MAXEY FLATS
NUCLEAR DISPOSAL SITE
CALENDAR YEAR 2013

SUMMARY REPORT

March 2014

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

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MFNDS CY2013 SUMMARY REPORT

Introduction

One thousand one hundred sixty five (1,165) water samples were collected during calendar year (CY) 2013 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 3,291 analyses on these samples. An additional 16,969 quality control (QC) analyses were performed to ensure the accuracy and precision of the analytical results. The cited 16,969 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 CY2013. 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 seeps, 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 environmental monitoring program is provided upon request.

In CY2013, the REMS conducted extended radionuclide analyses on groundwater samples from the USGS monitoring wells outside the restricted area and on samples from select water locations. Extended radionuclide analyses of samples provided the RHB with information regarding contaminant migration from the burial trenches following completion of Initial Remedial Phase CERCLA activities.

Data collected during 2013 was used to assess whether the actions implemented during the Initial Remedial Phase under CERCLA at the MFNDS were successful in meeting remedial goals. As this site is open to the environment, very little is truly known concerning the intricacies of groundwater flow (due to fracture flow and lack of data), and essentially all of the monitoring locations are impacted by areas outside of the site, it is extremely important to look at the data in ways other than a direct comparison of annual averages to a given limit. This is exacerbated by the relatively low levels of contaminants at the compliance point (due to distance and surface water contributions from non-impacted areas) and the significant variability introduced by having no way to account for volumetric flow at any monitoring point.

Additionally, since the contaminant utilized as an indicator at the site (tritium) is radioactive in nature, and as a consequence half of the total inventory of this contaminant will be gone in 12.3 years, it is important not to treat the data as if it were a normal metal or organic contaminant that remains stable in the environment. When attempting to utilize the data to determine how the remedy is impacting the generation and release of radioactive leachate, one must recognize that the sampling results following a remedy that had zero net impact on the generation and release of leachate would literally be an exponential downward trend in activity concentration.

Tritium provides a timely indicator of water movement from the trenches to the environment. Left unmitigated, these pathways of contaminant release will over time transport other radioisotopes with much longer half-lives to the environment. Because the public health impacts of exposure to some of these contaminants are much more severe, RHB remains focused on efforts to minimize or eliminate these release pathways while we still have the advantage of using tritium as an indicator.

While the CERCLA action limit has not been exceeded at the compliance point, long term upward trends at several monitoring points (including the compliance point) are concerning and are indicative of an exponential increase in the production and release of leachate since the current remedy was put in place in 2003. The details of the assessment of validated data from monitored or sampled 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 0.33 picocuries/milliliter (pCi/ml) for 5.0 ml sample aliquots used in the analysis of all on-site, off-site, drinking water wells, seeps, some monitoring wells, and surface water samplers to 14.9 pCi/ml for 0.1 ml aliquots used in the analysis of monitoring well and various other 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

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 11. HTO activity concentration in background and off-site surface-water locations were below the laboratory reported sample MDAs.

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. As part of entry into the Final Closure Period (FCP), Location 112 will be grouted and abandoned. It is currently considered a safety hazard.

East Hillside Monitoring

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.

LFS2 (Results greater than the MDA)											
Date	Isotope	Activity	Unit	Error	MDA	Date	Isotope	Activity	Unit	Error	MDA
1/10/2013	HTO	608.39	pCi/mL	1.67	0.29	5/16/2013	HTO	1433.19	pCi/mL	2.70	0.33
1/10/2013	HTO	652.62	pCi/mL	1.73	0.29	6/28/2013	HTO	639.24	pCi/mL	1.74	0.31
2/21/2013	U-234	1.17	pCi/L	0.33	0.06	6/28/2013	HTO	641.30	pCi/mL	1.74	0.31
2/21/2013	U-238	0.49	pCi/L	0.21	0.06	7/18/2013	HTO	620.04	pCi/mL	1.80	0.35
2/21/2013	HTO	1312.01	pCi/mL	2.58	0.34	7/18/2013	HTO	622.72	pCi/mL	1.81	0.35
2/21/2013	HTO	1296.20	pCi/mL	2.56	0.34	8/29/2013	HTO	330.80	pCi/mL	1.31	0.34
3/14/2013	HTO	810.97	pCi/mL	2.02	0.34	8/29/2013	HTO	333.29	pCi/mL	1.32	0.34
3/14/2013	HTO	812.61	pCi/mL	2.02	0.34	9/19/2013	HTO	352.31	pCi/mL	1.31	0.33
4/4/2013	HTO	1764.55	pCi/mL	2.88	0.31	9/19/2013	HTO	350.88	pCi/mL	1.30	0.33
4/4/2013	HTO	1758.77	pCi/mL	2.88	0.31	10/10/2013	U-234	1.00	pCi/L	0.34	0.07
4/4/2013	U-234	1.74	pCi/L	0.48	0.26	10/10/2013	U-238	0.62	pCi/L	0.29	0.32
4/4/2013	U-238	0.59	pCi/L	0.27	0.26	10/10/2013	HTO	2025.59	pCi/mL	3.14	0.31
4/26/2013	U-234	1.46	pCi/L	0.41	0.29	10/10/2013	HTO	2022.95	pCi/mL	3.13	0.31
4/26/2013	U-235	0.12	pCi/L	0.12	0.08	11/21/2013	HTO	1717.99	pCi/mL	3.04	0.36
4/26/2013	U-238	0.65	pCi/L	0.26	0.07	11/21/2013	HTO	1811.08	pCi/mL	3.12	0.36
4/26/2013	HTO	791.18	pCi/mL	1.92	0.31	12/12/2013	HTO	1532.01	pCi/mL	2.89	0.33
4/26/2013	HTO	792.15	pCi/mL	1.92	0.31	12/12/2013	HTO	1520.77	pCi/mL	2.88	0.33
5/16/2013	HTO	1365.50	pCi/mL	2.64	0.33	12/12/2013	U-234	1.07	pCi/L	0.32	0.06
						12/12/2013	U-238	0.49	pCi/L	0.22	0.20

Figure 1. LFS2 (Results greater than the MDA)

The REMS continues to monitor the East Main Drain Hillside for further evidence of radionuclide activity. East Drain seeps, LFS2, USF1, EMR1, EMR2, and EML3 were collected during the annual seep sample collection in CY2013 (Figure 11). Elevated HTO, uranium-234 and uranium-238 activity concentrations were detected in samples collected from the Farmers outcrop seeps surrounding the East Main Drain at four (4) of the locations sampled in CY2013.

Seeps collected April 26th, 2013 (Results greater than the MDA)					
Location	Isotope	Activity	Unit	Error	MDA
LFS2	U-234	1.46	pCi/L	0.41	0.29
LFS2	U-238	0.65	pCi/L	0.26	0.07
LFS2	HTO	791.18	pCi/mL	1.92	0.31
LFS2	HTO	792.15	pCi/mL	1.92	0.31
UFS1	U-234	0.79	pCi/L	0.29	0.21
UFS1	U-238	0.46	pCi/L	0.21	0.06
UFS1	HTO	2628.41	pCi/mL	3.50	0.31
UFS1	HTO	2632.86	pCi/mL	3.51	0.31
EMR1	U-234	1.32	pCi/L	0.41	0.26
EMR1	U-238	0.66	pCi/L	0.28	0.07
EMR1	HTO	3220.44	pCi/mL	3.88	0.31
EMR1	HTO	3219.52	pCi/mL	3.88	0.31
EMR2	U-234	1.32	pCi/L	0.44	0.30
EMR2	U-238	0.80	pCi/L	0.33	0.09
EMR2	HTO	2792.28	pCi/mL	3.61	0.31
EMR2	HTO	2794.16	pCi/mL	3.61	0.31

Figure 2. Seeps collected April 26th, 2013 (Results greater than the MDA)

Data for the LFS2 seep on the East Main Drain Hillside from January through December 2013 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 3. 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 upwardly trending 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.

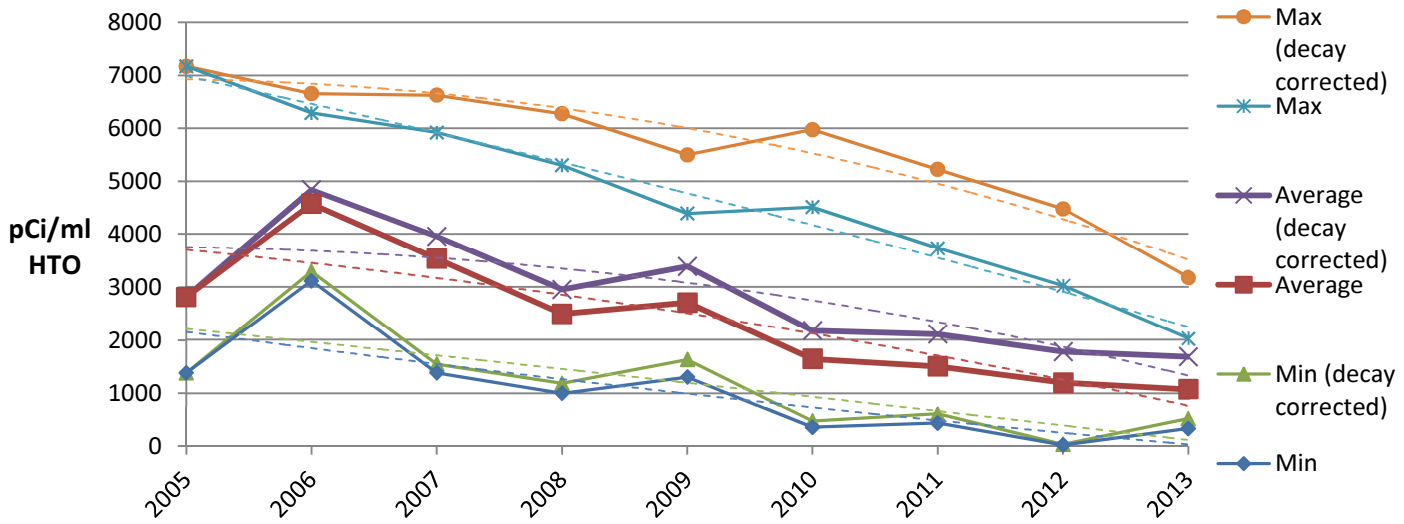

Figure 3. Minimum, Maximum, and Average HTO Activity Concentrations at LFS2

East Main Drain Monitoring

The HTO activity concentration at East Main Drain sampling locations 113 and 144 (Figure 11) 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 11). Based on two (2) samples collected at the EDOUTL in 2013, the average HTO in surface water at EDOUTL was 2.6 pCi/ml as compared to 73 and 159 pCi/ml at locations 144 and 113, respectively. Average HTO activity concentrations at 113 and 144 are shown in Figure 4.

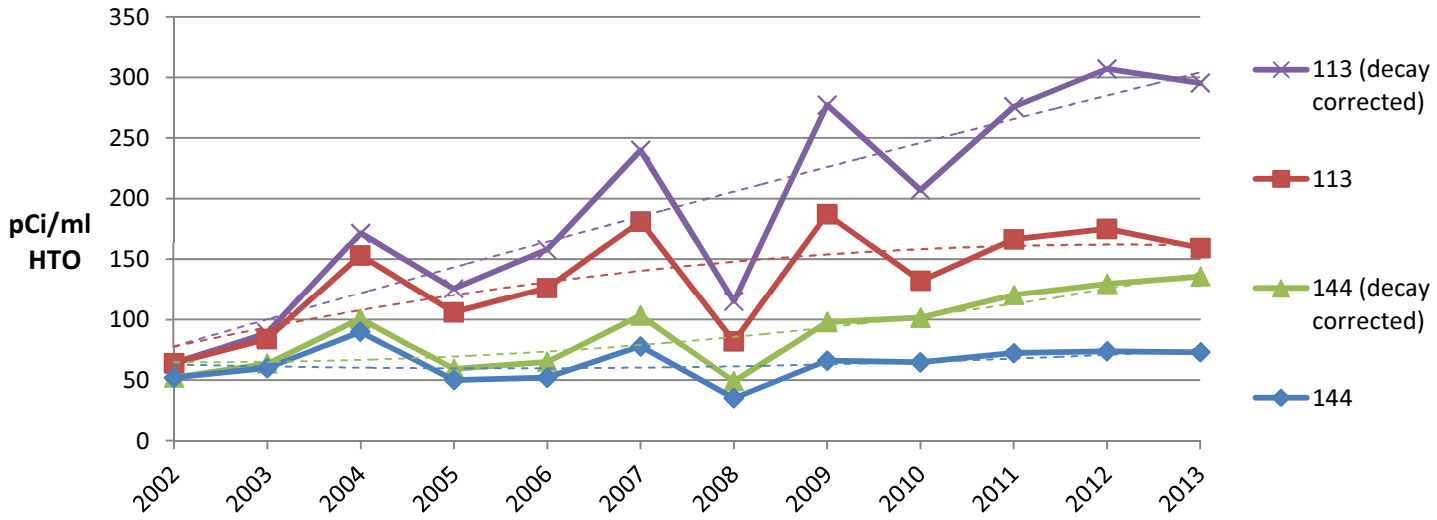

Figure 4. Average HTO Activity Concentrations at 113 & 144

The mean HTO activity concentration for the East Drain ISCO automatic sampler (EDRN) (Figure 11) at 800 feet above mean sea level (MSL) in the East Main Drainage Channel is shown in Figure 5, along with ranges for each year. An automatic sampler composites surface water samples on a daily basis.

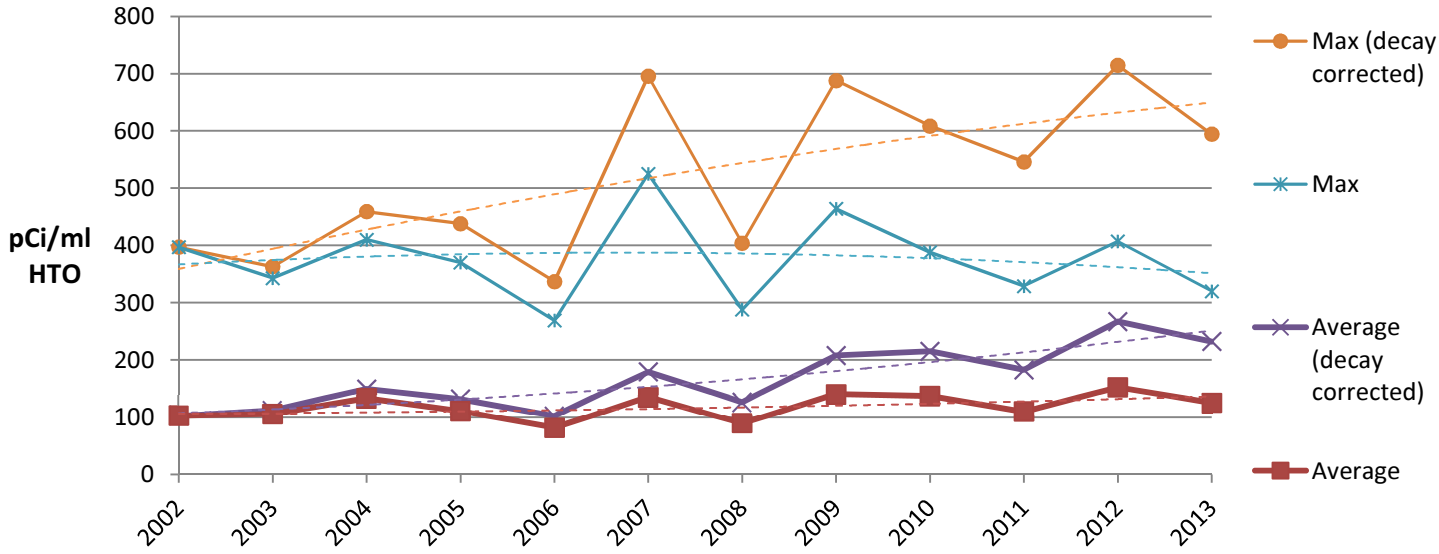

Figure 5. Maximum and Average HTO Activity Concentrations at EDRN

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 11). 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 that 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 ongoing and raise significant questions concerning 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 J107. 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.

A pond on the west side in the buffer area, Location 108 (Figure 11), was analyzed for specific radionuclides if the gross alpha/gross beta laboratory action limits were exceeded. Strontium-90 was identified three times; uranium-234 and uranium-238 were identified two times; and uranium-235 was identified one time during CY 2013 at 108. The source of this finding is still under investigation. Additional samples around the area have been collected, but results were not available at the time of the writing of this report.

108 (Results greater than the MDA)					
Date	**Isotope**	**Activity**	**Unit**	**Error**	**MDA**
4/4/2013	HTO	0.34	pCi/mL	0.10	0.31
4/4/2013	HTO	0.32	pCi/mL	0.10	0.31
6/28/2013	Sr-90	6.25	pCi/L	2.25	5.47
6/28/2013	HTO	0.42	pCi/mL	0.10	0.31
8/29/2013	HTO	0.46	pCi/mL	0.11	0.34
8/29/2013	Sr-90	26.34	pCi/L	2.93	4.89
10/10/2013	HTO	0.44	pCi/mL	0.11	0.31
10/10/2013	Sr-90	5.90	pCi/L	2.36	5.34
10/10/2013	U-234	14.34	pCi/L	1.77	0.23
10/10/2013	U-235	0.77	pCi/L	0.31	0.08
10/10/2013	U-238	14.77	pCi/L	1.80	0.07
12/12/2013	U-234	6.69	pCi/L	0.98	0.21
12/12/2013	U-238	6.80	pCi/L	0.99	0.06

Figure 6. 108 (Results greater than the MDA)

The mean HTO activity concentration for Drip Springs Creek Location 103 (Figure 11) grab-samples and ISCO are displayed in Figure 7. 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.

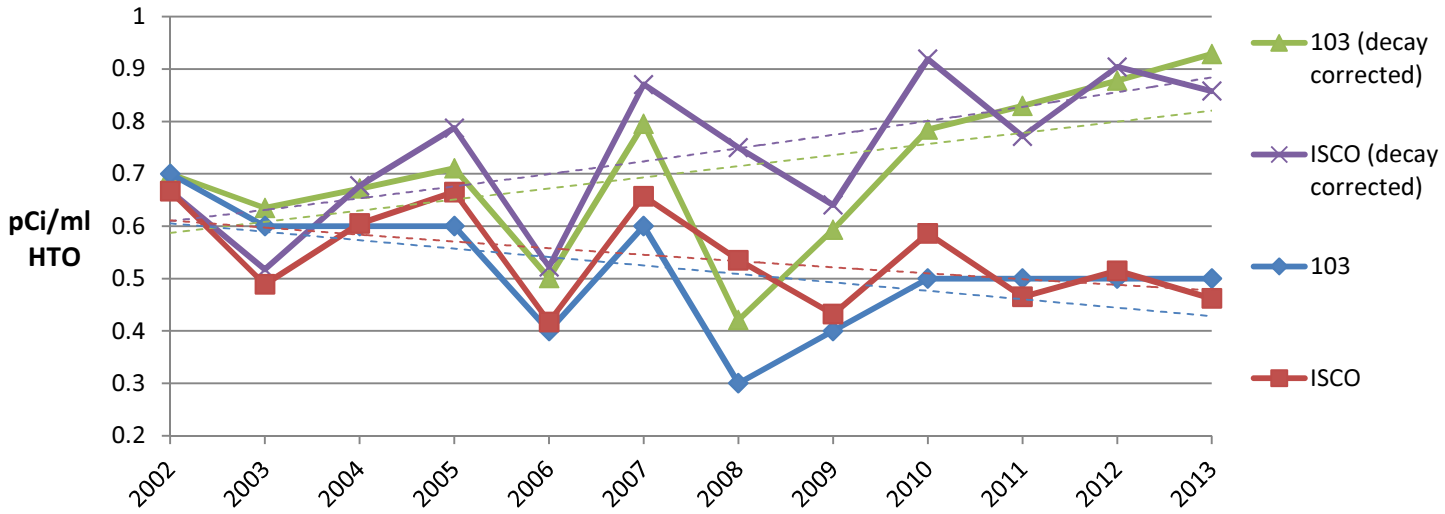

Figure 7. Average HTO Activity Concentrations at 103

South Hillside Monitoring

Location 143 (the bottom of the historical south drain) (Figure 11) was analyzed for specific radionuclides if the gross alpha/gross beta laboratory action limits were exceeded. Uranium-234, uranium-238 and plutonium-238 were identified in August at location 143. Data is shown in Figure 8. Additional samples around the area have been collected, but results were not available at the time of the writing of this report.

143 (Results greater than the MDA)					
Date	**Isotope**	**Activity**	**Unit**	**Error**	**MDA**
8/29/2013	U-238	5.55	pCi/L	0.89	0.07
8/29/2013	Pu-238	0.77	pCi/L	0.30	0.08
8/29/2013	U-234	5.74	pCi/L	0.92	0.23

Figure 8. 143 (Results greater than the MDA)

CERCLA Compliance Point Monitoring

The mean HTO activity concentration for location 102 (Figure 11) grab-samples and ISCO collected at the junction of Rock Lick Creek and Highway 158 are displayed in Figure 9. From 2003 to 2012, the activity concentrations at 102 have demonstrated a clear upward trend (with significant variability), and analysis of monitoring data at the tributaries indicates that the east side of the site is the primary contributor to this trend.

The addition of 2013 data does drive the non-corrected trend curve to appear as though the activity concentrations at the point of compliance have peaked, but this is actually an artifact of a limited data set and a significant year to year variance. If, for example, the same trend calculation were applied to the 2002-2006 data, it would show a significant downward trend beyond 2004, which is easily demonstrated to be inaccurate as additional data is collected.

It will take several more years of data to reliably determine if activity concentrations at the point of compliance have peaked, and regardless, decay correction of the current data set demonstrates that actual releases from the site continue their significant upward 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.

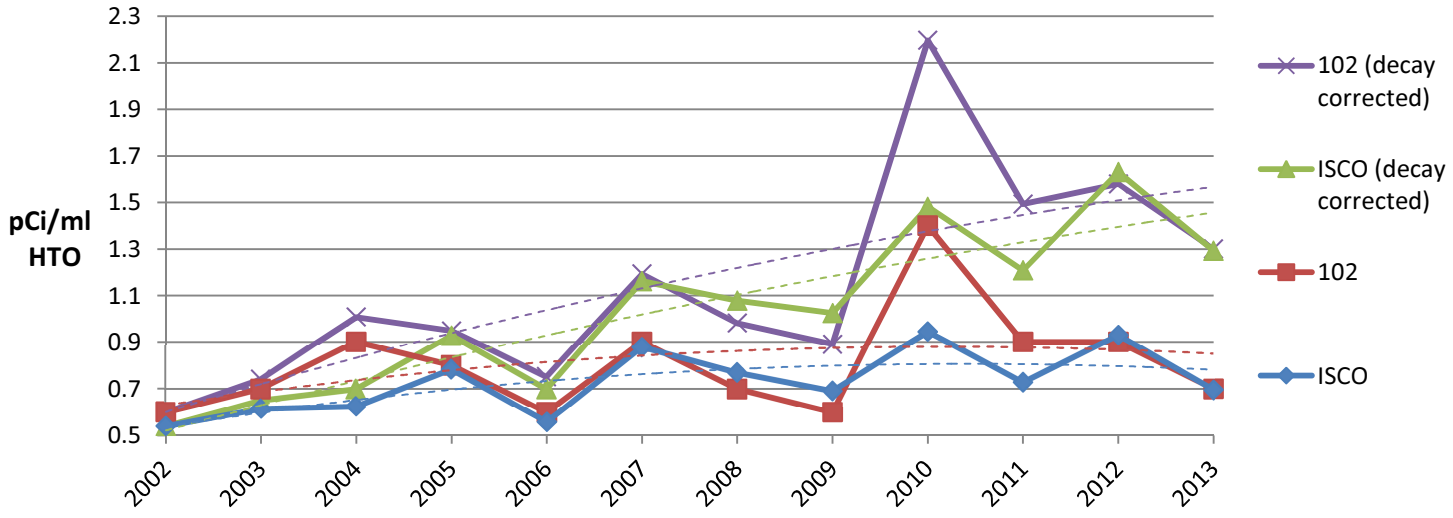

Figure 9. Average HTO Activity Concentrations at 102

USGS Monitoring Well Sampling

Extended radionuclide analysis of water from selected USGS monitoring wells (Figure 11) continued in CY2013. Data is shown in Figure 10. 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 CY2013 along with data collected from CY2000 through 2012 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 2013. Results are shown in Figure 10. Extended radionuclide analyses included; Strontium-90, carbon-14, plutonium-238, plutonium-239, uranium-238, uranium-235, and uranium-234. Gross alpha and beta analysis and gamma spectroscopy were also conducted on the samples. During the Final Closure Period, Location UF10a will be abandoned before installation of the final cap.

USGS Wells (Results greater than the MDA)

Collected April 22, 2013:

Location	Isotope*	Activity	Unit	Error	MDA
N2B	HTO	707.20	pCi/mL	13.66	15.69
N2B	HTO	684.14	pCi/mL	13.46	15.69
N2B	U-234	2.33	pCi/L	0.47	0.05
N2B	Pu-238	1.47	pCi/L	0.39	0.07
UE2	HTO	163538.02	pCi/mL	194.74	15.69
UE2	HTO	163472.90	pCi/mL	194.70	15.69
UE2	U-234	14.57	pCi/L	1.67	0.20
UE2	U-238	0.72	pCi/L	0.26	0.06
UE2	Pu-238	2.01	pCi/L	0.44	0.06
UE2	C-14	312.59	pCi/L	46.86	104.82
UE2	Sr-90	82.79	pCi/L	5.58	5.48
UF2	HTO	118472.16	pCi/mL	165.76	15.69
UF2	HTO	118394.76	pCi/mL	165.71	15.69
UF2	U-234	12.00	pCi/L	1.46	0.06
UF2	Pu-238	2.55	pCi/L	0.56	0.38
UF2	C-14	396.46	pCi/L	50.14	104.82
UF2	Sr-90	166.16	pCi/L	7.42	5.48
UF10a	HTO	27029.47	pCi/mL	25.03	1.57
UF10a	HTO	27035.32	pCi/mL	25.04	1.57
UF10a	U-234	5.98	pCi/L	0.94	0.30
UF10a	U-238	2.09	pCi/L	0.49	0.07
UF10a	C-14	186.79	pCi/L	43.82	114.82
UF10a	Sr-90	10.39	pCi/L	3.09	5.48
UK1	HTO	141807.34	pCi/mL	181.34	15.69
UK1	HTO	142191.57	pCi/mL	181.59	15.69
UK1	U-234	10.48	pCi/L	1.30	0.20
UK1	U-238	0.54	pCi/L	0.24	0.26
UK1	Sr-90	65.05	pCi/L	5.23	5.48
UK1	Pu-238	5.28	pCi/L	0.73	0.19
UK1	C-14	602.31	pCi/L	57.41	104.82

Note: * - Isotopes reported as U-234 are actually both U-233 and U-234, but these cannot be separated with current analysis.

Collected October 21, 2013:

Location	Isotope*	Activity	Unit	Error	MDA
N2B	HTO	114971.4	pCi/mL	176.22	17.04
N2B	HTO	115232.37	pCi/mL	176.42	17.04
N2B	C-14	303.06	pCi/L	37.82	78.61
N2B	Sr-90	44.75	pCi/L	4.44	6.44
N2B	U-234	8.18	pCi/L	1.74	0.71
N2B	Pu-238	2.79	pCi/L	0.61	0.28
UE2	HTO	142525.7	pCi/mL	196.19	17.04
UE2	HTO	142745.92	pCi/mL	196.34	17.04
UE2	C-14	460.31	pCi/L	43.34	78.61
UE2	Sr-90	88.29	pCi/L	5.74	6.44
UE2	U-234	17.76	pCi/L	2.32	0.32
UE2	U-238	1.18	pCi/L	0.44	0.42
UE2	Pu-238	3.88	pCi/L	0.78	0.4
UF2	HTO	137891.73	pCi/mL	192.98	17.04
UF2	HTO	137856.92	pCi/mL	192.95	17.04
UF2	C-14	734.78	pCi/L	51.57	78.61
UF2	Sr-90	203.59	pCi/L	8.09	6.44
UF2	U-234	17.47	pCi/L	2.08	0.08
UF2	U-238	0.54	pCi/L	0.25	0.08
UF2	Pu-238	4.78	pCi/L	0.9	0.5
UF10a	HTO	28855.89	pCi/mL	88.4	17.04
UF10a	HTO	28962.36	pCi/mL	88.56	17.04
UF10a	C-14	125.8	pCi/L	30.43	78.61
UF10a	Sr-90	14.07	pCi/L	3.19	6.44
UF10a	U-234	5.79	pCi/L	0.98	0.36
UF10a	U-238	1.71	pCi/L	0.48	0.08
UK1	HTO	187559.32	pCi/mL	225.04	17.04
UK1	HTO	187452.18	pCi/mL	224.98	17.04
UK1	C-14	426	pCi/L	42.2	78.61
UK1	Sr-90	83.75	pCi/L	5.79	6.44
UK1	U-234	12.34	pCi/L	1.63	0.08
UK1	U-238	0.74	pCi/L	0.31	0.27
UK1	Pu-238	7.87	pCi/L	1.53	0.55

Figure 10. USGS Wells (Results greater than the MDA)

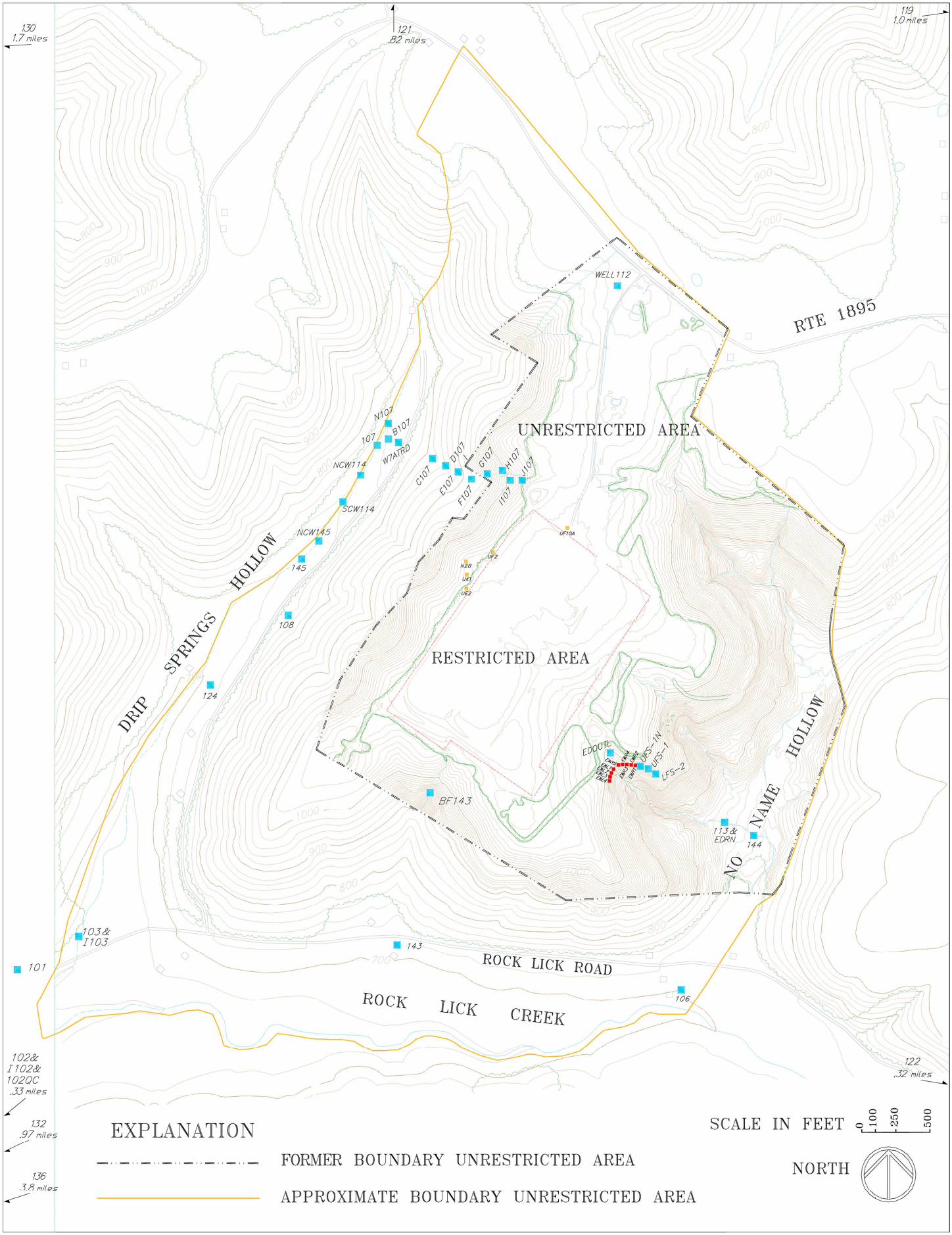

Figure 11. Maxey Flats Area Map

Rainfall Data and Surface Water Contamination

In 2013, site rainfall data was utilized to determine what (if any) effect rain events caused to the level of contamination in the surface water leaving the site. Daily site rainfall measurements and results from continuous surface water samplers at the site were plotted temporally. A moving average (8 points) was utilized in order to remove noise and better display trends. Data from 2013 at the CERCLA compliance point (102) is shown in Figure 12.

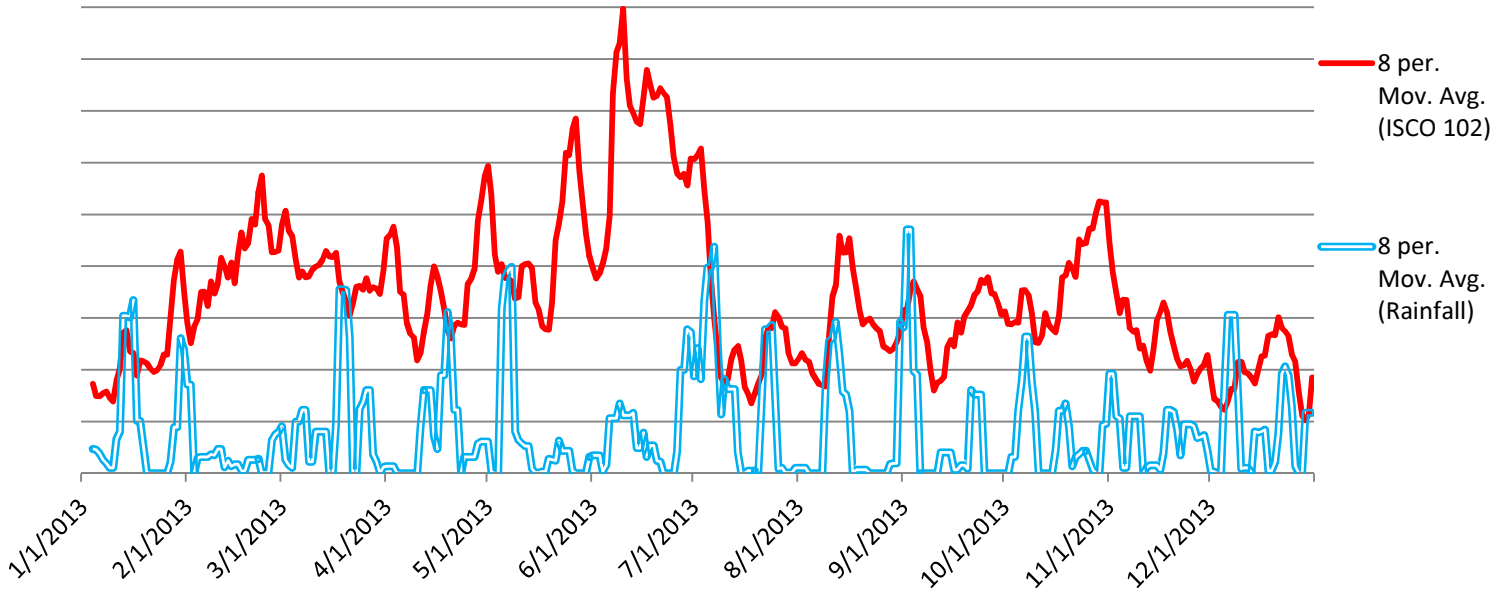

Figure 12. HTO Activity Concentrations at 102 vs. Rainfall (2013)

As would be expected, there was a significant correlation between the onset of rainfall events and the lowering of activity concentration reported in surface water. This is expected due to dilution, and the rate of change and duration of activity concentration trends are fairly consistent with the area under the curve for each rain event. Although there are several unknown factors that may affect both the timing and magnitude of this drop (e.g., soil saturation and permeability, precipitation rate, evapotranspiration rate, rainfall variance in the area), it is identifiable across the data set. Consistent with this observation, periods with little rain tend to show activity concentrations drifting higher on average, due to the surface water containing a larger percentage of site leachate than normal.

A second, more unexpected correlation was noted between the peaks of individual (single and multi-day) rain events and peaks in activity concentration. At the CERCLA compliance point, these peaks occurred consistently and were present in most cases where they were not expected to be masked by the dilution of another rainfall event.

This second correlation is troubling based upon what we know about the site. The response of these peaks indicates that rainfall may in fact be causing additional releases from the site. There is no known reservoir for tritium contaminated water other than the trenches, and there is no known way for rainfall to increase the rate of release from the site other than infiltration of these trenches and their slow release to the environment over many days following this infiltration.

The current cover, although difficult to maintain and susceptible to environmental degradation and damage due to wildlife, is essentially an impermeable barrier to rainfall. Even with a modest number of sizeable holes (which would not be an expected state, due to the diligence with which the onsite personnel inspect and repair the cap) there would only be a handful of gallons of leakage into the site trenches over a year. The primary reason is that, due to the lack of additional cover material to capture moisture and the design/grading of the site, essentially all of the water runs off immediately. Water simply does not remain on the cap for long enough to penetrate the cap.

As significant vertical infiltration is ruled out, long term horizontal infiltration into at least one trench is in all likelihood responsible for additional releases from the site. Site history has demonstrated the negative impacts of horizontal infiltration, and in fact the cap was extended from its original design on the southeast corner in order to cover a large part of the plateau that was previously allowing horizontal infiltration to the trenches. There remains a very small strip of potential sources for horizontal infiltration along the west side, south side, and portions of the east side. The more likely source, however, is the large portion of the plateau to the north.

Efforts are currently underway to gain a better understanding of these interactions. Methods of measuring and accounting for volumetric flow rate are being evaluated so that the effects of dilution can be minimized and total activity release can be calculated. Regardless, due to the likelihood of ongoing horizontal infiltration from the north, it is the recommendation of RHB that a method to fully control horizontal infiltration be implemented at the site. Every gallon of clean rainwater that enters a trench becomes a new gallon of radioactive waste.

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.

- 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. RHB had successfully negotiated in 2011 to have a remedy installed that would eliminate all possible sources of external flow to the extent practicable and add additional trench and environment monitoring capability, but as of the completion of this report none of the agreements made have been implemented despite the design portion of the FCP being well underway. In fact, closure of all sumps is currently planned for the FCP.

- Based on historical and CY2013 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.

Nature of Releases

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 3 provides the trend line for the LFS2 HTO activity concentration from 2005 through 2013. 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 twelve (12) years at location 113/EDRN ISCO. Location 113 and EDRN ISCO HTO activity concentration can be seen in Figure 4 and Figure 5, 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 4. 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 2013 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. Radiation doses will continue to be calculated at location 144 in order to assess long-term statistical trends.

Regulatory Requirements

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.

Dose and Risk Assessments

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 73 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 CY2013 HTO activity concentration at location 102 was 0.7 pCi/ml. Assuming surface water with an average HTO activity concentration of 0.7 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 0.03 mrem/yr from HTO. The annual radiation dose from HTO at location 102 is 0.14% 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 0.03 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 1.5×10^{-8} (from Risk/Dose Conversion Factors) and 2.4×10^{-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 CY2013 data indicates release of radionuclides from the disposal trenches continues subsequent to the Initial Remedial Phase activities. Based on analysis of CY2013 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. Moving forward, it will remain important to evaluation dose and assess risk as radionuclides other than tritum increasingly become contributors.

Changes to Sampling

In 2007 the REMS reduced sampling at grab sample locations surrounding the MFNDS to once every other month. This schedule was continued in 2013. 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 trenches on the East Main Drain Hillside and in the East Main Drainage Channel. The sample locations and frequency need 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.

Current Regulatory Status

The regulatory environment at MFNDS is complex. The site is owned by the Commonwealth of Kentucky with EEC being responsible for stabilization and decommissioning and CHFS being responsible for regulation and monitoring. These respective functions are required by statute to be funded as major program budget item in each agency's operating budget. As a result of this separation of responsibility, CHFS continues to regulate EEC via a site AEA license. This is a fairly straightforward relationship. The regulatory complexity arose when MFNDS was added to the NPL in 1986, based primarily on concerns of airborne tritium from the then on site evaporator. Once a CERCLA site, EPA became the primary regulator with respect to the development and implementation of a remedy to address the release or potential release of contaminants to the environment. The remedy that was ultimately chosen was identified and defined in the 1991 Record of Decision.

The Record of Decision was followed in 1995 by the Consent Decree which established the funding for the remedy through settling parties which included the Commonwealth of Kentucky. Of note, both the Record of Decision and the Consent Decree acknowledge the jurisdictional authority of the site AEA license issued by CHFS. There is also an MOA between CHFS and EEC which established EEC as the Commonwealth's lead agency with regard to the implementation of the remedy.

From the time it became involved with MFNDS, the EPA mission has been clear and consistent; move the site through the CERCLA process, the goal of which is long-term site stability. CHFS through RHB has focused efforts toward public health and safety including site workers, members of the public currently living in the vicinity of the site and future inhabitants. EEC has operated the site consistent with the overlapping missions of the EPA and CHFS along with their inherent mission to protect the environment.

As the site proceeded into the Final Closure Period, RHB has had objections to plans and activities that it believes are inconsistent with its mission; particularly to protect the health and safety of future generations living in the vicinity of the site. The result of these objections was conflict. The result of the conflict was a challenge to our regulatory role at the site.

At the time of this report, CHFS leadership is cooperating with EEC to effectively remove the regulatory authority of RHB. This shifting of the regulatory landscape is not expected to impact our environmental monitoring program. The site AEA license is still active, but it appears that we may no longer possess the authority to enforce its conditions or the supporting regulations. We also appear to have lost our ability to influence planning and policy to be consistent with the best interest of long term public health and safety. RHB continues to maintain that a viable regulatory presence is essential to carrying out our mission and fulfilling our responsibilities.

Conclusions

On the basis of the data generated by the Radiation Health Branch, Department for Public Health, Cabinet for Health and Family Services during CY2013, 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 CY2013 data along with data from previous years 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. It can further be deduced that the amount of leachate leaving the site is likely increasing exponentially.

Because the Final Closure Period planning documents do not contain plans for protective measures previously negotiated with EEC, nor does the currently designed cap appear to meet Low Level Radioactive Waste requirements, RHB believes that the final remedy presents an undue risk of not being protective of human health or the environment in the long-term.

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.

For 2013 MFNDS analytical data, please contact:

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