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Cost Evaluation of Alternative Radioisotope Disposal Methods at the Livermore Site

C. M. Trevino

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By: Carina Trevino

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Background

Lawrence Livermore National Laboratory (LLNL) permits the discharge of radioisotopes to sewer within mandated limits set by DOE Order 458.1 and Derived Concentration Technical Standard (DOE-STD-1196-2022). Wastewater undergoes sampling and need-based pH adjustment to dispose of properly through sanitary sewer. Sample analysis is done on and off site to address and treat discharges. Sampling on site incurs little to no costs as budgetary planning accounts for sampling frequency. Sampling off-site varies in price depending on turnaround time, analyte testing and lab preference.

Question Statement

How much cost savings or increases could Lawrence Livermore National Laboratory incur if radioisotope were no longer permitted in the sewer?

Things to Consider

1. How much is the lab spending on current sampling and discharging methods?

2. What are estimates and assumptions?

3. How much money would be saved if the lab only required sampling at the Sewer Monitoring Complex for Gross Alpha, Gross Beta and Tritium twice annually?

4. How much money would be saved if the lab only required sampling and disposal of Livermore Site wastewater retention tanks for Gross Alpha, Gross Beta, Tritium, and rad-screens twice annually?

5. Alternative methods for radioisotope management are:

    a. Shipping treated and untreated discharge batches to third party for disposal.

    b. Solidifying waste for landfill disposal

6. What are the estimated costs for alternative methods of radioisotope management?

7. Focus on nine Livermore Site buildings with radioisotope results in retention tank samples from 2023 WDAR data.

8. LLNL sewer bill is calculated by flow rate on a monthly basis. How much would be saved if the alternative methods were deducted from the total flow amount?

Assumptions

Livermore Site contains buildings which produce wastewater with radioisotopes in low volume and concentration. Some buildings are not connected to a retention tank even though they may have rad results. A total of 82 buildings produces over 1 nano curie of rad each. The following buildings with active retention tanks are listed as follows**,** 132S, 132N, 151, 153, 191, 212, 231 235, 251, 298, 322, 327, 332, 341, 364, 365 (collects for 368 as well), 412, 435, 492, 581, 612, 663, 681, 695, and 696. Buildings with inactive tanks such as 194, 231, 253, 490, 491, and 514 are typically non-lab spaces. Due to the small quantity of wastewater produced, high costs are not anticipated from the small wastewater batches and thus are not factored into this cost evaluation.

Sampling analysis is done on and off site. The in-house laboratories which manage the sampling suites are the Environmental Monitoring Radioanalytical Laboratory (EMRL) and the Radiation Monitoring Laboratory (RML). The initial project direction was to compare current lab costs of radioisotope management and disposal to alternatives methods. It was found that the in-house laboratories operate as in-line budget items, totaling $0. The estimated pricing of $0 stems from an overhead account, regardless of the sampling analysis workload the costs are factored in and therefore negligible in this cost evaluation.

Project assumptions for this cost evaluation are based off given information from actual estimates and their calculations. We assume the cost will have no significant change with or without the rad results from the 26 buildings without a retention tank. We also assume the EMRL and RML costs will not significantly affect the estimated costs as the sampling is already factored into laboratory expenses. The initial project direction was to compare lab costs from current radioisotope sampling and disposal to alternative methods if radioisotopes were no longer permitted to sanitary sewer. Due to the sampling analysis being an in-line budget item, comparison of alternative methods, shipping treated and untreated discharge batches to third party for disposal and solidifying waste for landfill disposal will be looked at. The overall goal is to reinforce how costs effective current practices are.

Prices revolved around transportation, solidification, and disposal. Treatment costs were looked at through on and off-site facilities. Discharged wastewater is sampled on site by the Environmental Monitoring Radioanalytical Laboratory (EMRL) or the Radiation Monitoring Laboratory (RML) and off site by GEL Laboratories. Costs associated with EMRL and RML are in-line budget items estimated at $0 under laboratory expenses. The initial direction for understanding outside cost estimates was to compare with current internal costs. With the estimated price at $0, the hypothetical situation looks at alternatives and reinforces why current lab practices should be maintained.

Data from nine buildings were paired with estimated prices to calculate differences between current radioisotope disposal methods and the three proposed alternative method costs. Buildings were chosen by radioisotope detection levels, although more than the nine buildings in focus have had radioisotope detected across the Livermore Site. Omitted buildings had over 1 nanocurie of radioisotopes detected but posed little to no risk to sanitary sewer. The nine buildings used for the cost evaluation were determined to pose a risk to sewer with radioisotopes detection. Radioisotopes that are generated in small amounts, containerized rather than collected in retention tanks, were not factored into cost estimations.

Livermore Site Building Map

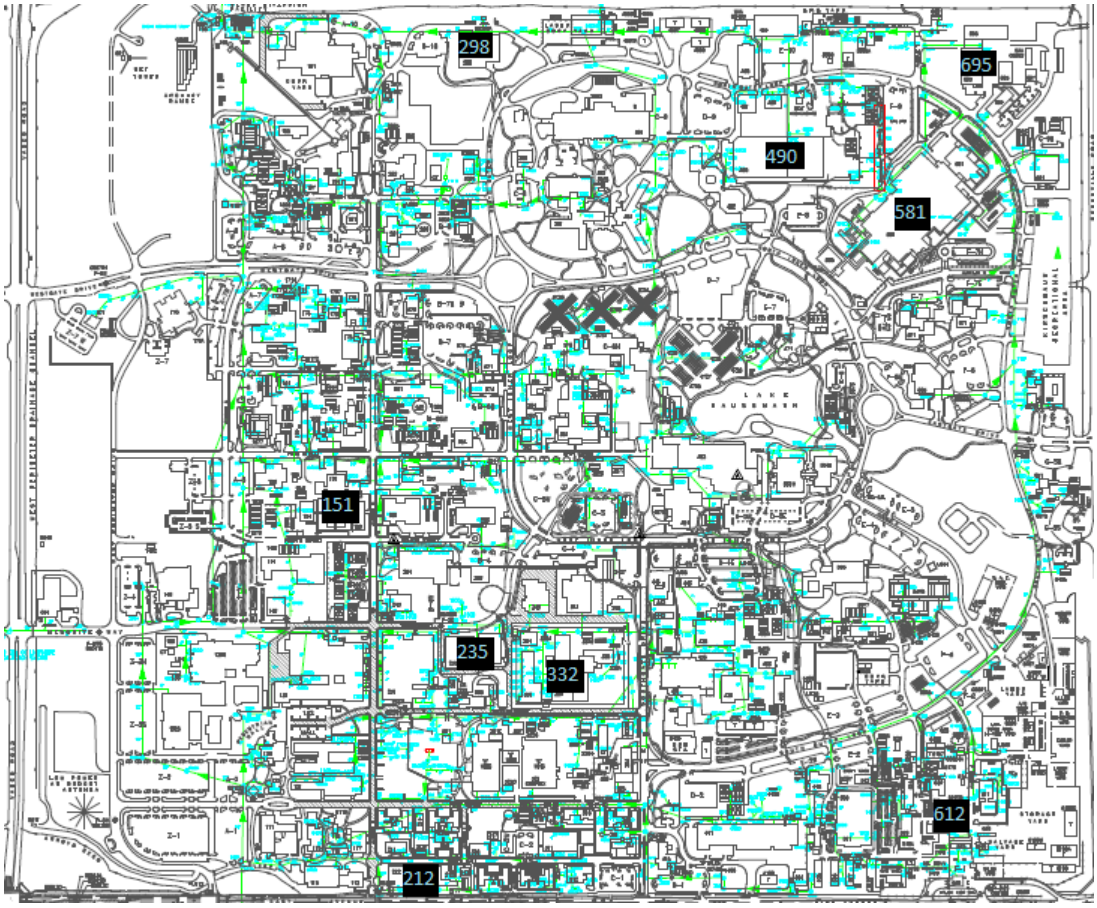

Figure 1. Livermore Site Building Map of the nine buildings being used to conduct the cost evaluation of alternative radioisotope disposal methods.

Methodology

A Waste Discharge Authorization Report (WDAR) data pull from 2023 focused on Livermore Site building radioisotope results from retention tank sampling. The data set was organized by buildings with gross alpha, gross beta and tritium concentrations. Each GABT finding was cross referenced with the associated WDAR number to collect retention tank capacity and number of discharges.

Table 1. Livermore Site Retention Tank Radioisotope Findings

BLDG	**[1]Rad Batches**	**Retention Tank**	**RT Capacity (L)**	**[2]Total Tank Discharge (L)**
151	2	R1A1 R1A2 R1A3 R1A4	11,355	22,710
212	4	R1A1 R1A2	3,785	15,140
235	5	R101 north R102 south	14,005	70,025
298	3	R1A2 R1A3	3,785	11,355
332	1	R1U1 north R1U1 south	3,785	3,785
490	1	R1U2 mid R1U1 north	3,785	3,785
581	2	R1U1 R1U2	3,785	7,570
612	1	R2U1-612A	22,710	22,710
695	2	R1A1/THL111 R1A2/THL112 R1A3/THL113 R1A4/THL114 R1A5/THL115 RR1A6/THL116	18925 (mixed)	[3] 28197
[1] Rad Batches showcases the number of rad detections from 2023 sampling data				
[2]Total Tank Discharge is calculated by multiplying tank capacity by number of rad batches				
[3]BLDG 695 discharge capacity does not follow the capacity multiplied by number of samples due to tank specifications, value is the sum of discharge found in WDAR reports 8636 and 8679				

Cost estimates were based on three alternative methods proposed if radioisotopes were no longer permitted for discharge in the sanitary sewer. Estimates were given by Chad Davis, a RHWM Technician. Below were the prompted questions and responses received:

1. How much would it cost to ship treated and untreated discharge?
    a. *Transportation costs will be around $15,000 for each 5,000-gallon tanker truck.*
2. How much would it cost to solidify the discharge batches?
    a. *To solidify and dispose of aqueous low-level waste would be $10 per gallon. If waste was RCRA or California regulated for metals the price would be $135 per cubic foot. If it contained RCRA or California regulated organics the price jumps to $10,450 per 55-gallon drum!*
3. How much would it cost to send treated discharge batches to landfill?
    a. *Prices in #2 include disposal.*

Utilization of Alternative Method 1

Alternative Method 1 is the shipment of treated discharge batches to a third party for disposal. Consideration of these methods includes the costs of treatment on and offsite, and costs of transportation (shipping). Partnership with a third-party waste management company would have to be negotiated for lab needs. Discharge batches with radioisotopes would vary greatly by volume and concentration throughout the year. Utilizing 2023 wastewater data, retention tanks by building with rad detection were evaluated to model estimated annual needs with alternative method 1. Nine buildings from Livermore Site populated with rad detection above the minimum detectable concentration (MDC). The total tank discharge was calculated by multiplying tank capacity by the number of times radioisotopes were detected in the samples. Once a retention tank's capacity is met, sampling takes place to ensure constituent concentrations meet sewer limits as is and or after treatment. Estimated treatment on site is already considered as an in-budget line item therefore no additional fees are calculated. Third party treatment varies by party and treatment required. Estimated shipping costs reflect costs for treated discharge batches following typical industry prices. Transportation costs are estimated at $15,000 for each 5,000-gallon tanker truck. Estimated costs total resulted in $146, 835.02 for alternative method 1.

Table 2. Costs Estimates for Shipping Wastewater

BLDG	**[1]Total Tank Discharge (L)**	**Total Tank Discharge (Gal)**	**Estimated Shipping Costs**
151	22,710	5999.34731	$ 17,998.04
212	15,140	3999.56487	$ 11,998.69
235	70,025	18498.648	$ 55,495.94
298	11,355	2999.67365	$ 8,999.02
332	3,785	999.891218	$ 2,999.67
490	3,785	999.891218	$ 2,999.67
581	7,570	1999.78244	$ 5,999.35
612	22,710	5999.34731	$ 17,998.04
695	28,197	7448.85936	$ 22,346.58
Total Costs			$ 146,835.02
[1]Total Tank Discharge refers to Table 1 calculations, values come from multiplying number of discharges with tank capacity			

Utilization of Alternative Method 1.a

Alternative Method 1.a is the shipment of untreated discharge batches to a third party for disposal. Very similar to Method 1, except the batches would not undergo treatment of any kind. The only step included would be shipping. Costs remain the same for treated and untreated estimates as treatment costs would vary among third parties, while shipment remains at an industry standard for estimation purposes.

Building 695, dealing with Radioactive Hazardous Waste Management (RHWM), processes wastewater of various blends including low level and mixed waste. During fiscal year (FY) 2023, there were only two processed blends with radioisotopes detected passed the MDC. These blends were 695-23-09 and 695-23-22. 695-23-22 was managed through RHWM while 695-23-09 was discharged to sewer. If applied, the calculated untreated batches were estimated at $192 while the calculated treated batches were estimated at $110,893.64.

Table 3. Cost Estimates for Shipping Processed Blend Wastewater

	Untreated	**Treated**
Plan Blends	Processing Plan 695-23-09	Processing Plan 695-23-09
Waste Types	LOW-LEVEL (R)	LOW-LEVEL (R)
Calculated Waste Quantity in Pounds	534.1	-
Liters	-	9765
Gallons	64.00	36964.54
Estimated Shipping Costs	$ 192.00	$ 110,893.64

Utilization of Alternative Method 2

Alternative Method 2 is the solidification of waste for landfill disposal. Any waste disposed of in a landfill must be solidified as per landfill requirements. Solidification was included in disposal costs. Method 2 does not involve any treatment after collection of wastewaters. Estimates factor in $10 per gallon for aqueous low-level waste and the $15,000 for each gallon tanker truck. The total estimated costs were calculated at $489,450.05.

Table 4. Estimated Costs for Solidification and Disposal of Wastewater

BLDG	**Total Tank Discharge (L)**	**Total Tank Discharge (Gal)**	**Estimated Solidification and Disposal Costs**
151	22710	5999.34	$ 59,993.47
212	15140	3999.56	$ 39,995.65
235	70025	18498.64	$ 184,986.48
298	11355	2999.67	$ 29,996.74
332	3785	999.89	$ 9,998.91
490	3785	999.89	$ 9,998.91
581	7570	1999.78	$ 19,997.82
612	22710	5999.34	$ 59,993.47
695	28197	7448.85	$ 74,488.59
Total Costs			**$ 489,450.05**

Costs Comparison of Alternative Methods

Methods 1, 1a and 2 approach disposing radioisotopes differently than current lab practices to determine possible costs. Cost estimates were separated by method and building as shown in Figure 1. Method 1 and 1a, shipping treated and untreated waste, was found to be the most cost effective of the alternatives proposed overall and by building. The solidification and disposal method were the most expensive to follow in comparison.

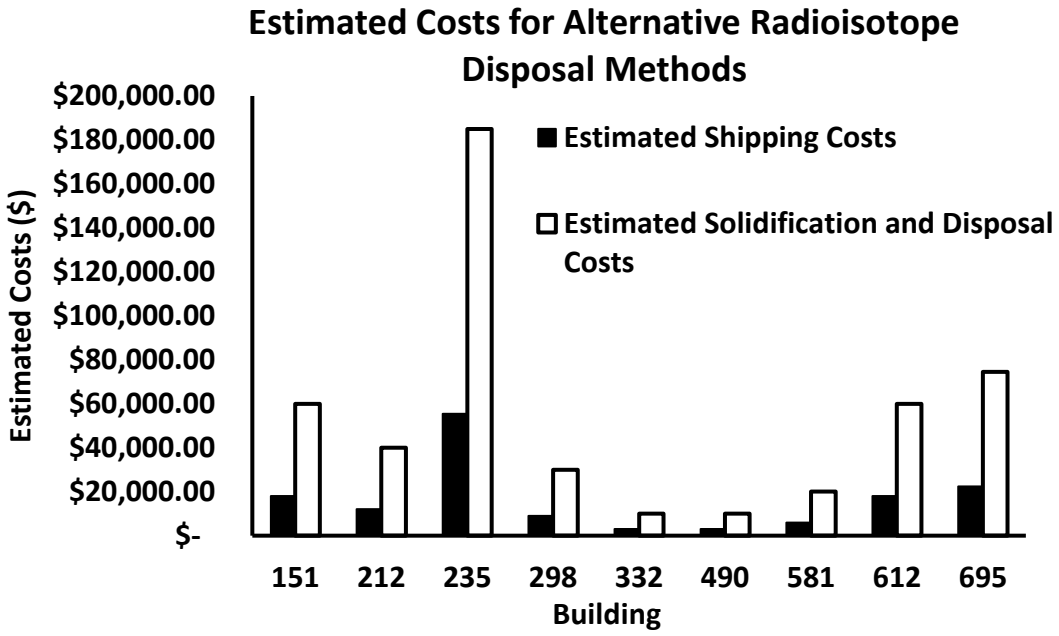

Figure 2. Estimated costs for alternative radioisotope disposal methods. Estimates were separated by two categories, shipping and solidifcation and disposal costs, to evaluate possible discharging needs. Transportation costs were significantly lower than solidifcation and disposal costs for each of the nine buildings.

Each method's estimated cost total does coincide with the amount of discharge by building. In figure 3, total tank discharge is measured aligning with figure 2 estimates. Building 235 has the highest peak for Method 1 and Method 2 although a clear difference in possible pricing can be seen. Factoring in discharge volume, Method 1 still proves to be most cost effective as the same calculations were done by building.

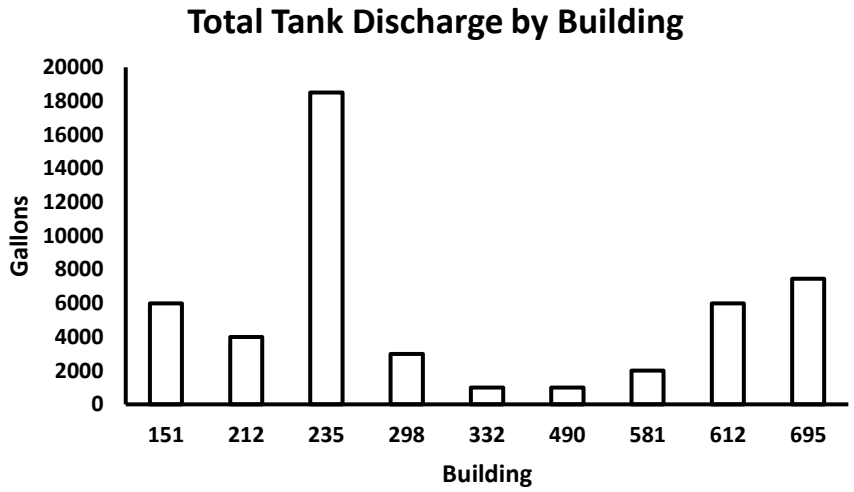

Figure 3. Total tank discharge by building in gallons. Nine Livermore Site buildings were looked at to help provide costs estimates from tank capacity and dicharge based on the number of rad batches found in table 1.

The overall total for the proposed alternative methods is represented below and detailed in table 5. A grand total of $636,285.08 is estimated to cover the combined alternative methods proposed. Method 1 and 1a, shipping amounted to $146,835.00 and solidification and disposal amounted to $489,450.04. Changing current lab practices of radioisotope sample and disposal methods would amount to a significant increase in lab spending.

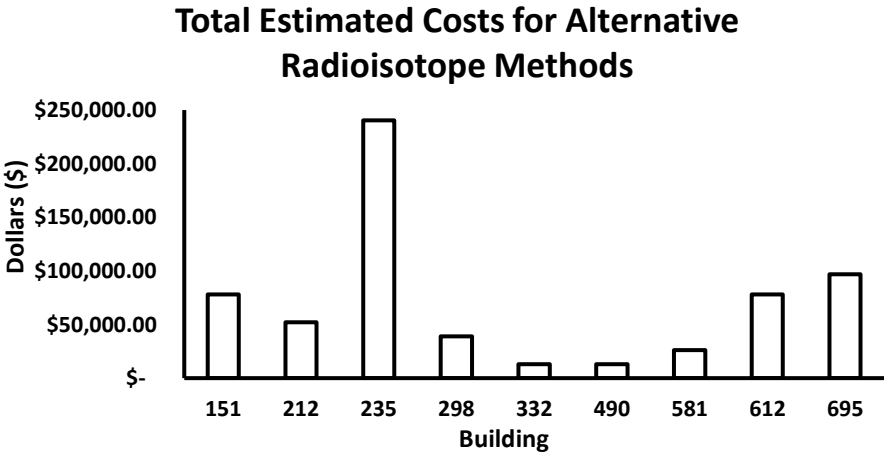

Figure 4. Total cost estimates for alternative radioisotope methods among the nine Livermore Site buildings. Total estimates costs include transportation, solidifcation and disposal.

Table 5. Total Estimated Costs for Each Method by Building

BLDG	Estimated Shipping Costs	Estimated Solidification and Disposal Costs	Total Costs
151	$ 17,998.04	$ 59,993.47	$ 77,991.52
212	$ 11,998.69	$ 39,995.65	$ 51,994.34
235	$ 55,495.94	$ 184,986.48	$ 240,482.42
298	$ 8,999.02	$ 29,996.74	$ 38,995.76
332	$ 2,999.67	$ 9,998.91	$ 12,998.59
490	$ 2,999.67	$ 9,998.91	$ 12,998.59
581	$ 5,999.35	$ 19,997.82	$ 25,997.17
612	$ 17,998.04	$ 59,993.47	$ 77,991.52
695	$ 22,346.58	$ 74,488.59	$ 96,835.17
Total Costs	$146,835.00	$489,450.04	$636,285.08
Total Costs include shipping, solidification and disposal costs as seen in previous figures.			

Conclusion

The purpose of this cost evaluation was to investigate a hypothetical in which radioisotopes were no longer permitted in the City of Livermore sanitary sewer. Three alternative methods were proposed to determine estimated costs and compare current practice costs to the latter. An assumption from the initial steps of the analysis was significant cost savings would be found with the alternative methods.

Referring back to "Things to Consider",

Question 1. How much is the lab spending on current sampling and discharging methods?

a. Negligible due to on-site practices set as in-line budget items.

Question 2. What are estimates and assumptions?

b. Refer to Figures 2-4 for cost estimates and assumptions section for more detail.

Question 3. How much money would be saved if the lab only required sampling at the Sewer Monitoring Complex for Gross Alpha, Gross Beta and Tritium twice annually?

c. The estimated annual costs for GABT sampling at the SMC would be $889.80. If only sampled twice annually, a total of $741.50.

Table 6. GEL Laboratory Estimated Costs for Analysis E906

BP_Matrix	Requested Analysis	Requested Details	Lab code	Selected TAT	Quantity	Subtotal	Estimated Annual Costs
AQ	E906	ALL	GE	20d	1	$74.15	$ 889.80
Subsequent testing is done by EMRL and RML within LLNL and therefore are in line budget items equal $0 in terms of lab finances							

Question 4. How much money would be saved if the lab only required sampling and disposal of Livermore Site wastewater retention tanks for Gross Alpha, Gross Beta, Tritium, and rad screens twice annually?

d. No cost savings would occur due to the alternative radioisotope methods surpassing current practice costs.

Question 6. What are the estimated costs for alternative methods of radioisotope management?

e. Method 1 and 1a, shipping amounted to $146,835.00 and solidification and disposal amounted to $489,450.04.

8. LLNL sewer bill is calculated by flow rate on a monthly basis. How much would be saved if the alternative methods were deducted from the total flow amount?

f. Considering the monthly loading charges from January 2024, we can take a look at the estimated billing amount the nine buildings from Livermore Site contribute to. Table 7 highlights the overall building discharge that would be sent to sanitary sewer. If utilizing the alternative radioisotope disposal methods, monthly flow would decrease as well as the flow charge. For this example, a look at January's 2024 sewer bill shows the current month flow charge amounting to $8,829.20. Monthly flow volume (in million gallons) is multiplied by the monthly flow loading charge billing factor of $1,014.85.

Table 7. 2023 Total Building Discharge

BLDG	**[2]Total Tank Discharge (L)**
151	22,710
212	15,140
235	70,025
298	11,355
332	3,785
490	3,785
581	7,570
612	22,710
695	[3] 28197
Total Building Discharge	185,277

Total building discharge accounts for the annual discharge sum of the nine buildings in focus. Estimating an annual cost saving evaluation, the sum discharge for the nine buildings was calculated at 185, 277 liters. Monthly flow volume used to determine the monthly flow loading charge is based off a million gallons. Converting liter to gallons and dividing the value by a million results in 0.048945 million gallons. We can use this value to multiply by the billing factor of $1.014.85 to find $49.67 as the monthly cost savings. Annual cost savings would be estimated at a total of $596.06.

A major influence on the project was RHWM, EMRL and RML cost estimates. Data received from was EMRL and RML is not presented as significant because estimated costs are in line budget items, calculated at $0. Due to this finding, project analysis could continue but direction shifted from cost savings to reinforcing current practices as most conducive for lab finances. Each method 1, 1a and 2 incurred additional costs. The $596.06 in savings would be outnumbered by each of the alternative methods. LLNL's radioisotope disposal to sanitary sewer is allowed through DOE Order 458.1 and Derived Concentration Technical Standard (DOE-STD-1196-2022). As the results stand, cost efficiency and rad levels should stay maintained by continuing with current radioisotope handling and disposal methods.

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