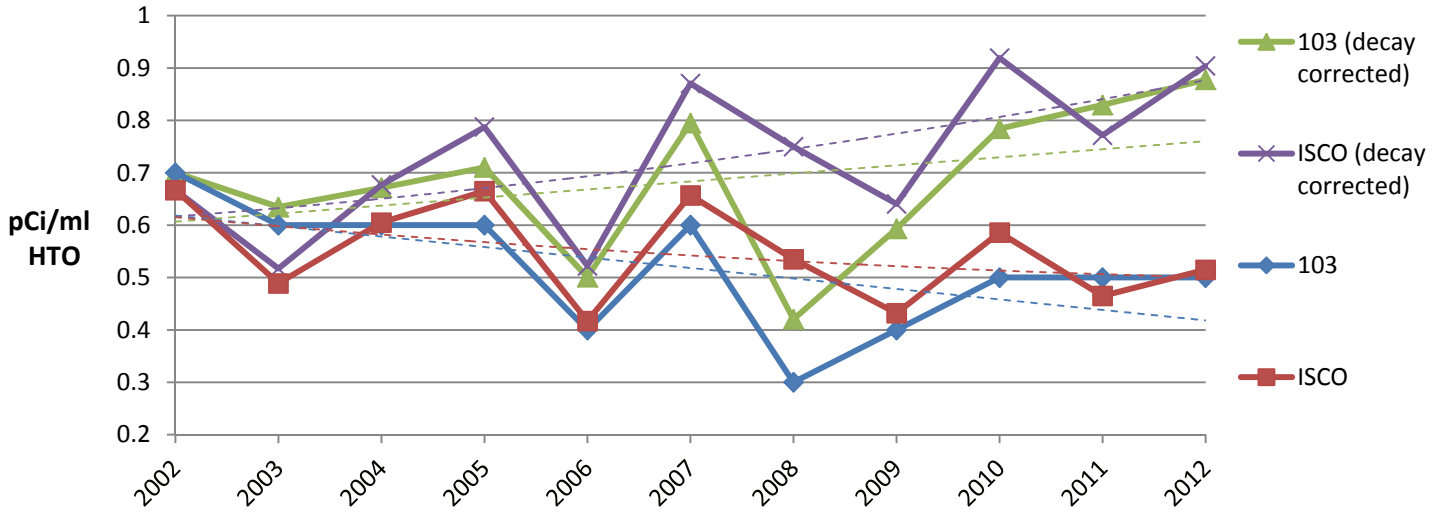

Figure 4. Average HTO Activity Concentrations at 103

CERCLA Compliance Point Monitoring

The mean HTO activity concentration for location 102 (Figure 6) grab-samples and ISCO collected at the junction of Rock Lick Creek and Highway 158 are displayed in Figure 5. The activity concentrations at 102 have demonstrated a clear upward trend that appears to become more significant with time, and analysis of monitoring data at the tributaries indicates that the east side of the site is the primary contributor to this trend. Although the dose derived from activity concentration is still far below regulatory requirements, the magnitude of the trend is concerning and it is clear that the remedy has failed to positively impact public health.

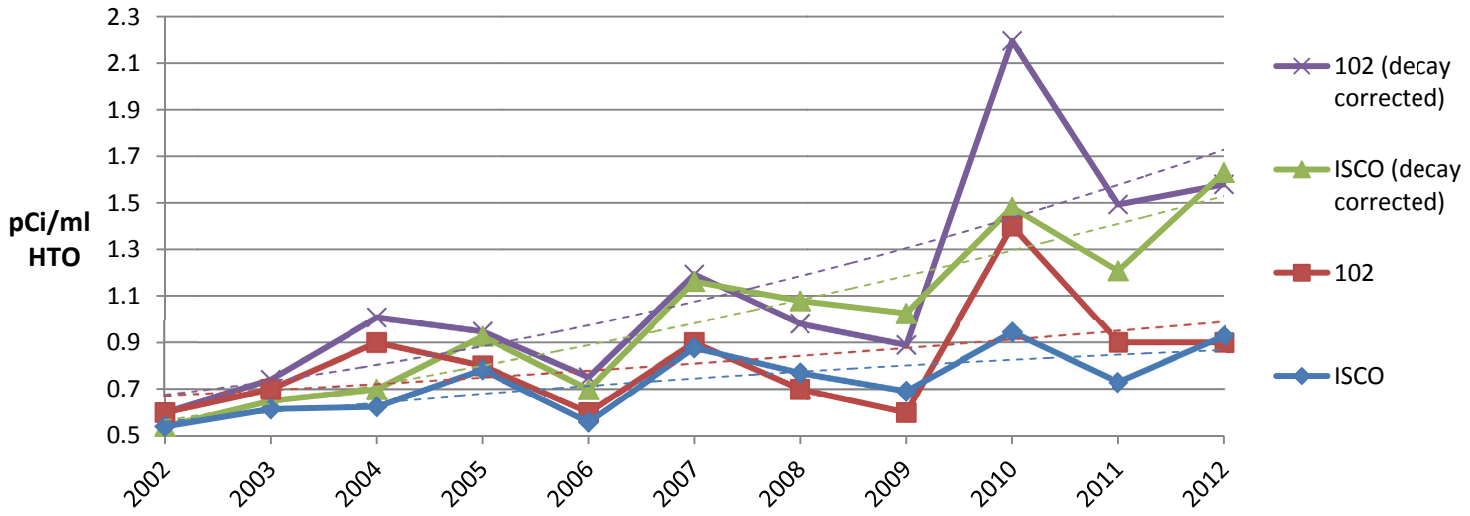

Figure 5. Average HTO Activity Concentrations at 102

USGS Monitoring Well Sampling

Extended radionuclide analysis of water from selected USGS monitoring wells continued in CY2012 (Figure 6). Extended radionuclide analyses were evaluated in order to monitor the flux of contaminants in groundwater contaminant plumes located under the Northwest corner of the Restricted Area. All monitoring wells along the eastern side of the Restricted Area were abandoned during the Initial Remedial Phase. Extended radionuclide data collected during CY2012 along with data collected from CY2000 through 2011 is critical for establishing trends that can be utilized for assessment of the performance and effectiveness of Initial Remedial Phase actions. Extended radionuclide analyses were conducted for USGS monitoring well groundwater samples collected in April and October 2012. Extended radionuclide analyses included; Strontium-90 (90Sr), carbon-14 (14C), plutonium-238 (238Pu), plutonium-239 (239Pu), uranium-238 (238U), uranium-235 (235U), and uranium-234 (234U). Gross alpha and beta analysis and gamma spectroscopy were also conducted on the samples.

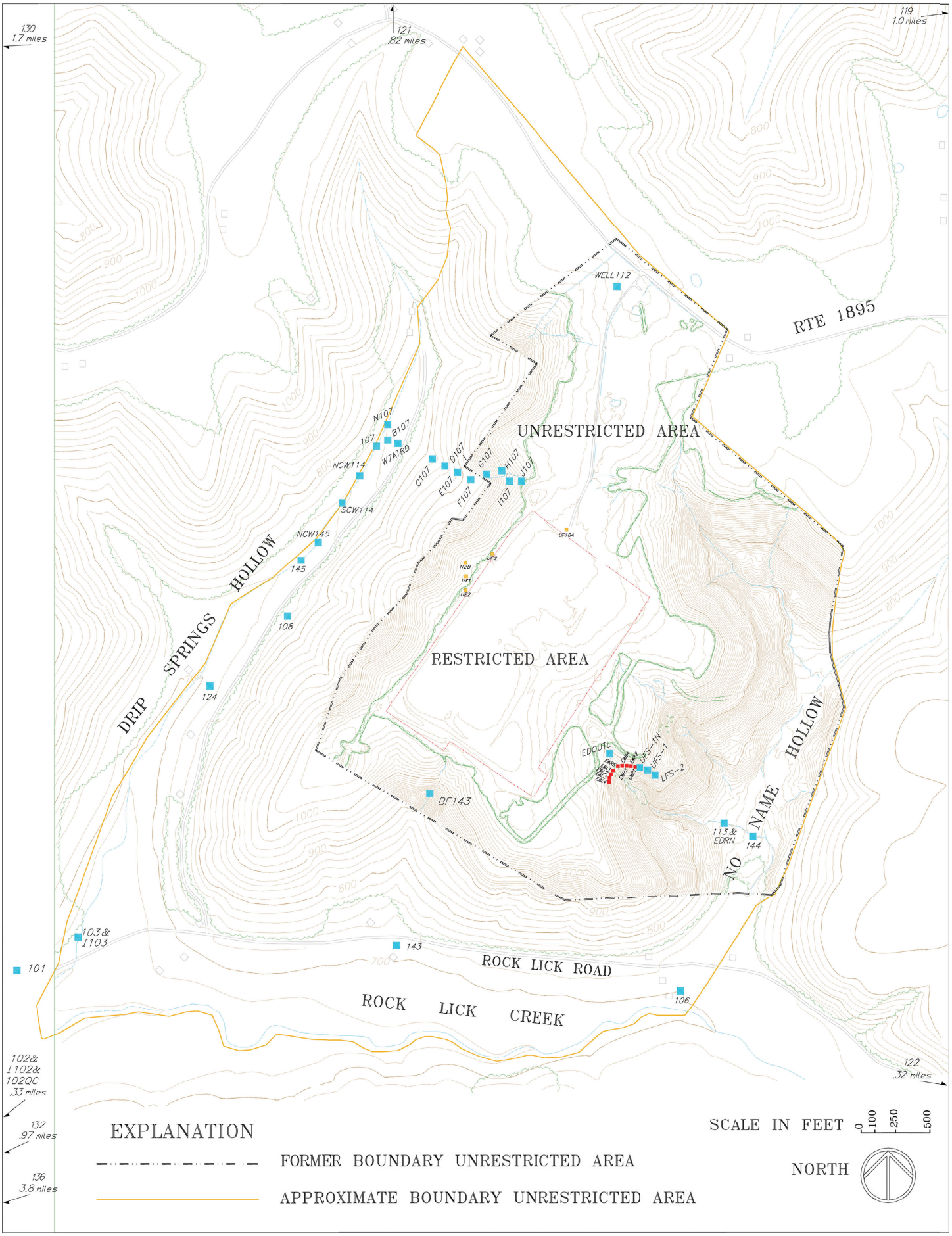

Figure 6. Maxey Flats Area Map

Summary of Extended Radionuclide and Trench Sump Data Analyses

- The fact that the primary contaminants leaving the site have a relatively short half-life can effectively mask trends in the transport of the contaminants. In order to properly evaluate the performance of the remedy, a decay correction must be performed. This allows the trend analysis to be strictly driven by the remedy, instead of having the normal decay of radionuclides give the appearance of a mitigation of the release of contaminants. Crediting the current remedy for reductions due to decay would be disingenuous.

- Trench sump levels are monitored at the site in order to help gain an understanding of the overall flow balance of the hydrologic system. The sump levels have been rising, as a whole, since the establishment of the current remedy at the site. Given the consistently increasing rate of release of contaminated leachate, this is likely indicative of a source of flow into the trenches from one of a number of possible external paths. Unfortunately, the data available is insufficient to make a defensible statement concerning what the exact source of water is. Efforts are currently in progress to install a remedy that would eliminate all possible sources of external flow to the extent practicable.

- Based on historical and CY2012 extended radionuclide and trench sump data analyses, radionuclides in groundwater continue to migrate away from the disposal trenches. Based on both standard linear and polynomial regressions, the rate of release of contaminated leachate is increasing significantly.

- Radionuclide movement away from the disposal trenches is most likely controlled by: 1) The potentiometric gradient in the Lower Sandstone Marker Bed (LMB) which is radially away from the center of the Restricted Area; 2) The dip of the LMB which is radially away from the center of the Restricted Area; and 3) by the fracture orientation of the LMB.

- Extended radionuclide data indicates that Initial Remedial Phase remedial measures may not have been in place for sufficient time to impact the migration of radionuclides or is not functioning to prevent continued releases to the environment.

- The continued monitoring of radionuclides in groundwater is critical into the future because elevated levels of radionuclides continue migration toward the perimeter of the MFNDS and the long-term potential for erosion to impact the discharge of groundwater to the surface resulting in increased radionuclide activity concentration in surface water.

Regulatory & Public Health Assessment

Kentucky Administrative Regulation, 902 KAR 100:022, Section 18 requires that the annual dose at the site boundary of a low-level radioactive disposal site not exceed 25 mrem. Kentucky Administrative Regulation 902 KAR 100:015, Section 2 establishes releases be maintained "As Low As Reasonably Achievable" (ALARA). A primary focus of a radiation protection program is to maintain concentration/doses ALARA. The license for the MFNDS and other licenses issued in the Commonwealth of Kentucky for the handling and release of radioactive material are based on ALARA requirements in order to minimize radiation doses to workers and members of the public.

The HTO activity concentrations at East Main Drain Hillside seep locations inside the site boundary need to be compared to a limit of 1,000 pCi/ml imposed by 902 KAR 100:019, Section 44(7) for the controlled release of tritium outside the boundary of the trenches and the Restricted Area. HTO activity concentrations for LFS2 are displayed in Figure 5. The LFS2 HTO activity concentration exceeds the established release limit (1,000 pCi/ml) for HTO. These temporal HTO activity concentration trends do not reflect cessation of releases from the trenches and Restricted Area and continue to exceed the release criteria in 902 KAR 100:019, Section 44(7).

Figure 1 provides the trend line for the LFS2 HTO activity concentration from 2005 through 2012. Based on the graph for HTO activity concentration at the Lower Farmers Seep, it is not clear whether the Initial Remedial Phase has significantly impacted HTO activity concentration at the Lower Farmers Seep on the East Main Drain hillside. It is likely that the reduction seen at LFS2 is due to flow changes at the site.

As LFS2 is a direct contributor to the east drain and shows slowly decreasing HTO activity concentrations while EDRN ISCO shows consistently increasing HTO activity concentrations, it must be presumed that the more consistent sampling and larger capture of the ISCO gives a better picture of overall site conditions and releases. It is then demonstrated that the release of HTO to bedrock, groundwater, and surface water has not yet been mitigated by the Initial Remedial Phase remedial activities.

Surface water sample location 113/EDRN ISCO is in the East Main Drainage Channel and within the MFNDS old site-license boundary. The HTO activity concentration remains elevated over the past eleven (11) years at location 113/EDRN ISCO. 113 and EDRN ISCO HTO activity concentration can be seen in Figure 1 and Figure 2, respectively.

Surface water sampling location 144 is at the MFNDS old site license boundary in the East Main Drainage Channel. The average annual HTO activity concentration for Location 144 is shown in Figure 1. This data along with the data for the Lower Farmers Seep and Location 113 indicates that release of HTO from the disposal trenches continues to impact the East Drainage Channel.

With the completion of the Initial Remedial Phase all surface water from the Initial Remedial Phase cap has been diverted to the East Main Drainage Channel. The increased discharge (volume) of surface water with a mean HTO activity concentration of approximately 1.0 pCi/l from the East Retention Pond to the East Main Drainage Channel should be diluting the HTO activity concentration. However, HTO activity concentration from 2002 to 2012 at locations 113 (EDRN) and LFS2 indicate that the remedial activities may not have mitigated releases to the East Main Drain hillside and East Main Drainage Channel.

With the addition of the buffer zone acquired during the Initial Remedial Phase the CERCLA compliance point was set at Location 102. Location 102 is the CERCLA point for comparison to the 25 mrem/yr dose standard in 902 KAR 100:022. Because the license for the site has not been amended to modify the site boundary, radiation doses will continue to be calculated at location 144 in order to assess long-term statistical trends and maintain compliance with license requirements.

The dose assessment at location 144 for HTO assumes: 1) sufficient surface water is available at or one mile within the new site boundary; 2) a person resides at the location for 365 days a year; and 3) a person consumes 2 liters of water per day. Based on these hypothetical assumptions, a person that consumes surface water at 74 pCi HTO/ml would receive an annual radiation dose from tritium of 3.6 millirem/year (mrem/yr). The hypothetical annual dose at location 144 would be 14.4 % of the 25 mrem/yr dose limit for the site boundary established by 902 KAR 100:022, Section 18. The annual dose for tritium was calculated using the age specific dose conversion factors in ICRP 72, Age–dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion Inhalation Dose Coefficient (September 1995).

The CERCLA compliance point requires calculation of the potential dose to a receptor at location 102. This location is immediately outside buffer zone on Rock Lick Creek. Grab samples and automatic samples with a sequential sampler were collected at location 102. The average annual CY2012 HTO activity concentration at location 102 was 0.9 pCi/ml. Assuming surface water with an average HTO activity concentration of 0.9 pCi/ml could be used as a drinking water source, an individual consuming 2 liters of water 365 days a year would receive an annual radiation dose of 0.04 mrem/yr from HTO. The annual radiation dose from HTO at location 102 is 0.18% of the 25 mrem/yr dose limit established by 902 KAR 100:022, Section 18 for the site boundary. The annual dose for tritium was calculated using the age specific dose conversion factors in ICRP 72, Age–dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion Inhalation Dose Coefficient (September 1995).

The 3.6 mrem/year radiation dose from HTO for an individual drinking surface water at the old site boundary, location 144, in the East Main Drainage Channel, one mile upstream of the new property boundary, would result in a risk of 1.7×10^{-6} (from Risk/Dose Conversion Factors) and 2.8×10^{-6} (from Slope Factors). However, the East Main Drainage Channel is not a perennial stream and it is unlikely that sufficient water would be present to provide 2 liters of drinking water for an individual 365 days per year.

The 0.04 mrem/year radiation dose from HTO for an individual drinking surface water at Rock Lick Creek location 102, outside of the property boundary at Rock Lick Road, would result in a risk of 1.9×10^{-8} (from Risk/Dose Conversion Factors) and 3.0×10^{-8} (from Slope Factors). The level for total Cancer risk from the slope factor was calculated using the Radionuclide Table: Radionuclide Carcinogenicity-Slope Factors at the following site: http://www.epa.gov/radiation/heast/docs/heast2_table_4-d2_0401.pdf

The release of elevated levels of HTO within the site boundary remains a significant long-term concern considering the potential for erosion on the east and west hillsides. Efforts were made during the Initial Remedial Phase to minimize both the release of radionuclides from the trenches and the potential for impacts by erosion of the hill slopes surrounding the disposal trenches. Analysis of CY2012 data indicates release of radionuclides from the disposal trenches continues subsequent to the Initial Remedial Phase activities. Based on analysis of CY2012 data, it is essential that sufficient monitoring be conducted to continue the evaluation of the effectiveness of the Initial Remedial Phase and to determine the potential for impacts on public health.

The International Commission on Radiation Protection (ICRP) proposed use of the effective dose (HT) as a primary radiation protection standard and Annual Limit of Intake (ALI) as a secondary standard (ICRP Publication 30 and 60) for radiation protection. These limits were adopted by the National Council on Radiation Protection and Measurements (NCRP, Report No. 116). NCRP Report No. 116 recommended a Negligible Individual Risk Limit (NIRL) of 1 mrem/year.

The NIRL is defined as the level of average excess fatal health risk from radiation exposure from any individual source or practice below which further effort to reduce individual exposure is unwarranted.

In 2007 the REMS reduced sampling at grab sample locations surrounding the MFNDS to once every other month. This schedule was continued in 2012. This action was supported by an assessment of the previous 13 years of data collected at the MFNDS by the REMS. It was determined ISCO samplers would provide sufficient samples and data for the assessment of continued releases of residual radioactive material on public health.

The REMS continues to maintain sufficient monitoring locations and collects samples at a more than adequate frequency for assessing impacts of continued releases from the disposal trench on the East Main Drain Hillside and in the East Main Drainage Channel. The sample locations and frequency needs to be maintained in order to assess present and future impacts of contaminant movement to locations within the new site boundary and to locations outside of the new site boundary. Sampling frequency allows for remedial actions to be planned and implemented and to address increases in radionuclide activity concentration, if necessary. The REMS also has sufficient monitoring locations on the west hillside to continue to effectively monitor releases from the disposal trenches to Wash 107 and Drip Springs Creek.

Conclusions

On the basis of the data generated by the Radiation Health Branch, Department for Public Health, Cabinet for Health and Family Services during CY2012, the MFNDS does not presently pose a threat to public health.

Analyses of water from monitoring wells, seeps, and surface water locations indicate that ex-filtration of leachate from the trenches continues to occur at the MFNDS. Though many monitoring points around the site are at background levels, assessment of CY2012 data provides unequivocal evidence that release of radionuclides to bedrock, groundwater, surface water, and sediment has not yet been mitigated, site wide, by the Initial Remedial Phase at the MFNDS.

Acknowledgments

The Maxey Flats Nuclear Disposal Site Summary Report has been historically prepared by the University of Kentucky for the Commonwealth of Kentucky. Some parts of this report have been carried over from historical reports prepared by the University of Kentucky.

Appendix 1

For 2012 MFNDS analytical data, please contact:

Kentucky Radiation Health Branch
Radiation/Environmental Monitoring Section
100 Sower Blvd., Suite 108
Frankfort, KY 40601
(502) 564-8390