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Approval Designator (F)	Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information	4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment	4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
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		Design Authority	See block 20 for signature			1	1	KJ Lueck	KJ Lueck	6/5/01	S6-72
		Design Agent				1	1	DK Smith	DK Smith	6/6/01	S6-71
1	1	Cog. Eng. DE Scully (T)	DE Scully	6/5/01	S6-72						
1	1	Cog. Mgr. NJ Sullivan	NJ Sullivan	6/6/01	S6-72						
		QA									
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KJ Lueck (signature) 6/6/01 KJ Lueck Signature of EDT Originator / Date	Authorized Representative for Receiving Organization / Date	NJ Sullivan (signature) 6-6-01 NJ Sullivan Design Authority/ Cognizant Manager / Date	Ctrl No. ______ ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments

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R Pillai	ETC-1/N224	H4-04	X			

HNF-8306
Revision 0

Waste Treatment Plant Liquid Effluent Treatability Evaluation

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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Richland, Washington

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Waste Treatment Plant Liquid Effluent Treatability Evaluation

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Fluor Hanford, Inc.

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Waste Treatment Plant Liquid *Effluent* Treatability Evaluation

Bechtel National, Inc. (BNI) provided a forecast of the radioactive, dangerous liquid effluents expected to be generated by the Waste Treatment Plant (WTP). The forecast represents the liquid effluents generated from the processing of 25 distinct batches of tank waste through the WTP. The WTP liquid effluents will be stored, treated, and disposed of in the Liquid Effluent Retention Facility (LERF) and the Effluent Treatment Facility (ETF). Fluor Hanford, Inc. (FH) evaluated the treatability of the WTP liquid effluents in the LERFIETF. The evaluation was conducted by comparing the forecast to the LERFIETF treatability envelope, which provides information on the items that determine if a liquid effluent is acceptable for receipt and treatment at the LERFIETF. The WTP liquid effluent forecast is outside the current LERFIETF treatability envelope. There are several concerns that must be addressed before the WTP liquid effluents can be accepted at the LERFIETF.

Key Words: Waste Treatment Plant, Forecast, Treatability Evaluation, Liquid Effluents, Effluent Treatment Facility

EXECUTIVE SUMMARY

Bechtel National, Inc. (BNI) provided a forecast (BNI 2001) of the radioactive, dangerous liquid effluents expected to be generated by the Waste Treatment Plant (WTP). The forecast represents the liquid effluents generated from the processing of 25 distinct batches of tank waste through the WTP. The WTP liquid effluents will be stored, treated, and disposed of in the Liquid Effluent Retention Facility (LERF) and the Effluent Treatment Facility (ETF). Fluor Hanford, Inc. (FH) evaluated the treatability of the WTP liquid effluents in the LERFIETF. The evaluation was conducted by comparing the forecast to the LERFIETF treatability envelope (Aromi 1997), which provides information on the items that determine if a liquid effluent is acceptable for receipt and treatment at the LERFIETF.

The WTP liquid effluent forecast is outside the current LERF/ETF treatability envelope. There are several concerns that must be addressed before the WTP liquid effluents can be accepted at the LERF/ETF. The concerns are:

- The total dissolved solids in the WTP liquid effluents will exceed the present ETF dryer capacity by an average of 2.5 times and as much as 6 times.
- The evaluation indicates that there will be particulate calcium carbonate in the WTP liquid effluents. The LERF cannot receive liquid effluents with solids that may settle and require an extensive cleanout effort
- No organics were identified in the WTP liquid effluents. This part of the evaluation could not be completed.
- The amount of Iodine-I29 in the WTP liquid effluents is probably in error as it is similar to the total amount estimated to be in the tank waste. Off-gassing during treatment in the ETF and disposal of the solid secondary waste powder are potential concerns.
- The radionuclide content of the WTP liquid effluents exceeds the source term limits for LERF to be a radiological facility.
- The maximum allowable batch volumes that can be accepted into the ETF for treatment is severely restricted by the radionuclide content of the WTP liquid effluents.
- The solid secondary waste powder produced by the ETF in treating the WTP liquid effluents may require further treatment to limit the mobility of Technetium-99.

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WASTE TREATMENT PLANT
LIQUID EFFLUENT TREATABILITY EVALUATION

1.0 INTRODUCTION

Bechtel National, Inc. (BNI) provided a forecast (BNI 2001) of the radioactive, dangerous liquid effluents expected to be produced by the Waste Treatment Plant (WTP). The forecast represents the liquid effluents generated from the processing of 25 distinct batches of tank waste through the WTP. The WTP liquid effluents will be stored, treated, and disposed of in the Liquid Effluent Retention Facility (LERF) and the Effluent Treatment Facility (ETF). Both facilities are located in the 200 East Area and are operated by Fluor Hanford, Inc. (FH) for the U.S. Department of Energy (DOE). The treatability of the WTP liquid effluents in the LERF/ETF was evaluated. The evaluation was conducted by comparing the forecast to the LERF/ETF treatability envelope (Aromi 1997), which provides information on the items that determine if a liquid effluent is acceptable for receipt and treatment at the LERF/ETF. The format of the evaluation corresponds directly to the outline of the treatability envelope document. Except where noted, the forecast for the individual batches of tank waste have the same treatability concerns. Background information on the LERF/ETF design basis is provided in the treatability envelope document.

2.0 WASTE ACCEPTANCE PROCESS

The process for acceptance of a waste into the LERF and ETF systems involves a series of steps. The acceptance process is designed to take full advantage of the flexibility and robust nature of the LERF and ETF systems. The LERF and ETF aqueous waste acceptance process involves the following three steps: (1) assemble waste information and screen for completeness; (2) compare waste to regulatory envelope; (3) compare waste to design envelope.

3.0 ADDITIONAL INFORMATION REQUIRED

Below is a preliminary list of additional information that is required to provide a complete treatability evaluation.

- Identification of specific organics – This is required to complete the regulatory evaluation for air and water discharges, and the design review for operation of the UV/OX system.

- Regulatory designation of waste – this is required to complete the regulatory evaluation for permit compliance.

4.0 REGULATORY ENVELOPE

The operation of the LERF and ETF is regulated under permits and approvals issued by the Washington State Department of Ecology (Ecology), Washington State Department of Health (WDOH). and the U.S. Environmental Protection Agency (EPA). The operation of the LERF and ETF is also authorized by the Department of Energy (DOE) and is therefore subject to the requirements contained in DOE Orders/Federal Regulations. This section evaluates the WTP forecast against the LERF and ETF environmental regulations/permits and safety documentation as discussed in the LERF/ETF treatability envelope document.

4.1 NEPA/SEPA

The regulations require that all modifications associated with a given project be addressed in a single environmental document (e.g., Environmental Assessment, Environmental Impact Statement). It is the assumption that the environmental document to be prepared by the WTP Project will address all changes to the LERF and ETF associated with WTP aqueous effluent discharges and will be in place prior to discharging any effluents to LERF or ETF.

4.2 Dangerous Waste Permit

The LERF and ETF facilities are permitted under the Washington Administrative Code (WAC) 173-303. The LERF and ETF are included in the Hanford Site dangerous waste permit for treatment, storage, and disposal of dangerous wastes. This permit allows for the acceptance of a variety of new feeds per the waste acceptance process. The LERFlETF is permitted to receive wastes with the F039 waste code derived from F001-F005 wastes. In the letter (Morton 2000) the F039 code was listed as a code that would apply to the WTP effluent but that the Double-Shell Tanks system has not received any F039 waste to date. In addition, the WTP Request for Proposal (Sol. No. DE-RP27-00RV14136) identifies the Double-Shell Tanks system to only be designated for multi source leachate (F039) derived from F001–F005. The LWPF has submitted a delisting modification that will expand the F039 envelope to include all wastes listed under F039. Therefore, so if the DST system were to receive F039 other than that derived from F001–F005, LWPF has already submitted a request for the necessary modification to the current LERFlETF delisting exclusion that should include any additional constituents under F039 that WTP would require.

4.3 State Waste Discharge Permit

Treated effluent from the ETF is discharged to a State Approved Land Disposal Site (SALDS) under State Waste Discharge Permit ST4500 (Discharge Permit). The permit allows the LERF/ETF to accept generator effluents containing approved constituents at approved concentrations. Of the constituents identified in the forecast, fluoride, manganese, sodium, nickel, and zinc are above the concentration in the Discharge Permit application (and subsequent permit modifications). At a minimum, a characterization study for these constituents, identifying them, as new constituents of concern will need to be submitted to Ecology for approval. Based on the concentrations, obtaining Ecology's approval should not be a problem. However, additional characterization studies may be required once BNI has identified the individual organic species. Because the individual organic analytes have not been identified, this evaluation cannot be completed.

4.4 LERF Radiological Inventory Management

Table E-1 of the LERFlETF treatability document summarizes the dose consequences of postulated releases from those radionuclides and levels as documented in the current hazard classification for the LERF. For the WTP forecast, all the batches exceed the LERF bounding source term for Iodine-129 and Technetium-99. A majority of the batches exceed the source term for Neptunium-237 and Tritium. Only a few of the batches exceed the source term for Carbon-14, Curium-244, and Cobalt-60. Batch LAW-2b was the only batch that exceeds the source term for Cesium-137.

If the LERF source term is exceeded, then a second screening is accomplished by comparing the WTP forecast to the maximum allowable dose from pool evaporation and spray release accident scenarios of 12.64 rem and 7.0 rem, respectively. Of the 25 batches, only batch LAW-10 did not exceed the maximum doses and therefore is acceptable into the LERF. Of the other 24 batches, the calculated evaporation pool doses ranged from 3.62 to 23.8 rem and for a spray release the doses ranged from 9.66 to 63.8 rem. The LERF could be recategorized as a nuclear facility; however, the cost associated with recategorizing the facility would need to be addressed in a future engineering study and is out of the scope of this treatability evaluation.

4.5 ETF Radionuclide Inventory Management

Radioactive inventory control at ETF is accomplished by characterizing feed streams for radionuclide inventory and calculating a maximum allowable feed batch volume that can be present at ETF. Based on the forecast, the allowable batch volume ranges from 13,000 to 68.900 gallons. This would mean that the ETF could only operate from 11 to 57 hours, then remove all WTP inventory from the facility before WTP feed from the LERF could be transferred into the ETF again. Processing in this manner is unrealistic. The concentration of 1-129 appears to be the limiting radionuclide that is causing the very low batch volumes.

The method used to calculate the ETF maximum allowable feed batch volume is conservative. The hazard categorization can be modified using less conservatism that would raise the radionuclide inventory allowed in the facility. The facility could also be categorized as a nuclear facility; however, the cost associated with recategorizing the facility would need to be addressed in a future engineering study and is out of the scope of this treatability evaluation.

4.6 Radioactive Air Emissions

The LERF and ETF radioactive air emissions are regulated under Title 40 CFR Part 61 and WAC 246-247. The facilities are permitted for radioactive airborne emissions through the EPA and WDOH approvals of Notice of Constructions (NOCs) having a specified source term (radionuclide quantity) used to determine the "potential-to-emit." The approved source term for the radioactive air emissions is the same as that for the LERF hazard category determination; therefore, the WTP forecast is outside the LERFlETF permissible radioactive air emissions.

4.7 Nonradioactive Air Emissions

Nonradioactive air emissions from the LERF and ETF are regulated under WAC 173-400 and 173-460 and are permitted by Ecology approval of a NOC. The approval order allows the ETF to treat waste streams containing toxic air pollutants and identifies specific pollutants that are approved for treatment. The evaluation of the nonradioactive air emissions against the NOC cannot be completed until specific organics are identified.

5.0 DESIGN ENVELOPE

The ETF consists of a series of process units that are configured to provide treatment for contaminants that might be present in aqueous wastes generated on the Hanford Site. The main treatment train includes those process units that destroy or remove dangerous and radioactive constituents from the aqueous waste. The unit operations of the main treatment train include pH adjustment, filtration. ultraviolet light mediated peroxide oxidation (UV/OX), degasification, reverse osmosis (RO), and mixed-bed ion exchange. Those constituents rejected from the main treatment train are concentrated and dried into a powder in the secondary treatment train via an evaporator and thin film dryer.

The WTP will process 25 distinct batches of waste from the Tank Farms, designated LAW-1 through LAW-24. For each of these batches, BNI has computed the composition, volume, and mass rate of the waste stream to the ETF. The spreadsheet provided in Appendix A, gives the data used in completing this treatability evaluation. The following sections provide a discussion of the different operating conditions that would require resolution during the development of a new ETF flowsheet.

5.1 Suspended Solids

All feeds are required to be filtered through a 5-micron (nominal) filter before receipt in the LERF or at ETF. Additional filtration could be required if a significant amount of suspended solids remain after the 5-micron filtration. The BNI effluent forecast indicates no TSS. However, computation of the product of calcium and carbonate molarities yield values that range from **4** to **2586** times the solubility product constant (Ksp) for calcium carbonate at **25°C**.

5.2 Organics

Organic destruction rates for the ETF UV/OX unit have been established through actual operating experience and pilot plant testing. A detailed evaluation against the organic acceptance criteria cannot be completed because specific organic analytes have not been identified in the forecast. Without specific organic analytes, UV/OX performance cannot be fully determined. However, the UV/OX system, in its current configuration, is designed to treat up to 110 parts per million of total organic carbon compared to the WTP forecasts that have total organic carbon concentrations of 14 to 700 ppm with a weighted average of **223** ppm. If it is assumed that most of the organics are volatile, they will be flashed in the evaporator and dryer and then redissolved in the distillates that return to the MTT for processing. The WTP forecast is considered outside of the design envelope and the current Discharge Permit limits of 1 1 parts per million may not be achieved.

Not considered in the discussion above is the removal of organics by the RO units. The RO unit has demonstrated removal of organics and that greater removal efficiencies are achieved with higher molecular weight organics. The nonvolatile organics rejected in the RO units are converted to powder after processing through the evaporator and thin film dryer. However, a percentage of the volatile and semi-volatile organics rejected from the RO units are recycled back to the main treatment train from the evaporator and dryer distillates. This may result in a buildup of organics in the system and breakthrough or damage of the RO units.

During the development of a new flowsheet, accommodation of higher organic levels than the current flowsheets would be evaluated, however, the specific organics and levels need to be identified.

5.3 Dissolved Solids

The concentration and nature of dissolved solids in a waste stream have a significant impact upon the LERF and ETF systems. The primary areas of concern include scaling of unit operations, compatibility with materials of construction, and ability to produce a dry powder waste.

Scaling – To avoid scaling of the RO membrane surface, the operation of the unit is controlled so solubility limits are not exceeded. The existing brackish water membranes used in the RO units at the ETF have an upper feed limit of **0.5** weight percent dissolved solids. Based on the forecast, the total solids range from 1.99 to **2.85** weight percent. In general, effluents with greater that **8** percent total dissolved solids cannot be separated by RO technology. However, processing the feed through the secondary treatment train first, with the resulting distillate then processed through the main treatment train would resolve this issue.

Processina pH Ranne – High chloride and fluoride levels are a concern for the ETF materials of construction, particularly in the secondary treatment train where the feed would be concentrated in the evaporator. An aqueous waste with chloride/fluoride levels greater that 10,000 parts per million is detrimental to the secondary treatment train equipment under acidic conditions. However, when choosing the correct pH conditions, the evolution of off-gas is a consideration for safety and regulatory concerns.

The waste stream total dissolved solids will be increased to a target of **25** weight percent in the evaporator. This selection is based on operating experience with both **242-A** evaporator process condensate and UP-1 groundwater. At this concentration the ammonia content will range from **2,748** to

58,298 parts per million (ppm). At these high levels of ammonia, acidic conditions are preferred at ETF to suppress the evolution of ammonia while promoting the venting of CO_2 into the offgas. When the pH of the WTP feed is lowered to 6.0 in the SWRT tanks carbonate will be converted to CO_2 and effervesce into the tank vessel vent system. Any residual dissolved CO_2 will be evolved in the evaporator as the brine is boiled. The calculated gas evolution rate ranges from 3.10 to 19.89 cubic feet per minute (cfm). However, this becomes more complex because of the undesirable off-gassing of Iodine-129 at acidic condition. Lowering the pH below a target of 6.0 is undesirable due to potential corrosion in the piping/vessels.

The chloride/fluoride levels in the WTP forecast ranges from 45 to 260 ppm in the evaporator. These concentrations are very similar to those experienced at the ETF running 242-A Evaporator process condensate at a feed pH of 6.0. In the SWRTs, the chloride/fluoride will range from 4 to 28 ppm. This also appears to be acceptable for the 304 SS material of construction of the SWRTs.

To achieve the target pH of 6.0, the WTP influent pH is adjusted down with 92 weight percent sulfuric acid. A substantial amount of acid will be required to lower the highly alkaline WTP waste down to 6.0 for suitable evaporator feed. This has been calculated at 0.18 gpm, or 7,800 gallons/month, 24 hours per day. This will add from 1,421 to 7,465 pounds per day of solids to the waste in the form of sulfate. This will significantly add to the overall secondary waste generated.

During the development of a new ETF flowsheet, the off-gassing of undesirable vapors as a result of operating the WTP effluent at a target pH of 6.0 will need to be resolved. The primary concern is the off-gassing of Iodine-129, loading/capacity of the vessel vent off-gas system, and the additional secondary waste that is generated by the amount of acid that would be required to lower the pH of the highly alkaline WTP effluent.

Evaporator/Dryer Feed Rate and Composition – Detailed waste characterization data is necessary to determine the drying characteristics of the concentrated waste (i.e., thin film dryer feed) that is produced in the evaporator. Based on the WTP forecast the weighted average powder composition is 17 wgt% ammonium sulfate, 1 wgt% sodium nitrate, and 82 wgt% sodium sulfate. This cornposition is very similar to 242-A Evaporator process condensate powder composition and should have excellent dryability in the ETF thin film dryer. As discussed in the previous section, the WTP feed would be increased to 25 weight percent in the evaporator.

The quantity of powder generated ranges from 2,201 to 12,106 pounds per day, with the weighted average being 5,497 pounds per day. With the ETF nominal dryer capability of 2,000 lbs/day, the current WTP forecast exceeds the dryer capacity.

Disposal of Secondary Waste - the Resource Conservation and Recovery Act (RCRA) designated powder that is produced in the STT is transferred for disposal to the Hanford Site Central Waste Complex (CWC) in the 200 West Area. As part of the treatability evaluation, the final powder matrix must be estimated and screened against the CWC waste acceptance criteria. As stated in the Hanford Site Solid Waste Acceptance Criteria, (FH 2001), if the concentration of any mobile radionuclide exceeds the mobile radionuclide reporting limit, stabilization could be required. Based on the estimated radionuclide concentrations in the powder that would be produced, Iodine-I29 and Technesium-99 may exceed the mobile radionuclide reporting limits for CWC acceptance.

Further work is required to determine if the total quantities of Technetium-99 are manageable in the Mixed Waste Trench. The total amount of Technetium-99 processed at the ETF during the lifetime of the WTP is 90.6 Curies. This quantity of Technetium-99 may require treatment to limit the mobility of Technetium-99 by packaging the drums in concrete boxes filled with low-diffusion grout. The cost of this additional treatment, if required, is not included in the life-cycle cost for operating the LERFIETF. Further evaluation is needed to verify the acceptability of the solid waste for disposal when additional quantitative information about the effluent volume and composition becomes available.

The amount of Iodine-I29 that may possibly be in the solid waste from treating the WTP liquid effluent was similarly calculated to be 61.4 Curies. Based on the projections, in just a few years of operation, Iodine-129 would exceed estimates of the total amount of Iodine-I29 produced at Hanford (approximately 60 Curies). Additional information is needed to evaluate the impact of the Iodine-129 in the solid waste.

6.0 CONCLUSIONS

The WTP liquid effluent forecast is outside the current LERFIETF treatability envelope. There are several concerns that must be addressed before the WTP liquid effluents can be accepted at the LERFIETF. The concerns are:

- The total dissolved solids in the WTP liquid effluents will exceed the present ETF dryer capacity by an average of 2.5 times and as much as 6 times.
- The evaluation indicates that there will be particulate calcium carbonate in the WTP liquid effluents. The LERF cannot receive liquid effluents with solids that may settle and require an extensive cleanout effort.
- No organics were identified in the WTP liquid effluents. This part of the evaluation could not be completed.
- The amount of Iodine-I29 in the WTP liquid effluents is probably in error as it is similar to the total amount estimated to be in the tank waste. Off-gassing during treatment in the ETF and disposal of the solid secondary waste powder are potential concerns.
- The radionuclide content of the WTP liquid effluents exceeds the source term limits for LERF to be a radiological facility.
- The maximum allowable batch volumes that can be accepted into the ETF for treatment is severely restricted by the radionuclide content of the WTP liquid effluents.
- The solid secondary waste powder produced by the ETF in treating the WTP liquid effluents may require further treatment to limit the mobility of Technetium-99.

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APPENDIX A

WASTE TREATMENT PLANT LIQUID EFFLUENT FORECAST

Batch													
Pretreatment Start		4/30/06	7/28/07	3/29/08	5/19/08	3/28/10	9/29/10	2/22/11	7/8/11	4/1/12	8/21/12	1/6/13	4/15/13
Operating Days		71	100	51	128	128	51	47	186	49	48	34	61
Batch Days		454	245	51	678	185	146	136	268	142	138	99	176
Total Condensate (gallons)		3.69E+06	3.82E+06	2.36E+06	4.50E+06	4.50E+06	2.75E+06	2.55E+06	6.34E+06	2.58E+06	2.57E+06	2.10E+06	3.38E+06
kilograms per hour (kg/hr)*		8.29E+03	6.11E+03	7.38E+03	5.61E+03	5.61E+03	8.69E+03	8.68E+03	5.45E+03	8.40E+03	8.60E+03	9.74E+03	8.85E+03
calculated specfic gravity		1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
average flow to ETF, gallons per minute (gpm)		5.6	10.8	32.2	4.6	16.9	13.1	13.0	16.4	12.6	12.9	14.7	13.3
OH-, kg/hr*		6.87E+00	3.24E+00	3.24E+00	3.02E+00	3.02E+00	1.37E+01	1.36E+01	2.91E+00	1.04E+01	1.26E+01	1.24E+01	1.61E+01
calculated pH		12.7	12.5	12.4	12.5	12.5	13.0	13.0	12.5	12.9	12.9	12.9	13.0
Components, kg/hr*	Ci/g												
129-Iodine	1.77E-04	7.74E-03	7.90E-03	8.10E-03	6.25E-03	6.25E-03	1.02E-02	1.04E-02	5.76E-03	1.57E-02	1.11E-02	1.22E-02	9.94E-03
134-Cesium	1.30E+03	4.27E-20	1.39E-11	1.39E-11	3.33E-20	1.74E-20	7.10E-20	6.62E-20	1.21E-20	9.89E-20	4.17E-20	3.98E-21	3.55E-21
137-Cesium	8.66E+01	1.02E-09	9.56E-10	9.56E-10	4.16E-10	4.16E-10	1.03E-09	1.03E-09	4.16E-10	1.02E-09	1.02E-09	1.02E-09	1.02E-09
14-Carbon	4.46	1.07E-08	2.69E-09	1.50E-08	1.02E-08	1.02E-08	1.10E-08	1.18E-08	5.25E-07	2.23E-06	1.14E-06	1.16E-06	8.94E-07
152-Europium	1.73E+02	1.18E-14	5.00E-20	9.15E-15	1.14E-14	1.03E-14	6.85E-17	7.34E-17	9.38E-15	2.22E-15	1.29E-20	8.78E-15	8.72E-17
154-Europium	2.64E+02	1.30E-12	9.83E-14	7.28E-13	1.25E-12	1.20E-12	9.73E-13	9.79E-13	2.45E-12	9.25E-13	8.30E-13	1.22E-12	8.14E-13
155-Europium	4.65E+02	5.35E-13	5.58E-14	2.40E-13	5.68E-13	5.50E-13	5.97E-13	5.98E-13	1.74E-12	4.68E-13	4.57E-13	5.07E-13	4.61E-13
237-Neptunium	7.05E-04	8.48E-06	2.52E-08	8.45E-08	8.37E-06	8.37E-06	9.83E-06	1.00E-05	8.17E-06	7.38E-06	7.15E-06	1.05E-05	7.23E-06
238-Plutonium	17.12	1.65E-13	4.14E-14	2.92E-15	1.21E-13	1.20E-13	1.65E-13	1.65E-13	1.14E-13	1.70E-13	1.64E-13	1.64E-13	1.65E-13
239-Plutonium	6.20E-02	3.19E-10	2.41E-11	5.62E-12	1.07E-10	1.07E-10	3.18E-10	3.18E-10	2.74E-10	3.25E-10	3.17E-10	4.13E-10	3.21E-10
240-Plutonium	2.27E-01	2.43E-11	5.61E-12	4.29E-13	7.89E-12	7.89E-12	2.43E-11	2.43E-11	1.58E-11	2.46E-11	2.42E-11	3.07E-11	2.44E-11
241-Americium	3.43	1.32E-11	1.81E-11	1.90E-11	8.79E-11	8.79E-11	1.39E-11	1.39E-11	1.99E-10	1.98E-11	1.31E-11	5.65E-11	1.50E-11
241-Plutonium	1.03E+02	2.15E-12	2.38E-13	3.80E-14	5.79E-13	5.76E-13	2.14E-12	2.14E-12	6.73E-13	2.15E-12	2.14E-12	2.14E-12	2.14E-12
242-Curium	3.31E+03	2.44E-24	7.09E-22	4.80E-24	4.53E-23	2.29E-24	1.05E-25	5.08E-26	1.51E-24	1.47E-26	6.70E-28	4.17E-27	4.43E-27
243-Americium	0.18	3.19E-16	4.00E-13	5.85E-13	1.97E-14	1.96E-14	9.01E-16	8.27E-16	1.04E-13	4.73E-15	9.87E-17	1.57E-15	1.22E-15
243-Curium	42.1	1.16E-12	3.21E-12	9.19E-14	2.99E-12	2.85E-12	8.28E-14	7.38E-14	3.75E-12	3.91E-13	9.59E-15	1.15E-13	1.61E-13
244-Curium	81.02	1.36E-11	4.28E-11	1.15E-12	3.27E-11	3.04E-11	4.21E-13	3.73E-13	1.43E-11	4.04E-12	4.44E-14	6.56E-13	7.55E-13
3-H (Tritum)	9.70E+03	1.63E-09	5.71E-11	3.98E-08	2.88E-11	2.59E-11	5.37E-10	4.85E-10	5.93E-09	3.00E-11	1.33E-10	1.56E-08	1.18E-08
60-Cobalt	1.13E+03	2.23E-11	2.62E-11	2.41E-12	9.02E-11	8.32E-11	2.93E-11	2.95E-11	9.94E-11	2.45E-11	2.18E-11	2.17E-11	2.05E-11
90-Strontium	1.39E+02	2.50E-11	1.11E-11	3.76E-12	1.90E-10	1.83E-10	2.47E-11	2.47E-11	2.40E-10	4.28E-11	3.72E-11	3.78E-11	4.02E-11
99-Technetium	1.70E-02	1.77E-04	7.28E-05	7.28E-05	5.66E-05	5.66E-05	1.85E-04	1.85E-04	5.51E-05	1.92E-04	1.94E-04	1.99E-04	1.90E-04
Silver (Ag+)		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Aluminium (Al+3)		8.58E-05	1.74E-05	7.54E-06	2.11E-05	2.11E-05	1.35E-04	1.36E-04	1.23E-05	1.46E-04	1.15E-04	1.22E-04	1.17E-04
Boron (B+3)		1.34E-03	1.50E-10	1.50E-10	1.37E-03	1.37E-03	1.28E-03	1.28E-03	1.37E-03	1.28E-03	1.28E-03	1.28E-03	1.28E-03
Barium (Ba+2)		2.01E-06	3.80E-06	3.00E-09	4.27E-05	4.28E-05	5.82E-05	6.20E-05	2.61E-09	8.85E-05	4.03E-05	5.59E-09	1.91E-06
Bismuth (Bi+3)		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E-08	1.95E-08	8.25E-08	1.28E-07	9.36E-08	8.81E-08	1.44E-09
Calcium (Ca+2)		6.88E-03	4.25E-05	1.87E-04	1.86E-02	1.86E-02	5.93E-03	6.00E-03	1.98E-02	7.92E-03	7.88E-03	9.87E-03	1.19E-02
Cadmium (Cd+2)		5.44E-06	5.93E-06	3.76E-09	1.28E-04	1.28E-04	5.48E-06	5.71E-06	4.30E-05	1.84E-05	3.11E-06	7.32E-09	1.69E-07
Chloride (Cl-)		5.18E-02	1.58E-03	4.58E-04	1.99E-02	1.99E-02	1.18E-01	1.17E-01	1.23E-02	1.36E-01	1.39E-01	1.50E-01	1.47E-01
Carbonate (CO3-2)		7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01
Chromium (Cr) (TOTAL)		2.46E-05	3.66E-05	8.28E-05	2.01E-05	2.01E-05	3.38E-05	3.41E-05	1.82E-05	3.12E-05	4.01E-05	2.28E-04	2.61E-04
Cesium (Cs+)		7.55E-07	1.30E-06	1.43E-06	3.80E-07	3.80E-07	8.62E-07	8.84E-07	4.05E-07	8.10E-07	6.69E-07	6.79E-07	5.62E-07
Fluoride (F-)		5.89E-02	2.78E-02	3.05E-02	1.22E-02	1.22E-02	1.43E-02	1.36E-02	2.50E-02	1.54E-02	3.09E-02	2.00E-02	2.34E-02
Iron (Fe+3)		4.18E-04	6.63E-05	8.01E-05	1.80E-03	1.80E-03	4.58E-04	4.61E-04	5.98E-03	5.03E-04	4.32E-04	1.05E-03	1.55E-03
Mercury (Hg+2)		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.54E-06	0.00E+00	0.00E+00	4.22E-07	7.86E-08
Potassium (K+)		3.77E-02	2.10E-03	2.66E-03	1.82E-03	1.82E-03	1.66E-02	1.68E-02	1.16E-03	1.75E-02	1.66E-02	1.53E-02	1.53E-02
Lanthanum (La+3)		5.40E-09	2.64E-09	9.55E-09	2.70E-09	2.70E-09	1.07E-08	1.11E-08	5.44E-08	5.40E-09	5.40E-09	2.33E-08	5.59E-09
Lithium (Li+)		7.79E-14	5.79E-11	5.79E-11	7.79E-14	7.79E-14	7.79E-14	7.79E-14	7.79E-14	7.79E-14	7.79E-14	7.79E-14	7.79E-14
Magnesium (Mg+2)		1.12E-03	7.25E-09	7.25E-09	5.22E-04	5.22E-04	1.12E-03	1.12E-03	5.22E-04	1.12E-03	1.12E-03	1.12E-03	1.12E-03
Manganese (Mn+4)		1.64E-04	1.18E-05	1.37E-05	1.05E-03	1.05E-03	1.76E-04	1.77E-04	1.53E-03	1.92E-04	1.72E-04	1.88E-04	1.94E-04
Molybdenum (+6)		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sodium (Na+)		7.23E+01	6.92E+01	7.18E+01	6.68E+01	6.68E+01	8.22E+01	8.19E+01	6.63E+01	7.68E+01	8.03E+01	8.00E+01	8.45E+01
Ammonia (NH3)		1.08E+01	1.71E+00	1.68E+00	2.45E+00	2.45E+00	1.58E+01	1.61E+01	2.13E+00	1.49E+01	1.27E+01	1.51E+01	1.30E+01
Nickel (Ni+2)		6.04E-05	1.98E-06	7.32E-06	8.47E-04	8.47E-04	5.19E-05	5.31E-05	1.09E-03	1.29E-04	5.79E-05	3.42E-04	5.75E-04
Nitrite (NO2-)		1.32E-01	4.29E-02	4.08E-02	5.68E-02	5.68E-02	1.92E-01	1.92E-01	5.24E-02	1.93E-01	1.94E-01	2.07E-01	2.15E-01
Nitrate (NO3-)		2.52E+00	1.67E+00	1.59E+00	1.76E+00	1.76E+00	2.30E+00	2.29E+00	1.85E+00	2.23E+00	2.32E+00	2.34E+00	2.17E+00
Hydroxide (OH(BOUND))		2.95E-04	2.12E-05	6.09E-07	7.33E-05	7.33E-05	1.50E-04	1.60E-04	2.65E-04	2.50E-04	1.17E-04	1.04E-04	2.94E-05
Hydroxide (OH-)		6.87E+00	3.24E+00	3.24E+00	3.02E+00	3.02E+00	1.37E+01	1.36E+01	2.91E+00	1.04E+01	1.26E+01	1.24E+01	1.61E+01
Lead (Pb+2)		4.70E-03	3.15E-05	3.15E-05	1.61E-02	1.61E-02	8.16E-03	8.34E-03	2.74E-02	9.79E-03	7.25E-03	6.84E-02	1.15E-02
Phosphorus (P) containing components		7.33E-03	2.35E-03	8.47E-04	6.94E-03	6.94E-03	1.49E-02	1.44E-02	6.41E-03	8.93E-03	1.85E-02	2.88E-02	2.44E-02
Selenium (Se+6)		5.53E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Silicon (Si+4)		2.82E-03	1.06E-03	2.51E-03	1.66E-03	1.66E-03	3.32E-03	3.31E-03	1.50E-03	3.08E-03	2.76E-03	3.78E-03	4.61E-03
Sulfate (SO4-2)		2.23E+00	6.82E+00	1.22E+01	2.44E+00	2.44E+00	3.68E+00	3.44E+00	1.67E+00	1.78E+00	2.84E+00	2.89E+00	1.94E+00
Strontium (Sr+2)		1.03E-08	6.50E-09	5.85E-09	9.65E-07	9.65E-07	1.04E-08	1.04E-08	9.68E-07	2.37E-08	1.91E-08	1.88E-08	1.08E-08
Titanium (Ti+4)		0.00E+00	0.00E+00	0.00E+00	2.63E-07	2.63E-07	0.00E+00	0.00E+00	2.63E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total Organic Carbon (TOC)		8.01E-01	8.67E-02	1.52E-01	3.18E+00	3.18E+00	6.17E-01	6.16E-01	3.88E+00	9.64E-01	8.44E-01	1.02E+00	1.31E+00
Uranium (U) (TOTAL)		1.08E-05	7.24E-06	7.36E-06	5.28E-06	5.28E-06	1.03E-05	1.03E-05	5.12E-06	1.03E-05	1.02E-05	1.04E-05	1.03E-05
Zinc (Zn+2)		1.01E-03	1.98E-05	1.98E-05	5.25E-04	5.25E-04	8.25E-04	8.25E-04	5.25E-04	8.25E-04	8.25E-04	8.25E-04	8.25E-04
Zirconium (Zr+4)		2.43E-07	1.13E-08	2.19E-08	2.08E-07	2.08E-07	1.74E-07	1.74E-07	2.76E-07	1.82E-07	1.66E-07	1.70E-07	1.64E-07
Water (H2O)		8.12E+03	5.95E+03	7.21E+03	5.46E+03	5.45E+03	8.49E+03	8.48E+03	5.29E+03	8.21E+03	8.41E+03	9.55E+03	8.65E+03
SUM		8.29E+03	6.11E+03	7.38E+03	5.61E+03	5.61E+03	8.69E+03	8.68E+03	5.45E+03	8.40E+03	8.60E+03	9.74E+03	8.85E+03

Batch																
Pretreatment Start	10/8/13	4/6/14	10/4/14	3/4/15	9/25/15	2/2/16	4/28/16	8/22/16	12/15/16	5/16/17	10/9/17	2/26/18	7/15/18	3/26/19	(Batch Days)	Average	
Operating Days	62	62	52	71	45	30	40	40	104	101	48	48	88				
Batch Days	180	181	151	205	130	86	116	115	152	146	140	139	254				4713
Total Condensate (gallons)	3.57E+06	3.59E+06	2.52E+06	3.82E+06	2.46E+06	1.61E+06	2.13E+06	2.12E+06	4.19E+06	4.08E+06	2.56E+06	2.56E+06	4.40E+06				
kilograms per hour (kg/hr)*	9.12E+03	9.16E+03	7.69E+03	8.57E+03	8.74E+03	8.66E+03	8.49E+03	8.47E+03	6.40E+03	6.42E+03	8.49E+03	8.48E+03	7.96E+03				
calculated specfic gravity	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01				
average flow to ETF, gallons per minute (gpm)	13.8	13.8	11.6	12.9	13.2	13.0	12.7	12.8	19.1	19.4	12.7	12.8	12.0		56079.78449	11.9	
OH-, kg/hr*	2.06E+01	2.10E+01	1.38E+01	1.41E+01	1.34E+01	1.37E+01	1.10E+01	1.05E+01	3.14E+00	3.21E+00	1.07E+01	1.06E+01	8.92E+00				
calculated pH	13.1	13.1	13.0	13.0	13.0	13.0	12.9	12.9	12.5	12.5	12.9	12.9	12.8				
Components, kg/hr*																	
129-Iodine	9.95E-03	9.78E-03	1.07E-02	1.06E-02	8.41E-03	8.06E-03	1.00E-02	1.00E-02	4.51E-03	4.59E-03	1.09E-02	1.10E-02	8.55E-03				
134-Cesium	3.51E-20	2.91E-20	3.35E-20	3.30E-20	5.38E-21	1.44E-21	7.85E-20	7.34E-20	2.44E-22	1.65E-21	8.49E-21	7.67E-21	2.83E-21				
137-Cesium	1.03E-09	1.03E-09	1.02E-09	1.02E-09	1.02E-09	1.02E-09	1.02E-09	1.02E-09	4.15E-10	4.15E-10	1.02E-09	1.02E-09	1.02E-09				
14-Carbon	8.74E-07	8.42E-07	1.04E-06	7.67E-07	3.14E-07	1.59E-06	6.25E-07	6.12E-07	3.00E-07	2.60E-07	1.41E-07	1.34E-07	5.78E-07				
152-Europium	6.09E-17	1.27E-19	1.94E-14	2.54E-14	2.87E-15	4.51E-18	1.14E-14	1.17E-14	1.10E-16	1.15E-15	1.60E-15	1.53E-15	1.39E-14				
154-Europium	8.60E-13	8.57E-13	8.68E-13	8.79E-13	9.17E-13	8.06E-13	1.04E-12	1.05E-12	8.70E-13	8.70E-13	9.09E-13	9.06E-13	1.06E-12				
155-Europium	5.30E-13	5.27E-13	5.30E-13	5.50E-13	4.72E-13	4.57E-13	5.29E-13	5.27E-13	4.92E-13	4.95E-13	5.17E-13	5.15E-13	4.89E-13				
237-Neptunium	9.30E-06	9.62E-06	9.74E-06	1.04E-05	8.41E-06	7.20E-06	1.06E-05	1.06E-05	6.50E-06	6.75E-06	1.08E-05	1.08E-05	1.00E-05				
238-Plutonium	1.67E-13	1.67E-13	1.66E-13	1.67E-13	1.90E-13	1.74E-13	1.72E-13	1.73E-13	9.50E-14	9.42E-14	1.66E-13	1.65E-13	1.71E-13				
239-Plutonium	3.34E-10	3.34E-10	3.23E-10	3.24E-10	4.20E-10	3.26E-10	4.07E-10	4.11E-10	8.82E-11	8.38E-11	3.34E-10	3.30E-10	4.39E-10				
240-Plutonium	2.52E-11	2.52E-11	2.46E-11	2.48E-11	3.22E-11	2.46E-11	3.02E-11	3.04E-11	6.51E-12	6.33E-12	2.51E-11	2.49E-11	2.87E-11				
241-Americium	1.43E-11	1.41E-11	1.32E-11	1.32E-11	3.01E-11	1.63E-11	5.12E-11	5.29E-11	5.97E-11	5.95E-11	1.66E-11	1.60E-11	2.90E-11				
241-Plutonium	2.16E-12	2.16E-12	2.16E-12	2.16E-12	2.32E-12	2.15E-12	2.15E-12	2.15E-12	5.57E-13	5.56E-13	2.15E-12	2.15E-12	2.16E-12				
242-Curium	2.07E-28	7.92E-29	9.12E-29	5.99E-29	1.38E-29	1.72E-28	4.14E-30	2.55E-30	1.77E-29	2.77E-30	4.03E-31	2.20E-31	3.27E-31				
243-Americium	1.46E-15	1.36E-15	2.51E-16	3.02E-16	5.53E-16	2.08E-15	6.02E-16	5.61E-16	1.50E-16	2.87E-17	5.66E-16	5.67E-16	2.56E-15				
243-Curium	2.48E-14	1.40E-14	3.42E-14	4.23E-14	2.15E-14	4.45E-13	9.74E-14	1.00E-13	1.84E-13	4.90E-14	2.22E-13	2.28E-13	1.04E-13				
244-Curium	2.03E-13	9.18E-14	2.24E-13	2.82E-13	9.30E-14	1.97E-12	9.99E-13	1.03E-12	9.18E-13	2.50E-13	2.36E-12	2.42E-12	9.77E-13				
3-H (Tritum)	1.34E-10	1.34E-10	2.05E-10	2.30E-10	3.38E-09	6.52E-10	5.14E-09	5.28E-09	2.09E-09	1.60E-09	1.71E-09	1.62E-09	6.02E-09				
60-Cobalt	2.47E-11	2.44E-11	2.18E-11	2.19E-11	2.01E-11	2.34E-11	2.47E-11	2.46E-11	5.92E-11	5.90E-11	2.09E-11	2.09E-11	2.14E-11				
90-Strontium	2.61E-11	2.56E-11	3.37E-11	3.27E-11	2.92E-11	3.30E-11	2.98E-11	2.99E-11	1.38E-10	1.38E-10	3.20E-11	3.21E-11	3.72E-11				
99-Technetium	1.82E-04	1.82E-04	1.87E-04	1.85E-04	1.82E-04	1.92E-04	1.83E-04	1.83E-04	5.68E-05	5.63E-05	1.80E-04	1.80E-04	1.78E-04				
Silver (Ag+)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.11E-11	0.00E+00	1.57E-10	1.64E-10	0.00E+00	0.00E+00	3.61E-11	3.44E-11	5.19E-10				
Aluminium (Al+3)	1.66E-04	1.67E-04	1.21E-04	1.23E-04	1.26E-04	1.18E-04	1.14E-04	1.11E-04	2.26E-05	2.86E-05	1.35E-04	1.35E-04	1.59E-04				
Boron (B+3)	1.28E-03	1.28E-03	1.28E-03	1.28E-03	1.28E-03	1.28E-03	1.28E-03	1.28E-03	1.37E-03	1.37E-03	1.28E-03	1.28E-03	1.28E-03				
Barium (Ba+2)	5.43E-05	5.32E-05	1.01E-05	5.59E-09	2.29E-07	1.17E-07	2.91E-06	3.28E-07	3.82E-08	1.15E-06	1.05E-07	1.00E-07	1.32E-06				
Bismuth (Bi+3)	8.05E-08	7.90E-08	2.85E-08	6.40E-09	5.65E-08	9.13E-11	1.08E-07	1.09E-07	2.05E-08	3.54E-08	3.20E-08	3.09E-08	8.64E-08				
Calcium (Ca+2)	5.44E-03	5.37E-03	7.39E-03	7.22E-03	9.69E-03	8.10E-03	7.20E-03	7.28E-03	1.04E-02	9.02E-03	7.01E-03	6.91E-03	6.65E-03				
Cadmium (Cd+2)	7.13E-06	6.80E-06	7.64E-07	7.32E-09	1.29E-07	1.77E-08	5.02E-07	2.54E-07	4.31E-05	4.31E-05	6.17E-08	5.91E-08	6.80E-07				
Chloride (Cl-)	1.02E-01	1.01E-01	1.00E-01	8.76E-02	1.09E-01	1.81E-01	1.16E-01	1.17E-01	3.43E-02	2.53E-02	1.22E-01	1.23E-01	1.29E-01				
Carbonate (CO3-2)	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01	7.95E+01				
Chromium (Cr) (TOTAL)	4.35E-05	4.39E-05	2.62E-05	2.15E-05	1.26E-04	6.11E-05	1.61E-04	1.67E-04	5.37E-05	9.45E-05	9.03E-05	8.89E-05	1.26E-04				
Cesium (Cs+)	7.75E-07	7.75E-07	7.69E-07	8.03E-07	6.54E-07	7.16E-07	7.72E-07	7.72E-07	3.24E-07	3.28E-07	7.14E-07	7.15E-07	8.12E-07				
Fluoride (F-)	1.64E-02	1.65E-02	2.88E-02	2.80E-02	1.41E-01	2.53E-02	3.31E-02	3.39E-02	2.94E-02	2.84E-02	8.56E-02	8.35E-02	1.88E-02				
Iron (Fe+3)	4.34E-04	4.32E-04	4.86E-04	5.04E-04	5.67E-04	5.11E-04	5.82E-04	5.90E-04	1.56E-03	1.53E-03	5.03E-04	5.01E-04	5.06E-04				
Mercury (Hg+2)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.66E-07	4.68E-09	1.68E-07	1.77E-07	1.20E-09	3.04E-07	4.52E-07	4.63E-07	1.62E-06				
Potassium (K+)	2.11E-02	2.12E-02	3.48E-02	4.10E-02	1.81E-02	1.60E-02	2.12E-02	2.12E-02	1.53E-03	3.29E-03	2.25E-02	2.26E-02	1.78E-02				
Lanthanum (La+3)	6.89E-09	7.07E-09	5.40E-09	5.40E-09	1.65E-08	5.42E-09	2.92E-08	3.01E-08	3.15E-09	2.74E-09	1.05E-08	1.02E-08	1.29E-08				
Lithium (Li+)	7.79E-14	7.79E-14	7.79E-14	7.79E-14	1.29E-10	7.79E-14	2.62E-10	2.77E-10	7.79E-14	7.79E-14	6.05E-11	6.04E-11	7.85E-10				
Magnesium (Mg+2)	1.12E-03	1.12E-03	1.12E-03	1.12E-03	1.12E-03	1.12E-03	1.12E-03	1.12E-03	5.22E-04	5.22E-04	1.12E-03	1.12E-03	1.13E-03				
Manganese (Mn+4)	1.71E-04	1.70E-04	1.82E-04	1.85E-04	1.90E-04	2.27E-04	1.84E-04	1.84E-04	9.90E-04	9.82E-04	1.91E-04	1.91E-04	2.70E-04				
Molybdenum (+6)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00				
Sodium (Na+)	9.03E+01	9.07E+01	8.12E+01	8.15E+01	8.15E+01	8.17E+01	7.85E+01	7.79E+01	6.68E+01	6.68E+01	7.81E+01	7.80E+01	7.51E+01				
Ammonia (NH3)	1.94E+01	1.96E+01	2.59E+01	3.04E+01	1.40E+01	1.31E+01	4.90E+01	5.04E+01	1.88E+00	3.31E+00	2.91E+01	2.97E+01	1.42E+01				
Nickel (Ni+2)	4.45E-05	4.19E-05	6.63E-05	6.92E-05	1.36E-04	1.78E-04	1.55E-04	1.60E-04	3.63E-04	3.50E-04	9.88E-05	9.73E-05	1.41E-04				
Nitrite (NO2-)	1.84E-01	1.84E-01	1.77E-01	1.71E-01	1.75E-01	2.42E-01	1.79E-01	1.79E-01	5.64E-02	5.01E-02	2.17E-01	2.19E-01	2.11E-01				
Nitrate (NO3-)	2.19E+00	2.18E+00	2.26E+00	2.24E+00	2.23E+00	2.46E+00	2.52E+00	2.54E+00	1.98E+00	1.95E+00	2.89E+00	2.92E+00	2.31E+00				
Hydroxide (OH(BOUND))	2.63E-05	1.94E-05	1.46E-04	1.56E-04	9.37E-05	2.05E-05	1.27E-04	1.32E-04	7.61E-06	1.66E-05	7.72E-05	7.66E-05	2.42E-04				
Hydroxide (OH-)	2.06E+01	2.10E+01	1.38E+01	1.41E+01	1.34E+01	1.37E+01	1.10E+01	1.05E+01	3.14E+00	3.21E+00	1.07E+01	1.06E+01	8.92E+00				
Lead (Pb+2)	9.13E-03	9.12E-03	1.00E-02	1.10E-02	2.63E-02	9.87E-03	5.60E-02	5.83E-02	8.73E-03	8.82E-03	1.26E-02	1.20E-02	1.50E-02				
Phosphorus (P) containing components	8.04E-03	8.02E-03	9.01E-03	5.79E-03	1.41E-02	4.63E-02	2.33E-02	2.41E-02	5.23E-02	3.68E-02	1.52E-02	1.52E-02	1.96E-02				
Selenium (Se+6)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.09E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00				
Silicon (Si+4)	3.53E-03	3.54E-03	3.12E-03	3.24E-03	4.28E-03	2.50E-03	3.17E-03	3.16E-03	3.45E-03	3.59E-03	2.77E-03	2.71E-03	3.00E-03				
Sulfate (SO4-2)	1.05E+00	1.03E+00	1.46E+00	9.91E-01	2.96E+00	2.61E+00	3.52E+00	3.63E+00	2.08E+00	1.87E+00	2.99E+00	2.99E+00	2.42E+00				
Strontium (Sr+2)	1.95E-08	1.93E-08	1.27E-08	1.05E-08	1.40E-08	1.08E-08	2.37E-08	2.39E-08	9.67E-07	9.65E-07	1.28E-08	1.28E-08	3.01E-08				
Titanium (Ti+4)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.63E-07	2.63E-07	0.00E+00	0.00E+00	0.00E+00				
Total Organic Carbon (TOC)	5.01E-01	4.87E-01	6.73E-01	6.15E-01	9.14E-01	1.51E+00	7.50E-01	7.62E-01	2.44E+00	2.36E+00	6.94E-01	6.86E-01	7.75E-01				
Uranium (U) (TOTAL)	1.02E-05	1.02E-05	1.06E-05	1.08E-05	1.38E-05	1.03E-05	1.22E-05	1.22E-05	5.17E-06	5.19E-06	1.11E-05	1.11E-05	1.72E-05				
Zinc (Zn+2)	8.25E-04	8.25E-04	8.25E-04	8.25E-04	8.25E-04	8.25E-04	8.25E-04	8.25E-04	5.28E-04	5.25E-04	8.25E-04	8.25E-04	8.25E-04				
Zirconium (Zr+4)	1.66E-07	1.66E-07	2.01E-07	2.13E-07	3.61E-07	1.71E-07	1.78E-07	1.79E-07	1.46E-07	1.44E-07	1.96E-07	1.90E-07	2.87E-07				
Water (H2O)	8.90E+03	8.95E+03	7.49E+03	8.36E+03	8.55E+03	8.47E+03	8.27E+03	8.24E+03	6.24E+03	6.26E+03	8.28E+03	8.28E+03	7.77E+03				
SUM	9.12E+03	9.16E+03	7.69E+03	8.57E+03	8.74E+03	8.66E+03	8.49E+03	8.47E+03	6.40E+03	6.42E+03	8.49E+03	8.48E+03	7.96E+03				

Batch	LAW-1	LAW-2a	LAW-2b	LAW-3	LAW-4	LAW-5	LAW-6	LAW-7	LAW-8	LAW-9	LAW-10	LAW-11	LAW-12
Pretreatment Start	4/30/06	7/28/07	3/29/08	5/19/08	3/28/10	9/29/10	2/22/11	7/6/11	4/1/12	8/21/12	1/6/13	4/15/13	10/8/13
Operating Days	71	100	51	128	128	51	47	186	49	48	34	61	62
Batch Days	454	245	51	678	185	146	136	268	142	138	99	176	180
Total Condensate (gallons)	3.69E+06	3.82E+06	2.36E+06	4.50E+06	4.50E+06	2.75E+06	2.55E+06	6.34E+06	2.58E+06	2.57E+06	2.10E+06	3.38E+06	3.57E+06
kilograms per hour (kg/hr)*	8.29E+03	6.11E+03	7.38E+03	5.61E+03	5.61E+03	8.69E+03	8.68E+03	5.45E+03	8.40E+03	8.60E+03	9.74E+03	8.85E+03	9.12E+03
calculated specfic gravity	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
average flow to ETF, gallons per minute (gpm)	5.6	10.8	32.2	4.6	16.9	13.1	13.0	16.4	12.6	12.9	14.7	13.3	13.8
OH-, kg/hr*	6.87E+00	3.24E+00	3.24E+00	3.02E+00	3.02E+00	1.37E+01	1.36E+01	2.91E+00	1.04E+01	1.26E+01	1.24E+01	1.61E+01	2.06E+01
calculated pH	12.7	12.5	12.4	12.5	12.5	13.0	13.0	12.5	12.9	12.9	12.9	13.0	13.1
Average Total Dissolved Solids (TDS), lbs/day to ETF	1447.0	3488.6	9012.3	1588.3	5818.6	3625.9	3597.3	5804.1	3404.2	3496.0	3552.6	3641.8	3919.5
Weight Percent (Wt%) TDS	2.11	2.66	2.31	2.84	2.84	2.28	2.28	2.91	2.22	2.23	1.99	2.25	2.36
[CO3-2]	0.16	0.22	0.18	0.24	0.24	0.15	0.15	0.25	0.16	0.16	0.14	0.15	0.15
[Ca+2]	0.00002	0.0000002	0.000001	0.00008	0.00008	0.00002	0.00002	0.00009	0.00002	0.00002	0.00003	0.00003	0.00002
[Ca+2][CO3-2]/Ksp @25°C	389	4	13	2286	2290	305	309	2586	436	413	403	587	254
OH- neutral to H2O at ETF, pounds per day (lb/day)**	56.7	69.6	171.4	30.2	110.2	251.1	247.3	106.6	189.4	229.3	227.0	294.6	378.1
CO3-- conversion to CO2 at ETF, lb/day**	655.9	1708.0	4206.3	792.3	2902.7	1454.0	1444.9	2911.7	1447.1	1451.0	1457.5	1454.4	1456.1
CO2 generated at 100F/1 atm, cfm***	3.10	8.08	19.89	3.75	13.73	6.88	6.83	13.77	6.84	6.86	6.89	6.88	6.89
NH3 conv. to NH4+ at ETF, lb/day**	89.1	36.8	88.9	24.5	89.6	288.5	292.7	78.0	270.8	232.3	276.1	237.5	356.0
SO4-- added at ETF, lb/day**	1461.0	3033.2	7465.1	1421.8	5208.6	3850.1	3836.7	5179.8	3614.8	3624.9	3752.5	3829.3	4402.6
gross powder production, lb/day	2201	4746	12105	2189	8020	5788	5759	7970	5398	5454	5637	5736	6509
92% H2SO4 add rate, gpm	0.07	0.15	0.38	0.07	0.26	0.19	0.19	0.26	0.18	0.18	0.19	0.19	0.22
gross feed rate to evap., gpm	5.7	11.0	32.6	4.7	17.1	13.3	13.2	16.7	12.8	13.1	14.9	13.5	14.0
chloride + fluoride in evap, ppm	156	45	45	50	50	164	163	58	200	218	217	210	136
NH4+ in evaporator, parts per million (ppm)	16068	2748	2580	4010	4010	20732	21204	3498	20738	17325	20292	16997	23636
POWDER PRODUCTION, lb/day**													
SO4--	1479.4	3179.8	8113.4	1446.2	5297.8	3917.4	3899.3	5241.0	3647.3	3676.8	3805.5	3864.9	4421.8
Na+	596.9	1488.1	3800.6	666.3	2441.0	1504.5	1489.9	2430.8	1398.8	1465.8	1467.6	1547.6	1654.1
NO3-	20.8	35.8	84.2	17.6	64.5	42.1	41.6	67.9	40.6	42.4	43.0	39.7	40.1
NH4+	94.3	38.9	94.2	25.9	94.9	305.5	310.0	82.6	286.8	245.9	292.4	251.4	376.9
Total	2191	4743	12092	2156	7898	5769	5741	7822	5373	5431	5608	5704	6493
Wt% Ammonium Sulfate													
Wt% Sodium Nitrate													
Wt% Sodium Sulfate													
cations, pound-equivalent/day (lb-equiv/day)	31.2	66.9	170.5	30.4	111.4	82.4	82.0	110.3	76.7	77.4	80.1	81.3	92.9
anions, lb-equiv/day	31.2	66.8	170.4	30.4	111.4	82.3	81.9	110.3	76.6	77.3	80.0	81.2	92.8
ionic imbalance, lb-equiv/day	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1
feed picocuries per liter (pCi/L)	2.48E+06	5.52E+05	5.33E+07	4.63E+05	4.56E+05	1.20E+06	1.15E+06	1.15E+07	1.98E+06	1.38E+06	1.68E+07	1.41E+07	1.13E+06
feed curies per cubic meter (Ci/m³)	2.48E-03	5.52E-04	5.33E-02	4.63E-04	4.56E-04	1.20E-03	1.15E-03	1.15E-02	1.98E-03	1.38E-03	1.68E-02	1.41E-02	1.13E-03
powder pCi/L	7.63E+07	1.51E+07	1.70E+09	1.17E+07	1.15E+07	3.27E+07	3.12E+07	2.85E+08	5.54E+07	3.94E+07	5.28E+08	3.93E+08	2.87E+07
TRU nanocuries per gram (nCi/g), powder	2.29E-02	9.90E-04	5.64E-04	2.89E-02	2.88E-02	2.22E-02	2.26E-02	3.04E-02	1.79E-02	1.71E-02	2.49E-02	1.66E-02	1.87E-02
99-Technetium, Ci	5.1	3.0	1.5	3.0	3.0	3.8	3.5	4.2	3.8	3.8	2.8	4.7	4.6
99-Technetium, Ci/m3 in powder	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01
129-Iodine, Ci	2.3	3.3	1.8	3.4	3.4	2.2	2.1	4.5	3.3	2.2	1.8	2.6	2.6

Batch	LAW-13	LAW-14	LAW-15	LAW-16	LAW-17	LAW-18	LAW-19	LAW-20	LAW-21	LAW-22	LAW-23	LAW-24	End Date	Sum: (Value) x	Weighted	Totals	wt%
Pretreatment Start	4/6/14	10/4/14	3/4/15	9/25/15	2/2/16	4/28/16	8/22/16	12/15/16	5/16/17	10/9/17	2/26/18	7/15/18	3/26/19	(Batch Days)	Average		
Operating Days	62	52	71	45	30	40	40	104	101	48	48	88					
Batch Days	181	151	205	130	86	116	115	152	146	140	139	254				4713	
Total Condensate (gallons)	3.59E+06	2.52E+06	3.82E+06	2.46E+06	1.61E+06	2.13E+06	2.12E+06	4.19E+06	4.08E+06	2.56E+06	2.56E+06	4.40E+06					
kilograms per hour (kg/hr)*	9.16E+03	7.69E+03	8.57E+03	8.74E+03	8.66E+03	8.49E+03	8.47E+03	6.40E+03	6.42E+03	8.49E+03	8.48E+03	7.96E+03					
calculated specfic gravity	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01					
average flow to ETF, gallons per minute (gpm)	13.8	11.6	12.9	13.2	13.0	12.7	12.8	19.1	19.4	12.7	12.8	12.0		56079.78449	11.9		
OH-, kg/hr*	2.10E+01	1.38E+01	1.41E+01	1.34E+01	1.37E+01	1.10E+01	1.05E+01	3.14E+00	3.21E+00	1.07E+01	1.06E+01	8.92E+00					
calculated pH	13.1	13.0	13.0	13.0	13.0	12.9	12.9	12.5	12.5	12.9	12.9	12.8					
Average Total Dissolved Solids (TDS), lbs/day to ETF	3920.4	3748.9	3843.9	3562.6	3563.9	4096.7	4143.0	5715.4	5843.3	3709.9	3750.1	3368.4		16765812.98	3557		
Weight Percent (Wt%) TDS	2.34	2.67	2.45	2.23	2.25	2.65	2.67	2.47	2.48	2.41	2.41	2.31					
[CO3-2]	0.15	0.17	0.16	0.15	0.15	0.16	0.16	0.21	0.21	0.16	0.16	0.17					
[Ca+2]	0.00001	0.00002	0.00002	0.00003	0.00002	0.00002	0.00002	0.00004	0.00004	0.00002	0.00002	0.00002					
[Ca+2][CO3-2]/Ksp @25°C	248	485	381	492	419	387	394	979	849	378	373	408		4107094.235	871		
OH- neutral to H2O at ETF, pounds per day (lb/day)**	383.1	251.6	259.4	244.5	249.5	200.1	193.4	113.7	117.9	193.5	193.9	163.7					
CO3-- conversion to CO2 at ETF, lb/day**	1450.2	1452.2	1456.5	1451.8	1452.1	1445.6	1458.4	2873.8	2917.0	1442.5	1455.0	1457.6					
CO2 generated at 100F/1 atm, cfm***	6.86	6.87	6.89	6.87	6.87	6.84	6.90	13.59	13.80	6.82	6.88	6.89		34659.87593	7.4		
NH3 conv. to NH4+ at ETF, lb/day**	357.1	473.9	557.4	256.5	239.4	890.8	924.9	68.1	121.7	528.4	543.6	260.0					
SO4-- added at ETF, lb/day**	4410.1	4372.0	4636.6	3737.3	3703.7	5393.3	5490.9	5111.2	5343.6	4346.3	4410.4	3528.5					
gross powder production, lb/day	6518	6445	6797	5619	5580	7897	8037	7843	8159	6451	6544	5291		25906978.15	5497		
92% H2SO4 add rate, gpm	0.22	0.22	0.23	0.19	0.19	0.27	0.28	0.26	0.27	0.22	0.22	0.18		869.8916437	0.18		
gross feed rate to evap., gpm	14.0	11.8	13.2	13.3	13.2	13.0	13.1	19.4	19.7	12.9	13.0	12.2		56949.67614	12.1		
chloride + fluoride in evap, ppm	135	154	135	315	260	162	163	99	83	250	247	199		653116.6994	139		
NH4+ in evaporator, parts per million (ppm)	23702	32806	37667	18767	17512	56298	57780	3107	5432	37025	37678	20115		83880962.97	17798		
POWDER PRODUCTION, lb/day**																	
SO4--	4428.8	4398.7	4654.8	3791.3	3751.4	5457.3	5557.6	5186.5	5412.4	4400.6	4465.1	3572.9		17440651.83	3701		68
Na+	1655.9	1483.9	1493.4	1489.2	1492.6	1428.4	1430.7	2417.1	2453.6	1417.0	1427.7	1378.2		6877480.879	1459		27
NO3-	39.9	41.3	41.0	40.7	45.0	45.8	46.5	71.8	71.5	52.5	53.5	42.3		194998.1496	41		1
NH4+	378.1	501.8	590.2	271.6	253.5	943.2	979.3	72.1	128.8	559.5	575.6	275.3		1219227.29	259		5
Total	6503	6426	6779	5593	5543	7875	8014	7747	8066	6430	6522	5269		25732358.15	5460		100
Wt% Ammonium Sulfate																	17
Wt% Sodium Nitrate																	1
Wt% Sodium Sulfate																	82
cations, pound-equivalent/day (lb-equiv/day)	93.0	92.4	97.7	79.8	79.0	114.5	116.6	109.1	113.8	92.7	94.1	75.2					
anions, lb-equiv/day	92.9	92.3	97.6	79.6	78.9	114.4	116.5	109.2	113.9	92.5	93.9	75.1					
ionic imbalance, lb-equiv/day	0.1	0.1	0.1	0.2	0.1	0.1	0.1	-0.1	-0.1	0.2	0.2	0.1					
feed picocuries per liter (pCi/L)	1.10E+06	1.56E+06	1.27E+06	4.50E+06	2.13E+06	6.86E+06	7.05E+06	3.71E+06	2.93E+06	2.66E+06	2.56E+06	8.34E+06					
feed curies per cubic meter (Ci/m³)	1.10E-03	1.56E-03	1.27E-03	4.50E-03	2.13E-03	6.86E-03	7.05E-03	3.71E-03	2.93E-03	2.66E-03	2.56E-03	8.34E-03					
powder pCi/L	2.80E+07	3.36E+07	2.91E+07	1.26E+08	5.98E+07	1.33E+08	1.35E+08	1.09E+08	8.38E+07	6.28E+07	6.01E+07	2.27E+08					
TRU nanocuries per gram (nCi/g), powder	1.92E-02	1.97E-02	2.00E-02	1.97E-02	1.70E-02	1.76E-02	1.75E-02	2.22E-02	2.24E-02	2.17E-02	2.15E-02	2.49E-02					
99-Technetium, Ci	4.6	4.0	5.4	3.3	2.3	3.0	3.0	2.4	2.3	3.5	3.5	6.4				90.6	
99-Technetium, Ci/m3 in powder	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01					
129-Iodine, Ci	2.6	2.4	3.2	1.6	1.0	1.7	1.7	2.0	2.0	2.2	2.3	3.2				61.4	

* Based on the Operating Days (Pretreatment processing days).

** Assumes that at the ETF 92 wt% H2SO4 will be added at the SWRTs to bring the waste pH down to 6.

100% of the OH- has been converted to H2O. The amount of water formed is minor and ignored in the above material balance.

100% of the NH3 has been converted to NH4+.

***At pH 6 all of the CO3-2 has been converted to CO2 which effervesces to the atmosphere via the SWRT and evaporator vessel vent systems.

The following reactions apply:

CO3-- + H2SO4 --> CO2 + H2O + SO4--

2OH- + H2SO4 --> 2H2O + SO4--

2NH3 + H2SO4 --> SO4-- + 2NH4+