



U.S. DEPARTMENT OF
ENERGY



TMI-2 Tritiated Water Experience

Presented to the
Tritiated Water Task Force of the Committee on
Contaminated Water Countermeasures
26 March 2014

By: Chuck Negin

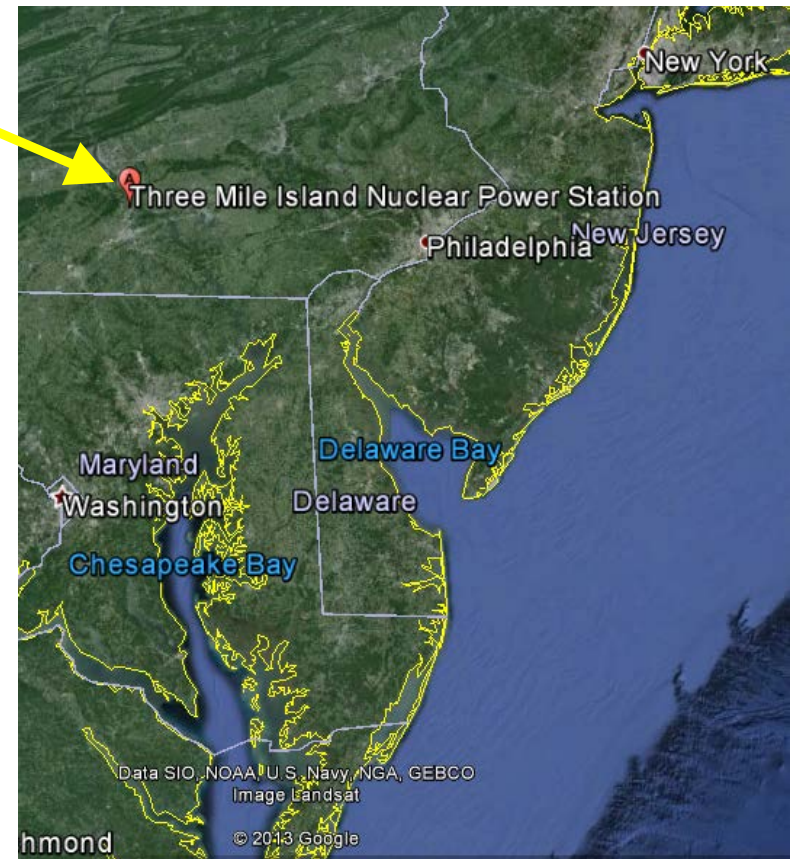
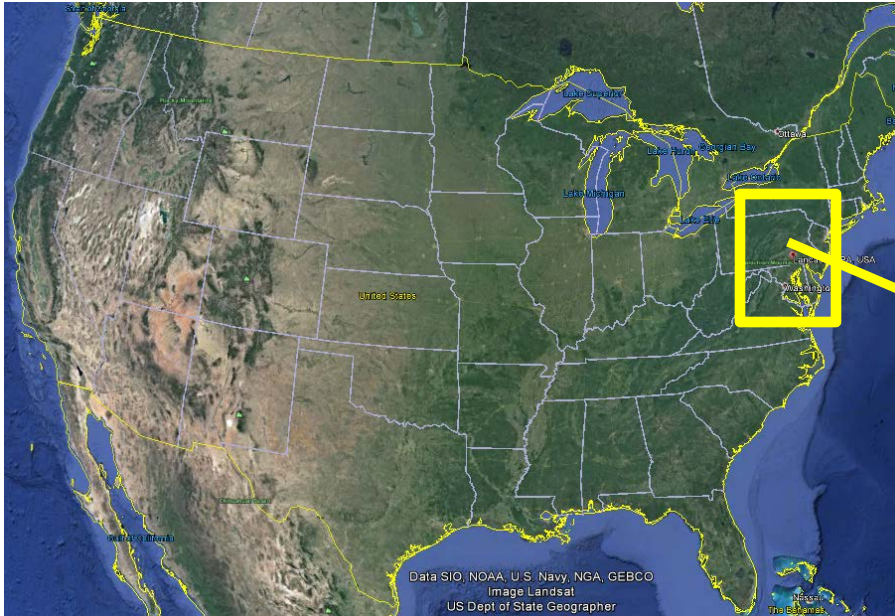


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Location in the USA



❑ By Road

- 200 km north of Washington DC
- 160 km from the Delaware Bay
- 40 km to city of Lancaster, PA

❑ By River

- 26 km to the city of Lancaster, PA water intake



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Overhead Aerial



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Relative to the City of Lancaster



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How much Tritium?

- ❑ Initial tritium: somewhat less than 3000 curies (111 tBq)
- ❑ Final tritium: 658* curies (24.3 tBq)
- ❑ Final Water: 2.3 million gallons (8706 metric tons)
- ❑ Final Concentration: 2.8×10^6 Bq/liter
- ❑ US EPA Drinking water standard: 740 Bq/liter
- ❑ Where did the tritium go? It was reduced by:
 - radioactive decay (12 year half life),
 - used for decontamination; loss via evaporation; removed by ventilation systems
 - via the air ejectors**

* Final PEIS estimate was 1020 Ci (37.7 tBq) in 1987

* * The air ejectors were used to maintain cooling in the reactor via the steam generators and the steam system; they were under internal vacuum relative to the reactor containment where they were located.



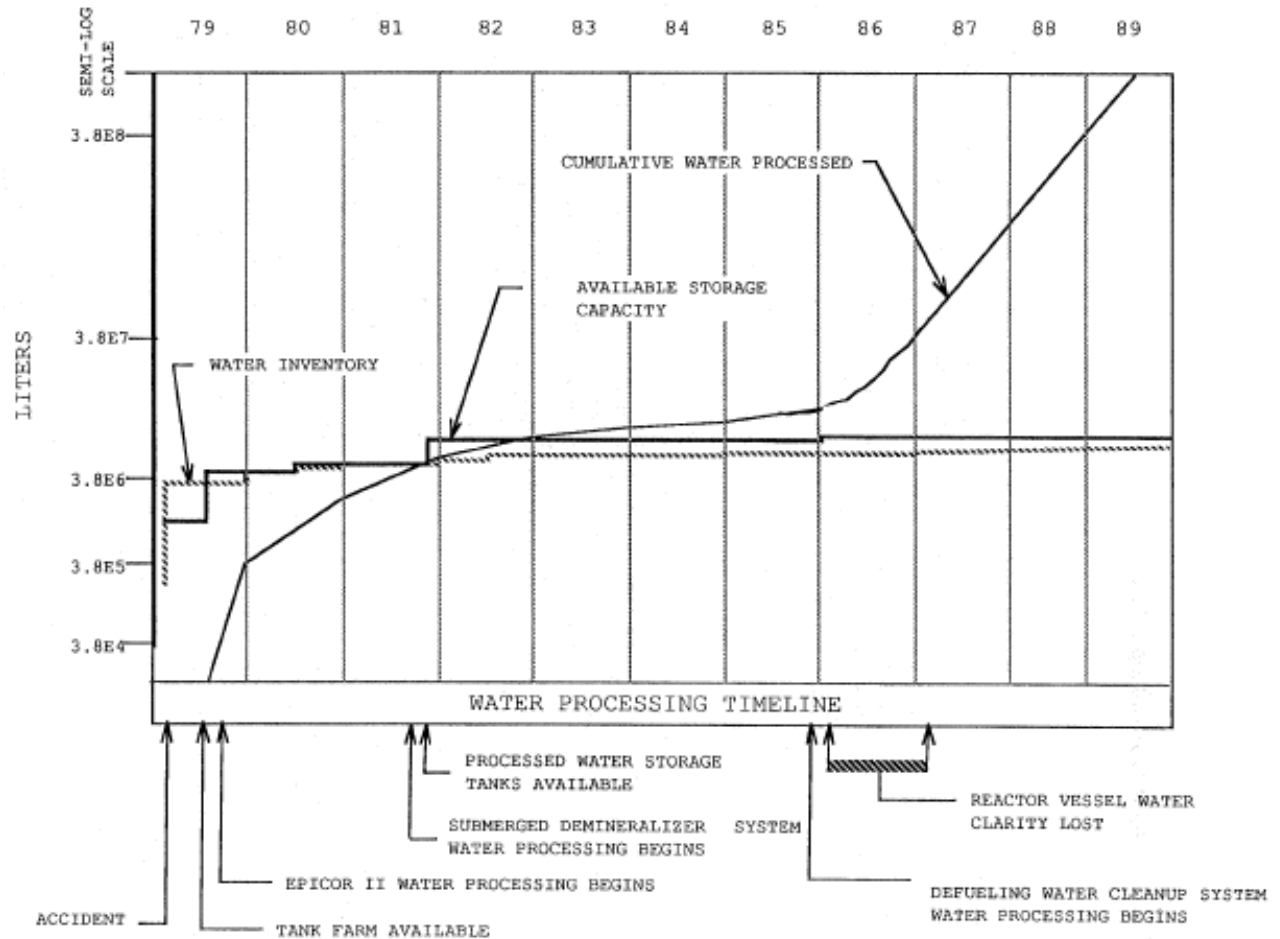
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Why Disposal Waited 10 Years

- The addition of water was not at a high rate
- There was some evaporation and discharge via ventilation
- Several storage locations within the plant
- The containment basement acted as a “surge tank”
- Eventually built 2 half million gallon tanks (5,000 metric tons) for processed water storage



March 1981 NRC:

"a decision could be deferred until after the water has been processed. Then the concentration of radionuclides remaining in the water will be low enough for the water to be stored safely onsite until the disposal decision is made ."



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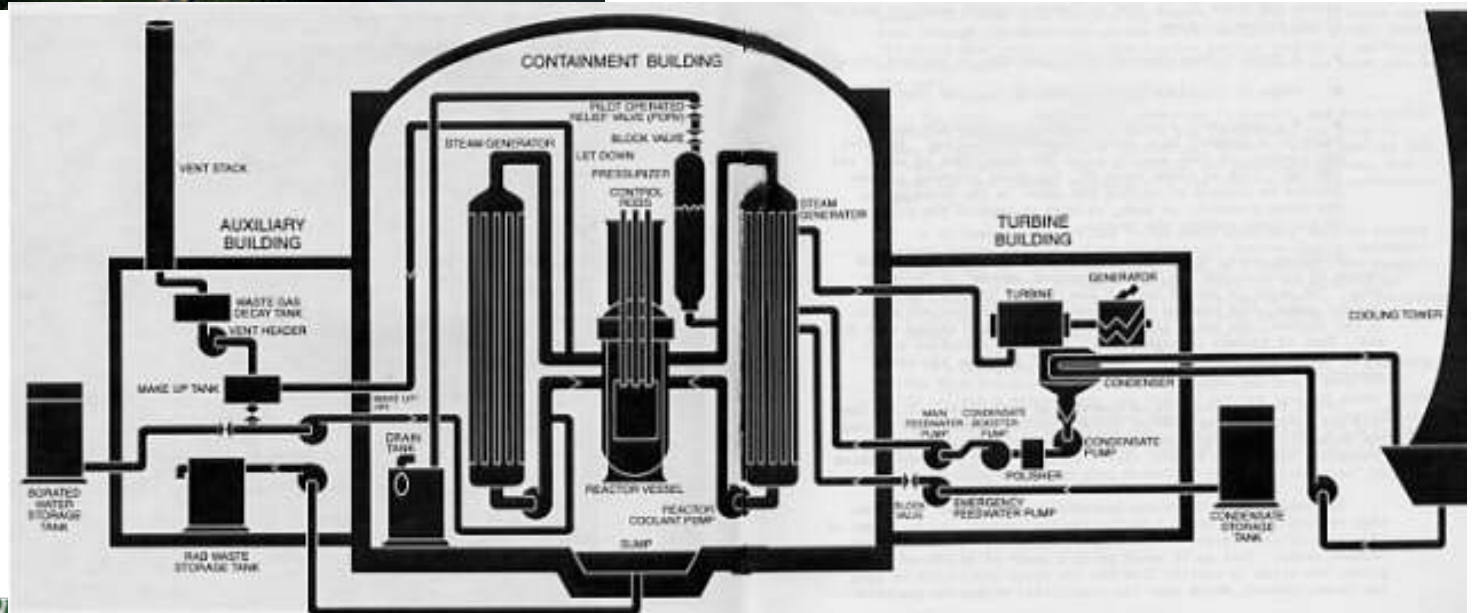
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TMI-2 Containment



Unit 2
Containment

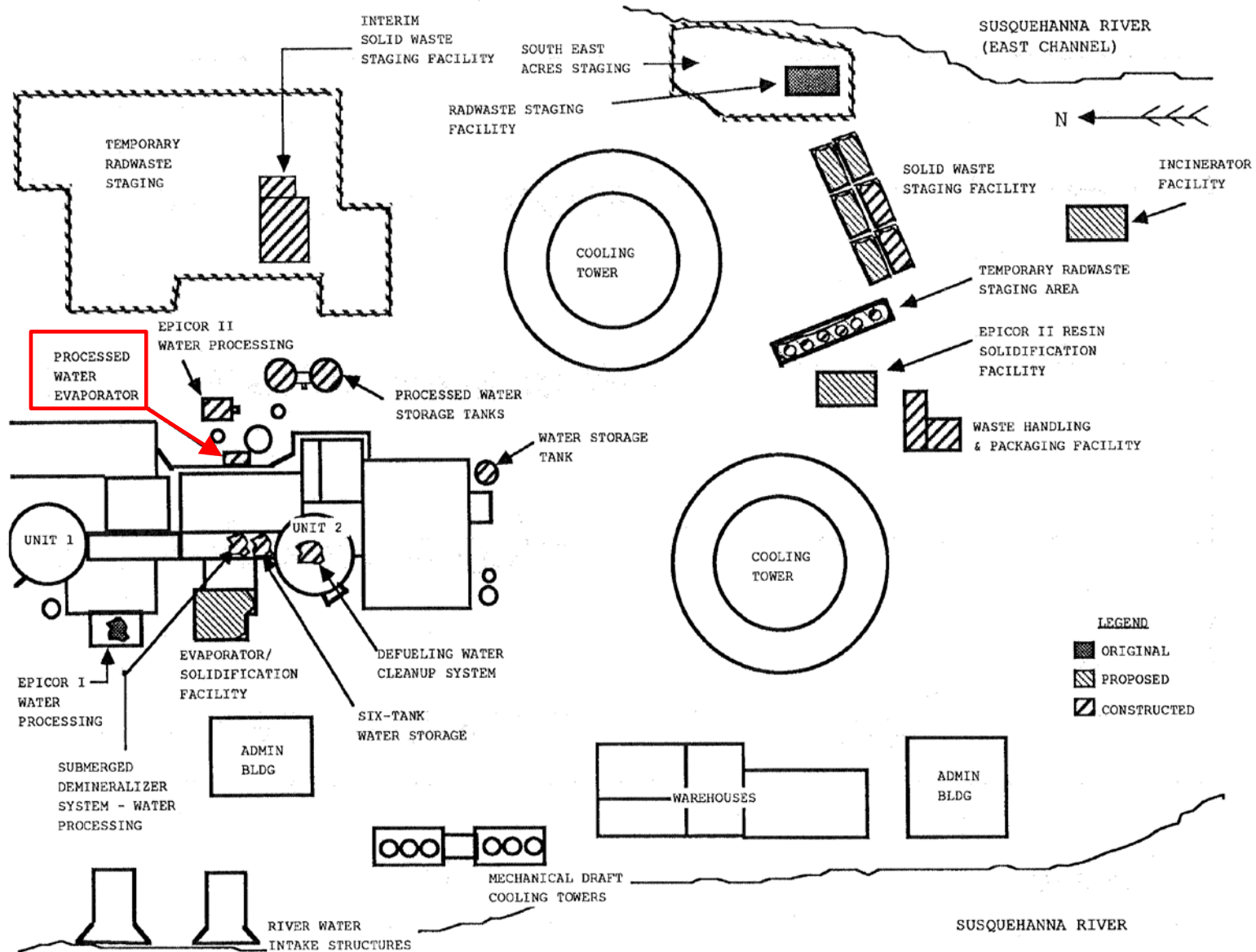


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TMI-2 Waste Management Facilities



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Why Evaporation was Preferred at TMI-2

- From the on-site and owner's viewpoint:
 - Know technology, system design was not complex
 - Could be designed, procured, installed, and operated without outside specialists
 - Reasonable cost
 - No offsite dependencies
 - Could begin in reasonable time

- Why not grouting the tritiated water and transport for disposal?
 - Technically feasible
 - On-site processing systems and buildings
 - Very large number of shipments
 - Very high cost for solidification, transport, and disposal.



Evaluation Method Background

- ❑ The National Environmental Protection Act (NEPA) requires evaluation for government actions affecting the environment
- ❑ Three levels of evaluation; increasing order of complexity:
 - Categorical Exclusion
 - Environmental Assessment
 - Environmental Impact Statement
- ❑ Environmental Impact Statement Topics (General)
 - Environmental Resource Impacts (subject table below)
 - Cumulative Impacts
 - Irreversible and Irretrievable Commitment Of Resources
 - Unavoidable Adverse Impacts

1. Land Use	6. Socioeconomic	11. Transportation Safety
2. Geology and Soils	7. Water Resources	12. Traffic
3. Noise	8. Historic Archeological and Native American Resources	13. Environmental Justice
4. Greenhouse Gas Impacts and Climate Change	9. Biological Resources	
5. Air Quality	10. Human Health and Safety	



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TMI-2 Evaluation Method

- ❑ Programmatic Environmental Impact Statement (PEIS)
 - License approval for discharge at TMI-2 is a government action, therefore a PEIS was conducted
 - PEIS conducted by the NRC (using specialists from national laboratories, such as SRNL, PNNL)
- ❑ TMI-2 Impacts see later viewgraph....
- ❑ Note: Separate safety analysis and operating specifications for the evaporator; Similar to NRA approval of Implementation Plans for Fukushima Daiichi operations.



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Nine Options Evaluated by the NRC

Option	Disposition of Tritium	Disposition of Borate*
Evaporation, solidification of bottoms**, and disposal at a licensed burial ground	Atmosphere at TMI	Commercial LLW burial ground
Evaporation, solidification of bottoms, and retention onsite	Atmosphere at TMI	TMI Site
Distillation (closed cycle evaporation), solidification of bottoms, and disposal at a licensed burial ground followed by river disposal of the distillate.	Susquehanna River	Commercial LLW burial ground
Offsite Evaporation at the DOE Nevada Test Station (NTS)	Atmosphere at NTS	Shallow land burial at NTS
Solidification and permanent onsite storage of solidified waste	Atmosphere at TMI***	Ground at TMI Site
Solidification and disposal at a commercial low-level waste site	Atmosphere at TMI***	Commercial LLW burial ground
Long term (years) discharge to the Susquehanna River	Susquehanna River	Susquehanna River
Short term (days) discharge to the Susquehanna River	Susquehanna River	Susquehanna River
Liquids storage in tanks (the no-action alternative)	TMI	TMI Site

* In every case there would be some cesium-137 and strontium-90 associated with the borate; however, in those options employing re-treatment of the water, the quantity is approximately 1/10 of what it is without retreatment

** "bottoms" refers to the concentrated solids mixed with water in the evaporator.

***** Here is what the NRC PEIS said: Approximately one half of the tritiated water would be released to the atmosphere during the concrete curing processes. Assuming a solidification system that processes water at a rate of 10 gal/min (38 L/min), 5 gal/min (1.9 L/min) would evaporate during curing, releasing tritium at an estimated rate of 41 μ Ci/sec. This rate is 7% of the TMI-2 Technical Specification limits (570 μ Ci/sec). The remaining 50% of the tritiated water would slowly exchange with environmental water until the tritium concentrations were equal.**



Impacts and Range

Impacts	Range of Impacts
Bone dose to the offsite population	0 to 14 person-rem total population (0 to 0.14 person-Sv) 0 to 0.4 mrem to the maximally exposed offsite individual (0 to 4 uSv)
Total body dose to the offsite population	0 to 3 person-rem total population (0 to 0.03 person-Sv) 0 to 5 mrem to the maximally exposed offsite individual (0 to 50 uSv)
Thyroid dose to the offsite population	Up to 6 person-rem total population (0 to 0.06 person-Sv) Up to 4 mrem to the maximally exposed offsite individual (0 to 40 uSv)
Estimated number of radiation-caused cancer fatalities to the offsite population	0 to 0.0004
Estimated number of radiation-caused genetic disorders to the offsite population	0 to 0.002
Occupational dose	0 to 25 person-rem (0 to 0.25 Sv)
Estimated number of radiation-caused cancer fatalities to the worker population	0 to 0.003
Land commitment	0 to 49,000 square feet (0 to 4552 square meters)
Radioactive waste burial ground volume	0 to 460,000 cubic feet (0 to 13,026 cubic meters)
Cost to the Licensee	\$100 thousand to \$41 million
Time to complete	0 to 36 months
Number of traffic accidents	0 to 12
Estimate number of traffic fatalities	0 to 0.8
Maximum individual dose from accidents	0 to 60 mrem total body (0 to 600 uSv) 0 to 3000 mrem bone (0 to 30 mSv)
Population dose from accidents	0 to 0.7 person-rem bone (0 to 70mSv) 0 to 0.02 person-rem total body (0 to 0.2 mSv)



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NRC Conclusions (partial)

No alternative was found to be clearly preferable to the licensee's proposed action. The total estimated impact to persons living near TMI and to the work force from any alternative is very small. While the quantitative estimates for some potential impacts (i.e., cost, long-term commitment of space, and time required) were found to vary for some of the alternatives, **these differences were not judged sufficiently large to allow for either identification of a clearly preferable alternative or rejection of any of the nine evaluated alternatives.**

The NRC staff has concluded, based on this evaluation and after considering comments on the draft supplement, that the licensee's proposal to evaporate accident-generated water is an acceptable disposal plan. As identified in this report, evaporation of the water at the TMI site, followed by the solidification and disposal of the remaining low-level radioactive solids **will not significantly affect the quality of the human environment.**



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Fifteen Options Rejected*

Ocean Disposal	Disposal at the Oak Ridge National Laboratory Hydrofracturing Facility
Pond evaporation onsite	Reuse
Distillation and solidification of the distillate	Land spraying at the Nevada Test Site (NTS)
Distillation followed by open cycle evaporation	Combined catalytic exchange treatment
Onsite cooling tower evaporation and concentrates disposal to the river	Water distillation treatment
Deep-well injection at Three Mile Island	High-altitude disposal
Deep well injection at the Nevada Test Site	Open cycle evaporation at Maxey Flats, Kentucky
Crib disposal at Hanford	

* Discussion of reasons are provided on a separate handout



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C. Negin Personal Observations

- ❑ Several evaluations of isotopic separation for waste water were negative; leads me to conclude the same will result for Fukushima Daiichi
- ❑ The NRC's health and safety summary of acceptable options leads me to infer the same will result for Fukushima Daiichi
- ❑ If not allowed to discharge to the ocean at the site, barging to a selected location reasonably offshore should be an option.
- ❑ Regarding Evaporation
 - Operation at the site must consider weather conditions for condensation on the site as well as rain and snow
 - Evaporation could also be done offshore, but would be costly to install and operate on a ship or barge



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Stakeholder Involvement at TMI-2

- Press Briefings; immediately after the accident
- Information meeting with residents in the beginning
- Advisory Panel formed November 1980, 20 months after the accident
- Public invited to submit comments on the Programmatic Environmental Impact Statement (PEIS)
- Eight State agencies were invited to comment on the PEIS



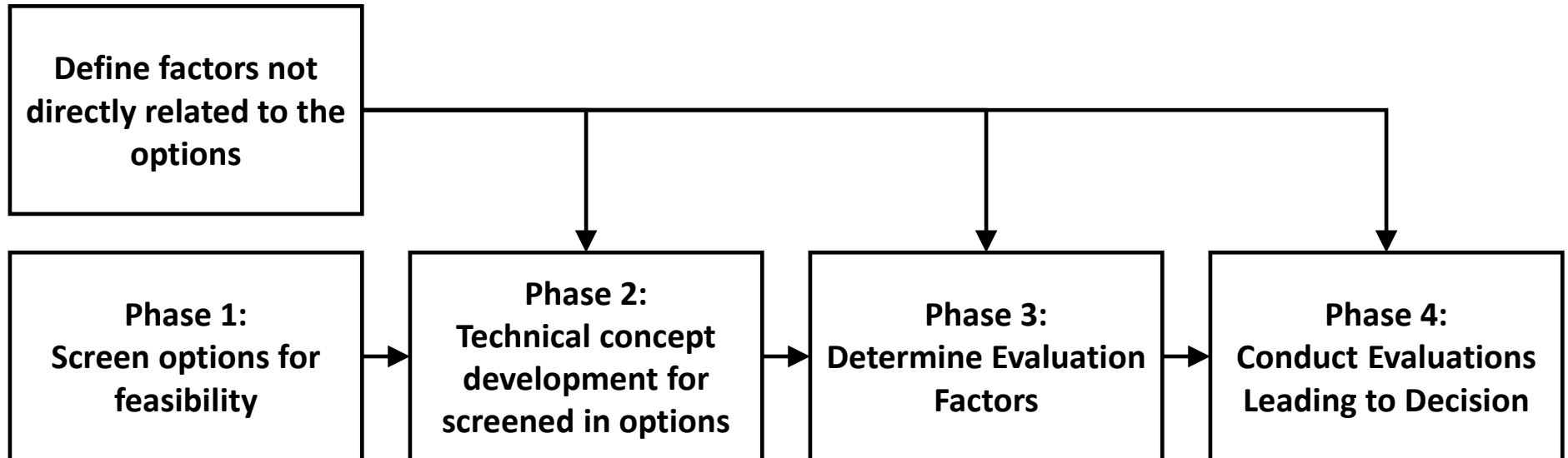
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Considerations for the Path Forward

- ❑ Factors that can affect evaluations
- ❑ Technical sequence for evaluating options:
 - “Screening” to reduce the number options to be evaluated
 - Develop sufficient details for those remaining to support the evaluation
 - Conduct evaluation of the impacts to support decisions



Examples of Factors not Directly Related to the Options

- ❑ Criteria for what is acceptable with regard to dose impact, population dose, maximum exposed individual, and worker
- ❑ Pathways analysis; describe steps, analytical methods to be used, form of results, etc. for dose to humans via all exposure paths for tritium
- ❑ Organization and Stakeholders:
 - Who has prime responsibility for conducting evaluations? NRA? METI? TEPCO?
 - Who will do an independent review of the analysis, what are required qualifications, the review approach, etc.
 - Is a qualified stakeholder group to be involved in following the analyses (like the NRC's advisory panel)?
 - Prefectures' review and public comment submittal and response
- ❑ Interpretation of the London convention; is this "dumping waste" if concentrations are similar to standard discharges from operating plants?
- ❑ Impacts of "no action" (continued storage) for the long term
- ❑ Elements of a monitoring program once an option is selected for implementation



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Phase 1: Screen Options for Feasibility (1)

1. Identify all options to be screened identifying the combination of the following phases as applicable to each
 - Processing/conditioning
 - Packaging/containerizing
 - Transportation
 - Disposal of tritium, other radionuclides (Cs, Sr, etc), and other constituents (e.g., borate)
2. Decide on technical screening factors, such as:
 - Past experience with the method
 - Technology maturity, degree of R&D needed
 - Technical data needed (example, geological conditions for deep well disposal)
 - Will a demonstration pilot plant be needed?
 - Processing rate



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Phase 1: Screen Options for Feasibility (2)

3. Decide on project implementation screening factors, such as:
 - Order of magnitude cost
 - Timeline
 - Effect on other operations
4. Conduct screening (Example: Judgment; maybe Kepner-Tregoe method)
 - Decide if any can be eliminated outright as not feasible
 - Conduct screening to select those for detailed evaluation



Screening Evaluation Approach

- What is the Kepner-Tregoe Method?
- Partially shown in the Criteria and Scoring viewgraphs #10 through #14 in the March 13 presentation by Stuart Knipe
- Scoring and ranking is done by a knowledgeable group of individuals
- When ranking is completed, the final step is to adjust using judgment to consider less tangible factors



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Phase 2: Technical Concept Development

1. Describe functions and steps
2. Concept description identifying facilities, systems, and equipment.
3. Overview description of the operations (for example, with high level process flow diagram, etc.).
4. Environmental and public exposure pathways for the release of water considering tritium, other residual radionuclides, total quantity, periods over which the disposal would occur, and other parameters that may be unique to each option.
5. Order of magnitude cost estimate for capital investment, overall project management, operations, and other important cost elements.



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Phase 3: Determine Evaluation Factors

1. Environmental Resource

Impact factors

- Land use
- Geology and soils
- Noise
- Greenhouse gas
- Air Quality
- Socioeconomic
- Water resources
- Historical preservation
- Biological resources
- Transportation safety
- Traffic impact

2. Human Health and Safety Factors

- Bone dose to the offsite population
- Total body dose to the offsite population
- Thyroid dose to the offsite population
- Estimated number of radiation-caused cancer fatalities to the offsite population
- Estimated number of radiation-caused genetic disorders to the offsite population
- Occupational dose
- Estimated number of radiation-caused cancer fatalities to the worker population
- Maximum individual dose from accidents
- Population dose from accidents

3. Implementation factors

- Laws, treaties, regulations, and standards that could be a barrier
- Radioactive waste burial ground volume
- Cost
- Time to complete



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Phase 4: Conduct Evaluations & Decide

1. Evaluate screened options for the selected factors and draft the results
2. Submit for prefecture review and public comment
3. Resolve prefecture and public comments (could require including an option that was screened out)
4. Recommend one or more options for implementation
5. Decide



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At the Hanford Site

- ❑ Disposal of low tritium concentration, high volume tritiated water at Hanford
- ❑ Overall conclusion was that tritium removal technologies are not economically viable for the large volumes of water with low concentrations.
- ❑ Deep well injection selected
- ❑ From December 1995, through August 2010, approximately 416 (15.4 tBq) curies of tritium were discharged in 10^9 liters of water; the concentrations were very low compared with TMI-2.
- ❑ Pacific Northwest National Laboratory is the best source for further details.

TABLE
Summary of Tritium Removal and Mitigation Technologies

Technology	Year Report Prepared						
	1994	1995	1997	1999	2001	2004	2009
Distillation	D, h		D, h	D, h	D, h	D, h	D, h
Gaseous diffusion	D, h						
Laser isotope separation	T, h	T, h	T, h				
Electrolysis	D, h	D, h	D, h				
Combined electrolysis and catalytic exchange (CECE)	D, h	D, h	D, h	D, h	D, h	D, h	D, h
Combined electrolysis catalytic exchange with vapor phase catalytic exchange					D, h		
Membrane separation process	T, l	T, l	T, l				
Cryogenic distillation	D, h	D, h	D, h	D, h	D, h		
Bithermal catalytic exchange		D, h		D, h	D, h	D, h	D, h
Isotopic exchange, air sparge		T, l					
Finely divided nickel catalyst		O					
Separation by Metanetix Inc.		O					
Substituted naphthalene		O					
Crown Ether Complexes		O					
Girdler-sulfide Process			D, h	D, h	D, h	D, h	D, h
Palladium Membrane Reactor							D, h
GE Integrated Systems							D, h
Liquid phase catalytic exchange with solid oxide electrolyte			D, h	D, h	D, h		
Liquid phase catalytic exchange with high-temperature steam electrolysis (Hot Elly)			D, h				
Sulfur resin ion exchange			O				
Metal hydride exchange			T, h				
Soil column discharge	D, l, h		D, l, h	D, l, h	D, l, h	D, l, h	D, l, h
Barrier formation			O	D, l, h	D, l, h	D, l, h	D, l, h
Air sparging			T, l				
Dual-temperature liquid-phase catalytic exchange				D, h			
Tritium resin separation process				T, l	T, l	T, l	T, l
Kinetic-isotope effect for concentrating tritium				T, l	T, l		
Pumping and recharging				D, l	D, l	D, l	D, l
Phytoremediation					D, l	D, l	D, l
Evaporation						D, l	D, l

Maturity:

- D = Demonstrated or developed technology that has been successfully applied in the field
- T = Testing or theoretical stage of development
- O = Observation indicates a potential process needing funding to continue

Applicability:

- l = Technology is applicable to larger wastewater volumes having lower levels of tritium (less than 1.0E-05 Ci/L)
- h = Technology is applicable to smaller wastewater volumes having higher levels of tritium (greater than 1.0E-05 Ci/L)



At the Savannah River Site

- ❑ From Task Force Meeting 1 presentation
 - Overview of the Savannah River Site
 - Status and Practicality of Detritiation WSRC-RP-96-0075 is related to environmental remediation
- ❑ P Reactor Disassembly Basin Evaporation during In Situ Decommissioning (Entombment) in 2010
- ❑ Tritium Separation Processes
- ❑ Savannah River National Laboratories is the best source for further details



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TMI-2 Evaporation Operations

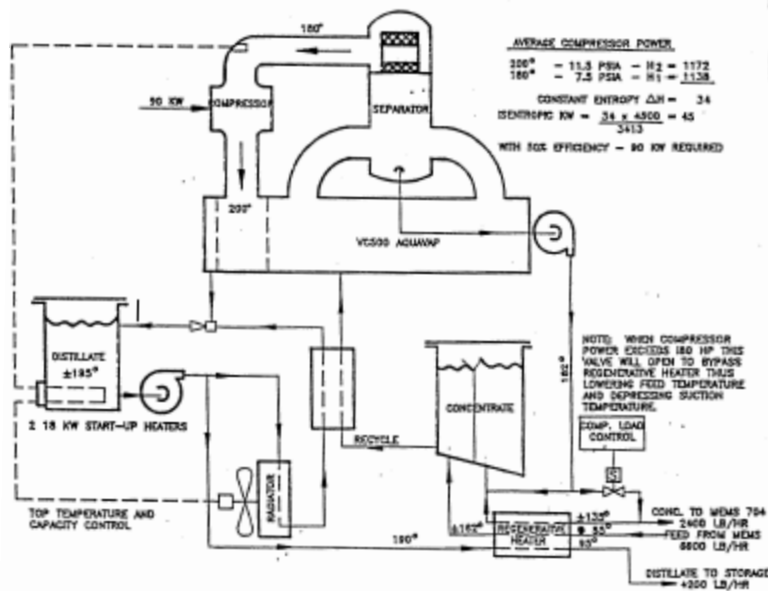
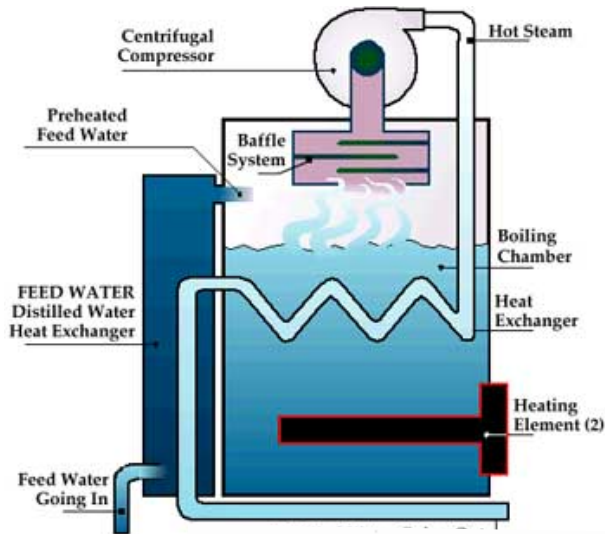


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Vapor Compression Distillation

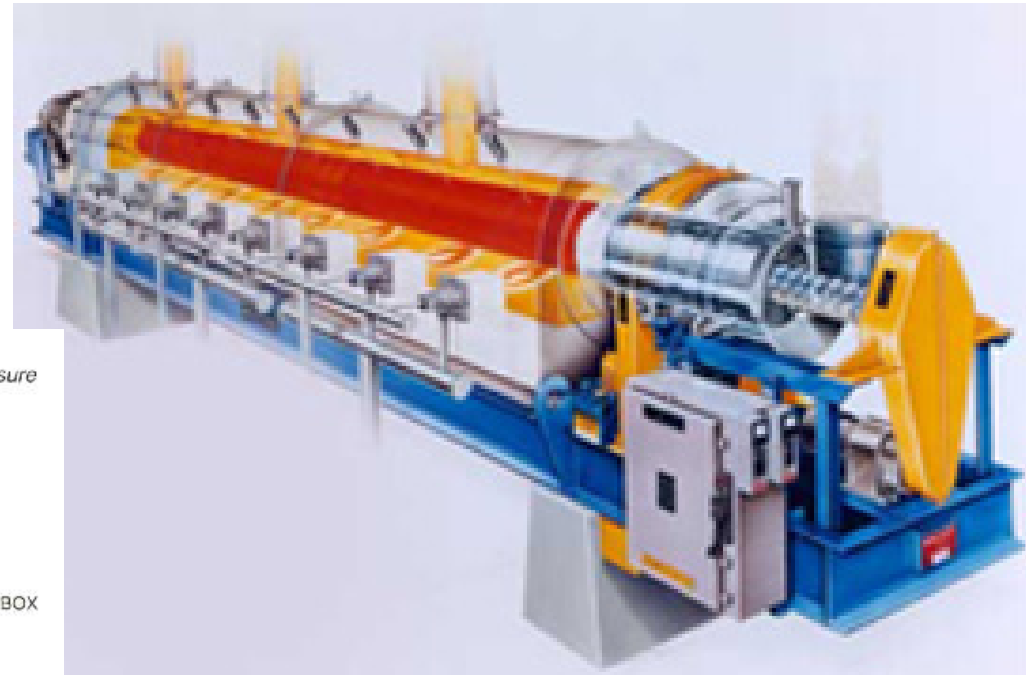


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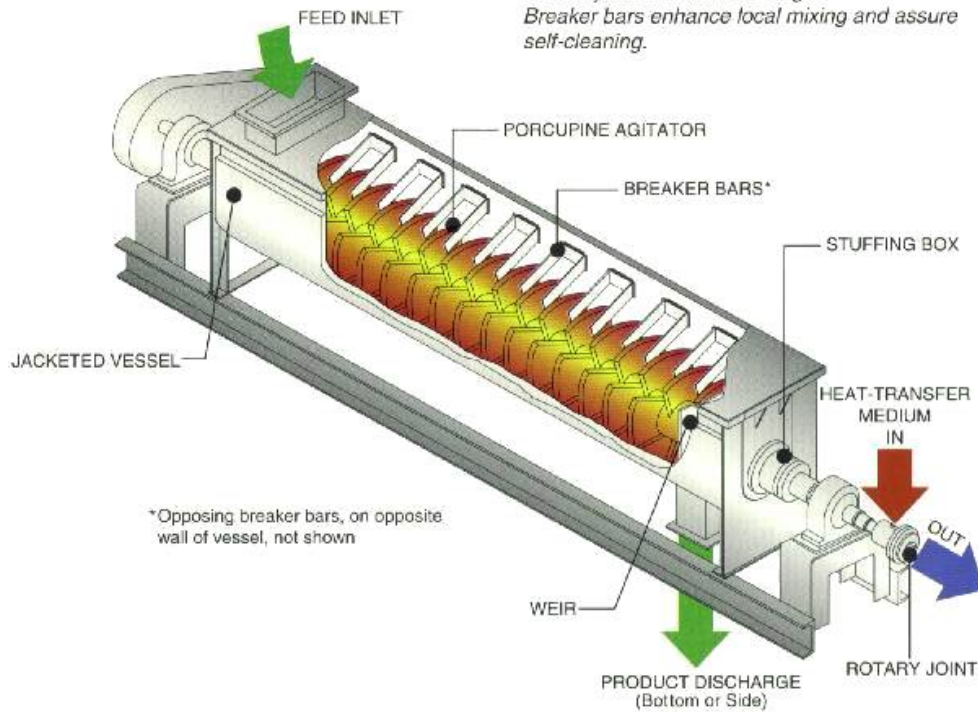
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Calciner



*Cutaway shows unitized design.
Breaker bars enhance local mixing and assure
self-cleaning.*

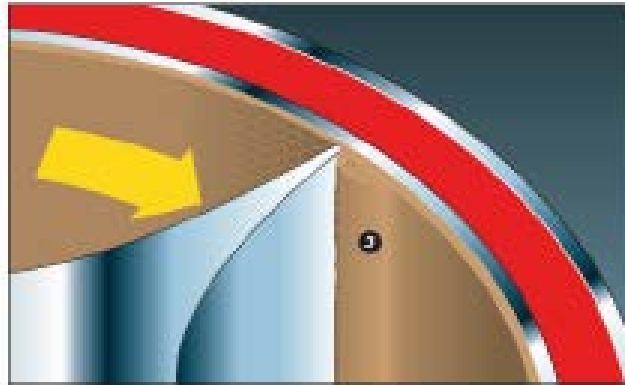


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Wiped Film Evaporator



An inherently simple device, the LCI agitated thin-film processor consists of two major assemblies: a heated body and a rotor. Product enters ❶ above the heated zone and is evenly distributed over the unit's inner surface by the rotor. As the product spirals ❷ down the wall, bow waves ❸ developed by the rotor blades generate highly turbulent flow, resulting in optimum heat flux and mass transfer.

Volatile components are rapidly evaporated. Vapors flow either countercurrently ❹ or co-currently ❺ through the unit, depending on the application. In both cases, vapors are ready for condensing or subsequent processing.

Nonvolatile components are discharged at the outlet ❻. Continuous washing by the bow waves minimizes fouling of the thermal wall where product or residue is concentrated most.

The combination of

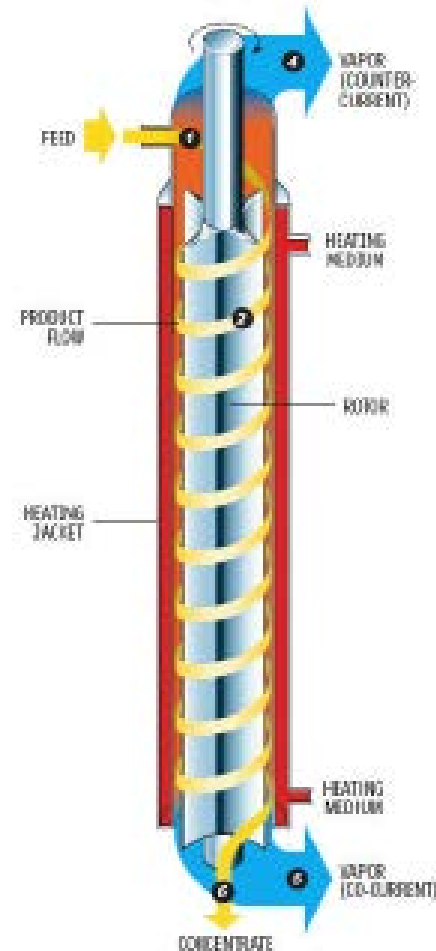
- extremely short residence time
- high turbulence
- narrow residence time distribution
- rapid surface renewal

permits the LCI thin-film evaporator to successfully handle heat-sensitive, viscous, and fouling-type fluids.

HEAT TRANSFER RATES, PROCESS PARAMETERS

System design must consider many variables such as feed rate, temperature, rotor speed, blade clearance, wall thickness, construction materials, and the physical and thermodynamic properties of processed materials.

These variables are interrelated in how they affect performance. Selecting the optimum combination to best solve your processing problems is just one of LCI's valuable services.



CONCEPTUAL REPRESENTATION OF A VERTICAL AGITATED THIN-FILM PROCESSOR

Source: <http://www.lci.com>

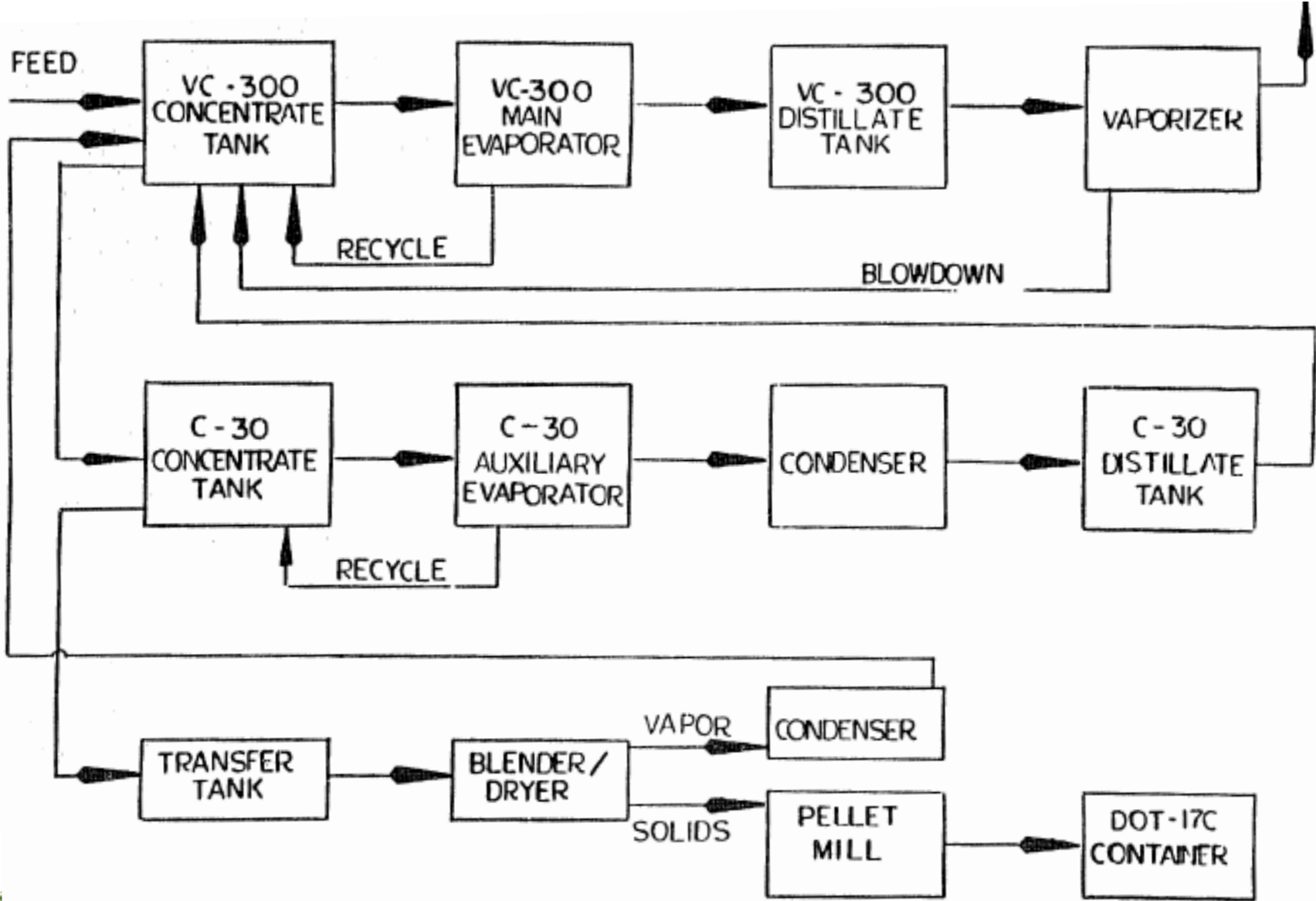


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Process Water Disposal System Block Diagram



Block Diagram Description

The PWDS disposed of the AGW via a two-stage evaporation process.

The PWDS consists of:

1. a vapor recompression distillation unit (main evaporator) that distilled the processed water in a closed cycle and recycled the purified distillate for subsequent release by vaporization;
2. an auxiliary evaporator that further concentrated the bottoms from the main evaporator;
3. a flash vaporizer unit that heated and vaporized the purified distillate from the main evaporator and released the vapor to the atmosphere in a controlled and monitored manner;
4. a waste dryer that further evaporated water from the concentrated waste, and produced a dry solid: and
5. a packaging system that prepared the dry solid waste in containers acceptable for shipment and burial in a commercial low level radioactive waste disposal site.



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Evaporation Timeline

1980	The Susquehanna Valley Alliance, based in Lancaster, successfully prevented GPU/Met Ed from dumping 700,000 gallons (2650 metric ton) of radioactive water into the Susquehanna River.
December 1990	GPU began evaporating 2.3 million gallons (8706 metric tons) of accident generated radioactive water (AGW). The evaporator was shut down two days after operations commenced due to mechanical problems.
January 1991	The evaporator was shut down four times due to electrical and mechanical "difficulties."
February 1991	An operator "inadvertently flooded the vaporizer" and several days later an operator was discovered "apparently sleeping."
March, 1991	A "small quantity of accident generated water was vaporized" without being processed.
April-May 1991	The evaporator was shut down for most of this period so GPU could "rewrite the main operating procedure." The Nuclear Regulatory Commission (NRC) issued a Notice of Violation related to evaporator operations
February 1992	The evaporator was shut down again due to the failure of the blender dryer. Replacement of the blender was delayed until August.
May 1992	GPU decided to use a "temporary" blender-dryer until a permanent replacement was installed in August..
August-Sept. 1992	Some of the water in the evaporator's borated water storage tank was "processed" twice due to "slightly higher activity levels."
Nov. 1992	Approximately 600,000 gallons (2271 metric tons) of AGW was processed twice due to "slightly higher activity levels."
August, 1993	Evaporation of 2.3 million gallon (8706 metric tons) of AGW was completed over six months behind schedule. The evaporator will be disassembled and removed from the site by October, 1993.
October 28, 1993	According to the Pennsylvania Department of Environmental Resources, the total activity during evaporation was 658 curies (24.3 teraBq)of tritium or 1 to 1.3 mR (.01 to .013 mSv) dose to the public.



Summary of the Evaluation of Alternatives for Tritiated Water Disposal from the TMI-2 Site

1. Introduction

The information in this brief was extracted from the June 1987 NUREG-0683, [final] Supplement No. 2, titled Programmatic Environmental Impact Statement Related to Decontamination and Disposal of Radioactive Wastes Resulting from March 28, 1979 Accident; Three Mile Island Nuclear Station, Unit 2. Note that some of the quantities (example, Ci of tritium) in the following were estimates prior to the evaporation of the water. *C. Negin, March 2014*

2. Tabulation of Alternatives Evaluated by the U.S. NRC

Option Evaluated	Retreatment (a)	Disposition of Tritium	Disposition of Borate (b)
1. Evaporation, solidification of bottoms, and disposal at a licensed burial ground	No	Atmosphere at TMI	LLW burial ground (c)
2. Evaporation, solidification of bottoms, and retention onsite	Yes	Atmosphere at TMI	TMI Site
3. Distillation, solidification, and disposal of bottoms followed by river discharge.	No	Susquehanna River	LLW burial ground
4. Offsite Evaporation at the NTS (d)	No	Atmosphere at NTS	Shallow land burial at NTS
5. Permanent on-site storage of solidified waste	Yes	Atmosphere at TMI	Ground at TMI Site
6. Solidification and disposal at a commercial low-level waste site	No	Atmosphere at TMI	LLW burial ground
7. Long term river discharge	Yes	Susquehanna River	Susquehanna River
8. Short term river discharge	Yes	Susquehanna River	Susquehanna River
9. Liquids storage in tanks (the no-action alternative)	No	TMI	TMI Site

(a) Retreatment of the accident-generated water means processing all of the water, including that currently in storage, with the SDS and EPICOR II systems.

(b) In every case there would be some cesium-137 and strontium-90 associated with the borate; however, in those options employing retreatment of the water, the quantity is approximately 1/10 of what it is without retreatment

(c) A commercial NRC-licensed site for low-level radioactive waste disposal. The site operated by U.S. Ecology near Richland, Washington is assumed.

(d) NTS = DOE Nevada Test Site, a DOE facility

Summary of the Evaluation of Alternatives for Tritiated Water Disposal from the TMI-2 Site

3. Overall Summary by the U.S. NRC

The Final Programmatic Environmental Impact Statement related to decontamination and disposal of radioactive wastes resulting from March 28, 1979, accident Three Mile Island Nuclear Station, Unit 2 was issued as NUREG-0683 by the U.S. Nuclear Regulatory Commission (NRC) in March 1981. That document discussed a variety of alternatives for disposal of water contaminated as a result of the accident (accident-generated water), and concluded that a decision could "... be deferred until after the water has been processed. Then the concentration of radionuclides remaining in the water will be low enough for the water to be stored safely onsite until the disposal decision is made." As a supplement to the PEIS, this document should be considered part of the earlier PEIS. For completeness, refer to the PEIS for all aspects of the NRC's National Environmental Policy Act (NEPA) review of the TMI-2 cleanup, other than disposal of accident-generated water, which is the subject of this supplement.

The initial processing to remove most of the radioactive material from the water contaminated as a result of the TMI-2 accident has now been completed, and much of the water is currently being used for cleanup, primarily for decontamination and/or shielding applications. The licensee, GPU Nuclear Corporation, has indicated, based on operational experience, that final processing prior to disposing of approximately 2.3 million gallons (8.7 million liters) will result in the following levels of activity: 1020 curies of tritium, between 0.03 and 0.29 curies of cesium-137, 0.08 to 0.9 curies of strontium-90, about 0.87 curies of carbon-14, and lesser amounts of other radionuclides. The water will also contain nonradioactive contaminants, boron, and sodium. Boron was introduced in the water as approximately 150 tons (136,000 kilograms) of boric acid. Sodium was introduced in the water as approximately 11 tons (10,000 kilograms) of sodium hydroxide.

The licensee has proposed to dispose of the accident-generated water by forced evaporation to the atmosphere, followed by onsite solidification of the remaining solids, and disposal in a commercially operated, NRC-licensed, low level waste burial facility. The disposal volume is expected to be 40,000 to 80,000 ft³ (1,000 to 2,300 m³). In accordance with the requirements of NEPA and the Commission's implementing regulations, the licensee's proposal and a number of alternative approaches were examined for their potential environmental impact.

Nine alternatives were evaluated:

- 1) Evaporation, solidification of bottoms, and disposal at a licensed burial site (the licensee's proposed alternative);
- 2) Evaporation, solidification of bottoms, and retention onsite;
- 3) Distillation (closed cycle evaporation), solidification of the bottoms, and disposal at a licensed burial site followed by river disposal of the condensate;
- 4) Off site evaporation at the U.S. Department of Energy (DOE) Nevada Test Site;
- 5) Solidification and permanent onsite storage of solidified waste;
- 6) Solidification and disposal at a commercial low-level waste site;
- 7) Long-term (years) discharge to the Susquehanna River;

Summary of the Evaluation of Alternatives for Tritiated Water Disposal from the TMI-2 Site

- 8) Short-term (days) discharge to the Susquehanna River;
- 9) Liquid storage in tanks on the Three Mile Island site.

An additional fifteen alternatives were considered but eliminated from further evaluation as being less desirable from a technical standpoint, or clearly inferior to the other alternatives that received more detailed consideration. The range of environmental impacts associated with the alternatives is summarized in Table S.I.

In attempting to identify whether any alternative was clearly preferable from an environmental impact perspective, alternatives were evaluated relative to the risk from radiation exposure both to the public and to workers, the probability and consequences of accidents, the commitment of resources (including costs), and the regulatory constraints. Alternatives were evaluated at a level of detail that is expected to conservatively bound the range of environmental impacts predicted in this report.

The estimated environmental impacts for all the considered disposal alternatives ranged from 0 to 0.003 radiation-induced cancer fatalities in the worker population (i.e., a maximum of 3 chances in 1000 that a single member of the total work force would develop a fatal cancer), 0 to 0.0004 radiation induced cancer fatalities in the offsite population (i.e., a maximum of 4 chances in 10,000 that a single member of the 50-mile offsite population would develop a fatal cancer), and 0.03 to 0.8 transportation-related traffic fatalities in the offsite population (i.e., a maximum of 8 chances in 10 that an individual would be fatally injured). For perspective, the risk of developing a fatal cancer among the 50-mile (80-kilometer) population from water disposal near TMI, as stated above, can be compared with the risk of the expected approximately 440,000 cancer deaths from all causes in the same population. The most significant potential impact associated with any disposal alternative was identified as the risk of physical injury associated with transportation accidents.

No alternative was found to be clearly preferable to the licensee's proposed action. The total estimated impact to persons living near TMI and to the work force from any alternative is very small. While the quantitative estimates for some potential impacts (i.e., cost, long-term commitment of space, and time required) were found to vary for some of the alternatives, these differences were not judged sufficiently large to allow for either identification of a clearly preferable alternative or rejection of any of the nine evaluated alternatives.

In addition to evaluating risks and costs, the staff concluded that there is a benefit to taking relatively near-term action to dispose of the existing accident-generated water. Ultimate disposal of the water is considered a fundamental element in accomplishing the overall cleanup of TMI-2. Relatively near-term action to safely dispose of the water would support the Commission's goal of safe and expeditious cleanup of the facility. Disposal of the water would be required in connection with ultimate decommissioning of the facility and release of the site for unrestricted use. Disposal of the water, regardless of some period of continued storage at TMI, is expected to be required since the water will remain slightly radioactive for several hundred years. The environmental impacts associated with disposal following even a relatively long period (10 to 30 years) of onsite storage are not expected to be significantly different from impacts associated with near-term disposal. Accordingly, the NRC staff further concluded that

Summary of the Evaluation of Alternatives for Tritiated Water Disposal from the TMI-2 Site

the no action alternative of extended storage* of the accident-generated water in tanks on the TMI site was inappropriate, even though it would involve relatively small environmental impact. This alternative, consideration of which is required by NEPA, would not directly result in the disposal of contaminated accident-generated water. Adoption of this alternative would only postpone action, which would ultimately be required to dispose of the existing water without presenting a significant environmental advantage.

A draft supplement was circulated to allow public input to the decision making process. The comments received are incorporated in Appendix A as are transcripts of statements from public meetings of the Commission's Advisory Panel for the Decontamination of TMI-2. Responses to comments received are included specifically in Section 7.0 and in changes and clarifications (designated by change bars) made throughout this final supplement. In addition, and as a result of comments on the draft supplement, three additional alternatives were considered and two previously evaluated alternatives were rejected for detailed evaluation in the final report. Both deep-well injection at the Nevada Test Site and crib disposal at Hanford, Washington were rejected on the basis of comments from DOE. Alternatives involving distillation of accident-generated water were added on the bases of comments and questions raised by persons living in the TMI vicinity. Distillation, solidification, and offsite disposal of residual solids, followed by river discharge of the distillate was evaluated in detail.

The NRC staff has concluded, based on this evaluation and after considering comments on the draft supplement, that the licensee's proposal to evaporate accident-generated water is an acceptable disposal plan. As identified in this report, evaporation of the water at the TMI site, followed by the solidification and disposal of the remaining low-level radioactive solids will not significantly affect the quality of the human environment. The staff has also concluded that any adverse impacts from the disposal program are outweighed by its benefits. Since the Commission has indicated its intent to take final agency action on any proposal for water disposition, the staff will recommend Commission approval of the licensee's proposal. Fully Evaluated TMI-2 Options This is a brief summary of the alternatives evaluated by the U.S. Nuclear Regulatory Commission for disposal of tritiated accident water from the TMI-2 facility.

Summary of the Evaluation of Alternatives for Tritiated Water Disposal from the TMI-2 Site

Table S-1 from the NRC Summary

Impacts	Range of Impacts
Bone dose to the offsite population	0 to 14 person-rem total population (0 to 0.14 person-Sv) 0 to 0.4 mrem to the maximally exposed offsite individual (0 to 4 uSv)
Total body dose to the offsite population	0 to 3 person-rem total population (0 to 0.03 person-Sv) 0 to 5 mrem to the maximally exposed offsite individual (0 to 50 uSv)
Thyroid dose to the offsite population	Up to 6 person-rem total population (0 to 0.06 person-Sv) Up to 4 mrem to the maximally exposed offsite individual (0 to 40 uSv)
Estimated number of radiation-caused cancer fatalities to the offsite population	0 to 0.0004
Estimated number of radiation-caused genetic disorders to the offsite population	0 to 0.002
Occupational dose	0 to 25 person-rem (0 to 0.25 Sv)
Estimated number of radiation-caused cancer fatalities to the worker population	0 to 0.003
Land commitment	0 to 49,000 square feet (0 to 4552 square meters)
Radioactive waste burial ground volume	0 to 460,000 cubic feet (0 to 13,026 cubic meters)
Cost to the Licensee	\$100 thousand to \$41 million
Time to complete	0 to 36 months
Number of traffic accidents	0 to 12
Estimate number of traffic fatalities	0 to 0.8
Maximum individual dose from accidents	0 to 60 mrem total body (0 to 600 uSv) 0 to 3000 mrem bone (0 to 30 mSv)
Population dose from accidents	0 to 0.7 person-rem bone (0 to 70mSv) 0 to 0.02 person-rem total body (0 to 0.2 mSv)

Summary of the Evaluation of Alternatives for Tritiated Water Disposal from the TMI-2 Site

4. Alternatives Considered but Rejected and not Evaluated

Several alternatives for disposal of the accident-generated water were considered but were eliminated from further evaluation as being less desirable from a technical standpoint or clearly inferior to other alternatives receiving more detailed consideration. The bases for these findings included insufficiently developed technology, lack of cost effectiveness, and regulatory and institutional issues not expected to be resolved in a reasonable period of time. These alternatives are briefly described here along with the basis for their rejection.

Note this is not the full text of the NRC's reasoning.

Ocean Disposal

Ocean disposal either as a bulk liquid or as a solidified packaged solid (concentrated in drums) was considered. However, EPA approval under the provisions of 40 CFR Subchapter H would be required. Congressional approval would be required.

A resolution of the London Dumping Convention (IMO 1985), to which the United States is a signatory, has established a moratorium on ocean disposal of radioactive wastes. Therefore, approval is highly unlikely in the near future. Costs are not expected to be substantially less than other, more available options.

Pond Evaporation Onsite

Pond evaporation onsite was considered, but was rejected for two "reasons. First, onsite ponds would collect rain water at approximately the same rate as water would evaporate; therefore, although the tritium would be released to the atmosphere, the total volume of water to be disposed of would not decrease. This drawback might be overcome by the addition of heaters or spray systems to the ponds. However, if this equipment were installed to enhance evaporation, the occupational exposure to tritium would be the highest of any alternative considered, and no significant advantages over a commercial low-level liquid waste evaporator were identified.

Onsite Cooling Tower Evaporation and Bottoms Disposal to the River

On site evaporation in a forced draft cooling tower with the cooling tower blowdown going to the river was considered in the PEIS (NRC 1981) and reevaluated briefly. To implement this alternative, the accident-generated water would be re-treated, and diluted before being fed to the forced draft cooling tower. Approximately 90% of the tritium and 20% to 30% of the cesium, strontium, and boron would be released to the atmosphere. The tritium would be released primarily in water vapor. The cesium, strontium, and boron would be dissolved in water and released in fine water droplets and particulates. The larger droplets would deposit in the immediate vicinity and smaller droplets and particulates would be dispersed over a wider range. The remaining 70% to 80% of cesium, strontium, and boron, as well as the remaining tritium, would be released to the Susquehanna River in the cooling tower blowdown.

This alternative was rejected for the following reasons : the cesium and strontium release to the atmosphere would be 20 to 30 times the amount released using a commercial LLW evaporator; there would likely be areas, at least on- site, where boron deposition would inhibit vegetation growth for some time; the onsite radionuclide concentrations in the vicinity of the

Summary of the Evaluation of Alternatives for Tritiated Water Disposal from the TMI-2 Site

cooling tower would be higher than with other alternatives; and river releases are not eliminated, but merely reduced relative to river disposal of the bulk water.

Distillation and Solidification of the Distillate

Distillation (closed cycle evaporation) of the accident-generated water as discussed in Section 3.1.3 is a more effective means of particulate radionuclide removal than reprocessing by the SDS and EPICOR II system. The alternative using distillation instead of SDS and EPICOR II pretreatment prior to onsite disposal as a solidified solid (as discussed in Section 3.3.1) -was considered. However, since the amount of radioactive material in the water following either SDS/EPICOR reprocessing or evaporation is relatively small, the environmental impacts of solidification/onsite disposal following either procedure would not be significantly different. Thus, except for the relatively higher cost associated with evaporation versus SDS/EPICOR reprocessing (i.e., \$6.2 to 12 million versus approximately \$2.3 million), the environmental impacts of this alternative are similar to those already presented and no further consideration has been given this alternative.

Distillation Followed by Open Cycle Evaporation

The alternative of distillation followed by disposal by open cycle evaporation was considered and rejected. Not less than 99.9% of the cesium, strontium, and carbonate would be retained in the bottoms from either open or closed cycle evaporation. Reducing particulates to 0.0001% of their initial quantity while leaving the concentration of tritium (and iodine if present) unaffected does not warrant the additional cost.

Deep-Well Injection at Three Mile Island

Deep-well injection on the TMI site would require an extensive investigation of the underlying strata to ensure that the requirements of 40 CFR Subchapter D are met (40 CFR 144). The likelihood of finding suitable hydro-geologic conditions is considered small. Following the investigations, state and EPA approval would be required before starting well construction. This alternative for disposal is estimated to require at least five years. There is a high probability that it would not gain approval.

Deep Well Injection at the Nevada Test Site

This alternative requires that the accident-generated water be shipped by truck to the NTS, unloaded into a tank, and injected into underground cavities created by nuclear explosives testing. The accident-generated water would be transported by truck to the NTS. Approximately 420 shipments in 5,000-gallon (19,000-liter) tank trucks would be required. The water would be unloaded into temporary storage tanks from which it would be pumped or drained into a cavity. The geology and hydrology at the NTS make the site ideal for deep-well disposal. Prior injections of liquid waste into wells that discharge into weapons test cavities have demonstrated isolation capabilities (ERDA 1977). The rate of groundwater flow at the NTS and the type of strata are such that further human exposure to the water is unlikely prior to radioactive decay of essentially all of the activity, a process that requires approximately 300 years.

Summary of the Evaluation of Alternatives for Tritiated Water Disposal from the TMI-2 Site

Although this alternative was technically feasible, it was rejected for the reason that it violated a then Department of Energy Policy in its waste management requirements.

Crib Disposal at Hanford

This alternative involves transporting the accident-generated water to Hanford and introducing it into existing in-ground structures for the disposal of low-level liquid radioactive waste. These structures are called cribs. The disposal of low-level (liquid radioactive waste by percolation through the cribs at the Hanford Site is an established procedure, and a feasible alternative for the accident-generated water disposal. Approval from the DOE would be required.

Bulk shipment in 5,000-gallon (19,000-liter) tank trucks is considered more practical than packaged shipment in 55-gallon (200-liter) drums. Bulk rail shipment of accident-generated water might prove feasible but truck shipment was considered more likely. Approximately 420 truck shipments each containing 2.5 curies of tritium, plus traces of cesium and strontium, would be required. Shipment by tank trucks is allowed under the provision of 49 CFR 173, and would require about 9 to 18 months, depending on the number of trucks available and the shipping distance.

Although this alternative was technically feasible, it was rejected for the reason that it violated a then Department of Energy Policy in its waste management requirements.

Disposal at the Oak Ridge National Laboratory Hydrofracturing Facility

Disposal of the accident-generated water at the Oak Ridge National Laboratory (ORNL) hydrofracturing facility involves transporting the bulk accident-generated water to ORNL where it would be mixed with grout and injected into the ground under sufficient pressure to fracture the strata. The mixture would then harden to fix the water in a solid sheet in the strata.

Additional facilities at ORNL and the approval of DOE would be required. The estimated seven-year disposal time and the fact that the cost would not be less than the cost of trucking the accident-generated water were the reasons that precluded further consideration of this alternative.

Reuse

Disposing of the all the accident-generated water (either in its present form or as a residue following evaporation) by reuse in other reactors or facilities was considered and found to be impractical. The licensee 's proposal indicated that accident-generated water, especially if concentrated by evaporation, contains impurities (e.g. river silt, corrosion products, sulfates, phosphates, carbonates, and biological debris) that are not acceptable for use in reactor cooling systems.

For use in other reactors, the accident-generated water would be comingled with RCS liquids, collected as normal plant letdown, processed through plant radwaste systems, and released to the host plant liquid waste discharge system. The TMI reactors, other commercial reactors, and DOE reactors were considered for the reuse alternative.

Disposal through reuse at TMI-1 would involve the consumption of approximately 300 gallons (1100 liters) of accident-generated water per day and would require 19 years for disposal. The

Summary of the Evaluation of Alternatives for Tritiated Water Disposal from the TMI-2 Site

19-year disposal period is not desirable; but the alternative was rejected primarily because it has no advantages over other alternatives that result in release to the Susquehanna River.

Reuse at other reactors would require an agreement among utilities to accept the accident-generated water and discharge it at their sites. A wide range of regulatory and institutional issues would need to be resolved and, because reactor coolants are purified by ion exchange, the ultimate environmental release would not be appreciably lower than for other alternatives involving discharge to the environment.

Disposal by reuse at DOE facilities is not practical. The accident-generated water is unsuitable for use in DOE reactors because of the borate concentration, and reuse at other types of DOE facilities did not appear advantageous.

Land Spraying at the Nevada Test Site (NTS)

Land spraying at NTS was considered in addition to pond evaporation and deep-well injection. Transportation considerations are, of course, the same. Additional storage capacity at the NTS would be required because spraying would only be done during favorable climatic conditions. The borate and boric acid salts containing cesium and strontium would remain on the surface, where they could become airborne. In addition, land spraying has no identified advantages over deep-well injection or pond evaporation at the NTS.

Combined Catalytic Exchange Treatment

Methods to remove the tritium from the stable water were investigated. In a method called the combined catalytic exchange treatment, electrolysis is used to produce hydrogen and oxygen gas from the accident-generated water.

The oxygen gas is vented off and the hydrogen gas, which contains the tritium from the original water, is put in contact with the bulk solution. Under these circumstances the liquid phase becomes enriched in tritium and the gas phase becomes depleted in tritium. The gas then may be released. The liquid phase would still require disposal.

Application of this technology to the accident-generated water would require a significant, costly research and development effort because the method has never been implemented on such a large scale and never in the presence of boric acid. Moreover, the partitioning of tritium is incomplete and a relatively large tritium-enriched liquid waste would remain from such an effort. The alternative was therefore rejected in favor of the proven and less costly technology of the other alternatives,

Water Distillation Treatment

Another method for removing tritium from the stable water is by distillation. Distillation columns, in conjunction with catalytic exchange, have been used to produce relatively pure tritium and tritium-depleted water. The technique has proven effective in reducing water containing 3 Ci/kg of tritium to 1 Ci/kg of tritium; however, data are not available to indicate that it would be effective in further reducing the tritium level from its approximately 0.00014 Ci/kg in the accident-generated water. This alternative was also rejected in favor of proven and less costly alternatives.

Summary of the Evaluation of Alternatives for Tritiated Water Disposal from the TMI-2 Site

High-Altitude Disposal

The alternative of high-altitude disposal was rejected because shipping the bulk liquid to the Harrisburg International Airport, loading it in planes, and discharging into the very high atmosphere over the ocean would result in a population dose and a cost that would be considerably higher than other offsite disposal options.

Open Cycle Evaporation at Maxey Flats, Kentucky

Approval to transport the TMI-2 accident-generated water to Maxey Flats, commingle it with the trench water, and process it through the evaporator would involve the Commonwealth of Kentucky and would not have a high probability of approval. It would result in the release of tritium to the atmosphere both onsite and offsite just as other evaporation alternatives would. This alternative was rejected

Path Forward Considerations for Tritiated Water Disposition

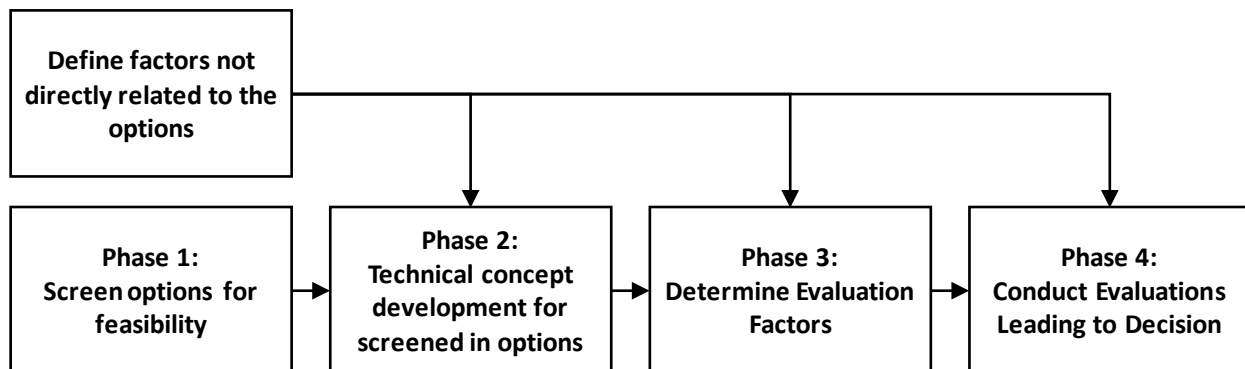
(C. Negin, March 2014)

Purpose

This discussion is offered for consideration by the Tritiated Water Task Force of the Committee on Contaminated Water Countermeasures. It outlines phases (see the figure below) and factors in a management process leading to the selection of a preferred method for disposal of the tritiated processed water from Fukushima Dai-chi site. Some of the factors may be viewed as activities.

The main purpose of this discussion is to provide an idea of the many factors that may be needed to reach a decision on the preferred option for water disposition. It is not intended that the factors listed are complete or that the order in which they are listed is the only way to proceed. For example, there may be several additional activities for involvement of the Fukushima Prefecture and other stakeholder.

The basis for this discussion is history in the United States for: a) programmatic environmental evaluations in general, b) the U.S. NRC's evaluation for the disposition of tritiated water from the TMI-2 accident site, and c) the TMI-2 owner's considerations at the time. It is understood that the process within Japan may differ.



Define factors not directly related to the options

1. Criteria for what is acceptable with regard to dose impact, population dose, maximum exposed individual, and worker
2. Pathways analysis -- describe steps, analytical methods to be used, form of results
3. Organization and Stakeholders:
 - Who has prime responsibility for conducting evaluations? NRA? METI? TEPCO?
 - Who will do an independent review of the analysis, what are required qualifications, the review approach, etc.
 - Is a qualified stakeholder group to be involved in following the analyses (like the NRC's advisory panel)?
 - Prefectures' review and public comment submittal and response
4. Interpretation of the London convention; is this "dumping waste" if concentrations are similar to standard discharges from operating plants?
5. Impacts of "no action" (continued storage) for the long term
6. Elements of a monitoring program once an option is selected for implementation

Path Forward Considerations for Tritiated Water Disposition

(C. Negin, March 2014)

Phase 1: Screen options for feasibility

1. Identify all options to be screened identifying the combination of the following phases as applicable to each:
 - Processing/conditioning
 - Packaging/containerizing
 - Transportation
 - Disposal of tritium, other radionuclides (Cs, Sr, etc), and other constituents (e.g., borate)
2. Decide on technical screening factors:
 - Past experience with the method
 - Technology maturity, degree of R&D needed
 - Technical data needed (example, geological conditions for deep well disposal)
 - Will a demonstration pilot plant be needed?
 - Processing rate
3. Decide on project implementation screening factors
 - Order of magnitude cost
 - Timeline
 - Effect on other operations
4. Conduct screening (example: Judgment; maybe Kepner-Tregoe method)
 - Decide if any can be eliminated outright as not feasible
 - Conduct screening to select those for more detailed evaluation

Phase 2: Technical concept development for screened in options

1. Description of functions and steps
2. Concept description identifying facilities, systems, and equipment.
3. Overview description of the operations (for example, with high level process flow diagram, etc.).
4. Environmental and public exposure pathways for the release of water considering tritium, other residual radionuclides, total quantity, periods over which the disposal would occur, and other parameters that may be unique to each option.
5. Order of magnitude cost estimate for capital investment, overall project management, operations, and other important cost elements.

Path Forward Considerations for Tritiated Water Disposition

(C. Negin, March 2014)

Phase 3: Determine Evaluation Factors

1. Select Environmental Resource Impact factors from among the following
 - Land use
 - Geology and soils
 - Noise
 - Greenhouse gas
 - Air Quality
 - Socioeconomic
 - Water resources
 - Historical preservation
 - Biological resources
 - Transportation safety
 - Traffic impact
 2. Select human health and safety factors (from the NRC approach)
 - Bone dose to the offsite population
 - Total body dose to the offsite population
 - Thyroid dose to the offsite population
 - Estimated number of radiation-caused cancer fatalities to the offsite population
 - Estimated number of radiation-caused genetic disorders to the offsite population
 - Occupational dose
 - Estimated number of radiation-caused cancer fatalities to the worker population
 - Maximum individual dose from accidents
 - Population dose from accidents
- Implementation Factors
- Laws, treaties, regulations, and standards that could be a barrier
 - Radioactive waste burial ground volume
 - Cost
 - Time to complete

Phase 4: Conduct Evaluation Leading to Decision

1. Evaluate screened options for the selected factors and draft the results
2. Submit for prefecture review and public comment
3. Resolve public comments (could require including an option that was screened out)
4. Recommend one or more options for implementation
5. Decide on preferred option



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from the Savannah River Site

Revision 4 Action Memorandum Issued for the Disposition of Water in the 105 P Disassembly Basin at the Savannah River Site

The U.S. Department of Energy (DOE) previously selected the preferred alternative for the non-time critical removal action at the Disassembly Basin within the 105 P Reactor Complex located at the Savannah River Site's (SRS's) P Area. A 30-day public comment period was held for the Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA) from March 13, 2008 to April 14, 2008.

P Area, located in the southeast portion of the SRS, is approximately 14.2 miles from A Area, which is on the northwest edge of the SRS. P Area, which includes Building 105 P, is located entirely in Barnwell County. The Disassembly Basin, a concrete basin inside the 105 P Reactor Building, is comprised of seven interconnected sections and currently has approximately 4.4 million gallons of water over contaminated sediments and reactor activated metal components.

On June 16, 2008, the DOE submitted the Action Memorandum documenting its selection of RSER/EE/CA Alternative #3, Forced Evaporation of the Basin Water, as the preferred alternative to the U.S. Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (ARF #015483; DOE Letter, ACP-08-183). A revised Action Memorandum was issued on September 26, 2008 (ARF #01563; DOE Letter, ACP-08-225). The revised Action Memorandum acknowledged continued use of the 105 P Disassembly Basin to receive potentially contaminated rainwater from basins and sumps within the reactor building and from ancillary facilities.

Revision 3 of Action Memorandum for the 105 P Disassembly Basin (ACP-09-173, dated May 12, 2009) did not modify the original selection of forced evaporation to treat the basin water, but included sending approximately 380,000 gallons of shield water from the 105 R facility over to the 105 P Disassembly Basin for evaporation. The closure of the 105 R Disassembly Basin was being accomplished by placing the grout under the shield water and filling the basin with grout. The original calculations for the closure of the 105 R Disassembly Basin indicated that most of the radiological shield water would need to be transferred for treatment/disposal after completion of the grouting; however, the grouting process actually used all of the shield water. As a result, there will not be a transfer of this water over to the 105 P Disassembly Basin for evaporation.

This revision, Revision 4 of the Action Memorandum for the NTCR Action for Disposition of Water in the 105 P Disassembly Basin, includes the following additional actions:

- Acknowledgement that 380,000 gallons of shield water from the 105 R Disassembly Basin will not be sent to the 105 P Disassembly Basin for evaporation.
- Transfer of up to 300,000 gallons of water, primarily contaminated with tritium, from sources within the R-Area Operable Unit (RAOU), including the 106 R tank and the stack void area pit within the R Reactor building, to the 105 P Disassembly Basin for evaporation. The water is compatible with the water already undergoing evaporation in the 105 P Disassembly Basin. This water must be removed from the RAOU facilities to complete the RAOU CERCLA removal action. SRS will utilize the existing CERCLA Off-site Rule approval for the disposition of this water at the 105 P Disassembly Basin.

Copies of the Revision 4 Action Memorandum (ARF # 17061; DOE Letter, ACP-10-252) are available in the Administrative Record. The Administrative Record is available in the information repositories listed below:

- DOE Public Reading Room at the Gregg-Graniteville Library at the University of South Carolina Aiken campus in Aiken, SC; and
- Thomas Cooper Library Government Documents Department at the University of South Carolina in Columbia, SC.

Hard copies of the Action Memorandum are available at the following locations:

- Reese Library at Augusta State University in Augusta, GA; and
- Asa H. Gordon Library at Savannah State University in Savannah, GA

Paul Sauerborn
Savannah River Nuclear Solutions, LLC
Savannah River Site
Building 730-1B
Aiken, SC 29808
1-803-952-6658
paul.sauerborn@srs.gov