Tennessee Sample Results Show No Difference In Radioactivity Levels Between BSFR and Non-BSFR Landfills

The results of landfill leachate samples analyzed by the State of Tennessee showed no difference in the radioactivity levels between landfills that accept low level radioactive waste and those that do not. In response to concerns raised over the Bulk Survey For Release (BSFR) program, the Tennessee Division of Environmental Conservation (TDEC) sampled leachate from landfills around the state in early June. The BSFR process allows disposal of very low level radioactive materials at some Tennessee Class I landfills. The samples the state analyzed were taken at landfills that accept BSFR material and also from landfills where no BSFR material has ever been buried.

Leachate is the water that collects at the bottom of a lined landfill. Lined landfills have plastic liners on top of a layer of clay, to hold liquids that come in contact with the waste within the landfill. The leachate is mainly rainwater that has percolated through the landfill at locations were waste is being dumped and do not have a clay cap installed over it. This water must be periodically pumped and disposed of at local sewage treatment facilities.

Leachate can contain other materials that the water picks up as it percolates through the waste. Landfill operators routinely test leachate for non-radioactive contaminants prior to disposing of it in sewage systems. The State of Tennessee tested leachate for tritium (H-3), as well as alpha, beta, and gamma emitting radionuclides.

The results of the leachate sampling are shown in Figure 1. A pCi or picoCurie is a unit of radioactivity that equates to about 2.2 radioactive decays per minute. The only gamma emitting radionuclides that showed up in the samples were potassium 40 (K-40), lead 212 (Pb-212) and bismuth (Bi-214). All of these nuclides are naturally occurring in the environment. Tritium, gross alpha emitting and gross beta emitting radionuclides are also naturally occurring and found in the environment.

	Carter's Valley	Iris Glen	Chestnut Ridge	Alcoa Maryville Blount Countty	North Shelby	South Shelby	Jackson	Middle Point	Bi-County
Recieves BSFR?	YES	NO	YES	NO	YES	YES	NO	YES	NO
Alpha Emitting	54	50	67	297	6.8	125	19		
Beta Emitting	4,652	552	1,700	484	204	207	784		
H-3	14,341	36,595	19,451	330	12,538	15,660	24,067	34,000	
K-40	3,409	449	1,214	660	224	192	851		

Figure 1 - Results of Tennessee Leachate Sampling Reported in pCi/liter

The tritium levels (H-3) were higher than those found naturally in the environment. Tritium is not one of the more abundant nuclides in the BSFR wastes. The Pennsylvania Department of Environmental Protection sampled 54 Pennsylvania solid waste landfills in 2004 and again in 2005. Five control samples were also taken for a total of 59 samples. The Pennsylvania laws prohibit dumping radioactive materials in solid waste landfills. Yet, Pennsylvania landfills also exhibited elevated tritium levels in their leachate, just as the landfills in Tennessee that are not permitted to accept BSFR waste did. The Pennsylvania 2004 study results showed that tritium was identified in 57 or 97% of the 59

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samples analyzed from Pennsylvania landfills. Results ranged from 6.86 to 94,400 pCi/L. The mean concentration was 25,200 pCi/L. Results from follow-up samples taken in 2005 showed that tritium was still present in nearly all of the landfills. It was identified in 55 samples, or 93% of the 59 samples analyzed. The 2005 Pennsylvania tritium concentrations ranged from -62 to 181,700 pCi/L, with a mean concentration of 20,900 pCi/L. Figure 2 provides a chart showing the Pennsylvania tritium results.

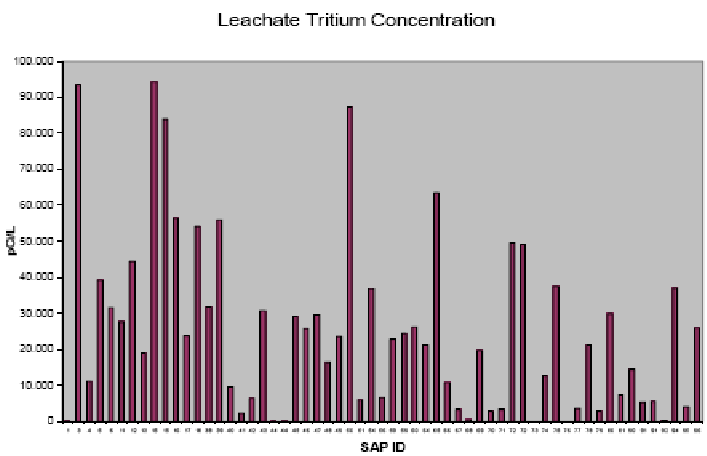

Figure 2 - 2004 Pennsylvania Landfill Tritium Results

The Pennsylvania DEP had the following to say about the tritium results, "*The source of higher-than-background levels found in landfill leachate samples was presumed to originate from the improper disposal of self-luminescent exit signs found in construction/demolition (C/D) waste and other solid waste streams. There are no other known sources of tritium in industrial or consumer products that would cause elevated levels of tritium in landfill leachate. Thus, it is apparent that tritium exit signs, which when new may contain up to 25 curies, or 25,000,000,000,000 picocuries (pCi) of tritium, are entering landfills via municipal or residual waste streams. The typical amount is 10 Ci or 10,000,000,000,000 pCi. A single tritium emergency exit sign has the potential to cause the tritium levels observed.*" Similarly the Tennessee landfill with the highest tritium levels in the leachate has never had BSFR waste disposed of in it. In fact tritium is not one of the principle nuclides in BSFR waste. Nuclides such as Cs-137 would be expected to be present in the leachate in far greater quantities.

The next highest radioactivity levels were for potassium 40 (K-40). This was also observed in 90% of the Pennsylvania landfills, where results ranged from 16.3 to 1,080 pCi/L, with a mean activity concentration of 270 pCi/L. The Pennsylvania DEC had this to say about the observed K-40 in the leachate samples, "*The next most prevalent radionuclide measured was potassium-40 (^{40}K; identified in 53 samples), a completely naturally-occurring radioactive material whose identification was inconsequential*."

Potassium-40 (K-40) is present as a very small fraction of naturally occurring potassium, which is an element found in large amounts throughout nature. Potassium is the seventh most abundant element in the crust of the earth and the sixth most abundant element in solution in the oceans. The half life of K-40 is 1.27 billion years. Thus much of the K-40 produced in the formation of the earth is still around. Potassium is an essential electrolyte in our bodies. Our bodies try to maintain relatively constant levels of potassium within us. Some of this potassium is K-40. On average our bodies contain about 1.5 pCi/g of potassium. This results in 10 to 25 mrem/year of internal dose from the naturally occurring K-40 in our bodies. For more information about K-40 in the environment see http://www.ead.anl.gov/pub/doc/potassium.pdf or http://www.orau.org/ptp/collection/consumer%20products/potassiumgeneralinfo.htm
Potassium 40 is not one of the principle nuclides in BSFR waste streams.

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In general, the gross alpha levels in the Tennessee landfills were higher than those observed in the Pennsylvania leachate. The Pennsylvania gross alpha results ranged from -7.72 to 21.1 pCi/L, with a mean activity concentration

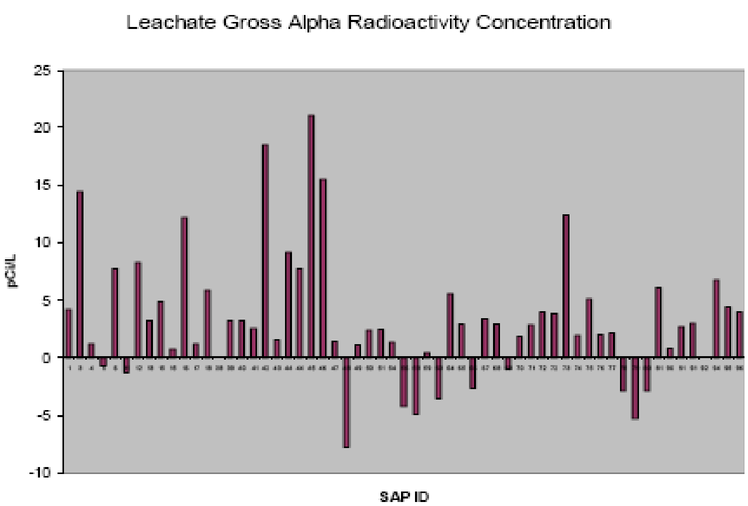

Figure 4 - 2004 Pennsylvania Landfill Gross Alpha Results

of 3.37 pCi/L. Some of the Pennsylvania samples were unable to see gross alpha levels below 37 pCi/L. A chart of the Pennsylvania leachate gross alpha levels in provided in Figure 3. The highest Tennessee gross alpha levels were at the Alcoa/Maryville facility, a landfill that does not accept BSFR waste. Uranium and thorium are naturally occurring alpha emitting radionuclides commonly found in rocks and soils. In addition

	Carter's Valley	Iris Glen	Chestnut Ridge	Alcoa Maryville Blount Countty	North Shelby	South Shelby	Jackson	Middle Point	Bi-County
Recieves BSFR	YES	NO	YES	NO	YES	YES	NO	YES	
Alpha Emitting	54	50	67	297	6.8	125	19		
Corrected Beta Emitting	1,564	89	541	-400	-2	-89	8		
H-3	14,341	36,595	19,451	330	12,538	15,660	24,067	34,000	
K-40	3,409	449	1,214	660	224	192	851		

Figure 3 - Results of Tennessee Leachate Sample Results Corrected for Gross Beta Reported in pCi/liter

burial of technologically-enhanced naturally-occurring radioactive material (TENORM) e.g., foundry sand or bricks, coal-powered power plant ash, stack flyash and/or stack scrubber residue at a landfill can increase leachate gross Uranium and thorium levels.

It is notable that the highest tritium and alpha levels were at the Iris Glen and Alcoa/Maryville landfills respectively and they do not receive BSFR waste. The landfills with the highest beta emitting nuclide levels, Carter's Valley and Chestnut Ridge do accept BSFR, but they also had the highest levels of K-40 levels. Potassium 40 emits beta particles of high enough energy so that 89% would contribute to the gross beta results. The betas emitted by tritium H-3 are not strong enough to be detected on the gross beta results. Nearly all alpha emitters also give off beta particles that would also contribute to the results. When the overlap between the alpha emitters, K-40, Bi-214 and Pb-212 are subtracted out of the gross beta results, the corrected gross beta results are as shown in Figure 4

	Carter's Valley	Iris Glen	Chestnut Ridge	Alcoa Maryville Blount
Recieves BSFR?	YES	NO	YES	NO
Alpha Emitting	2%	2%	2%	10%
Corrected Beta Emitting	31%	2%	11%	
H-3	0.1%	0.4%	0.2%	0.003%
K-40	9%	1%	3%	2%

Figure 6. The gross beta results obtained in the Pennsylvania study ranged from 7.25 to 564 pCi/L, with a mean activity concentration of 152 pCi/L. The Pennsylvania results did not include K-

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40 either. A chart of the Pennsylvania results is provided in Figure 5.

Gamma emitting radionuclides which are prevalent in BSFR waste, such as Cobalt 60 (Co-

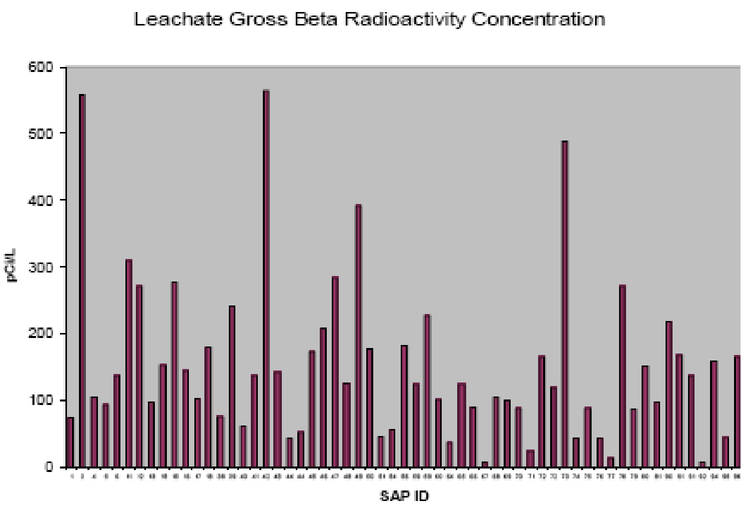

Figure 5 - 2004 Pennsylvania Landfill Gross Beta Results

60) and Cesium 137 (Cs-137), were not detected in the Tennessee leachate samples. These would be the best indicators of whether or not BSFR waste was increasing radioactivity in the landfills where it is disposed of. The absence of Cs-137 and Co-60 from the samples demonstrates that the amounts of BSFR radioactivity placed in these landfills is insignificant in comparison to the naturally occurring radionuclides, like K-40 already found in landfill waste. By contrast the Pennsylvania landfills, which do not accept "radioactive" waste did detect these nuclides in their leachate. For the liquid samples, the Co-60 results ranged from -4.24 to 3.81 pCi/L, with a mean activity concentration of -0.366 pCi/L. Cobalt 60 is not found in the natural environment and could only have come from licensed radioactive material entering the landfills. The Pennsylvania study identified Cs-137 in 7% of the samples. The results ranged from -7.91 to 4.23 pCi/L, with a mean activity concentration of 0.012 pCi/L. Cs-137 is not naturally occurring and is a major constituent of BSFR wastes. However, unlike Co-60 it is widely distributed in the environment due to fallout from atomic bomb testing. The Pennsylvania study also found Eu-154 in 3% of the samples and Am-241 in 7% of the samples. It is almost certain that if any of these nuclides were detected in the Tennessee samples they would have been attributed to BSFR waste. When a nuclide is detected in a landfill it is very difficult to say which waste it came from. Sources made of Co-60 and Cs-137 are used in many industrial applications such as X-raying welds and in coal fired power plants to sense when hoppers are filled with coal. The Pennsylvania results demonstrate the need for caution when speculating about the origin of a radionuclide found in a landfill sample.

The Tennessee DEC officials who contracted the analysis of the leachate samples and reviewed the results are professionals in the field of Health Physics with many years of experience and with degrees in Health Physics or a related science. TDEC officials characterized the results as "*what would be expected given the prevalence of naturally occurring radioactive isotopes in our environment such as Potassium 40 (K-40), uranium, and thorium; and the common disposal of tritium-containing self-luminous products such as exit signs, etc., which are not disposed as part of the Bulk Survey for Release program*." In addition TDEC concluded that "*there is nothing in these results that is unusual or would constitute a threat*." This is consistent with the explanation given by the Pennsylvania DEC with regard to radioactivity in their landfills.

Tennessee landfill leachate is typically disposed of at sewage treatment facilities. Many of the users of radioactive materials such as universities, hospitals, and medical clinics dispose of radioactive materials also release short lived radionuclides to sewage treatment facilities. Patients treated with radioactive materials eliminate them into sewage facilities they use after

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being treated. Federal Regulations and most state regulations, including Tennessee's, set limits on the concentrations of radionuclides that can be disposed of in this manner. These concentration limits only take credit for a factor of 10 dilution at the sewage treatment plant. In other words the regulations assume that for every gallon of liquid entering the sewage treatment facility containing radioactive materials only 9 gallons of liquid from all other sources will also enter the facility on average. The regulations are set so that if someone were to use the liquid right out of the outfall of sewage treatment plant as their sole source of drinking water, they would receive 50 mrem/year. This is half the Nuclear Regulatory Commission and Tennessee DEC limit to a member of the public which is 100 mrem/year.

sake of comparison of the leachate sample results to the Tennessee sewage disposal limits it can be assumed that the gross alpha is from Uranium-238 and the gross beta is from Sr-90. This is very unlikely since no Co-60 or Cs-137 was detected in the leachate and there are many naturally occurring radionuclides that emit alpha and beta particles. In addition, Sr-90 is not one of the principle beta emitters in BSFR waste, however it is one with very low limits for disposal in sewage. As shown in Figure 6, even when these conservative assumptions are made the leachate is acceptable for disposal in sewage treatment facilities.

The Tennessee samples identified radioactivity at similar levels both BSFR and non-BSFR landfills.. In some instances the landfills that never accepted BSFR, had the highest radioactivity levels. In

	Carter's Valley	Iris Glen	Chestnut Ridge	Alcoa Maryville Blount	North Shelby	South Shelby	Jackson	Middle Point	Bi-County
Recieves BSFR?	YES	NO	YES	NO	YES	YES	NO	YES	NO
Alpha Emitting	2%	2%	2%	10%	0.2%	4%	1%		
Corrected Beta Emitting	31%	2%	11%				0.2%		
H-3	0.1%	0.4%	0.2%	0.003%	0.1%	0.2%	0.2%	0.3%	
K-40	9%	1%	3%	2%	1%	0.5%	2%		

Figure 6 - Results of Tennessee Leachate Percent of Sewage Disposal Limit

TDEC summarized the Tennessee leachate results as follows, "*To put these numbers in perspective, it is more appropriate to compare the individual isotopes to State Regulations for Protection Against Radiation (SRPAR) numbers for what is permitted to be released by a licensed user of radioactive material into a wastewater treatment plant, particularly given that leachate is collected and treated. All of these results are well within SRPAR limits.*" These limits apply to material used under a TDEC "license" such as medical radionuclides and do not apply to those from unlicensed sources like uranium in bricks and fly ash or K-40 in fertilizer. Nevertheless, for the

addition, the Pennsylvania landfill results show that there is nothing unusual about the radioactivity levels in Tennessee landfills. Radioactivity is everywhere in nature. We have radioactive potassium 40 in our bodies that gives us 10 to 25 mrem a year of internal dose. The BSFR materials are disposed of at concentrations that limit dose to 1 mrem/year from both external and internal sources.

Even though higher radioactivity levels and more radionuclides like Co-60, Cs-137, Eu-154, etc. were found in the Pennsylvania landfills, the evaluations made by the Pennsylvania officials led

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them to conclude that they did not pose a public health risk. This is also true for the low levels of radioactive material detected in the Tennessee landfills.

Landfills are designed to retain the leachate to ensure surrounding groundwater is not contaminated. They are equipped with monitoring wells where local groundwater is routinely sampled and tested to ensure the liners are not leaking and the groundwater is not being contaminated. If landfills can safely contain the low levels of radioactivity found in every day waste, and BSFR nuclides are not even detected in the water (leachate) from within the landfill, is it wise to react by stopping BSFR disposal at Tennessee landfills? Just because we do not sense or realize the radioactivity and radiation we are exposed to in our every day lives, it does not mean it is a problem.

Radioactive materials are used to X-ray welds on oil pipe lines to prevent oil leaks, to diagnose and treat cancer, heart disease, and other medical disorders. They are used to study genetics and to develop cures and better medicines in pharmaceutical research and for many, many other purposes that are essential for our health and well being and for protecting the environment in the modern world. When we fill up the available radioactive waste disposal facilities with BSFR material, we make it ever more difficult and costly to derive the many benefits we gain from responsible use of radioactive materials.

Radioactivity was discovered in 1898 and the effects have been studied for well over a half century. The levels established as safe for sewage disposal are based upon decades of study and research and the recommendation of international bodies dedicated for formulating safe practices for exposure to these materials. These are not newly developed materials with limited data on the effects of exposure to them or their impact on the environment. Many colleges and universities, including the University of Tennessee, offer degrees in Health Physics, the branch of science dedicated to studying radioactivity, radiation and the effects on man and nature.

The Tennessee leachate results show that BSFR materials have not significantly elevated the levels of radioactivity in Tennessee landfills and that Tennessee is applying common sense and practical science to manage this process. The BSFR program us a process that should serve as a model to other states for disposal of such materials to ensure our nations low level radioactive waste disposal resources are managed wisely.

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Waste Management Harrisburg, Pennsylvania
Project No. 040-195 October 3, 2005