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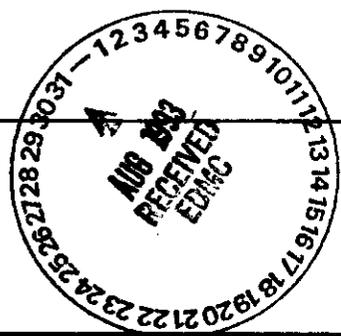
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7. Abstract

The paper examines the need for removal of those contaminants present in Hanford Site double-shell tank wastes, which could potentially require removal before such wastes can be disposed of by incorporation into grout.

A number of technical problems with grout are identified and alternative waste disposal forms examined.

If grout can be produced to meet existing regulatory requirements, no removal of contaminants is considered necessary for those wastes planned to be disposed of before 2001.

A development program is proposed to study alternative technologies to act as a backup for grout.

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**WHITE PAPER**

**GROUT FEED CONTAMINANT REMOVAL**

R. E. Worthington

July 1991

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## EXECUTIVE SUMMARY

This paper examines the contaminants present in Hanford Site double-shell tank (DST) wastes which could potentially require removal before such wastes can be disposed of by incorporation into grout. It especially addresses the wastes planned for disposal before the year 2001. The need for contaminant removal is assessed from regulatory, technical, and economic viewpoints.

A brief history of the evolution of the current design of grout vaults as a disposal system is presented, along with a summary of the present DST waste inventory and a review of future inventory requirements.

The current position with regard to low-level waste disposal, with special reference to grout, is discussed. A number of technical issues have been identified and are being resolved with the help of an independent panel of Westinghouse Hanford Company engineers and scientists, whose findings will soon be published. Issues covered are:

- The long term viability of the asphalt pavement barrier
- The leachability of grout
- The lack of a proven current formulation for grout which meets all physical and regulatory requirements, unless means are provided for removal of the heat generated during the curing period

- The current petition by the states of Washington and Oregon for the Nuclear Regulatory Commission (NRC) to amend regulations to require treatment to remove all radioisotopes, to the extent technically feasible, from waste to be disposed of near surface. This would require extensive pretreatment of all DST wastes before disposal by any means.
- The potential requirement to treat wastes to remove or minimize nitrite, which is classified as Extremely Hazardous Waste (EHW) by the Washington State Department of Ecology (WDOE)
- The potential presence of Environmental Protection Agency (EPA) Land Disposal Restricted (LDR) organic materials in some of the waste.

Solutions to the first three issues, which are grout specific, may be achieved sufficiently to allow disposal of at least part of the DST wastes in a manner which allows current regulatory requirements to be met, while the viability of potentially preferable, alternate disposal solutions are examined. Changes in regulations could modify this situation.

The potentially problematic waste components are identified as transuranic (TRU) isotopes,  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{99}\text{Tc}$ ,  $^{129}\text{I}$ ,  $\text{NO}_2$ ,  $\text{NO}_3$ , organic LDR constituents, and complexing agents. It is shown that none of them presents a restraint, under current regulations, on the disposal of those wastes, double-shell slurry (DSS), double-shell slurry feed (DSSF) and dilute noncomplexed (DN), which are programmed to be grouted before the year 2001. Pretreatment options are presented, as needed, for each component for each of the wastes

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due to be grouted after this date. Such pretreatment could be necessary on waste due for earlier disposal if the regulatory rules change. Pretreatment costs are shown to be high. They are higher in many cases than the remainder of the costs of disposal as grout.

Two approaches are presented as alternative positions if any new treatment should become necessary. The first approach uses extra DST or Liquid Effluent Retention Facility (LERF) capacity to delay disposal of the tank wastes until waste treatment facilities are made available. The second approach uses alternative processes to grout to dispose of the wastes.

Six alternatives are discussed:

- Encapsulation in polyethylene.
- Conversion to glass in containers
- Conversion to a glass aggregate in sulfur concrete
- In situ vitrification
- Conversion to a low temperature mineralized grout
- Conversion to a ceramic encapsulated in Portland cement.

Rough-order-of-magnitude (ROM) costs of each alternative process are presented along with an appraisal of their ranking compared with the current grout process.

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Recommendations are:

- The unit cost of potential pretreatment is so high and sufficient uncertainties exist in the grout program to justify the instigation of a program to study disposal forms alternative to grout as a fallback position. The best alternatives are presently all seen as being vitrification processes, particularly in situ vitrification. A program to develop one or more of these processes in collaboration with Pacific Northwest Laboratory (PNL) should be undertaken at the earliest opportunity.

Such a program should include input from WDOE and NRC. It would include systems engineering studies (including performance assessment, safety and regulatory requirements), leach testing on waste forms, and laboratory and pilot plant development testing.

- Full agreement should be ensured from the WDOE that the presence of nitrate and nitrite at their current concentrations in these wastes will not present any impediment to closure of the grout vaults as landfills.
- The absence from USS, DSSF and DN wastes of organic LDR constituents, at concentrations prohibited by the EPA, should be confirmed at the earliest possible opportunity.
- Assuming that the problems currently associated with the grout facility are successfully resolved, there is no apparent current

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need to remove any radioisotopes from DSS, DSSF, or DN wastes before disposal as grout to satisfy current federal or state regulations or DOE Orders. If the NRC redefines HLW to require treatment to remove radioisotopes from DSS and DSSF waste, this will make pretreatment to remove at least cesium and possibly other species, necessary. This would have significant cost and schedule impact on the disposal of DST LLW at the Hanford Site.

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GROUT FEED CONTAMINANT REMOVAL

## 1.0 INTRODUCTION

Westinghouse Hanford Company (Westinghouse Hanford) has been instructed by the U.S. Department of Energy-Richland Operations Office (DOE-RL) to complete the first four grouting campaigns of double-shell tank (DST) waste by April 1994. This requirement is driven by the perceived need to provide DST space required by the current waste volume projections and is consistent with the recent changes to the *Hanford Federal Facility Agreement and Consent Order* (referred to as the Tri-Party Agreement) as it relates to the grout program. On the basis of analyses performed to date, the waste to be treated during these six campaigns does not contain sufficient transuranic (TRU) material or land disposal restricted (LDR) constituents to require any pretreatment before grouting. Waste scheduled for disposal in subsequent campaigns, however, may, in some cases, require removal of such materials to conform to the requirements of the permits regulating the grout facility.

The current performance assessment of the grout facility shows that the potential impact on the water in the underlying aquifer is strongly influenced by the presence in the wastes of  $^{99}\text{Tc}$ ,  $^{129}\text{I}$ ,  $\text{NO}_2$  and  $\text{NO}_3$ . All of these ions are extremely mobile and have the potential, under adverse conditions, such as severe barrier failure, of reaching the groundwater in concentrations exceeding state and federal government standards. With the asphalt pavement diffusion barrier substantially intact even the worst case scenarios studied gave results no more than one half of the limiting concentration for any of these ions over 10,000 years.

The states of Washington and Oregon have petitioned the U.S. Nuclear Regulatory Commission (NRC) to amend 10 CFR 60.2, through the rulemaking process to ensure that, to the extent technically achievable, all radioisotopes be removed from wastes prior to near surface land disposal. This would require removal of  $^{137}\text{Cs}$  and possibly  $^{90}\text{Sr}$  and other radioisotopes, from wastes at the Hanford Site which are currently classified as low-level waste (LLW). Such a change would prevent these wastes being disposed of in near surface landfills without major pretreatment.

The U.S. Environmental Protection Agency (EPA) prohibits the disposal of Land Disposal Restricted (LDR) materials, such as acetone, methyl ethyl ketone, etc. in surface impoundments and landfills at concentrations above specified levels. The presence of such constituents in the DST waste would prevent near surface disposal in landfills, as currently planned. Measurements taken have shown such chemicals, where present, to be at concentrations well below the levels permitted, but confirmation awaits more extensive sampling and analysis.

Nitrite, in concentrations found in DST wastes and grouts made from them is classified by the State of Washington Department of Ecology (WDOE) as Extremely Hazardous Waste (EHW). As such it could potentially be banned from landfills, the form in which it is planned to close the grout vaults for final disposal.

All of these factors are discussed in this paper. The feasibility, impacts and benefits of removing such elements from the waste before grouting are also assessed. Other possible alternatives are discussed that would allow postponement of treatment. If the decision is made to process the contents of the single-shell tanks (SST), the DST waste could potentially be treated using the same facilities. This would avoid the need to duplicate such facilities, or to provide similar capability to handle the short term needs of the DST program from 1994 until joint SST and DST facilities could be made available at the end of the decade.

Finally, alternative disposal processes to replace grout and resolve problems identified as being generic to LLW and radioactive mixed wastes, will be introduced and compared.

## 2.0 HISTORY

The Hanford Grout Disposal Program was originally conceived in early 1983 as a simple, inexpensive way to convert liquid, low-level, radioactive wastes into a solid, immobile waste form which could be disposed of by near-surface burial. The initial effort envisioned the use of a transportable grout production facility to mix the dry blended grout-forming solids with radioactive liquid waste and place the grouted waste in the void spaces in the SSTs where solidification and stabilization would take place.

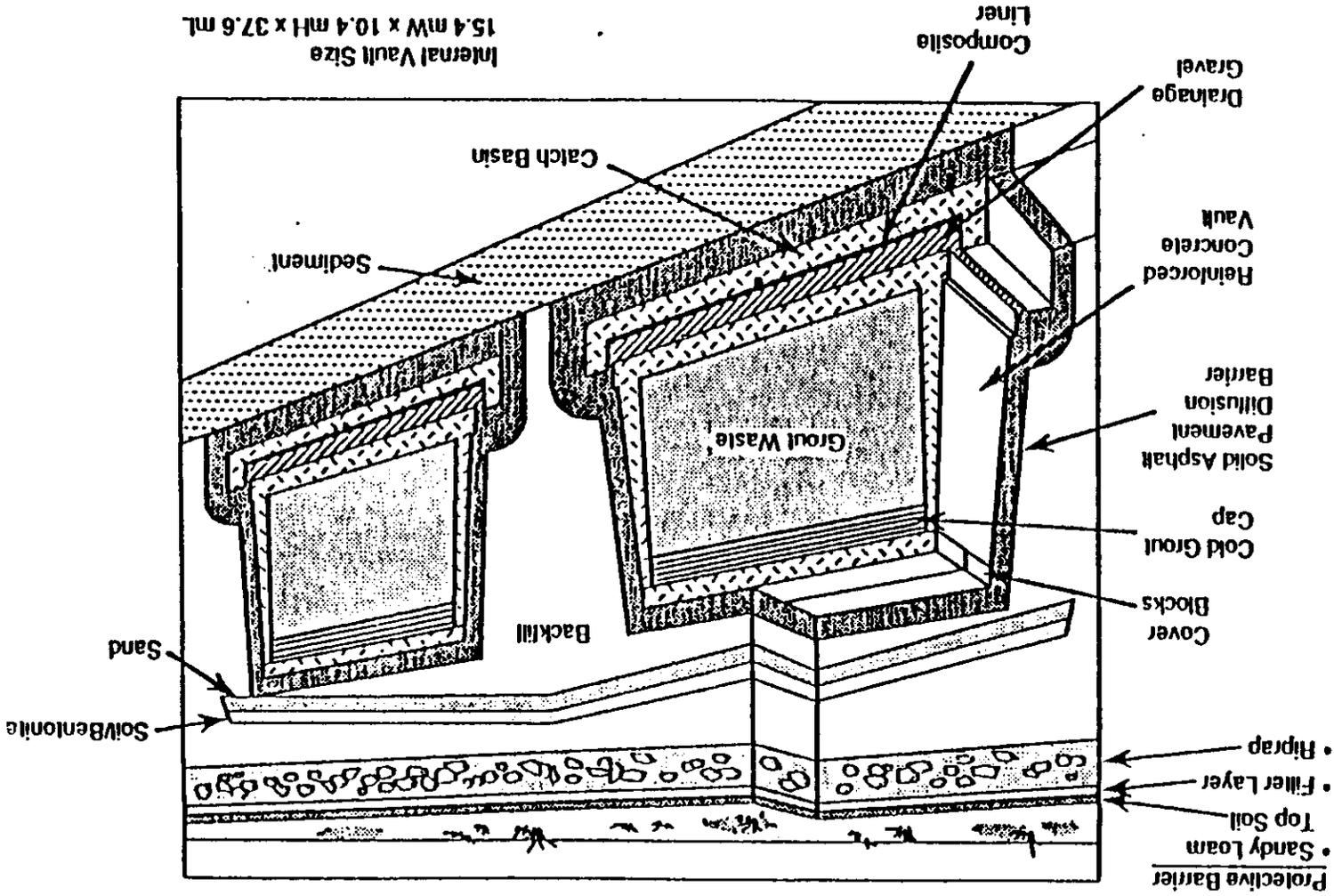
This early concept was abandoned in favor of establishing a selected disposal site where the grouted waste would be placed in trenches. The selection of the disposal site and development of grout facility design and performance criteria was completed in 1984. Meanwhile, grout formulation, performance assessments and regulatory assessments were being developed by the project participants.

During 1985, it became evident that the disposal facilities would likely be required to meet Resource Conservation and Recovery Act (RCRA) requirements (and Washington [State] Administrative Codes [WAC] 173-303). In early 1986, after further examination of disposal system design concepts to incorporate the double liner-leachate collection systems, a decision was made to use reinforced concrete vaults with double liners to satisfy both DOE orders and RCRA requirements for disposal systems.

During the preparation of vault design media in 1986, it was determined that the disposal of future DST waste would require additional barriers to control the release of long-lived soluble radioactive constituents to the soil column and groundwater. Consequently, a decision was made to complete the original vault design to support the disposal of low activity nonhazardous phosphate-sulfate waste (PSW) during the full-scale demonstration run of the grout facility and prepare a modified vault design for the disposal of the DST wastes. Construction of the initial vault was completed in 1988 and facility startup commenced on August 30, 1988.

The design of the current vaults (see Figure 1) was prepared in 1988 with an extensive formal design review conducted during 1989. The current disposal

Figure 1. Current Vault Design.



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system consisting of a coated reinforced concrete vault (upper liner) on top of a lined reinforced concrete catch basin (lower liner) surrounded by a solid asphalt pavement diffusion barrier was adopted in 1990. This barrier is the most significant feature of the disposal system for controlling the release of long lived radionuclides and chemical constituents. A RCRA compliant closure cover is placed over the vaults after filling the vaults with grout. The disposal system design contemplates the placement of the Hanford Protective Barrier sometime after the year 2000.

Construction of the first four vaults for the disposal of DST waste is currently in process and will be completed in time to support the facility startup for the grouting of DST wastes in late 1992.

### 3.0 WASTE CHARACTERIZATION

#### 3.1 WASTE CLASSIFICATION

DST waste is classified according to its content and previous history. Current classes are (Hanlon 1991):

- Aging waste (NCAW)
- Concentrated complexant waste (CC)
- Concentrated phosphate waste (CP)
- Dilute complexed waste (DC)
- Dilute noncomplexed waste (DN)
- Double-shell slurry (DSS)
- Double-shell slurry feed (DSSF)
- PUREX decladding waste (PD/PN or NCRW)
- PFP TRU waste (PT).

These classifications are defined in Appendix B.

#### 3.2 CHEMICAL AND RADIOISOTOPIC ANALYSIS

Source terms for the grout disposal program are derived in the source term document *Waste Disposal Source Term, Grout, Design Criteria, Waste Composition*, WD-SD-WM-TI-355, Rev. 1 (Hendrickson 1990). This is derived from samples taken from three tanks, one of which, 106-AN, is atypical. However, enough data exists in the Tank Farm Databank, and elsewhere, on the contents of 14 other tanks to make meaningful predictions on the pretreatment requirements necessary before disposal as LLW is permissible. The results of these analyses are presented in Table 1. It should be noted that the spread

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of this data is much broader than that used to define the generic source term for the grout project. In particular it shows the wide variation in total ionic strength as indicated by the sodium content. Sodium accounts for over 75% of the cations present and is, therefore, an excellent indicator of the total molarity of the waste. Such variation can have a profound detrimental effect on both the setting rate and the physical and leach properties of grout. Before grouting, therefore, wastes will be blended with dilute waste to a normalized sodium concentration of about 5 M, a concentration at which setting rates of the grout have been satisfactory, and at which most, if not all, of the soluble salts are in solution. Grout will in fact be processing dissolved salts as its primary feed.

Table 2 shows the estimated average chemical composition of all of the DSTs, taken from the DOE Integrated Data Base for 1989, (Spent Fuel and Radioactive Waste Inventories, Projections and Characteristics, DOE/RW-0006, Rev. 5, December 1989).

Table 3 shows the total inventory of representative radionuclides in DST wastes from the same source.

The DSS, DSSF and DN wastes are estimated (Wodrich 1991) to contain between 4.4 and 5.4 million curies of  $^{137}\text{Cs}$  and 0.2 to 0.25 million curies of  $^{90}\text{Sr}$ . This represents, in the case of  $^{137}\text{Cs}$ , about 2% of the total activity in wastes currently stored at the Hanford Site, or 15% of the activity in waste stored in DSTs. The  $^{90}\text{Sr}$  in the DSS, DSSF, and DN wastes amounts to less than 0.5% of the total activity, or 2.5 to 20% of the activity in the DSTs (the wide spread is a consequence of the uncertainty of the amount of  $^{90}\text{Sr}$  in the CC waste). These low fractions of the total activity are the basis for not requiring removal of these isotopes before disposal of the DSS and DSSF wastes. The current configuration of the grout facility will not be processing significant quantities of solids and so the strontium will largely remain unprocessed in these initial grout campaigns.

Recent analytical results [WHC-SD-CP-TP-065 (Welsh 1991) and WHC-SD-WM-PLN-005, Rev. 1 (Hendrickson 1991)] suggest that, at least in a small fraction of the tanks examined, the concentration of those organic LDRs found to exist in the tanks, is much lower than the level at which they are banned from disposal in landfills.

#### 4.0 DST WASTE VOLUME PROJECTIONS

Figure 2 depicts the current disposition of the DST contents as well as one set of projections for the future. It shows that little space remains available if segregation of wastes, as practiced at present, is to be maintained.

The most recent waste volume projections for the DSTs are presented in a letter from J. N. Strode and a DSI from J. N. Strode and G. M. Koreski. They are presented in Appendix A and are summarized in the following paragraphs.

Table 2. Chemical Composition of Current and Future Radioactive Waste In Hanford<sup>a</sup> Double-Shell Tanks.

Component	Composition, wt%
NaNO <sub>3</sub>	14.8
NaNO <sub>2</sub>	5.6
Na <sub>2</sub> CO <sub>3</sub>	1.9
NaOH	7.0
NaAlO <sub>2</sub>	6.0
NaF	0.4
Na <sub>2</sub> SO <sub>4</sub>	0.3
Na <sub>3</sub> PO <sub>4</sub>	0.8
KF	0.4
FeO(OH)	0.2
Organic carbon	1.2
NH <sub>4</sub> <sup>+</sup>	0.08
Al(OH) <sub>3</sub>	4.9
Cr(OH) <sub>3</sub>	0.02
Ni(OH) <sub>2</sub>	<0.1
ZrO <sub>2</sub> ·2H <sub>2</sub> O	0.2
Fission Products	<0.1
H <sub>2</sub> O	56.2
Other	<0.1
TOTAL	100.0
Density, g/mL	≈1.3

<sup>a</sup>Total tank composition. Taken from U.S. Department of Energy, Integrated Data Base for 1989: *Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 5 (December 1989)

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Table 3. Representative Radionuclide Composition (Ci) of Current Radioactive Waste in Hanford Double-Shell Tanks. (Sheet 1 of 2)

Radionuclide	Curies
<sup>14</sup> C	5.29E+02
<sup>55</sup> Fe	3.13E+03
<sup>60</sup> Co	1.06E+04
<sup>59</sup> Ni	3.15E+00
<sup>63</sup> Ni	6.75E+02
<sup>79</sup> Se	6.39E+01
<sup>89</sup> Sr	3.60E+03
<sup>90</sup> Sr	1.16E+07
<sup>90</sup> Y	1.16E+07
<sup>91</sup> Y	1.71E+04
<sup>93</sup> Zr	3.08E+02
<sup>95</sup> Zr	4.06E+04
<sup>93m</sup> Nb	6.82E+01
<sup>95</sup> Nb	9.14E+04
<sup>95m</sup> Nb	3.05E+02
<sup>99</sup> Tc	1.30E+04
<sup>103</sup> Ru	2.02E+02
<sup>103m</sup> Rh	1.82E+02
<sup>106</sup> Ru	4.25E+06
<sup>106</sup> Rh	4.25E+06
<sup>107</sup> Pd	8.01E+00
<sup>110</sup> Ag	1.08E+01
<sup>110m</sup> Ag	8.16E+02
<sup>113m</sup> Cd	4.38E+03
<sup>115m</sup> Cd	1.16E+00
<sup>113</sup> Sn	2.08E+02
<sup>119m</sup> Sn	1.84E+04
<sup>121m</sup> Sn	5.47E+01
<sup>123</sup> Sn	3.60E+03
<sup>126</sup> Sn	1.01E+02
<sup>124</sup> Sb	7.06E-01
<sup>125</sup> Sb	7.68E+05
<sup>126</sup> Sb	1.42E+01
<sup>123m</sup> Te	4.00E-12
<sup>125m</sup> Te	1.87E+05
<sup>127</sup> Te	5.63E+03
<sup>127m</sup> Te	5.74E+03
<sup>129</sup> Te	5.23E-01
<sup>129m</sup> Te	8.04E-01
<sup>129</sup> I	2.58E-01
<sup>134</sup> Cs	5.00E+05
<sup>135</sup> Cs	5.75E+01
<sup>137</sup> Cs	1.65E+07
<sup>137m</sup> Ba	1.56E+07
<sup>141</sup> Ce	2.21E+01
<sup>144</sup> Ce	1.42E+07

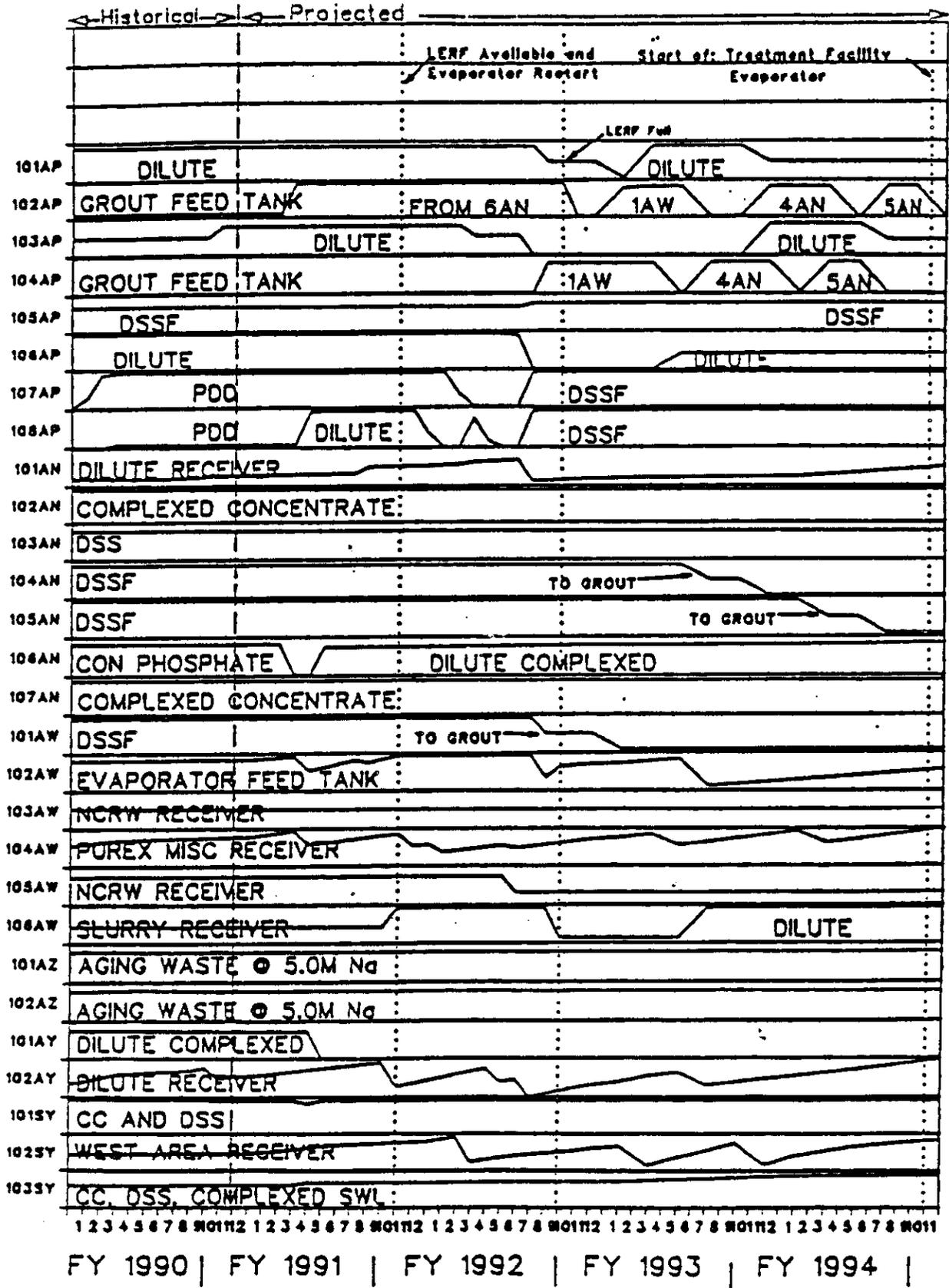
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Table 3. Representative Radionuclide Composition (Ci) of Current Radioactive Waste in Hanford<sup>D</sup> Double-Shell Tanks.  
(Sheet 2 of 2)

Radionuclide	Curies
<sup>143</sup> Pu	3.00E-08
<sup>144</sup> Pu	1.42E+07
<sup>144m</sup> Pu	1.70E+05
<sup>147</sup> Pm	1.66E+07
<sup>148</sup> Pm	1.74E-01
<sup>148m</sup> Pm	3.09E+00
<sup>151</sup> Sm	2.30E+05
<sup>152</sup> Eu	6.45E+02
<sup>154</sup> Eu	9.02E+04
<sup>155</sup> Eu	1.65E+05
<sup>153</sup> Gd	6.05E+00
<sup>160</sup> Tb	9.22E-01
<sup>234</sup> U	5.77E-03
<sup>235</sup> U	4.93E-02
<sup>236</sup> U	1.16E-01
<sup>238</sup> U	9.13E-01
<sup>237</sup> Np	3.92E+01
<sup>238</sup> Np	2.54E-01
<sup>238</sup> Pu	2.96E+02
<sup>239</sup> Pu	3.31E+03
<sup>240</sup> Pu	8.98E+02
<sup>241</sup> Pu	3.97E+04
<sup>242</sup> Pu	9.25E-02
<sup>241</sup> Am	5.28E+04
<sup>242</sup> Am	5.05E+01
<sup>242m</sup> Am	5.08E+01
<sup>243</sup> Am	2.99E+01
<sup>242</sup> Cm	9.44E+01
<sup>244</sup> Cm	1.24E+02
TOTAL	1.11E+08
Specific activity, Ci/L	1.4E+00

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Figure 2. Tank Levels During Four Year Simulation.



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#### 4.1 SHORT TERM PROJECTIONS

Projection to the end of 1994 shows that, with no grouting, the tank capacity would not be exceeded until 1996, assuming that the evaporator restart is not delayed and that a third LERF, is available, as planned, in 1993.

#### 4.2 LONGER TERM PROJECTIONS

Projections to the year 2015 show that after 1994, assuming that processing at Purex does not commence, and that the construction of four new DSTs is complete by 1998, at least four vaults need to be grouted by 1996 in order not to exceed the capacity of available tanks. Another option is to do no grouting but postpone all SST retrieval until after the new tanks are on line in 1998.

#### 4.3 VOLUMES OF WASTE TO BE TREATED

During the period under review, 1994 to 2001, the wastes to be disposed of as grout will be DSS, DSSF, and DN. These wastes are the least likely, under present regulations, to require pretreatment before grouting.

The most current report (Hanlon 1991) gives the present inventory of these wastes and shows total volumes of 0.95 million gallons for DSS, 5.1 million gallons of DSSF and 8.1 million gallons of DN wastes. Allowing for necessary dilution to control cesium concentration and total ionic strength, this corresponds to around 20 to 25 grout vaults. This number requires the grouting of between 3 and 4 vaults per year. See Figures 3 and 4.

In the event that NRC finds in favor of the Washington/Oregon petition and redefines HLW, it will most probably become necessary to remove additional radionuclides, especially cesium and possibly strontium from some or all of the DSS and DSSF wastes before disposal. Assuming that the B Plant facility can be used for this pretreatment and that upgrades are completed as planned by 1997/1998, grouting could begin in 1998 and available tank capacity should be adequate, if the start of SST retrieval is delayed until 1998. Otherwise grouting would need to be delayed until after this date and this would create problems with tank space availability unless other changes are made to the current waste disposal program. If B Plant cannot be used then a delay of several years will occur while any new plant is designed, permitted and built. In this case a complete reevaluation of the waste disposal program and the Tri-Party Agreement timing would become necessary.

#### 5.0 GROUT FORMULATION

Up to this point a satisfactory grout formulation, which meets all physical, regulatory and design requirements, has not been developed for the disposal of DSS and DSSF waste. The cement solid mixes originally developed

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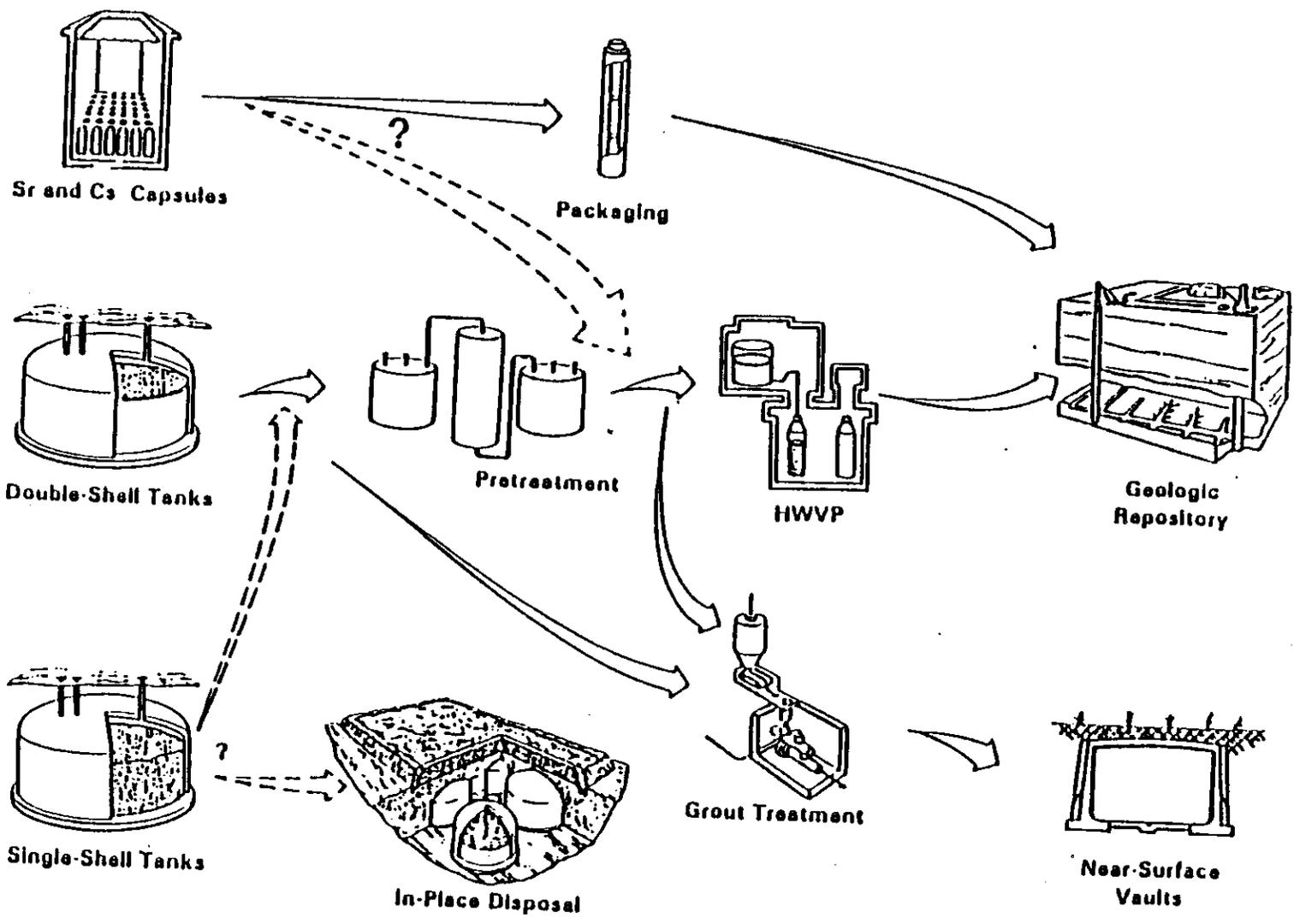


Figure 3. Hanford Waste Management Program.

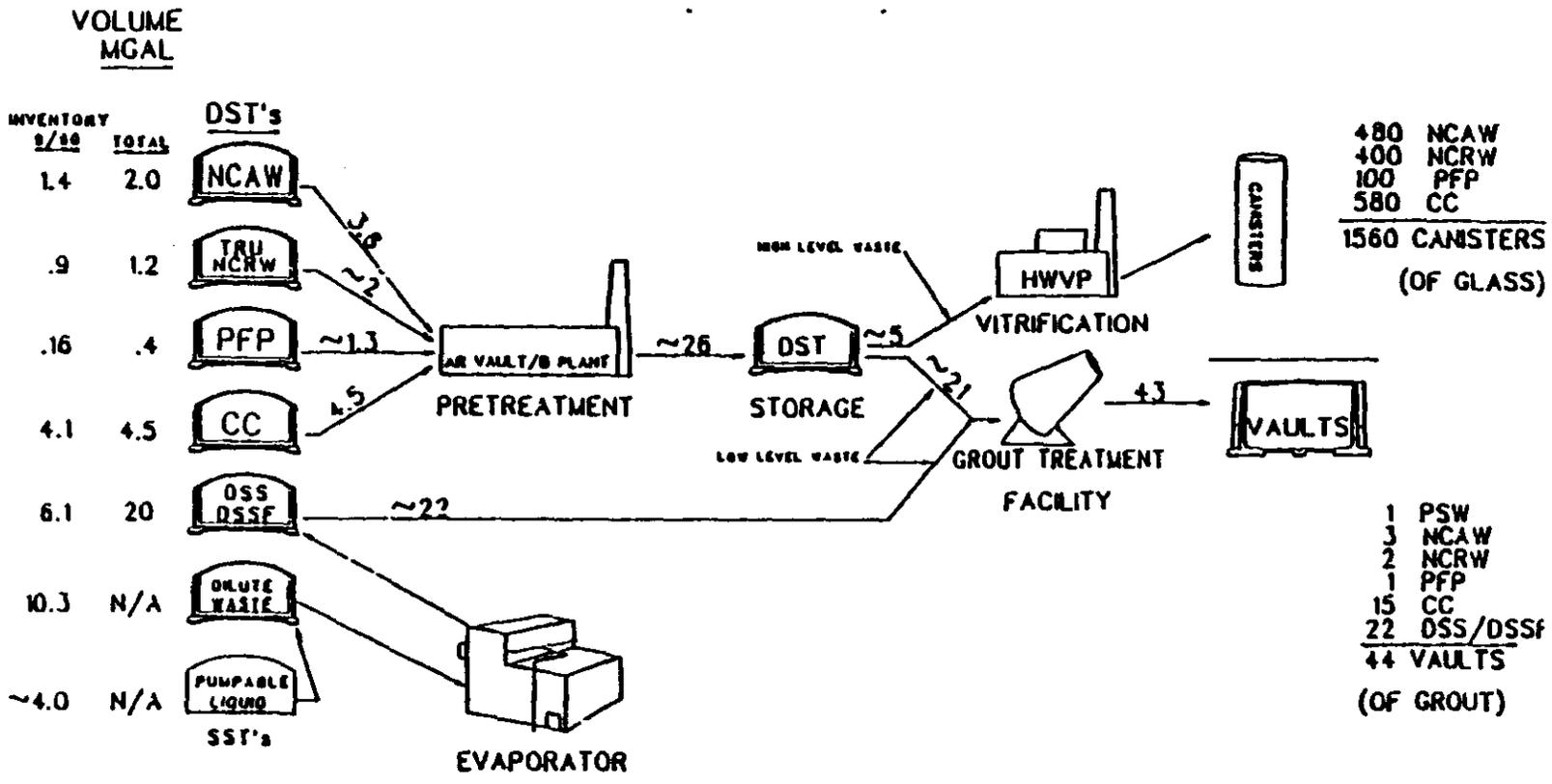


Figure 4. Current Plan--Double-Shell Tanks Liquid Waste Inventory and Flow Diagram for Waste Disposal. (Estimate)

• Based on completing N-Fuels, PWR core II and FFTF fuel reprocessing in PUREX.

1000A

for the first DST grout campaign consisted of Portland cement, 6%; fly ash, 47%; blast furnace slag, 47%. This formulation met regulatory requirements with an ANSI 16 leach index greater than 7, but generated excessive heat, creating temperatures in excess of design, during curing. An alternative formulation containing Portland cement, 6%; fly ash, 27%; basic slag, 27%; and ground limestone, 40% was then tested in an attempt to reduce the temperature generated by the heat of hydration of the active cement solids. This formulation, when used in tests on CP and DSSF wastes, has resulted in temperature rises due to heat of hydration which exceed the design parameters. This excess heat results in reduced leach index, changes in the physical properties of the grout and potentially, degradation of the asphaltic vault liner. Such grouts do not meet the NRC guidelines as set out in *Technical Position on Waste Form* (NRC 1991). This thermal problem, although basically a result of the heat of hydration of the cement solids, is extended in time by the thermal emission of radioisotopes present in the waste. Their rapid decay will minimize their thermal influence after about 30 years.

Four alternatives are being studied as ways to reduce the effect of the heat of hydration:

1. New formulations are currently under study at Pacific Northwest Laboratory (PNL) and Oak Ridge National Laboratory (ORNL). The aim is to develop formulations which generate less heat during curing by using solid grout components which generate less heat of hydration.
2. An alternative solution is to pour the grout in several "lifts," rather than in one continuous pour. This would allow heat to dissipate between lifts and thereby maintain a lower temperature in the grout. This technique requires that several vaults be available for filling at the same time to allow continuous grout production to be achieved.
3. The use of enlarged exhausters to increase the heat removal capacity of the vault.
4. Pretreatment of the waste to remove species creating exothermic reactions during curing of the grout.

For the purpose of this paper it is assumed, on the basis of results to date, that such solutions will be found to be effective in overcoming the heat problem. Should this not prove to be the case, the current grout program appears to be in jeopardy.

It is likely that, because of the variation in individual tank contents, further formulation modifications will be necessary in the future to enable disposal of some DST wastes, such as CC waste, which it is planned to occur after the year 2001. Pretreatment of these wastes to remove radionuclides so as to remove them from classification as HLW is already planned. In addition, in some cases, it may be necessary to additionally pretreat the waste to produce grouts complying with the NRC criteria. Such pretreatment could include acid treatment to reduce the high heat of hydration produced by some aluminum compounds present at high pH and/or removal of cesium from the waste before grouting.

## 6.0 PERMITTING REQUIREMENTS

The current state regulations, DOE Orders and NRC guidelines for grout as a waste disposal form, as presently interpreted, do not make it necessary to remove cesium, strontium, technetium or iodine from the DSS and DSSF waste. The Performance Assessment (PA) shows that none of these isotopes, nitrate or nitrite will enter the environment at concentrations of concern throughout the 10,000-year period modelled, assuming that the barrier system remains intact. Cesium and strontium have decayed to levels of no concern after about 300 years.

The closure of grout vaults could, conceivably, be restricted by the presence of large quantities of nitrite, which is present in DST wastes at levels which cause the waste to be classified as EHW by the WDOE. The EHW is excluded from landfills, although language in Washington law RCW 70.105.050 excludes the Hanford Site from such restrictions under specific circumstances and the current belief in Westinghouse Hanford's Environmental group and the DOE is that this clause does permit closure. Indeed, when the WDOE issues the Part B Permit, it will include closure of the site as a landfill. Should the presence of EHW in the waste create a closure problem in the future, the removal or destruction of nitrite in grout feed wastes could become an issue.

The EPA has prohibited the disposal of organic LDR components, such as acetone, methyl ethyl ketone, etc. in land disposal systems if their concentration exceeds specific limits. Should such LDR components turn up in prohibited concentrations in DST wastes, this issue could prevent DST LLW being allowed in the surface impoundment, without removal of such LDRs, unless WDOE is prepared to issue a variance. Up to the present they create no cause for concern at the concentrations present in the only tank analyzed, Tank 106-AN.

## 7.0 WASTE PRETREATMENT PRIOR TO GROUTING

As discussed above, potential problems have been identified for a number of waste components, although current interpretation of the various regulations opines that none of them presents a regulatory reason to pretreat the CP, DSSF or DSS wastes. Any change in the definition of HLW by NRC could change the rules and require removal of cesium and, possibly other radioisotopes from the DSS and DSSF wastes prior to disposal as LLW.

A decision by WDOE that the presence of nitrite in the grout would prevent closure of the vaults as a landfill would require at least partial removal or destruction of this ion before grouting the waste and could result in a reappraisal of grout as the preferred mixed LLW disposal form.

Other wastes, both DST and possibly SST, to be treated in the future will, in most cases, require pretreatment to remove specific radioisotopes or other chemicals before disposal as grout is permissible. Such components and potential means for their removal from wastes are explained in the following sections.

## 7.1 TRANSURANIC ISOTOPES (TRU)

The presence of TRU is not permissible in Class C LLW at concentrations greater than 100 nCi/g. This level is exceeded in both aging waste (NCAW), in concentrated complexant waste (CC), and in waste (PT) from the Plutonium Finishing Plant (PFP). Removal of TRUs to acceptable levels from these wastes will be required before they can be disposed of in grout. Two methods are being proposed for such removal from both applicable SST and DST wastes.

The first method is applicable to wastes such as NCAW, where almost all of the TRU is present in the undissolved solids. The solids are separated from the supernatant liquid and then thoroughly washed before being sent for disposal along with other HLW. The washings along with the supernatant are sent for disposal as grout.

The second method is the Transuranic Extraction (TRUEX) process. It is planned to use this process for treatment of those wastes, such as CC wastes, where the TRU is held in solution by complexing agents, and for NCRW and PT wastes where large amounts of other solids swamp the TRU solids. In these cases the waste is acidified to place the TRU solids in solution and the resulting solution subjected to solvent extraction using CMPO (a commercially available substituted phosphine oxide extractant) and tributyl phosphate in a paraffin hydrocarbon diluent. The TRU is then recovered from the extract and processed as HLW. The raffinate from the process is disposed of in grout. By this means the amount of waste treated as HLW is minimized, thereby reducing the overall cost of waste disposal.

No TRU problem is known to exist for the DSS, DSSF, or DN wastes which are to be treated before the year 2001.

## 7.2 <sup>137</sup>Cs and <sup>90</sup>Sr

The current problems with these isotopes are related to the radiation generated by their radioactive decay and to the heat generated by this decay.

The heat generated by these isotopes, or more accurately by their short lived daughters, results in a temperature rise in the grout (or other waste form), which peaks at about 15 to 20 years after grouting. If this temperature maximum exceeds the limits set for the concrete in the vault walls or in the grout itself, reduction in the concentration of cesium in the waste will become necessary before it can be grouted. The controlling criteria will vary not only with the waste composition, but also with any change in vault design. An assessment of the cesium content of the waste in each tank will be necessary before each grout campaign can be undertaken.

The half-life of these isotopes, about 30 years, means that the amount of radiation decreases over a period of 200 to 300 years to levels of little or no concern. The high level of initial radiation, however, requires that the vaults be buried below ground level for shielding. This results in a considerably more complex vault system design than is the case at the DOE Savannah River Site (SRS) (Wilhite 1990 and Wodrich 1991). Lower radiation levels would also have operational benefits by reducing dose and simplifying, in particular, maintenance and sampling.

The precipitation techniques used at SRS to precipitate the cesium, using tetra phenyl boron, are not applicable to the Hanford wastes, mainly because of the large concentration of potassium ion present in the latter. This potassium would be precipitated along with the cesium thereby requiring excessive amounts of the extremely expensive reagent and resulting in massive volumes of precipitated solids. Removal of the cesium ion from the wastes at Hanford requires a comparatively expensive ion exchange technique. Tetra phenyl boron treatment introduces benzene into the wastes, which would create an additional safety and environmental problem.

Strontium tends to be present in the precipitated solids in the DSTs and will, therefore, be removed along with the TRU solids and sent to HWVP in those cases where sludge washing is used to separate these solids. In the case of CC wastes where TRU will be extracted from acidified solution a currently undeveloped, solvent extraction technique for strontium, which is a modification of the TRUEX process called SREX, could potentially be used. Both processes result in increased waste volumes for disposal. In any case  $^{90}\text{Sr}$  is a beta emitter and makes a much smaller contribution to dose than does the gamma emitting  $^{137}\text{Cs}$ .

It is recognized that removal of cesium from the NCAW and CC wastes will be necessary, since this is the location of the major portion of these isotopes in the DSTs. Treatment and removal from these sources is planned starting around the end of the century. It has been assumed that these wastes will be treated in an updated B Plant facility. If the use of B Plant for any processing is not permitted by the State, a new facility will be required and this could be designed to treat both DST and SST waste, if treatment of the latter is undertaken.

Unless NRC redefine HLW so as to require treatment to remove cesium and strontium from DSS, DSSF and DN wastes, such removal is not required to meet any current regulatory requirements.

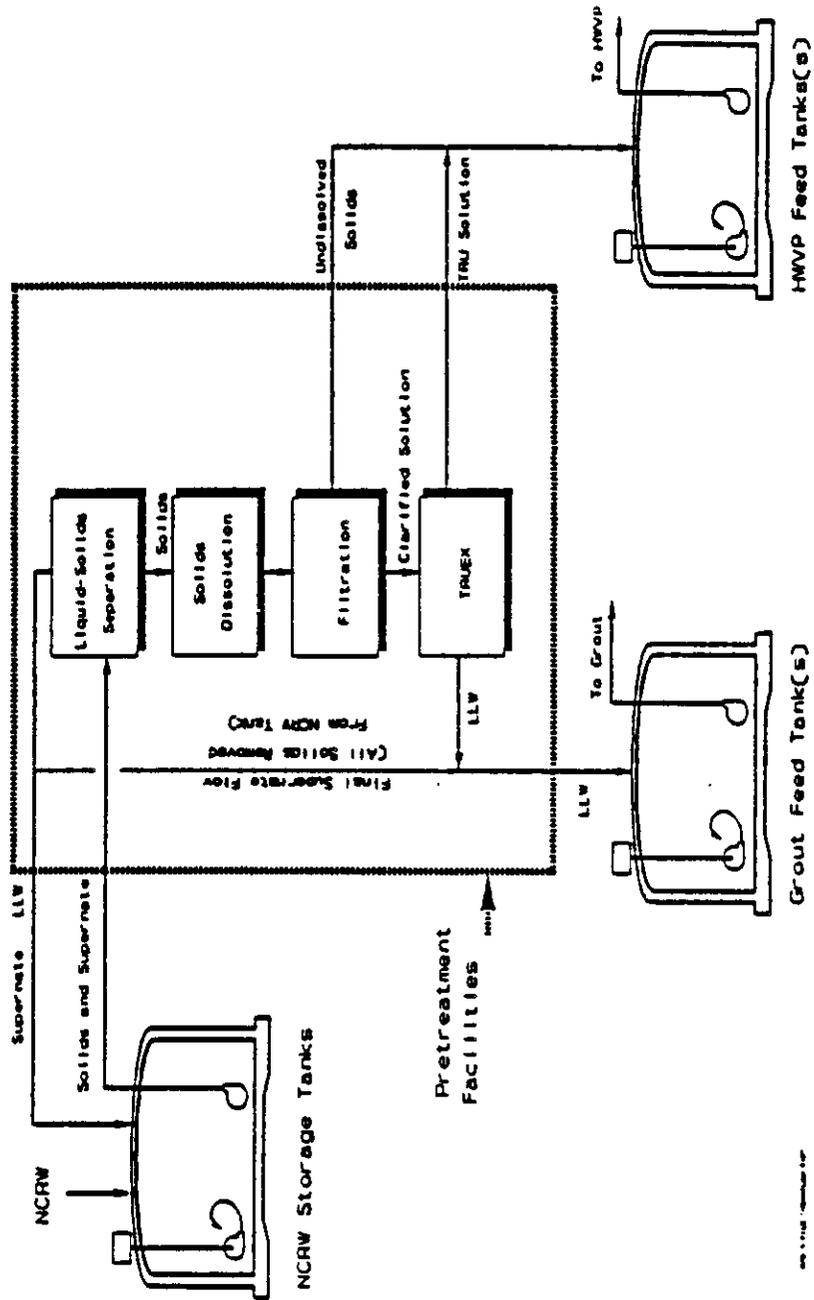
### 7.3 $^{99}\text{Tc}$ and $^{129}\text{I}$

Technetium and iodine are the most mobile radioactive species present in the waste. They have been the object of considerable interest for long-term disposal. Examination of the Draft Performance Assessment for the Grout Treatment Facility (GTF) shows, however, that neither of these isotopes, although they are extremely mobile even under grout conditions, is liberated in sufficient concentration to approach drinking water standards so long as the asphalt barrier around the vaults remains substantially intact (see Figure 5).

Laboratory studies suggest that technetium can be removed from DST waste using anion exchange resins. The technology is presently undeveloped and meaningful cost estimates are not possible. It is clear that very large volumes of ion exchange wash solution are generated, which require additional evaporative capacity. After recovery, technetium can be disposed of along with high level waste, as glass. Technetium recovery is, therefore, technically possible, but is neither technologically available or economically attractive at this time.

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Figure 5. Neutralized Cladding Removal Waste Flow Diagram.



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No viable technology is known to exist, or be under current development, for recovery of iodine at the extremely low levels at which it exists in DST waste.

There is no current regulatory requirement to remove technetium or iodine from DSS, DSSF, or DN wastes before grouting.

#### 7.4 NITRATE AND NITRITE

Although the major anion present in DST waste is nitrate ion, it does not create a problem unless it exceeds the concentration in drinking water set out in EPA 40 CFR 141. It is not listed as a dangerous waste by the WDOE regulations.

Nitrite, in the form of sodium nitrite, is listed and classified by the U.S. Environmental Protection Agency (EPA) as Hazardous Waste Class B in 40 CFR part 302.4 and as such is regulated by the WDOE as EHW, as defined in WAC 173-303. The Performance Assessment for the GTF shows that nitrite is not expected to enter the drinking water supply in concentrations which exceed the limits set out in EPA 40 CFR 141 and proposed in EPA 51 FR 34836-34862, unless the asphalt barrier fails.

Nonetheless, nitrite, since it is classified under WDOE regulations as an EHW at concentrations present in grout or other waste forms made from DST wastes, could potentially create a problem at closure of the waste sites. The EHW is not normally permitted in landfills and the site plan calls for the grout vaults to be closed as landfills. Westinghouse Hanford environmental personnel are on record as stating that the vaults are excluded from this restriction by the Washington Hazardous Waste Act RCW 70.105.050 para.(2), which states, "Extremely hazardous wastes that contain radioactive components may be disposed at a radioactive waste disposal site that is (a) owned by the United States department of energy or a licensee of the nuclear regulatory commission. However, prior to this disposal, all reasonable methods of treatment, detoxification, neutralization, or other waste management methodologies designed to mitigate hazards associated with these wastes shall be employed, as required by applicable federal and state laws and regulations." (To the author the underlined word represents a veritable "Pandora's Box" for the regulators, should they feel disposed to open it at some future date.) Assuming that the Part B Permit is granted by the WDOE, no current reason exists to remove or reduce the amount of nitrite in the waste before grouting.

Should the removal of nitrates and nitrites become necessary at any future time, it can be best achieved by decomposition, using thermal, chemical or electrolytic processes. Treatment of any offgases from thermal processing is necessary to prevent atmospheric pollution by any oxides of nitrogen and sulfur evolved as by-products during the destruction of the wastes.

Several thermal processes have been demonstrated on the large scale and are available for use with little or no further development. Excellent reviews of these processes are available (Arnold and Johnson 1986 and Freeman 1985). The nitrates and nitrites decompose at temperatures above 400 °C to produce oxides, which must be further treated to convert them to

sulfates, or some other grout compatible form, such as a clay mineral, before the waste can be incorporated into grout. Treatment of any offgases from thermal processing is necessary to prevent atmospheric pollution by any oxides of nitrogen evolved during the destruction of the wastes.

The chemical and electrolytic processes are much less developed and would require major developmental input before they could be used on an industrial scale (Blakesly et al. 1982, Hobbs et al. 1986, Arnold and Johnson 1986).

Vitrification, either as glass logs in containers or using the "in situ" technique, developed by PNL, results in simultaneous denitration and mineralization. These processes are seen as alternatives to the grout process, rather than as precursors.

Any of the processes described would remove both nitrate and nitrite to levels where they would no longer be of concern. However, since the products of all the denitration processes consist mainly of sodium oxide or hydroxide, they must be further treated before they are suitable for grouting. Some form of mineralization appears to be the best bet, since converting the bases to sulfates, as has been suggested, could present serious obstacles to grout formation. Special cements are needed in applications where sulfates are present in order to attain usable strength in the cement product. Processes producing such minerals are described in Sections 9.1.5 and 9.1.6 of this paper. They could be used as aggregate in normal hydraulic cements, which could be disposed of in the same way as grout, but which would possess intrinsically better leachability.

On the assumption that WDOE will, in response to the current application, issue a Part B Permit to allow grout disposal at the Hanford Site, no removal of nitrate or nitrite is necessary to allow for disposal of the DSS, DSSF or DN wastes from the DSTs.

## 7.5 LAND DISPOSAL RESTRICTED CONSTITUENTS

The EPA prohibits the presence of organic LDR constituents such as acetone and methyl ethyl ketone in grout or other land disposal waste forms. The concentration of such contaminants is currently being studied and it is difficult at this point to prejudge the findings. Should such volatile materials be found present in quantities which would preclude their incorporation in grout, their removal can be achieved by feeding to the evaporators. The volatile components will distill off and be collected in the condensate from the evaporator. These condensates would be treated to remove such components before being released to the environment.

No treatment is currently expected to be needed to remove LDR constituents from DSS/ DSSF wastes in order to comply with EPA regulations, since these wastes have already been subject to treatment in the evaporators.

## 7.6 COMPLEXING AGENTS

Many of the DST wastes, especially the CC waste, contain large quantities of complexing agents such as EDTA, HEDTA, citric acid, etc. These were added

to maintain the TRU and other metallic ions in solution in the waste during storage and processing. Such compounds are known to interfere with the setting of hydraulic cements and it is likely that they would adversely effect the leachability of any grout in which they were present. Their presence in wastes for grouting is, therefore, undesirable. Removal is, however, extremely difficult. Treatment with hydrogen peroxide does not destroy the complexants completely but merely converts them to simpler forms, such as oxalate, which still act as complexants, albeit less powerful ones. For complete destruction two methods are available. The first is thermal decomposition, which could be carried out along with nitrate/nitrite destruction, if this is necessary. The second is supercritical water oxidation, a complex high pressure process which is still in the development stage as an industrial process and is likely to be extremely costly. Estimates made for the Single-Shell Tank Engineering Study, currently in preparation, predict total costs of around \$250/gal for treatment of CC wastes using this process.

Removal of complexing agents from DSS, DSSF and DN wastes is not considered necessary at this time, as their concentration in these wastes has not been found to create any significant problems during grouting tests carried out to date on samples of such waste. Modification to the grout formulation could change this. Testing with individual wastes and formulations to study grout performance will be needed to define the need for treatment for each waste type.

## 8.0 WASTE PRETREATMENT PROCESSES

### 8.1 BASELINE PRETREATMENT PROCESS

The previous section shows that, under current NRC rulings, it not necessary to pretreat to remove radioisotopes from those DST wastes to be disposed of in grout before about the year 2001. It has been recognized for some time that some treatment is necessary for most, if not all, of the DST wastes planned for later disposal. These are classified as HLW and/or TRU and must be pretreated to remove them from that classification before they can be converted to grout and disposed of near surface at Hanford. Although the supernatant liquid in NCRW and PT wastes is suitable for immediate grouting, the sludge in both cases is high in TRU and cannot, therefore, be disposed of as LLW. The sludge in NCAW waste is also high in TRU, but the supernatant in this case also contains TRU in concentrations too high for LLW disposal. The CC waste contains TRU in high concentrations in supernatant liquid, slurry, saltcake and sludge and no fraction is suitable for LLW disposal without pretreatment. Treating the supernatant, where applicable, while processing the sludges as HLW is the easiest way to handle the problem but takes no account of the high cost of treating unnecessarily large volumes of HLW. A better approach is to pretreat the sludge to separate TRU, thereby reducing the volume of HLW and to dispose of the residual LLW in grout. For NCAW waste at least 90% of the <sup>137</sup>Cs would need to be removed from the LLW stream before grouting in order to meet NRC HLW requirements for the site.

Requirements for acceptable feed to the HWVP were established in *Hanford Waste Vitrification Technical Data Package* (Kalia 1988). The technical bases for disposing of NCAW supernatant in grout were described in *Technical Bases for NCAW Demonstration Processing Product Specifications* (Poling 1987). Criteria for land disposal of restricted wastes as grout are being developed and a draft *Grout Formulation Materials Specifications*, WD-SD-CSD-003 exists. The waste treatment process target is to provide feedstock to grout and vitrification processes that are not only acceptable to the process, but which will minimize upsets, maximize throughput and minimize the volume of glass, which requires expensive disposal in a geologic repository.

Proposals to meet these basic requirements is presented in the Baseline Process described in *Double-Shell Tank Waste Disposal Functions and Requirements*, WHC-SD-WM-DB-005 (Sowa 1991).

The elements of the DST waste disposal mission (Figures 6 through 8) will serve to:

Retrieve 20.5 Mgal of wastes stored in DSTs for transfer and feed to either the pretreatment facilities or GTF.

Pretreat 8.5 Mgal of as is NCAW, NCRW, PT and CC wastes. (These wastes will need dilution before grouting and so the actual volume of grout feed will be about doubled.)

Retrieve pretreated wastes for transfer and feed to either the HWVP or GTF.

The complexing agents will still potentially interfere with the setting of grout and with the mobility of some species in any grout produced from the raffinate. This fact, along with the potential restrictions on the concentration of organic LDR materials allowed in the landfill, may require the destruction of the organics before disposal of the LLW fraction in grout. A number of possible processes to destroy these organics is being investigated.

Four LLW types have been identified as being suitable for feed to grout without pretreatment. They are:

DSSF--LLW which has been concentrated to a point just short of sodium aluminate crystallization.

DSS--LLW which has been concentrated to the level at which it contains a high percentage of solids.

DN--Dilute LLW which has not yet been concentrated.

CP--Waste from N Plant decontamination.

The volume of DSSF and DSS varies depending on the quantity of wastes generated and operation of the waste volume reduction facilities. A total of 44 1-Mgal grout campaigns are planned in completing the DST waste disposal mission. Of these about 24 vaults will be required for disposal of DSS, DSSF, DN, and CP wastes.

Figure 6. Neutralized Current Acid Waste Flow Diagram.

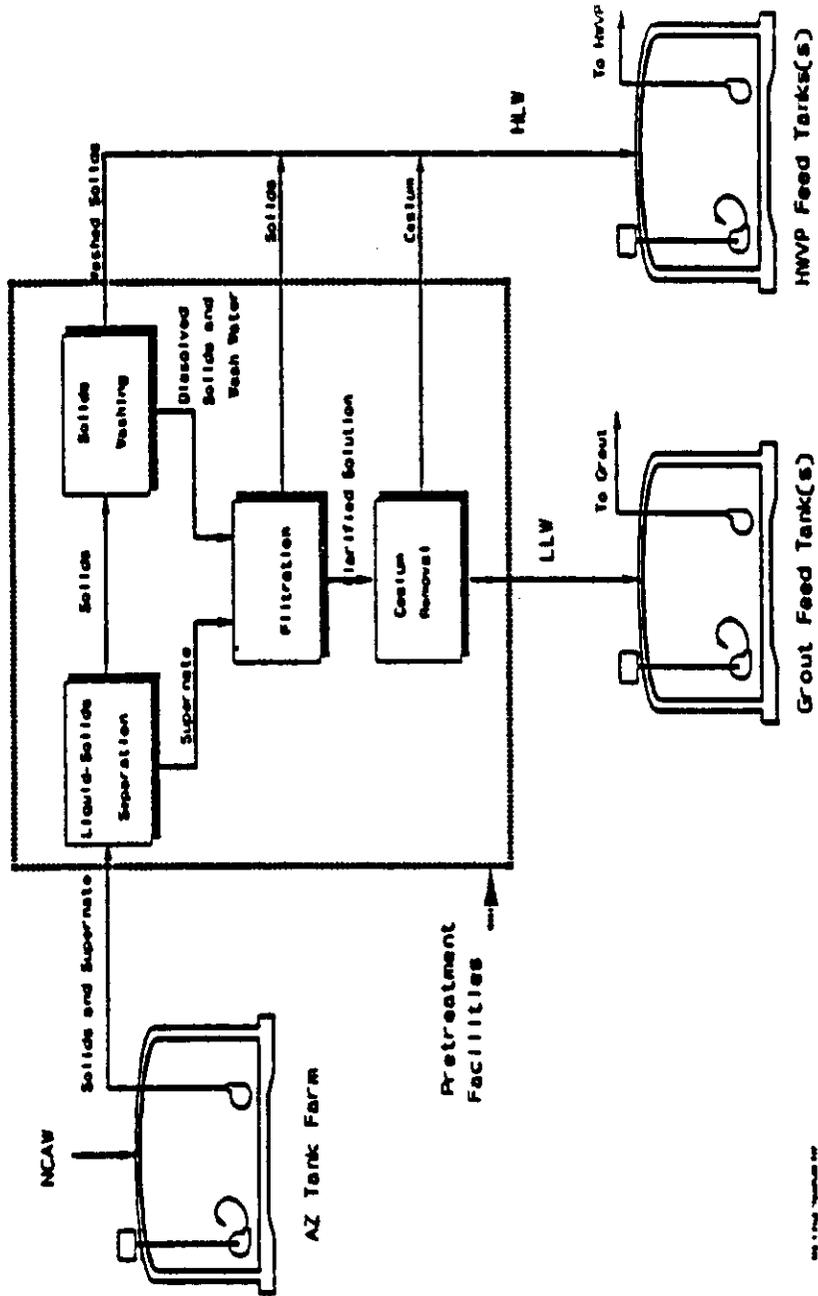
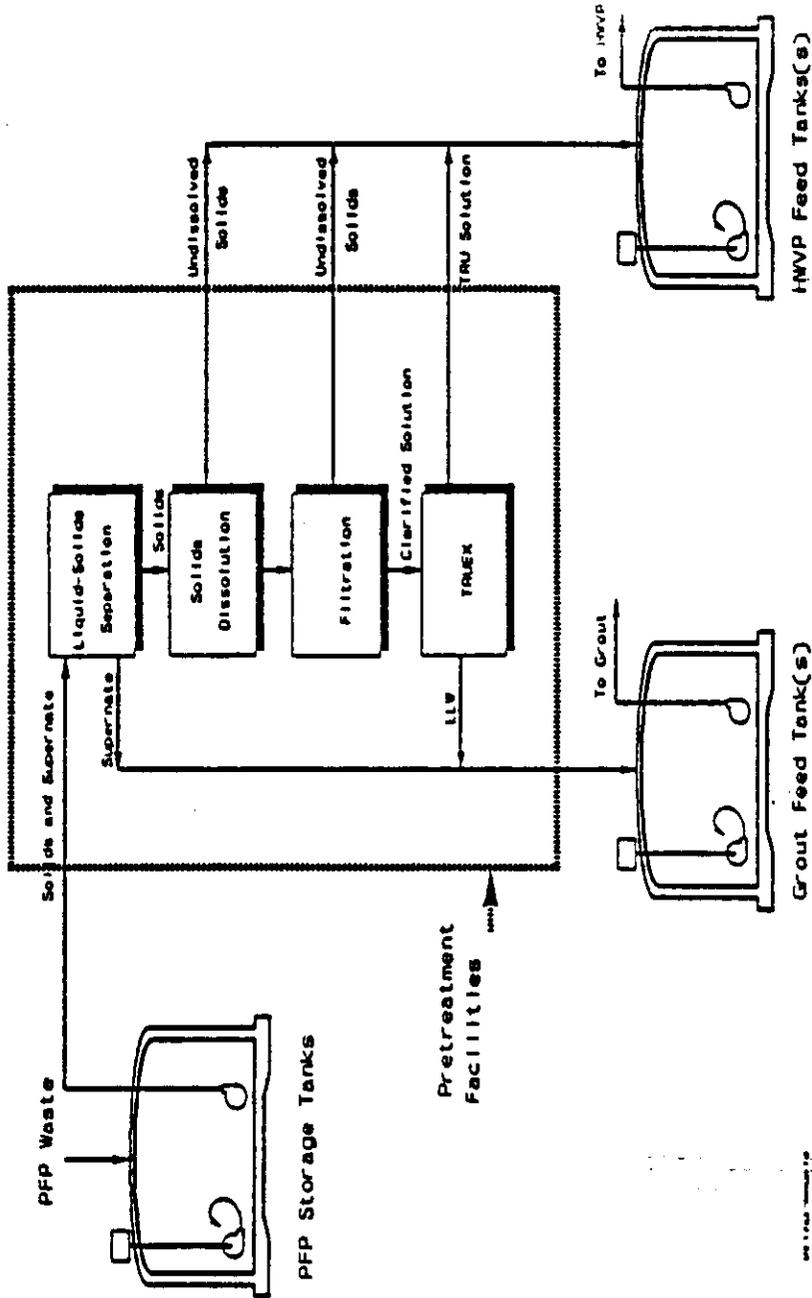
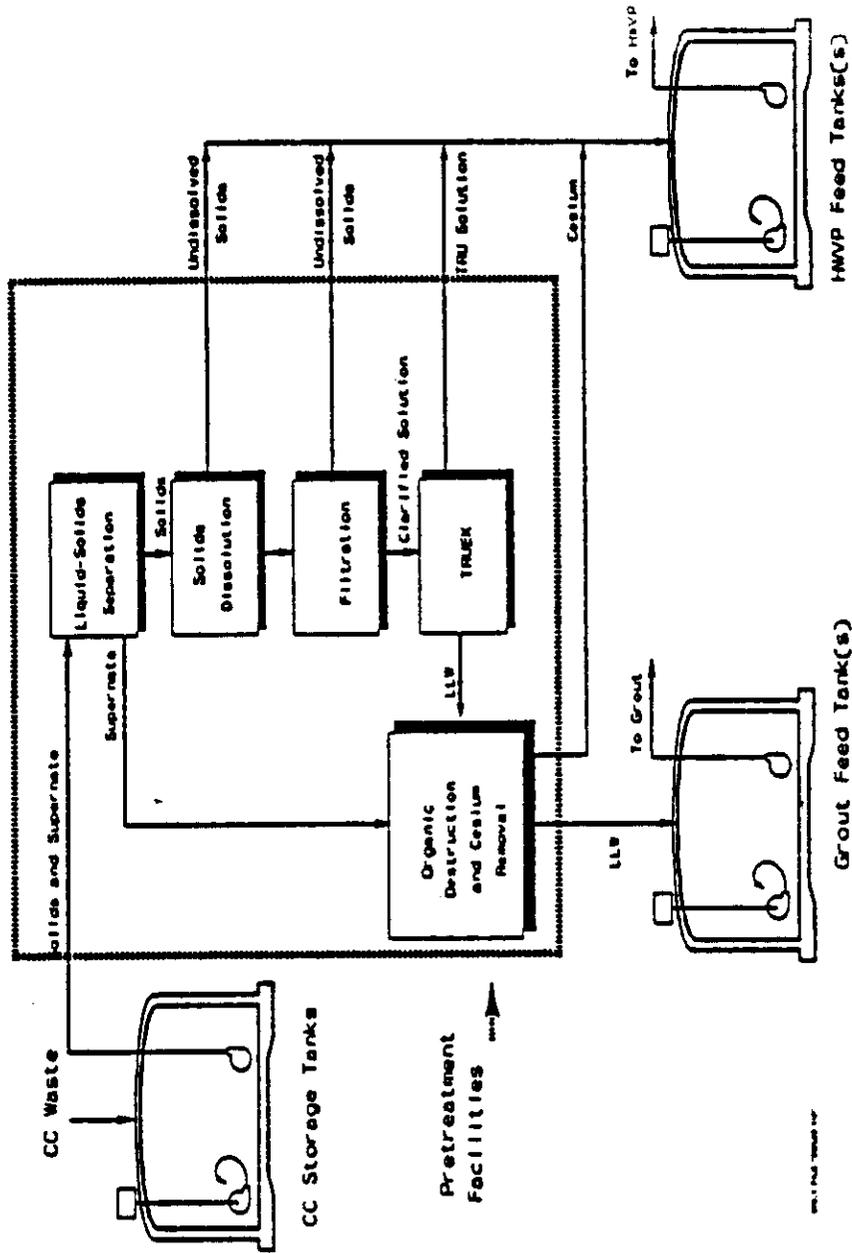


Figure 7. Plutonium Finishing Plant Waste Flow Diagram.



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Figure 8. Complex Concentrate Flow Diagram.



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## 8.2 ESTIMATED PRETREATMENT COSTS

### 8.2.1 Baseline Costs

Costs for the Baseline Pretreatment option (WHC-SP-0464), which removes TRU, cesium and, where necessary oxidizes organic complexants using hydrogen peroxide, from NCAW, NCRW, CC, and PT wastes, are estimated at a total of \$1.6 billion, if carried out in B Plant.

### 8.2.2 Costs of Cesium Removal from DSS/DSSF

The cost of removing cesium from DSS and DSSF wastes, using ion exchange, has been estimated to be \$360 million and require 2 to 5 years of B Plant operation (Place 1991). It would require the use of additional cells in B Plant to install the necessary extra columns, which would make it impossible to install TRUEX in this plant. Use of the Purex facility for this purpose would decrease both the cost and the treatment time for cesium removal.

If B Plant or the PUREX facility cannot be used, both the cost of pretreatment and the date at which such treatment could start would be unfavorably impacted.

### 8.2.3 Strontium Removal Costs

Strontium removal, using the SREX solvent extraction process has been estimated to add between \$150 and \$350 million to the cost of waste treatment (Wodrich 1989). Considerable further development, with consequent additional cost and delay is needed before this process is ready for use on the industrial scale.

It is important to note that the current cost of disposing of waste in grout is about \$15/gal of waste. Estimates place the cost of removing cesium from DSS/DSSF wastes at between \$30 and \$53/gal (Place 1991, see Appendix D).

If removal of EHW or LDR chemicals becomes necessary, grout's biggest attractions as a waste disposal form, its low unit disposal cost and simplicity could disappear. Definitive cost estimates for alternative LLW disposal forms are clearly needed in order to enable rational choices to be made in the future. Such estimates themselves need decisions on what treatment is, in fact, necessary before disposal and the treatment will depend upon the chosen waste form.

## 8.3 ALTERNATIVE PRETREATMENT PROCESSES

A study of alternative processes to pretreat DST wastes prior to disposal as grout or as an alternative form is currently under way and a preliminary report is due in September 1991. It will include technetium and strontium removal and organic destruction options in addition to the options presented in the Baseline proposal (Section 8.1).

## 9.0 ALTERNATIVE APPROACHES

A different approach to the DST LLW disposal problem is to avoid the need for pretreatment removal of the various undesirable nonradioactive components from the waste. In order to achieve this objective a number of alternatives have been identified. These alternatives are discussed in this section.

Note that all costs presented in this section are ROM estimates based on engineering and operational experience. They are mainly used to develop process ranking and are considered adequate for this purpose. Work is underway to determine better estimates based on preliminary design data.

### 9.1 ALTERNATIVE WASTE FORMS

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One way to overcome the need to remove specific elements from wastes before grouting, is to dispose of the waste in forms other than grout, which are not affected by those elements. Such processes should produce disposable waste forms where the leachability has been reduced to the point where it is of no concern. Processes such as producing glass in containers or in situ vitrification would fix some elements in a form with extremely low leachability, while volatilizing and/or destroying others, such as nitrites and organics, and thereby coincidentally removing them the waste. It should be noted that TRU, cesium and strontium removal are still required, where necessary to ensure designation of the waste, by the NRC, as no longer being HLW.

Further development work is currently needed on all of these alternatives to confirm their suitability for disposing of Hanford Site LLW. It is necessary, for example, to confirm the means for recycling or disposing of the wastes created by the scrubbing of offgases generated by some of the processes.

Process descriptions for the processes described are presented in Appendix C.

#### 9.1.1 Polyethylene Encapsulation

The polyethylene encapsulation process has been used for solidification of LLW in the Netherlands and Argentina (Heiser et al. 1989). A recent draft paper from Brookhaven National Laboratory (BNL) (Kalb et al. 1991) describes work on both the laboratory scale and on the full scale using commercially available equipment. The process produces a product with low dispersability and an ANS 16.1 leach index greater than 10, several orders of magnitude higher than that for Hanford grout as currently formulated. The physical properties of the product meet all NRC requirements and waste loadings, much higher than those attainable with grout, were achieved.

Capital cost for a facility is expected to be higher than for a grout facility, \$400 million compared with \$150 million for a new grout facility (the existing facility cost was much lower). The operating costs (which include vault costs) are expected to be somewhat lower. The BNL report

predicts an overall processing cost per gallon of waste treated which is no more than half of that for Hanford Site type grouts, but this is for extremely low activity wastes, where less shielding is required and prolonged cooling of the plastic matrix is not necessary. Costs for polyethylene disposal of Hanford wastes are expected to be somewhat higher than for grout.

### 9.1.2 Containerized Glass

Glass is the chosen solidification form for HLW, based on its low leach rate and high durability. Its use has been demonstrated in a number of countries including the USA, France, Germany, Japan, the USSR and the UK and a wide literature exists. The glass process is subject to fewer problems than competing processes of similar durability. Glass manufacture is a technology with a long pedigree, but the industry is noted for its commitment to continuous improvement and innovation. This means that the glass process is based on well developed, clearly demonstrated large scale experience. Those attributes which make glass attractive as a HLW disposal form apply equally to its use with LLW. Little or no new development is required to adapt existing technology to low level waste disposal.

Vitrified LLW will be a highly stable, low dispersal waste form with a projected ANS 16.1 leach index of 13 to 15, which greatly exceeds the NRC recommended value of 6.0 and no nitrite or organic content.

The capital cost of such a plant, which is lower than that for HWVP because of the less complex design needed to handle LLW rather than HLW, is "guesstimated" to be around \$500 million, operating costs including raw materials are expected to be somewhat higher than those for grout. Better cost estimates will be available before the end of the current fiscal year.

### 9.1.3 Glass in Sulfur Concrete

One of the major complications in the vitrification of LLW waste is the casting and subsequent rapid cooling and handling of the canisters. This can be avoided by making the glass into an aggregate for encapsulation in an inert binder which can be pumped to a disposal vault or similar system.

The use of Portland or other siliceous cements as a matrix material to encapsulate glass is not desirable because the alkalinity of the cement attacks the glass and reduces the leach index. Sulfur concrete formulations overcome this difficulty and are used in this process (Arnold et al. 1985, van Dalen 1989).

Modified sulfur concrete is a commercially proven material originally developed by the Sulfur Council and the U.S. Bureau of Mines. It is composed mainly of elemental sulfur with plasticizing agents added to inhibit crystal growth and control polymerization and viscosity. The material is used in conjunction with aggregates as a construction material for use in corrosive environments. It is normally laid or hot cast using asphalt handling equipment and cures rapidly, achieving 80% of its ultimate strength in hours.

A typical industrial mix uses 22 to 26 wt% sulfur and 74 to 78 wt% aggregate. In the proposed process the aggregate consists of glass cullet manufactured from the DST waste.

The glass formulation is similar to that required in the glass monolith process, i.e., 15% Na<sub>2</sub>O and 25% waste oxides.

Glass/sulfur concrete, like the products of other vitrification processes has a high ANS 16.1 leach index of between 13 and 15 and sulfur concrete has been shown to have low permeability and excellent corrosion resistance. The glass would contain no nitrite or organic compounds.

The capital cost of the plant is estimated at \$500 million, with raw material and operating costs about 30 to 50% higher than for grout.

#### 9.1.4 In Situ Vitrification

In situ vitrification (ISV), a process developed by PNL, involves the joule heating of contaminated soil, in place, to convert it into an immobile, durable, glass or crystalline waste form (Buelte et al. 1987) (Campbell et al. 1990). To start the process, electrodes are placed vertically in the soil in a precalculated pattern and an electric current passed between them. The resistance heating, so created, raises the temperature of the soil to the point where it melts into a vitreous mass. A portable hood placed over the site is equipped with a suitable offgas treatment system to collect and treat fumes generated by the process.

One modification of the proposed process adapts the basic concept to generating a molten pool up to 25 m diameter, 15 m deep using virgin soil to which glass forming additives might be added. The waste slurry would then be injected deep into this pool, where it would liberate water, decompose at the high temperature and react to become an indistinguishable part of the vitreous mass. The use of a large melt not only decreases the number of melts required, but the deeper pool thus created increases the scrubbing of offgas bubbles and so reduces the treatment needed at the surface.

An alternative technique, which is very similar to the process which has been demonstrated, would mix the waste with a clay or similar absorbent, or form a grout, which would be placed in impoundments, which would then be vitrified using the ISV process as currently demonstrated.

ISV waste will be a highly stable, low dispersal waste form with a projected ANS 16.1 leach index of 13 to 15, similar to other glass processes and will contain no nitrites or organic compounds.

Capital costs are "guesstimated" to be over \$200 million, comparable with those for a new Hanford Site grout plant. Raw material and operating costs should be about 10 to 20% lower than for grout. Better cost estimates are in preparation and will be available by the end of the current fiscal year.

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CADFILE	B117954A		CADCODE	2B:IBM:ACD2:10.C2:SS		
ENGINEERING RELEASE		<p align="center">U.S. DEPARTMENT OF ENERGY</p> <p align="center">Richland Field Office DE - AC06-86RL10838</p> <p align="center">  <b>FLUOR DANIEL, INC.</b>  <b>ADVANCED TECHNOLOGY DIVISION</b> </p> <p align="center"> <b>STRUCTURAL</b>  <b>VIT BLDG</b>  <b>WALL ELEVATIONS</b> </p>				
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SYSTEMS MGR.						
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SUPERVISOR		PROJECT TITLE				
R. P. KUMAR	11/11/92	<b>HANFORD WASTE VITRIFICATION PLANT</b>				
DESIGN ENGINEER		PROJECT	FLUOR CONTRACT NO.	CWBS NO.		
G. KUILANOFF	11/11/92	<b>B-595</b>	<b>8457</b>	align="center"> <b>B210A</b>		
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### 3.1.7 Waste Disposal Form Volume

The different waste disposal forms generated by the alternate processes described result in considerable differences in the volume of disposable waste form which is generated by the same volume of DST waste. Additionally the way in which the waste is stored will vary. Glass and polyethylene in containers will not need vaults for disposal, although sanitary landfill requirements, incorporating liner/ leachate collection systems will be necessary. In situ vitrification will result in a glass and mineral monolith which will merely remain where formed without further barriers, since it will no longer exhibit Dangerous Waste characteristics.

Table 4 shows the relative volume of waste created by each of the processes and indicates the disposal system.

The objective of the above section is not to choose a grout alternative, but to demonstrate that such alternatives exist and should be further studied to determine their viability in the Hanford Site waste clean up program.

## 9.2 MORE STORAGE

Another potential approach would be to postpone treatment of appropriate DST wastes until the facilities needed by an SST retrieval program, should it be decided upon, are available for use. Such a delay would require the construction of further DSTs to allow for storage of the extra waste after 1996, when the present tanks are projected to be full, and prior to treatment starting in such new facilities.

Plans are in hand and funding has been requested for the construction of a new DST farm. The first four new tanks are planned for completion in fiscal year 1998, with a further four about two years later and either four or six more by the end of the year 2002. The estimated cost of these tanks is \$15 to 20 million each.

This would provide the necessary buffer volume if planned developmental recovery work on the SSTs, specifically on 106-C, were delayed (J. N. Strode, Westinghouse Hanford Internal Memo, "Impact of No Additional Grout Campaigns on Projected Double-Shell Tank Requirements, April 1991), see Appendix A.

Since most of the excess waste volume identified in Section 3.2 is condensate, another approach to generate more available DST space is to construct further Liquid Effluent Retention Facility (LERF) basins. This would minimize the requirement for further DSTs. LERF basins can be built much more rapidly and at considerably lower unit storage cost than DSTs. Provision for about 9 million gallons of additional LERF capacity would appear to be sufficient. Expansion of the present unit by a further 6 million gallons is already under consideration and such an expansion could be achieved at a supplemental cost of less than \$20 million.

### 9.1.5 Denitrated Low Temperature Mineralized Grout

DST waste is continuously fed at a controlled rate to a calciner where it is heated to a temperature of about 450 °C and maintained at that temperature for sufficient time to allow complete decomposition of both nitrite and nitrate. The water distilled from the waste is condensed for treatment or reuse and the offgases generated are scrubbed in a HEPA filter before liquid scrubbing to remove NO<sub>x</sub>, SO<sub>2</sub>, etc. and release to atmosphere. After cooling, the solid residue is hydrated to ensure conversion of alkali and alkaline earth metals to hydroxide and is mixed with metered quantities of clay, sodium silicate and zinc oxide and water to form a mineral grout. This grout, with physical properties similar to the current grout, is then poured into vaults and treated similar to current grout. Such a grout would have no nitrite or nitrate problem and the leachability of Cs would be markedly reduced, but the leachability of Tc or I would be little different from that of current grout.

This waste disposal form is expected to have an ANS 16.1 leach index of 8 to 10, which is considerably better than that currently demonstrated for Hanford grout. By definition it will contain no nitrite or nitrate and most of the organic content will have been destroyed.

The estimated capital cost for this process is about \$340 million, while the raw material and operating costs are estimated as 30% higher than for grout.

### 9.1.6 Ceramic in Grout

As with the previous process, DST waste is metered continuously to a calciner, or to a drier followed by a calciner. In this process the temperature reached by the waste in the calciner is between 600 and 800 °C. At this higher temperature not only are the nitrite and nitrate decomposed, but the residual waste reacts with clay fed to the calciner to produce nepheline as a solid, ceramic clinker. After cooling and any necessary size reduction, the clinker is mixed with normal Portland cement or similar material to form a concrete slurry. This concrete slurry is then handled in the same manner as conventional grout and is stored in vaults.

High temperature (~2200 °C) instantaneous decomposition using a high temperature fluid wall reactor, followed by ceramic clinker formation is a somewhat higher cost approach which might become competitive in the future as cheaper reactors are developed.

The product is expected to show an ANS 16.6 leachability index of between 7 and 8, as measured for Portland and similar cements. However, measurements on ceramics indicate a figure of 13 to 15 for the waste containing ceramic aggregate. The waste form will contain no nitrite or organics.

Capital costs for this process are "guesstimated" at \$400 million, while operating and raw material costs are expected to be 30 to 50% higher than for grout. Better cost estimates are due before the end of the fiscal year.

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Until a firm program and projection for future waste generation is established, however, all such estimates must be viewed as preliminary and approximate. The capacity and cost of any additional storage will be dependent upon the degree to which the problem is indeed condensate driven. If the increased volume is greater than 50% condensate it is unlikely that any further tanks, beyond those already in the planning stage, will be needed and the lower cost LERF option would be the preferred approach.

## 10.0 ASSESSMENT AND RANKING OF POTENTIAL ALTERNATIVE APPROACHES

### 10.1 ASSESSMENT OF PRETREATMENT COSTS

Estimates of capital and operating costs for the processes identified in the baseline pretreatment proposal are presented in a paper by Defense Waste Management Division (WHC-SP-0464, 1990) and total about \$1,600 million. This equates to about \$150/gal on the wastes programmed to be treated.

The removal of cesium from DSS and DSSF waste would add between \$30 and \$50/gal to the overall disposal cost.

### 10.2 ASSESSMENT OF ALTERNATIVE PROCESSES TO GROUT

Estimates of capital and operating costs for each of the alternative processes is presented in Table 5. It might be noted that all of these costs are of a similar order to the costs for grout disposal without any pretreatment.

Each process was assessed on the basis of leachability, availability (degree of development), complexity, cost, a perceived level of confidence in its ultimate acceptability to the regulatory authorities and probability of success. The ratings apportioned to each of these characteristics, along with a weighting factor related to the perceived importance of each is presented in Table 6.

The evaluation criteria used were:

State of Development:

5. Process demonstrated on full scale
4. Process parts demonstrated full scale
3. Pilot plant demonstration
2. Laboratory scale demonstration
1. Conceptual.

Leachability (All based on ANS 16 leach index):

5. Index >12 demonstrated
4. Index >12 inferred
3. Index >8<12 demonstrated

Table 4. Waste Disposal Volume for Alternate Processes.

Waste Disposal Process	Waste Form Volume (m <sup>3</sup> /M gals Waste)	Number of Vaults	Number of Canisters
Hanford Grout	5,300	1	
Polyethylene Encapsulation	2,800		2,400 (300 gals each)
Containerized Glass	1,500		100(4,000 gals each)
Glass in Sulfur	3,000	0.6	
In-Situ Vitrification	1,900	(0.25 melts)	
Low Temp. Mineral Grout	8,400	1.66	
Ceramic in Grout	3,900	0.75	

Table 4. Waste Disposal Volume  
for Alternate Processes.

Table 6. Rating of Processes.

Table 6. Rating of Processes

Process	Rating (1 - 5)				
	Leachability of Product	Degree of Development	Complexity	Acceptability to Regulators	Cost
Barford Grout	2	5	5	4	5
Polyethylene Encapsulation	4	4	Rating of Processes 4	4	3
Carbonized Glass	5	4	2	5	2
Glass in Sulfur Concrete	5	4	4	4	2
In-Situ Vitrification	5	3	5	4	5
Low Temperature Mineral Grout	3	3	3	3	3
Calcemic In Grout	4	3	3	4	2
New LEIG or ISIs		5	5	3	5

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Table 5. Estimated Costs for Alternate Processes

Process	Capital Cost (\$ ,000)	Capital Cost / Million gals waste (\$ ,000)	Operating Cost / Million gals waste (\$ ,000)	Total Cost / Million gals waste (\$ ,000)
Hanford Grout (Current)	50,000	2,000	28,000	30,000
(New)	150,000	6,000	28,000	34,000
Polyethylene Encapsulation	400,000	16,000	25,000	41,000
Containerized Glass	500,000	20,000	28,000	48,000
Glass in Sulfur	500,000	20,000	30,000	50,000
In-Situ Vitrification	200,000	8,000	25,000	33,000
Low Temp. Mineral Grout	340,000	13,500	30,000	43,500
Ceramic in Grout	400,000	14,000	35,000	49,000

Table 5. Estimated Costs  
for Alternate Processes.

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Table 7. Ranking of Alternatives.

Weighting	Weighted Score (Rating Score x Weighting)					Total Weighted Score	Ranking
	5	3	2	5	5		
Process	Leachability	Development	Complexity	Acceptability	Cost		
Barford Grouz.	10	15	10	20	25	80	2
Polyethylene Encapsulation	20	12	8	20	15	75	4
Containerized Glass	25	12	4	25	10	76	3
Glass in Sulfur Concrete	25	12	8	20	10	75	4
In-Situ Vitrification	25	9	10	20	25	89	1
Low Temperature Mineral Grouz.	15	9	6	15	15	60	7
Ceramic in Grouz.	20	9	6	20	10	65	6
New IRR or DSTs		15	10	15	25		Interior Solution Only. Not Ranked

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2. Index >8<12 inferred
1. Index <8 demonstrated.

Complexity:

5. Simple plant and operation, few process steps, process factors flexible.
4. Simple plant and operation, more process steps, process factors more critical.
3. More complex plant, more process steps, process factors not critical.
2. Complex plant, skilled operation, process factors critical.
1. Very complex plant, very skilled operation, process factors very critical.

Acceptability to Regulators:

3. Clearly meets all WDOE, EPA and DOE requirements without further study
2. Meets most requirements without further study or treatment.
1. Needs further work to ensure compliance without treatment. Costs were derived by factoring those developed for the SST study and then ranking them

### 10.2.1 Ranking of Alternatives

Table 7 shows the product of the rating and weighting for each characteristic, the sum of these products for each process considered and the ranking of the processes on these bases.

An examination of the results presented in Table 7 allows a division of the alternatives into three groups:

#### 10.2.1.1 Best Option

In situ vitrification.

#### 10.2.1.2 Next Best Options

Hanford grout  
Containerized glass  
Glass in Sulfur concrete  
Polyethylene encapsulation.

#### 10.2.1.3 Least Attractive Options

Ceramic in grout  
Low temperature mineral grout.

Scoring is not sufficiently precise to allow selections to be made within groups, indeed it is difficult to justify any significant difference between groups 10.2.1.1 and 10.2.1.2.

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The first option is estimated to have lower costs than the second group and, therefore, is selected as "best buy." Choice will probably depend ultimately upon a combination of factors. On this basis any of the processes in 10.2.1.1 or 10.2.1.2 must be considered as a viable option at this time.

## 11.0 RECOMMENDATIONS

### 11.1 RECOMMENDATION 1

The unit cost of potential pretreatment is so high and sufficient uncertainties exist in the grout program to justify the instigation of a program to study disposal forms alternative to grout as a fallback position. The best alternatives are presently seen as being vitrification processes, particularly in situ vitrification. A program to develop one or more of these processes to the level of full scale demonstration, probably in collaboration with PNL, should be undertaken at the earliest opportunity.

### 11.2 RECOMMENDATION 2

Full agreement should be ensured from the WDOE that the presence of nitrate and nitrite at the concentrations at which it is present in these wastes will not present any impediment to closure of the grout vaults as landfills.

### 11.3 RECOMMENDATION 3

The absence from DSS, DSSF, and DN wastes of organic LDR constituents, at concentrations prohibited by the EPA, should be confirmed at the earliest possible opportunity.

### 11.4 RECOMMENDATION 4

Assuming that the problems currently associated with the grout facility are successfully resolved, there is no apparent current need to remove any radioisotopes from DSS, DSSF, or DN wastes before disposal as grout to satisfy federal or state regulations or DOE Orders. If the NRC redefines HLW in such a way as to require the removal of additional radionuclides, particularly cesium and strontium, from DSS and DSSF waste, pretreatment to remove one or both of these elements will become necessary.

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APPENDIX A

WASTE VOLUME PROJECTIONS FOR THE DOUBLE-SHELL TANKS

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J. S. Garfield  
Page 2  
April 11, 1991

The no grout case exceeds the available tank space by two tanks beginning in FY 1996. By 1998, the difference between the two cases would be predicted to be on the order of 9-10 tanks based on the difference in vaults poured. However, the actual difference between the two projections is only 6-7 tanks since the two grout feed tanks and the retrieval tank (used to retrieve grout solids for grouting) would not be needed in the no grout projection and were used to store additional DSSF.

Since it is doubtful that new tanks could be constructed by FY 1996, the two tank space shortage would have to be alleviated by changing other assumptions:

1. Operation without a spare or contingency tank has not been considered as acceptable alternatives in the past.
2. Complete four grout vaults by FY 1996. This would lower the required tank space to match the available space past the year 2002. This might allow still additional tanks to be built or for other options to be pursued which would allow the removal of DSSF from the double-shell tanks.
3. Postpone all SST solids retrieval efforts until after the additional tanks are available in FY 1998. This would also lower the required tank space to match available space.

If you have additional questions on these projections, please feel free to contact me.

*J. N. Strode*  
J. N. Strode, Scientist  
Technology Data Management

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Westinghouse  
Hanford Company

Internal  
Memo

From: Technology Data Management  
Phone: 3-1280 R2-18  
Date: April 11, 1991  
Subject: IMPACT OF NO ADDITIONAL GROUT CAMPAIGNS ON PROJECTED DOUBLE-SHELL TANK REQUIREMENTS

To: J. S. Garfield R3-63

cc: R. D. Fox *RD* R2-18  
G. W. Jackson R4-01  
G. M. Koreski R2-18  
M. J. Kupfer R2-07  
B. E. Opitz H5-49  
G. F. Williamson R4-01  
JNS/Lb

The purpose of this letter is to transmit the results of a special waste volume projection completed to assess the impact to double-shell tank (DST) space requirements if no additional grout campaigns were completed prior to the construction of four new tanks. This projection assumed that a third LERF module would be ready by FY 1993 and that four additional one million gallon tanks would be available in FY 1998. The results of this projection indicate that the projected required DST space would exceed available space by two tanks beginning in FY 1996. Some possible changes in assumptions to avoid this problem are listed in the results and discussion section.

### Assumptions

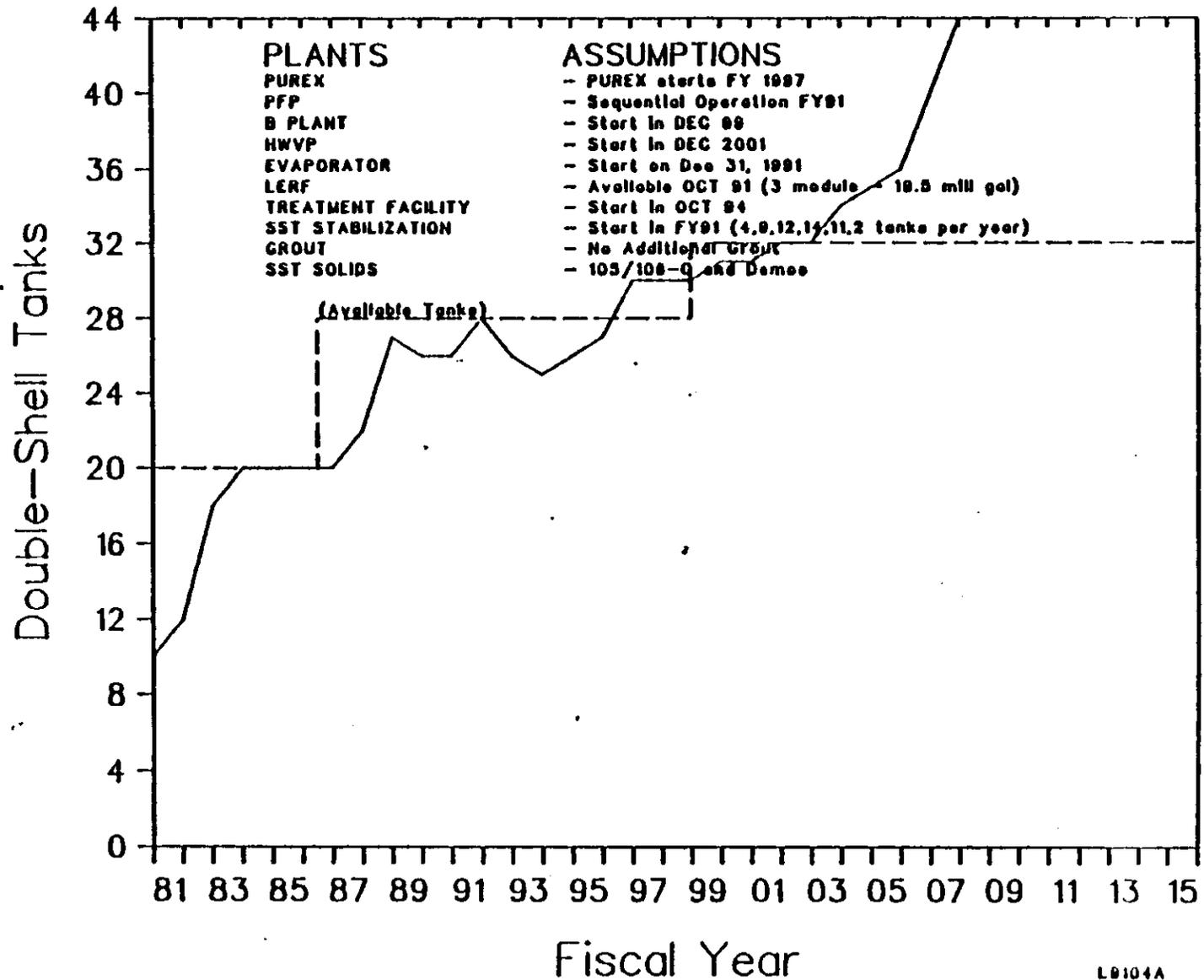
This special projection (L9104A) used the waste management minimization rates for facility waste generations. It was assumed that a third LERF module would be available in FY 1993 (total LERF capacity, 19.5 million gallons). It was also assumed that four additional one million gallon tanks would be available beginning in FY 1998. For comparison purposes the results of this projection will be compared to the last nineteen month grout delay case (L9102A). Both cases still use B Plant for waste pretreatment beginning in 1999. Alternative processing of waste for future grouting was not included in projection L9104A. The intent of this projection was to determine DST needs up to the time that new tanks could be constructed. A summary of the assumptions used in these two projections is presented in Table 1.

### Results and Discussion

The results of this projection are presented graphically in Figure 1. Results of the similar nineteen month grout delay case are presented in Figure 2. The nineteen month grout delay case assumes that grouting will continue at a rate of up to 4 vaults/year through the year 2015, as feed will allow.

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FIGURE 1. NO GROUT LONG RANGE PROJECTION



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Table 1 Summary of Assumptions for Projections

Facility	No Grout Special Projection L9104A	Long Range Projection L9102A
PUREX		
Segregation	Yes	Yes
WG Processing	FY 1997	FY 1997
FG Processing	FY 1998	FY 1998
LERF	6.5 Mgal	6.5 Mgal
PFP		
Segregation	Yes	Yes
PRF	1/91	1/91
RMC	3/91	3/91
Grout		
Delay	NA	19 Mo
Vaults Filled thru 1994	1	7
Vaults Filled thru 1998	1	20
Evaporator		
Restart	12/31/91	12/31/91
LERF	19.5 Mgal	13 Mgal
Treatment Facility		
Start-up	10/94	10/94
Rate	150 gpm	150 gpm
TOE	70%	70%
Tank 106-C Waste		
Receiver	101-AY	101-AY
Date	FY 1996	FY 1996
8 Plant		
Start-up	12/99	12/99
LLW volume	Reg.	Reg.
WVRF	Reg.	Reg.
HWVP		
Start-up	12/01	12/01
SWL		
Porosity	35%	35%
Complexed SWL	14%	14%
SST		
106-C solids	1996	1996
Tank Demo	1998	1998
Farm Demo	2004	2004

Notes

1. All Cases use waste minimization management limits for waste generation rates + 12/5/90 SWL pumping schedule.

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DON'T SAY IT --- Write It!

DATE: January 31, 1991

TO: G. W. Jackson R4-01

FROM: *JNS* J. N. Strode/G. M. *AK* Koreski  
3-1280  
R2-18

cc: R. D. Fox *RF* R2-18  
D. W. Hendrickson R4-03  
J. A. Voogd R4-03  
G. F. Williamson R4-01

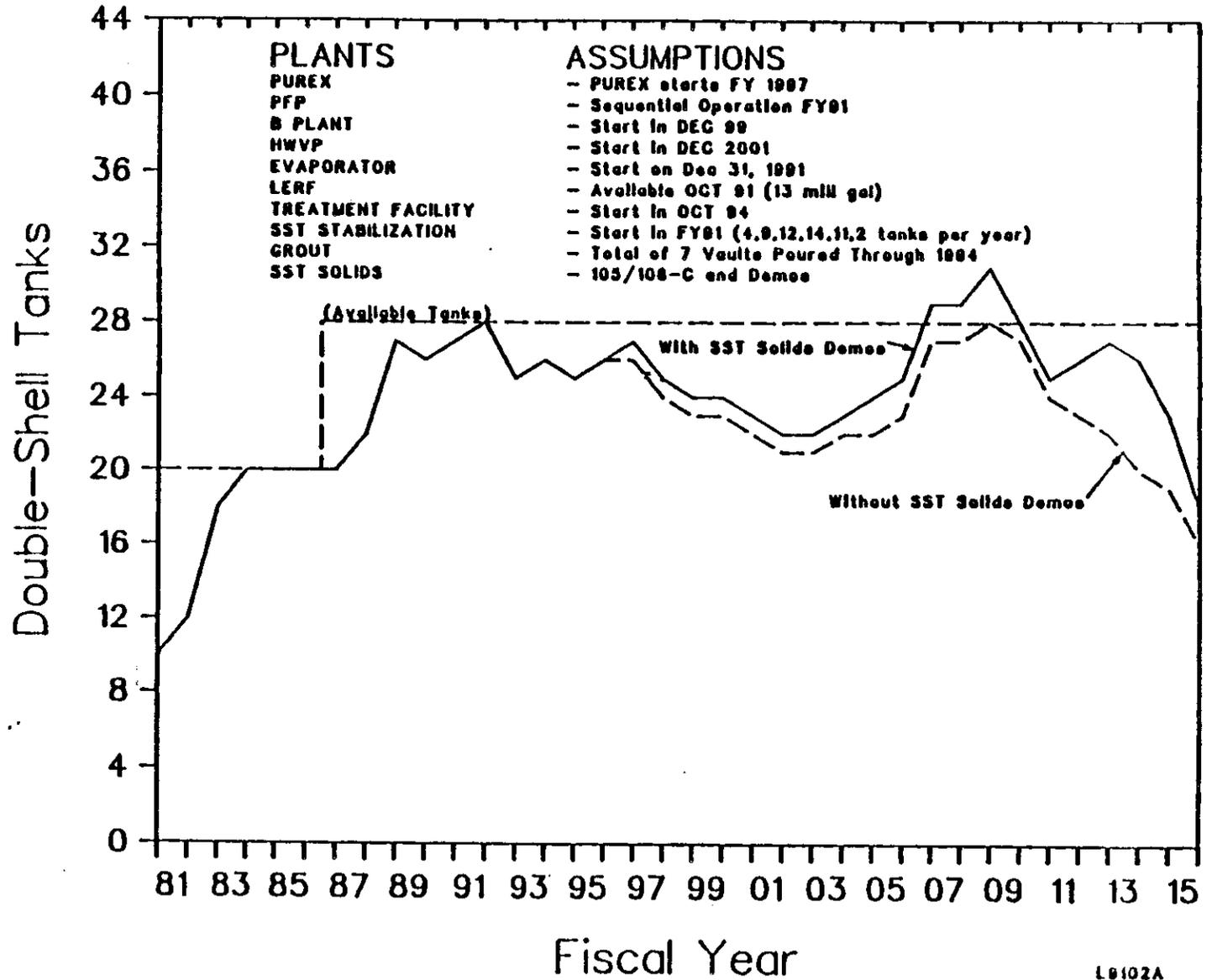
SUBJECT: Grout Waste Volume Projection Cases

Enclosed are the results of the grout waste volume projection cases that were requested in our meeting on January 24, 1991. The results of these projections are shown in Figures 1-4. Figure 1 shows the projected double-shell tank (DST) volume if seven grout vaults are poured through FY 1994 (this figure was presented to you during our earlier meeting). Figure 2 shows the projected DST volume if no grouts are completed through FY 1994. Figure 3 shows the projected DST volume for the minimum grouting case (3 vaults poured through 1994). Figure 4 is a long range projection using the same assumptions and grouting schedule as were used for Figure 1. Table 1 lists the detailed assumptions for the seven grout vaults through FY 1994 cases (Figures 1 and 4) under the column entitled "L9101A". Tables 2 and 3 list the makeup for the "Specific Use Space."

Although Figure 3 shows that we should be able to get by with grouting only 3 vaults thru FY 1994, we are not recommending this grouting schedule for the Hanford site. It has been our experience that the assumptions usually change in a way to aggravate the tank space situation (increased waste generation rates, additional waste sources, additional tanks required for processing, effluent treatment facility delay, etc). Evaporation (coupled with effluent treatment) or grouting the waste out of the double-shell tanks are the only means we have in the near term to reduce existing DST waste volumes. Possible delays in the effluent treatment facility starting date could force us to build additional LERFs and/or to grout additional wastes to avoid exceeding DST volumes.

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FIGURE 2. LONG RANGE PROJECTION L9102A

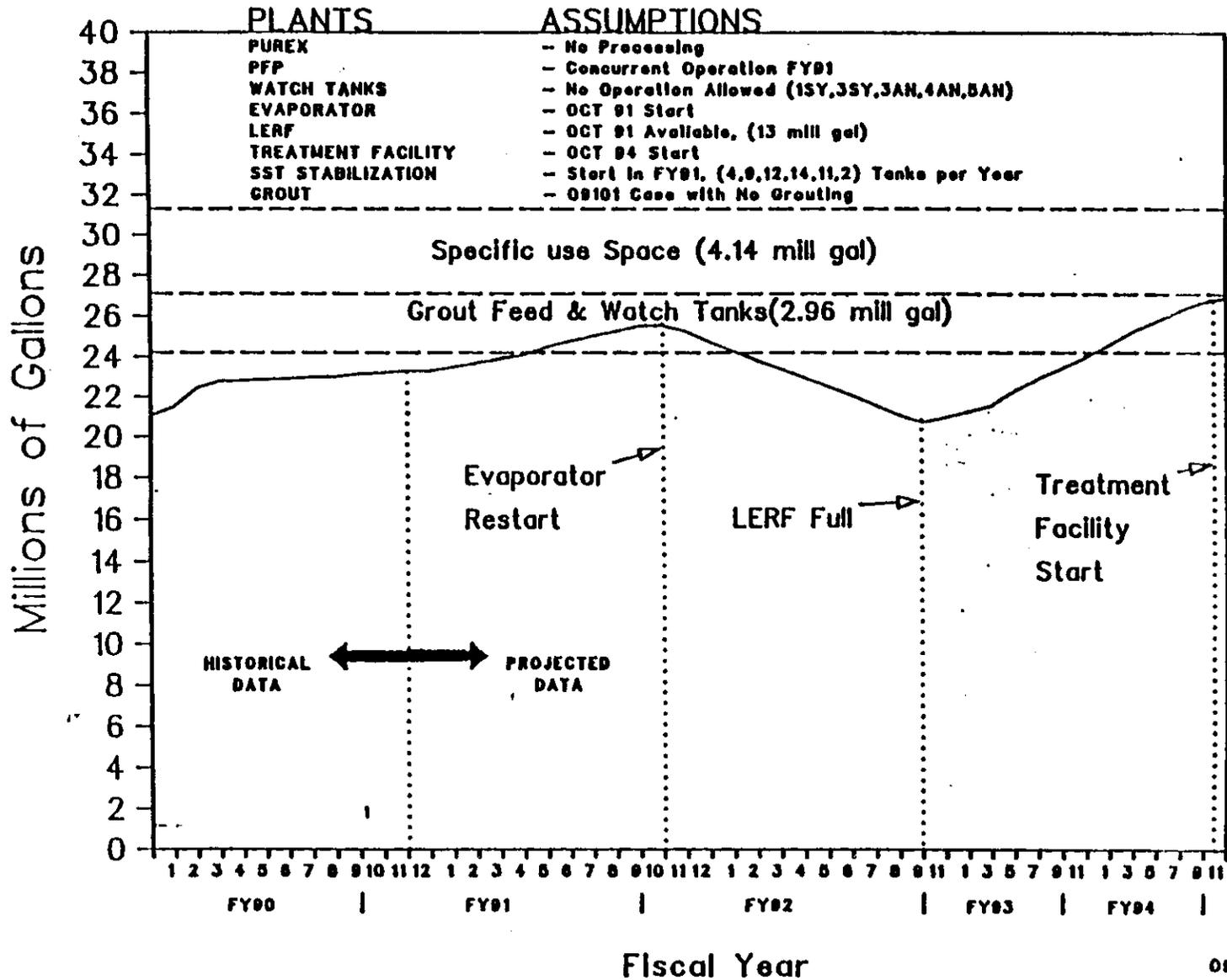


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Figure 2. Short Range Projection with No Grouting.

Summary of Combined Tank Space

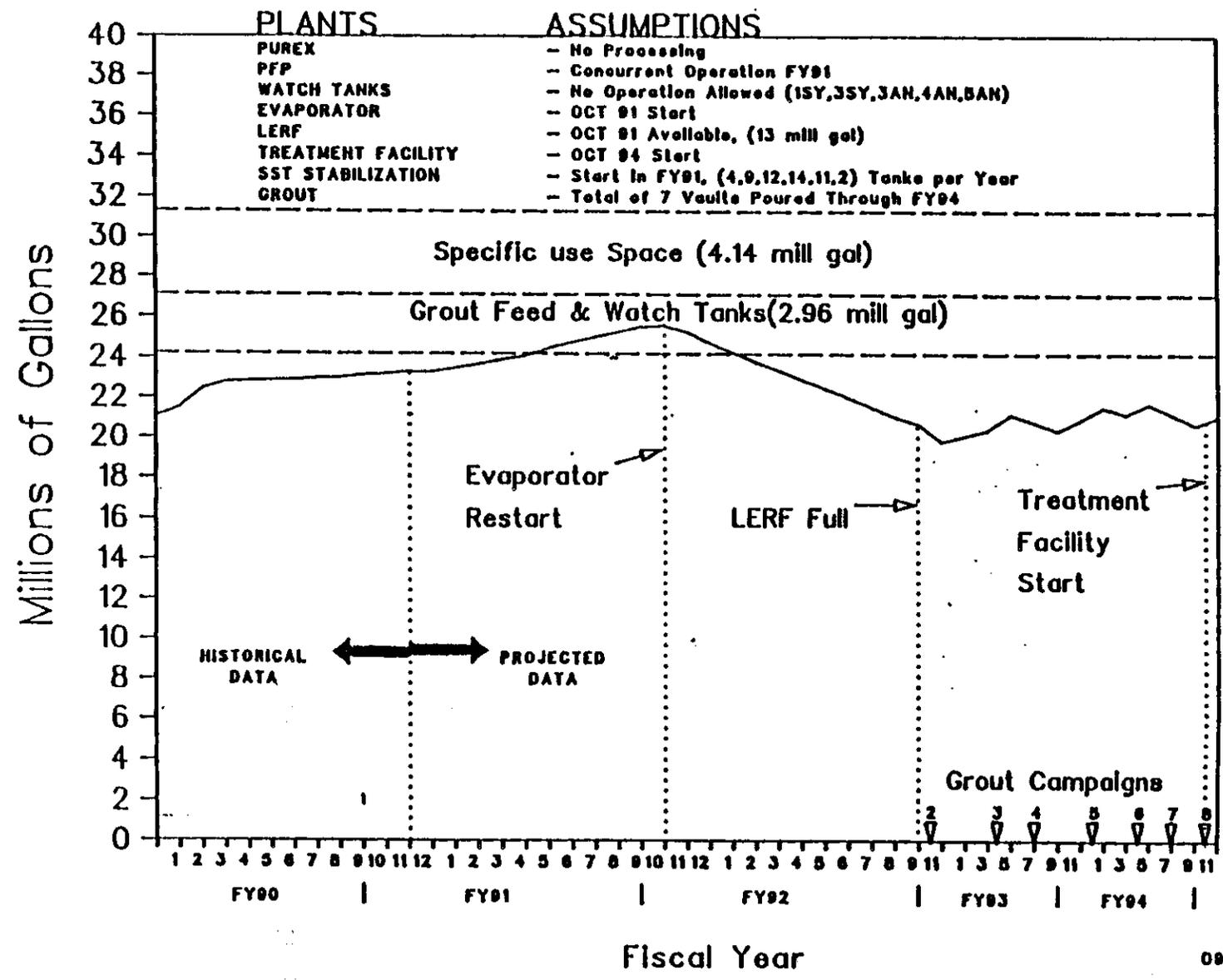


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Figure 1. Short Range Projection with 7 Grout Vaults Poured thru FY 1994.

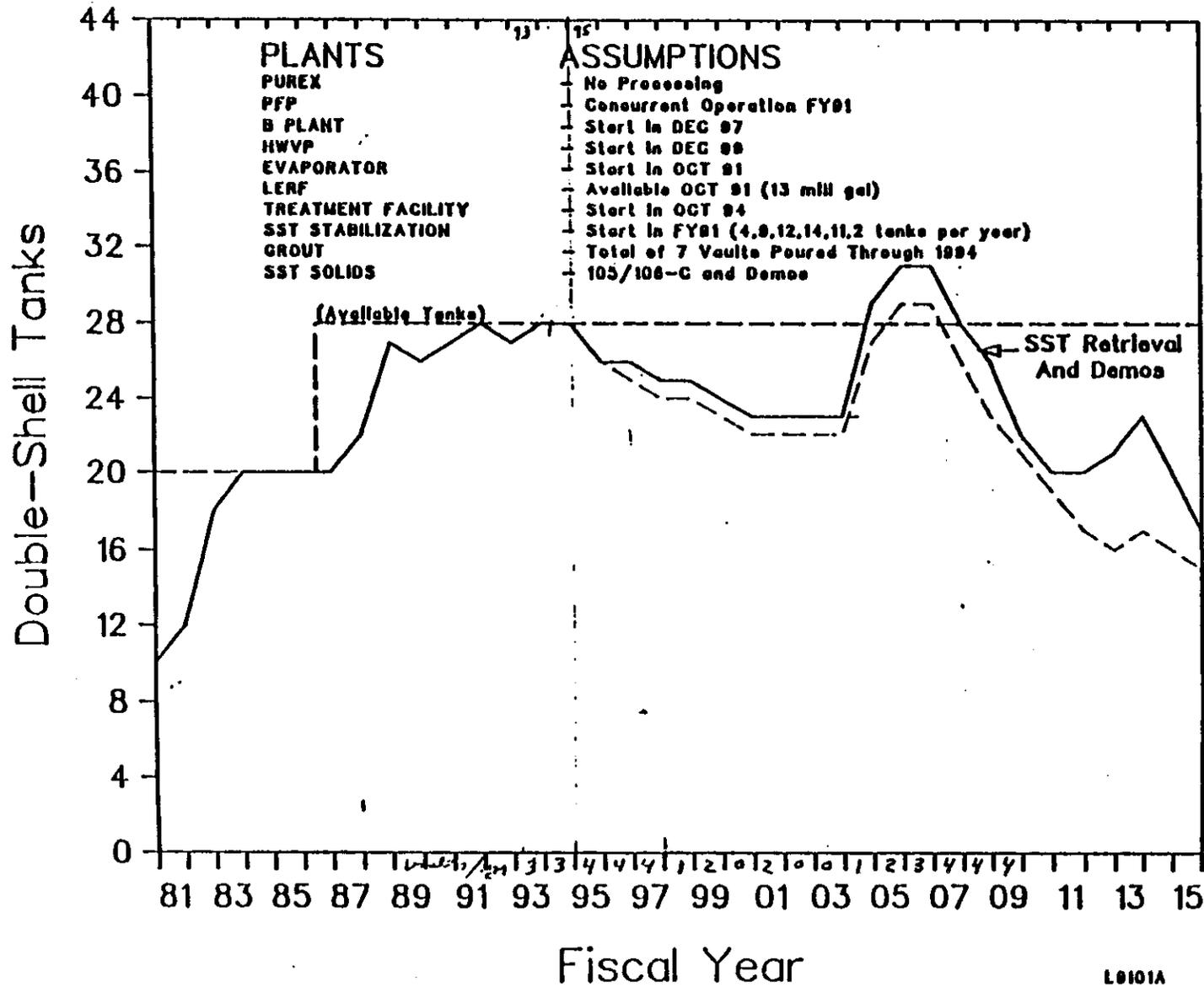
### Summary of Combined Tank Space



A-7

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Figure 4. Long Range Projection with 7 Grout Vaults Poured thru FY 1994.  
 LONG RANGE PROJECTION

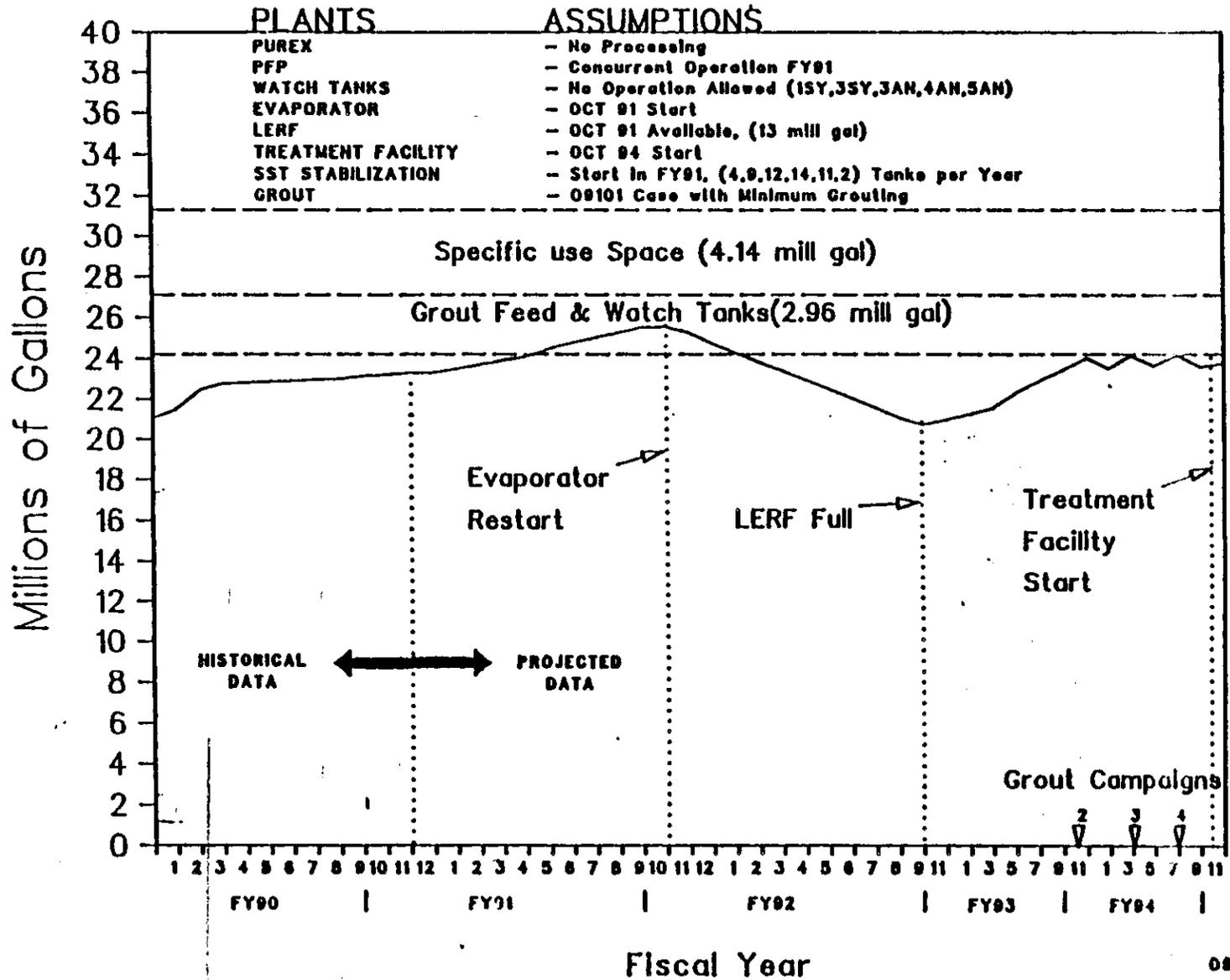


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Figure 3. Short Range Projection with Minimum Grouting.

### Summary of Combined Tank Space



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Space Designated for Specific Use (4.14 mgal).

## SPACE DESIGNATED FOR SPECIFIC USE

Spare Tanks (1 Aging & 1 Non-Aging Waste Tank)	2.28 mgal
Segregation (CC) (101AY, 102AN, 107AN)	.22 mgal (SWL = .7 mgal 101AN to be used)
Segregation (NCRW) (103AW, 105AW)	.6 mgal
Head Space	.5 mgal
West Area Transfer (102SY)	.54 mgal
Grout Feed Tanks (102AP, 104AP) (2.28)	
Watch List Tanks (0.62) (101SY, 103SY, 103AN, 104AN, 105AN)	
	<hr/> 4.14 mgal

Table 1. Assumptions for Waste Volume Projections.

Projection Cases from 9056761\*, Hamilton special\*, 1990 AHVP Cases\*

*Graphical Data*  
L9101A

Facility	Case 9	WH1*	WH2*	WH3*	WH4*	L9010*	90CC*	90TC*	90LPC*	90UPC*	L9101A
<b>PUREX</b>											
Segregation	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	No
WG Processing	3/91	3/91	No	3/91	No	No	12/90	12/90	12/90	12/90	No
FG Processing	12/93	12/93	No	12/93	No	No	10/92	10/92	6/93	12/93	No
LERF	6.5 Mgal	6.5 Mgal	No	6.5 Mgal	No	No	6.5 Mgal	6.5Mgal	6.5 Mgal	6.5 Mgal	No
<b>PFP</b>											
Segregation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cross-Site	BS	BS	BS	BS	BS	BS	BS	BS	BS	BS	BS
PRF	7/90	7/90	7/90	7/90	7/90	1/91	7/90	7/90	7/90	7/90	1/91
RMC	3/91	3/91	3/91	3/91	3/91	3/91	3/91	3/91	3/91	3/91	3/91
<b>Grout</b>											
Delay	15 Mo	15 Mo	15 Mo	15 Mo	15 Mo	----	0	4 Mo	9 Mo	>15 Mo	19 Mo
Vaults Filled thru 1994	9	9	9	9	9	4 thru FY 2000	14	13	11	8	7
<b>Evaporator</b>											
Restart	12/90	12/90	12/90	12/90	12/90	6/91	12/90	12/90	3/91	6/91	10/91
LERF	13 Mgal	13 Mgal	13 Mgal	13 Mgal	13 Mgal	13 Mgal	13 Mgal	13 Mgal	13 Mgal	13 Mgal	13 Mgal
<b>Treatment Facility</b>											
Start-up	12/93	12/93	12/93	12/93	12/93	6/94	10/92	10/92	6/93	12/93	10/94
Rate	150 gpm	150 gpm	150 gpm	150 gpm	150 gpm	150 gpm	150 gpm	150 gpm	150 gpm	150 gpm	150 gpm
TOE	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
<b>Tank 106-C Waste</b>											
Receiver	101-AY	101-AY	101-AY	101-AY	101-AY	No	101-AY	101-AY	101-AY	101-AY	101-AY
Date	FY 1996	FY 1996	FY 1996	FY 1996	FY 1996	-----	FY 1996	FY 1996	FY 1996	FY 1996	FY 1996
B Plant	5/96	5/96	5/96	1/99	6/99	6/99	5/96	5/96	5/95	5/95	12/97
HMVP	12/99	12/01	12/01	12/04	12/04	12/04	12/99	12/99	12/99	12/99	12/99
<b>SWL</b>											
Complexed SWL	14%	14%	14%	14%	14%	14%	0%	14%	14%	47%	14%
Delay	No	No	No	No	No	Yes	No	No	No	No	Yes
<b>SST</b>											
Solids Retrnl.	6/04	6/04	6/04	6/04	6/04	No	6/04	6/04	6/04	6/04	6/04
Full Scale	No	12 Tank	12 Tank	12 Tank	12 Tank	No	Demos	12 Tank	75 Tank	149 Tank	Demos

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(V2--10/92)

BS - Before Startup

Case L9010 uses waste minimization management limits for waste generation rates.

Case L9101A--waste minimization management limits for waste generation rates + 12/5/90 SWL pumping schedule.

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Table 3. Space Designated for Specific Use (7.1 mgal).

## SPACE DESIGNATED FOR SPECIFIC USE

<p><b>Spare Tanks</b> (1 Aging &amp; 1 Non-Aging Waste Tank)</p>	<p><b>2.3 mgal</b></p>
<p><b>Segregation (CC)</b> (101AY, 102AN, 107AN)</p>	<p><b>.2 mgal</b> (SWL = .7 mgal 101AN to be used)</p>
<p><b>Segregation (NCRW)</b> (103AW, 105AW)</p>	<p><b>.6 mgal</b></p>
<p><b>Head Space</b></p>	<p><b>.5 mgal</b></p>
<p><b>Operational (Grout and West Transfer)</b> (102AP, 104AP, 102SY)</p>	<p><b>2.8 mgal</b></p>
<p><b>Watch List Tanks</b> (101SY, 103SY, 103AN, 104AN, 105AN)</p>	<p><b>.7 mgal</b></p>
	<hr/> <p><b>7.1 mgal</b></p>

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APPENDIX B

CLASSIFICATION OF DOUBLE-SHELL TANK WASTE TO BE TREATED

04/20/00



APPENDIX B

CLASSIFICATION OF DOUBLE-SHELL TANK WASTE TO BE TREATED

The classification used is presented by B. M. Hanlon in "Tank Farm Surveillance and Waste Status Summary Report for November 1990," published January 1st 1991.

DST waste is classified as follows:

Aging Waste. Also called Neutralized Current Acid Waste (NCAW). High level, first cycle solvent extraction waste from PUREX.

Concentrated Complexant (CC). Concentrated product from the evaporation of dilute complexed waste.

Concentrated Phosphate Waste (CP). Waste originating from the decontamination of N Reactor. It is diluted to form dilute phosphate waste.

Dilute Complexed Waste (DC). Mainly saltwell liquid containing a high organic carbon content. The main complexants present are EDTA, citric acid, HEDTA and IDA.

Dilute Noncomplexed Waste (DN). Low activity liquid waste originating from T and S Plants, the 300 and 400 Areas, PUREX facility (decladding supernate and miscellaneous wastes), 100 N Area (sulfate waste), B Plant, saltwells and PFP (supernate).

Double-Shell Slurry (DSS). Waste evaporated just past its sodium aluminate saturation boundary or 6.5 molar hydroxide. DSS is considered a solid for reporting purposes.

Double-Shell Slurry Feed (DSSF). Waste evaporated to just below the sodium aluminate saturation boundary or 6.5 molar hydroxide content. Not as concentrated as DSS.

PUREX Decladding (PD/PN). Also called Neutralized Cladding Removal Waste (NCRW). The solids portion of the PUREX facility neutralized cladding removal waste stream, received at the tank farms as a slurry. Classified as TRU waste.

PFP TRU Solids (PT). Liquid waste containing TRU solids from West Area operations.

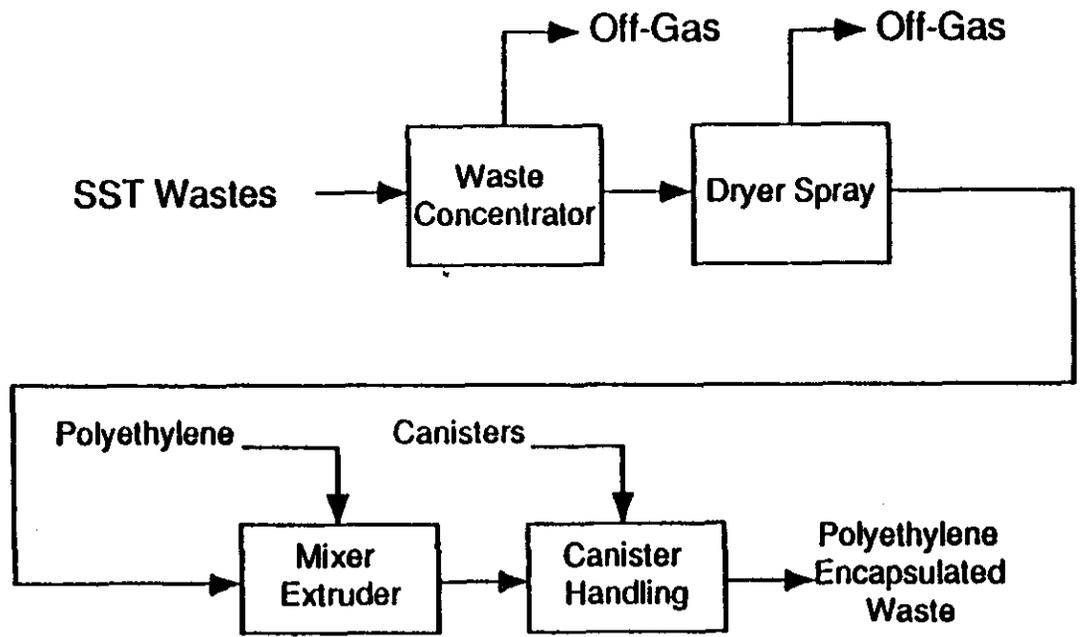
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APPENDIX C

ALTERNATIVE PROCESSES--PROCESS DESCRIPTIONS

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C-2

Figure C-1. Salt/Polyethylene Process.

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Rev.2

## APPENDIX C

## ALTERNATIVE PROCESSES--PROCESS DESCRIPTIONS

Polyethylene Encapsulation (Section 9.1.1)

A simplified flow diagram for the process is given in Figure C-1.

Premixed waste is adjusted to a pH of 8 to 10 and fed to a concentrator, where the bulk of the water is removed. The concentrate is then fed to appropriate driers, where it is converted to a powder. This powder is then metered, along with the appropriate amount of polyethylene chips, to heated continuous screw evaporator-extruders in which the waste is mixed with the now molten polyethylene and any residual water evaporated. The polyethylene encapsulated waste is discharged, at a temperature of about 160 °C, into 2 m diameter by 6 m tall containers. After being closed the containers are cooled and externally decontaminated before being transported to the burial ground. The burial ground consists of an array of 11 m deep sleeves or culverts inserted vertically into the ground. After the waste container is inserted into the bottom of the sleeve, the latter is backfilled with soil.

The polyethylene waste form is about one half the volume of equivalent grout, based on a 50% waste loading factor.

Containerized Glass (Section 9.1.2)

A simplified flow diagram is presented in Figure C-2.

The process chosen is based on commercial glass industry practice using electric, joule heated melters that produce 100 tons of glass per day. The melters, each with a holdup of 100 tons of glass, will be mounted on rail cars for ease of replacement and enclosed in shielded cells. The remainder of the process equipment will be installed in a typical canyon facility.

The homogenized waste from the DST will be adjusted to a pH of 8 to 10, before being fed to a concentrator to remove the bulk of the water content. From here it will be metered to batch tanks, where it will be blended with glass formers or frit before being fed to the melter. The frit/waste slurry blend forms a cold cap on top of the molten glass. The glass is resistance heated by the passage of an electric current through it. Heat from the molten glass evaporates the remaining water from the slurry and ultimately melts the cold cap material, which dissolves in and reacts with the underlying pool of molten glass. Molten glass is continuously withdrawn from the melter at a rate to match the feed.

Alternatively the waste might be dried or calcined prior to being fed to the melter. This would reduce both the size of the melter and its power usage.

Molten glass is discharged into containers, 2 m in diameter and 6 m tall. The containers are then cooled as rapidly as possible and externally

decontaminated before being transported to the burial ground. Here they will be placed in below ground sleeves and subsequently covered with a shielding layer of soil.

The glass will contain up to 25% by weight of waste expressed as oxides and 15% by weight of sodium oxide to maintain the desired physical properties of the glass.

Offgases generated in the process are catalytically reacted with ammonia to destroy  $\text{NO}_x$  before being passed through a HEPA filter and discharged to atmosphere via a stack.

### Glass in Sulfur Concrete (Section 9.1.3)

A simplified flow diagram is presented in Figure C-3.

Waste is adjusted to pH 8 to 10 and then concentrated to remove the bulk of its water content. The concentrate is then slurried with glass formers or frit and is fed to the melter. The melters proposed for this process are of a different design from those described for glass monolith production in Section 9.1.2.1 above, but either design might be used satisfactorily. The melters are based on a design developed by the Gas Research Institute and are much more compact than normal melters. The feed stream is suspended in high temperature combustion air and transported by the air into a high intensity gas burner. The exhaust from the burner discharges into a collection tank, where separation from the gases occurs and the glass forming reactions proceed to completion. The exhaust gases are processed to destroy  $\text{NO}_x$  and are then exhausted to atmosphere, after passing through HEPA filtration units.

Molten glass from the collection tank flows into water filled quench tanks where the glass is rapidly cooled and shatters into gravel sized chunks, called cullet. This is a common operation in the glass industry, where it is used to convert off-specification material or other glass to be remelted into a readily handled form. The cullet is separated from the water and dried for use as aggregate in sulfur concrete.

The cullet and molten sulfur, modified with additives, at a temperature of about 160 °C, are metered into a progressive cavity pump. Here the glass mixes with the sulfur to form a sulfur concrete which is pumped through heated pipelines to disposal vaults.

### In Situ Vitrification (Section 9.1.4)

A simplified process diagram is presented in Figure C-4.

The process described is the slurry injection process.

Prior to start up, a portable, double-walled hood is installed over the site to be vitrified. The hood assembly contains several offgas system components and provides support for the electrode assemblies and waste injection equipment.

Power is supplied to the electrodes and after a period of about 30 days a 25 m diameter x 15 m deep pool of glass is formed. At this point injection of

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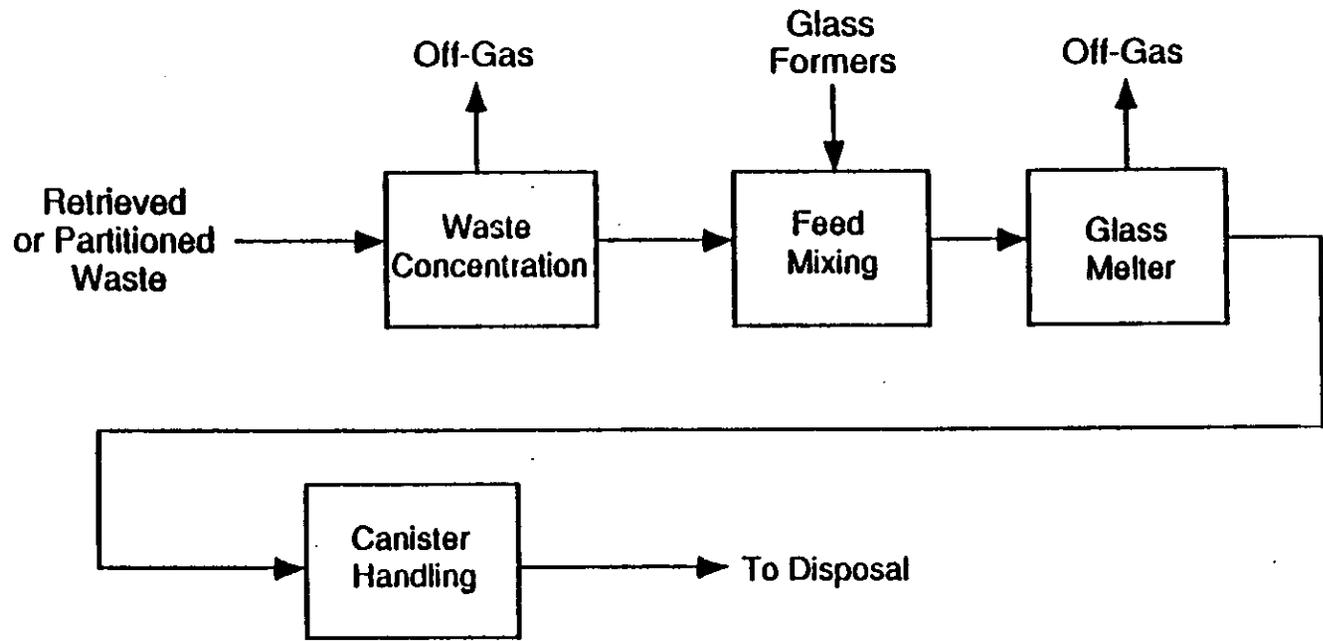
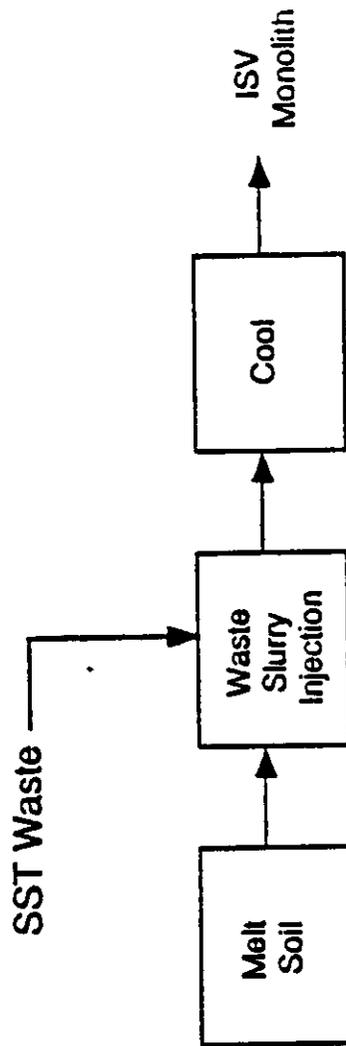


Figure C-2. Glass Container Process.

Figure C-4. Slurry In Situ Vitrification Process.



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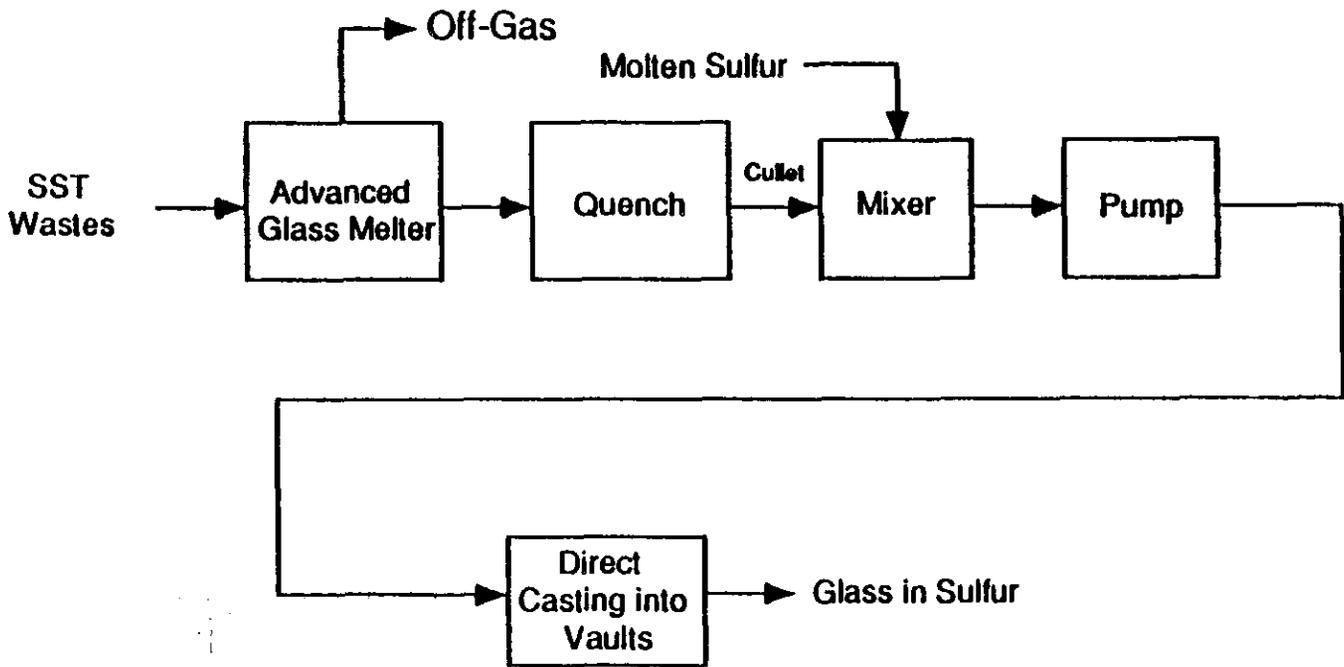
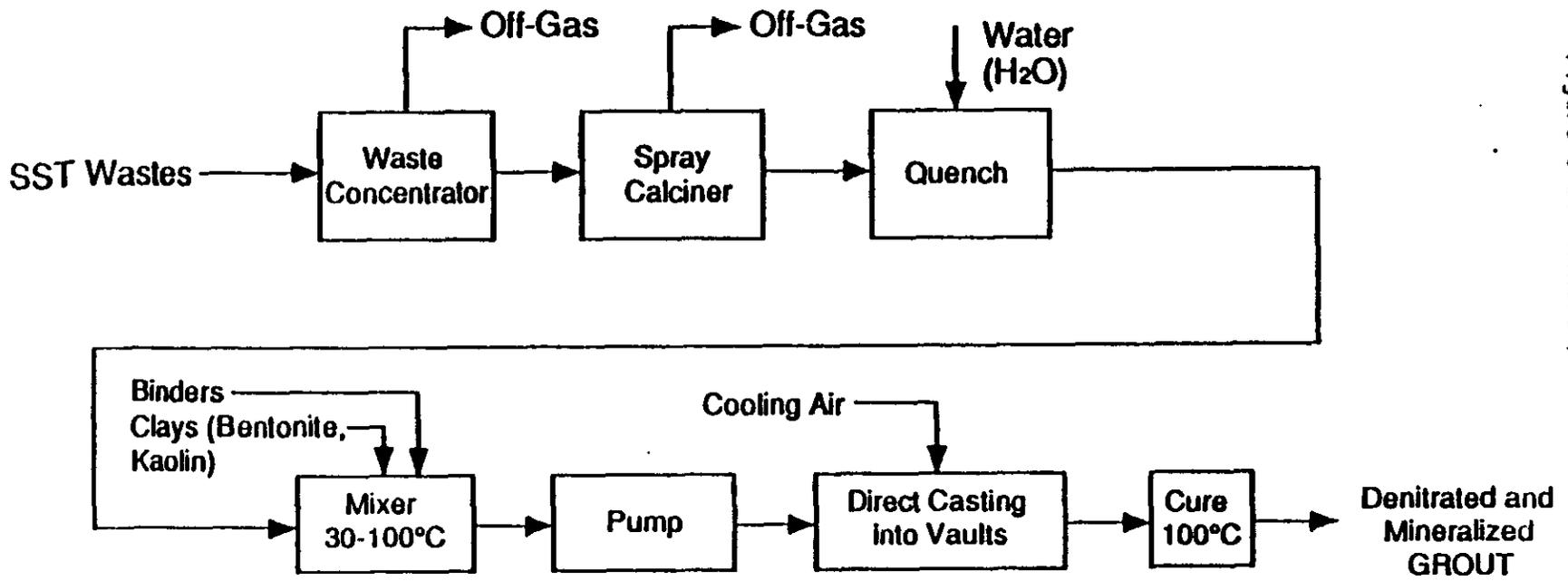


Figure C-3. Glass in Sulfur Process.



C-8

Figure C-5. Mineral/GROUT Process.

the waste can be started. No concentration or calcination of the waste is necessary. Conservative calculations determine that for a waste/soil glass composition containing 9.73 wt% sodium, about 4 million gallons of 5M sodium concentration waste feed could be incorporated into each melt. Multiple slurry injection pipes would be used to ensure distribution of waste throughout the molten mass. Convection currents in the glass will ensure homogeneity.

The vitrified mass is left to cool before being covered with a layer of soil to act as shielding.

Dry treatment of the offgas is visualized in order to avoid generation of secondary liquid wastes at a portable facility. The gas is burned in a propane burner to destroy the bulk of the  $\text{NO}_x$  and is then catalytically reacted with ammonia to destroy any residual  $\text{NO}_x$ . The gases are then passed through a HEPA filtration system and finally through a limestone bed, to remove sulfur oxides, before release to atmosphere via a stack. The gas is maintained above its dew point throughout this treatment.

#### Denitrated Low Temperature Mineralized Grout (Section 9.1.5)

A simplified process flow diagram appears in Figure C-5.

The waste is first concentrated to a slurry to remove the bulk of the water before it is fed to a calciner, where it is heated to 400 °C. After leaving the calciner the calcined waste is quenched with water to yield a caustic slurry, which is metered into a twin screw paddle mixer, or plunger, along with metered feeds of bentonite clay, sodium silicate and zinc oxide. The wet grout from the mixer is fed by progressive cavity pumps to an underground vault, where it solidifies and cures.

Offgas generated during the denitration step is catalytically reacted with ammonia to destroy  $\text{NO}_x$ , after which it is passed through a HEPA filtration system and discharged to atmosphere via a stack. Any liquid effluents are returned to the grout feed tank for disposal in subsequent batches.

A 100% excess of bentonite is used to ensure complete reaction of the sodium hydroxide to analcite, the desired mineral form. At 100 °C the reaction is complete within 100 hours. Longer reaction times are required at lower temperatures. The small quantities of sodium silicate and zinc oxide are added to bind the clay into a solid. Otherwise, on a dry chemical basis the reaction mixture contains 50% clay, 50% waste solids. The water content of the grout is similar to that for Hanford grout, 9 pounds solids to 1 gallon water.

#### Ceramic in Grout (Section 9.1.6)

A simplified process flow diagram is given in Figure C-6.

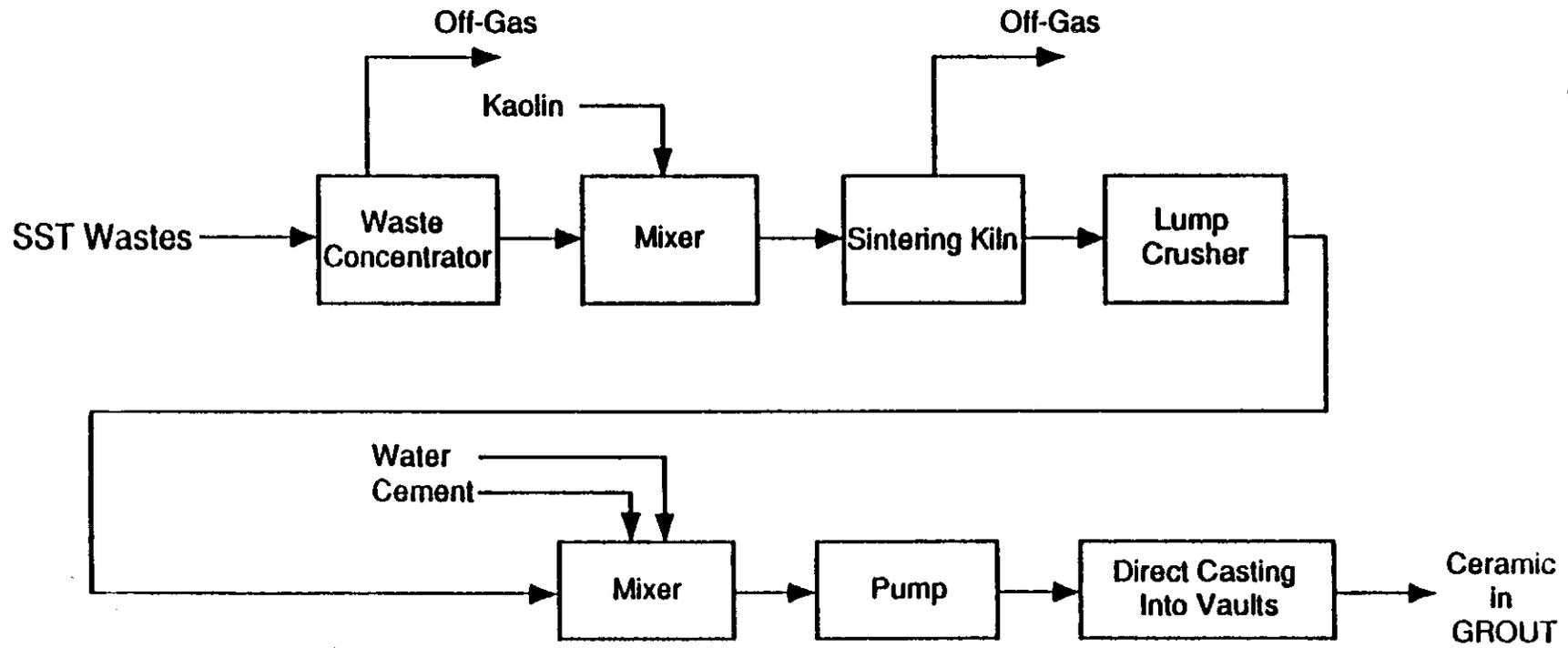
The waste is first concentrated to remove water, after which it is blended with a 10% excess of kaolinite clay and fed to the calciner. Here the mixture is fired at 600 to 800 °C to form ceramic powder and clinker. The

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resulting powder/clinker mix will be used as an inert aggregate and mixed with water and Portland or similar cement in a grout mixer before being pumped to underground vaults.

As with other denitration processes  $\text{NO}_x$  in the offgases will be catalytically destroyed using ammonia before these gases are passed through a HEPA filter and released to atmosphere.

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C-9

Figure C-6. Ceramic in Grout Process.

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APPENDIX D

PROCESSING ESTIMATES FOR CESIUM-137 RECOVERY FROM  
DOUBLE-SHELL SLURRY/DOUBLE-SHELL SLURRY FEED

9430-01

PROCESSING TIME ESTIMATES FOR CESIUM REMOVAL FROM DOUBLE SHELL SLURRY FEED

Ion Exchange Capacity

Use December 1988 estimates by D. E. Kurath with the exception that resin capacity should be corrected for the following factors:

1. Actual column resin capacity = 2000 gal./2162 gal = 0.925
  2. Higher potassium levels than experimental data = 0.9 (est.)
  3. Reduced capacity of newer CS-100 resin production = 0.8
  4. Allowance for chemical/radiation resin attrition = 0.82 (avg.)  
(0.9% per cycle for 40 batches)
- Overall resin capacity reduction factor = 0.546

Time Cycle Calculations for Single Column - Case 1

Description for Case 1 - Single Column

1. Assume an IX flowsheet similar to the one developed for NCAW. Existing B Plant ion exchange column, cesium product concentrator and LLW concentrator are used.
2. Feed rate is 0.6 column volumes/hour or 20 gpm.
3. IX scrub and elution steps limited to 20 gpm and regeneration limited to 40 gpm due to capacity of existing low level waste (LLW) concentration system.
4. Eliminate sodium scrub from 1st IX cycle. Note that this increases the volume of 1st cycle product (higher Na to Cs ratio) and requires concentrator overflow to the product receiver tank during the concentration cycle. This will also eliminate scrub losses, which constituted 2 to 3% of the cesium fed to the column during previous B Plant operations with an ammonium carbonate flowsheet.
5. Increase cesium product concentration rate from 10 gpm to 14.5 gpm so that the completion of product concentration coincides with completion of IX column regeneration. The additional steam condensate from the E-20-2 concentrator (5 gpm) will be allowed to build up in the LLW concentration feed tank (TK-24-1).

First IX Cycle:

STEP	Volume	Time
Loading Cycle (0.546 x 15,100 gallons)	8,245 gallons	6.9 hours
Feed Flush	3,500 gallons	2.9 hours
Sodium Scrub	0 gallons	0 hours
Cesium Elution	14,000 gallons	11.7 hours
Elution Flush	7,000 gallons	5.8 hours
1st Regeneration (0.5 M NaOH)	1,750 gallons	0.7 hours
2nd Regeneration (2.0 M NaOH)	3,500 gallons	1.5 hours
Regeneration Water Flush	1,750 gallons	0.7 hours
Finish Product Concentration		0 hours
<b>TOTAL CYCLE TIME</b>		<b>30.2 hours</b>

4132010017



Westinghouse  
Hanford Company

Internal  
Memo

From: Waste Pretreatment Engineering 85310-91-003  
 Phone: 3-4545 S6-70  
 Date: March 7, 1991  
 Subject: PROCESSING ESTIMATES FOR CESIUM-137 RECOVERY FROM DSS/DOSF

To: M. J. Kupfer R2-07

cc:  
 J. N. Appel R2-07  
 W. B. Barton *WB* S6-70  
 P. A. Baynes S6-70  
 J. W. Gehrke S6-70  
 M. E. Johnson S4-58  
 B. C. Landeene R2-07  
 A. K. Lee S6-70  
 D. D. Wodrich R2-23  
 DEP File/LB

Reference: Evaluation of Treatment Alternatives for the Removal of Cs-137 from Double Shell Tank Waste to Meet the Class A Disposal Limit, D. E. Kurath, December 1988, (document number not assigned).

Estimated processing rates for removing cesium-137 from double shell slurry (DSS) and double shell slurry feed (DSSF) are provided in Attachment 1. Two scenarios were developed: (1) a single ion exchange column similar to the existing B Plant column; and (2) a three column Merry-Go-Round arrangement with enhanced low level waste (LLW) and cesium product concentration capacities. Both scenarios are based on previous work by D. E. Kurath (Reference) and assume Class A disposal limits. Higher processing rates would be achievable for less restrictive disposal limits.

Simplified schematics of the two process are provided in Attachments 2 and 3. Please contact me if you need further information.

*D. E. Place*  
 D. E. Place, Principal Engineer  
 Waste Pretreatment Engineering

Received By  
 D. D. WODRICH

MAR 16 1991

mmn  
 Attachments (3)

Action: \_\_\_\_\_  
 Copies: \_\_\_\_\_  
 Route: \_\_\_\_\_  
 File: \_\_\_\_\_

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3. The two tanks in Cell 17 would be converted for IX feed and scrub/elution/regeneration feed.
4. The lag storage for filtered IX feed (previously in Cell 17) would be replaced with a 14,000 gallon tank in an another processing cell.
5. Two waste receiving tanks for the IX columns (function previously performed by TK-18-1) would be installed in another process cell.
6. Cesium product concentration capacity would be doubled. This would require replacement of existing concentrator, condenser and product receiving tank. This may or may not require the use of one additional B Plant process cell.
7. LLW concentration capacity would be doubled. This would require installation of a 2nd concentrator, feed tank and waste handling tanks (3 process cells needed).
8. Filtration capacity would be doubled by installation of larger capacity (40 gpm) PHP filter in Cell 34.
9. The required B Plant modifications would preclude installation of TRUEX equipment due to the use of 5 to 6 additional process cells.

First IX Cycle:

STEP	Volume	Time
-----	-----	-----
Loading Cycle (0.546 x 27,200 gallons)	14,850 gallons	6.2 hours
Feed Flush	3,500 gallons	1.5 hours
Sodium Scrub	14,900 gallons	6.2 hours
Cesium Elution	14,000 gallons	5.8 hours
Elution Flush	7,000 gallons	2.9 hours
1st Regeneration (0.5 M NaOH)	1,750 gallons	0.4 hours
2nd Regeneration (2.0 M NaOH)	3,500 gallons	0.7 hours
Regeneration Water Flush	1,750 gallons	0.4 hours
Finish Product Concentration		0 hours
TOTAL CYCLE TIME		24.1 hours
LIMITING TIME CYCLE FOR MERRY-GO ROUND		17.9 hours

Second IX Cycle:

STEP	Volume	Time
-----	-----	-----
Loading Cycle (eight-1st cycle product batches)	3,320 gallons	1.4 hours
Feed Flush	3,500 gallons	1.5 hours
Sodium Scrub	9,600 gallons	4.0 hours
Cesium Elution	10,500 gallons	4.4 hours
Elution Flush	7,000 gallons	2.9 hours
1st Regeneration (0.5 M NaOH)	1,750 gallons	0.4 hours
2nd Regeneration (2.0 M NaOH)	3,500 gallons	0.7 hours
Regeneration Water Flush	1,750 gallons	0.4 hours
Finish Product Concentration		0 hours
TOTAL CYCLE TIME		15.6 hours

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Second IX Cycle:

STEP	Volume	Time
-----	-----	-----
Loading Cycle (eight-1st cycle product batches)	4,000 gallons	3.3 hours
Feed Flush	3,500 gallons	2.9 hours
Sodium Scrub	9,600 gallons	8.0 hours
Cesium Elution	10,500 gallons	8.8 hours
Elution Flush	7,000 gallons	5.8 hours
1st Regeneration (0.5 M NaOH)	1,750 gallons	0.7 hours
2nd Regeneration (2.0 M NaOH)	3,500 gallons	1.5 hours
Regeneration Water Flush	1,750 gallons	0.7 hours
Finish Product Concentration		0 hours
 TOTAL CYCLE TIME		 <u>31.8 hours</u>

Overall Processing Time:

	Number	Time	Volume
IX 1st Cycles	40	1,208 hrs	329,800 gallons at 7.2 M
IX 2nd Cycles	5	159 hrs	20,000 gallons at 5.8 M
Rework of 2nd Cycle Scrub Waste	2 equiv.	60 hrs.	---
Grout Feed	---	---	558,200 gallons at 5.0 M

Note: Approximately 29,800 moles sodium hydroxide are added each IX Cycle for resin regeneration. Each scrub neutralization adds approximately 7,200 moles.

The total processing time for above scenario is 1,427 hours or 59.5 days.

At 53% Total Operating Efficiency:

DDSF processing = 1.07E6 gallons per year  
 Grout feed produced = 1.82E6 gallons per year  
 Ratio grout to feed = 1.69 (poor, adding 18% to Na)  
 Time to Process 1.767E7 gallons DSSF = 16.5 years

Time Cycle Calculations for Merry-Go-Round - Case 2

Description for Case 2 - Three Column Merry-Go-Round

1. Merry-Go-Round arrangement of three 2,000 gallons columns (one being regenerated and two on-line in series arrangement). The three IX columns and associated valving/manifolds would be located in Cell 18 and TK-18-3/TK-18-1 functions would be relocated to other cells.
2. Feed, scrub, elution and regeneration rates would be double the rates for the single column in Case 1.

Process Condensate Calculations

Volumetric Inputs for 17.67 million gallons DSSF @ 7.2 molar sodium

	Single Column -----	Merry-Go Round -----
Feed Loaded	1.767E7 gal.	1.767E7 gal.
Feed Flushes	8.81E6 gal.	4.68E6 gal.
Sodium Scrubs		
1st IX Cycle	0 gal.	1.77E7 gal.
2nd IX Cycle	2.57E6 gal.	1.43E6 gal.
Eluant (recycled)	0 gal.	0 gal.
Eluant Flushes *	1.26E7 gal.	6.69E6 gal.
Regenerates/Flushes	1.76E7 gal.	9.37E6 gal.
Neutralization IX Product	2.25E5 gal.	1.19E5 gal.
Scrub Neutralization		
1st IX Cycle	0 gal.	1.19E5 gal.
2nd IX Cycle	2.68E4 gal.	1.49E4 gal.
Acid Butt to Cs Concentrator	7.05E5 gal.	3.75E5 gal.
Steam to Cs Concentrator	4.53E7 gal.	2.40E7 gal.
<b>TOTAL IX INPUTS</b>	<u>1.06E8 gallons</u>	<u>8.22E7 gallons</u>
LLW Concentrator Deentrainer Sprays (4.5 gpm during processing)	2.07E7 gallons	6.36E6 gallons
Vessel Vent Jet Condensate (4.4 gpm during processing)	2.02E7 gallons	6.22E6 gallons
Vessel Vent Heater Cond. (0.6 gpm continuously)	5.20E6 gallons	1.60E6 gallons
<b>TOTAL INPUT VOLUME</b>	<u>1.52E8 gallons</u>	<u>9.64E7 gallons</u>
<b>LESS GROUT FEED PRODUCED</b>	2.99E7 gallons	2.83E7 gallons
<b>TOTAL PROCESS CONDENSATE **</b>	<u>1.22E8 gallons</u>	<u>6.81E7 gallons</u>

\* Assuming 5,000 gallons net per cycle since 2,000 gallons of the 7,000 gallon eluant flush is routed to the cesium product concentrator. The 2,000 gallons becomes excess eluant which will be neutralized and used as regenerate solution.

\*\* Add 7.77E6 gallons if IX feed is diluted from 7.2 to 5 molar sodium before processing.

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Overall Processing Time:

	Number	Time	Volume
	-----	-----	-----
IX 1st Cycles	40	715 hrs	594,000 gallons at 7.2 M Na
IX 2nd Cycles	5	78 hrs	16,600 gallons at 3.9 M Na
Rework of 2nd Cycle Scrub Waste	0	---	---
Grout Feed	---	---	950,400 gallons at 5.0 M Na

Note: Approximately 37,000 moles sodium hydroxide are added each IX Cycle for scrub neutralization and resin regeneration.

The total processing time for above scenario is 793 hours or 33.0 days.

At 53% Total Operating Efficiency:

DDSF processing = 3.48E6 gallons per year  
 Grout feed produced = 5.57E6 gallons per year  
 Ratio grout to feed = 1.60 (moderate, adding 11% to Na)  
 Time to Process 1.767E7 gallons DDSF = 5.1 years

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## Notes:

1. A more selective and/or higher capacity ion exchange resin would be highly desirable to increase throughput and reduce the sodium added during ion exchange processing.
2. LLW could not be batch collected or batch sampled for either of the above processing alternatives due to the high throughput and limited LLW storage capacity. Proportional sampling of the LLW stream leaving B Plant may be possible.
3. Although the lab data cited in the Kurath report was for a 7.2 molar sodium concentration, dilution of the feed to 5.0 molar or lower may significantly improve selectivity for cesium. This would allow larger feed batches and reduced overall processing time. However, feed concentrations below 5.0 molar sodium would require additional LLW concentration before grout processing.
4. The method for reworking 2nd IX cycle wastes (Case 1) were not clearly defined in the Kurath report. Storing of a fraction of the concentrated low level wastes is probably not practical from the standpoints of storage volume or the segregation of wastes to be reworked. Only the sodium scrub actually needs to be neutralized and reworked. I have assumed that the rework of the scrub wastes from a 2nd IX cycle would be accomplished by neutralizing the material and loading it as part of the next 1st IX cycle feed (the rework would constitute the equivalent of 25% of a 1st IX cycle feed batch). A new transfer route would be needed to support recycle of scrub wastes.
5. The number of 1st IX cycles per 2nd IX cycle might be somewhat conservative and should be optimized.
6. Mike Johnson has suggested that the 2,000 gallons of eluant discarded each IX cycle (not shown in the Kurath report) could be neutralized with excess sodium hydroxide (to 0.5 or 2.0 molar NaOH) and used as regenerate. This option reduces LLW concentrator boiloff and is assumed in the above calculations.
7. The low level waste concentrator will be operated near capacity for the single column option due to the addition of approximately 9.5 gpm from the vessel vent heaters, vessel vent jet condensate and deentrainer spray water. The deentrainer spray can be reduced from 4.5 to 3.0 gpm if necessary. The concentrator/deentrainer should be able to achieve 40 gpm total boiloff; however, only 35 gpm has been demonstrated to date due to concentrator vacuum constraints. The vacuum could be enhanced by eliminating air inleakage or vent system modifications.
8. This analysis assumes that LLW concentration is performed in B Plant (ie. a BCP treatment system is provided so that the process condensate can be discharged to the environment). If the 242-A evaporator is used for LLW concentration, processing rates may be further constrained by available evaporator concentration capacity and/or double shell tank storage space.
9. The average cesium-137 concentration in the feed is taken from the December 1988 Kurath report and is based on early characterization results from 7 tanks. The average cesium-137 concentration for all DSS/DSSF tanks may be considerably less.
10. It is assumed that the ion exchange kinetics are fast enough to allow a feed rate of 1.2 column volumes per hour (40 gpm) for the three column Merry-Go-Round.

MIKE KUPFA  
4/2/91

INCREMENTAL COSTS FOR REMOVING  
<sup>137</sup>Cs FROM DSS/DSSF IN B PLANT

	CASE 1 (16.5 yrs)	CASE 2 (5.1 yrs)
B Plant Operating	10.5 yrs (\$43M) + 3 yrs (\$20M) + 3 yrs (\$0M) = <u>\$510M</u> †10	5.1 yrs. (43M) = <u>\$220M</u>
B Plant Capital	<u>\$0</u>	\$350M (.2) = <u>\$ 75M</u>
Grout Vaults	4 (\$15M) = <u>\$ 60M</u>	2 (\$15M) = <u>\$ 30M</u>
HWVP Operations	109/320 (\$80M/yr) = <u>\$ 27M</u>	61/320 (\$80M/yr) = <u>\$ 15M</u>
Repository	109 (.35m) = <u>\$ 38M</u>	61 (\$.35M) = <u>\$ 21M</u>
TOTALS	= <u>\$635M</u>	= <u>360M</u>
	* 53/gal	* = 30/gal

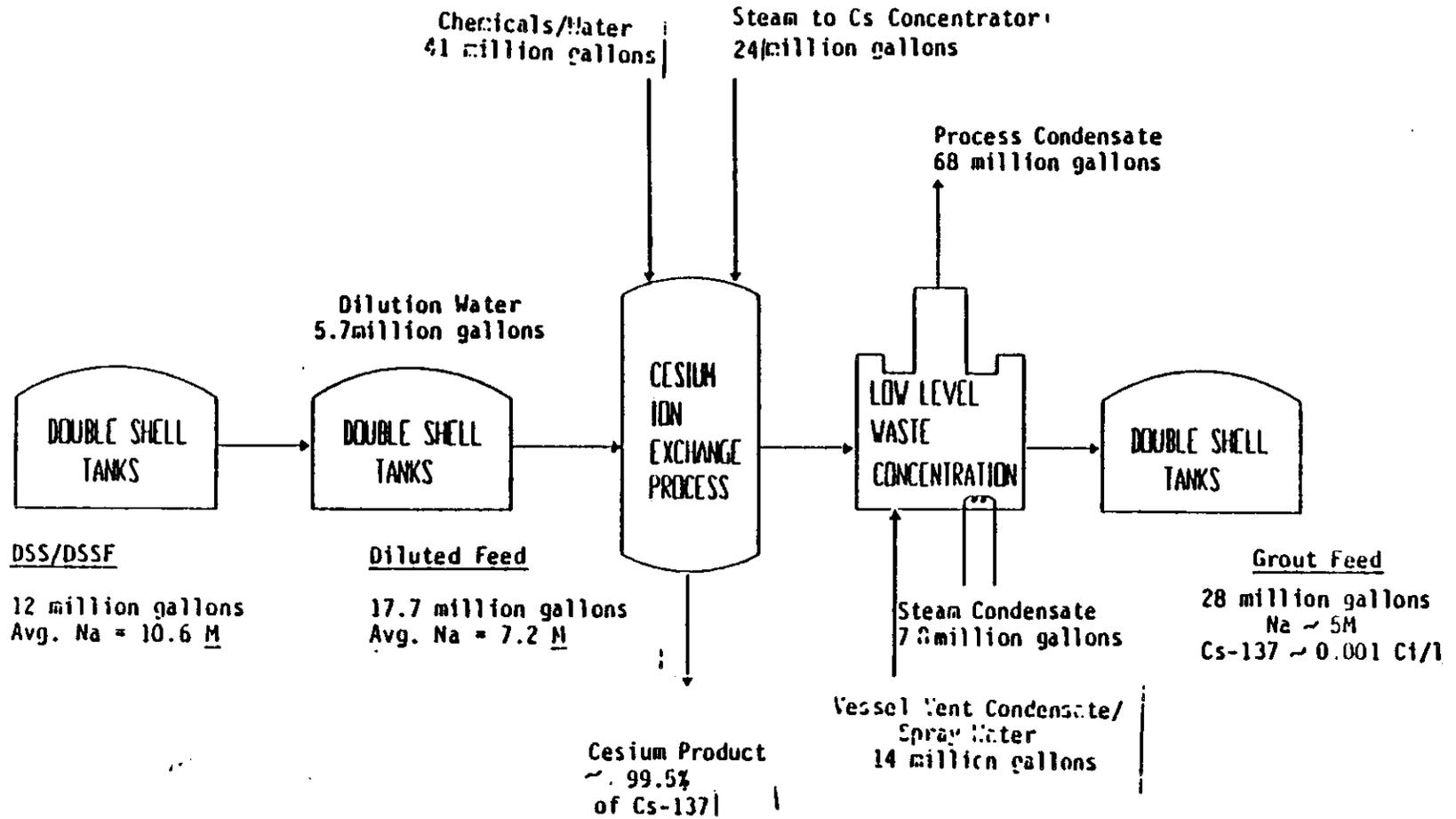
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\* Cost per gallon, assuming 12M gallons.

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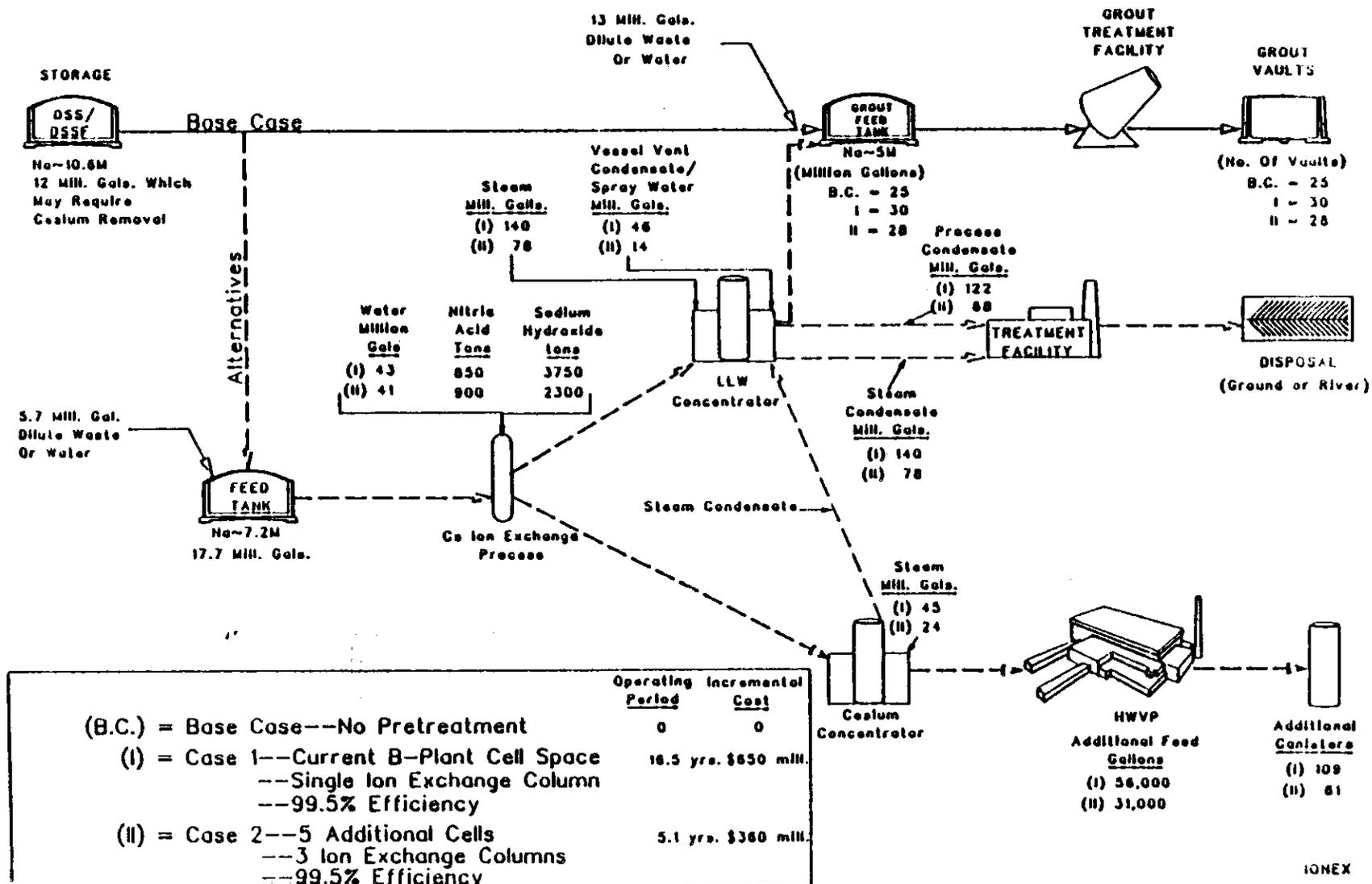


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CESIUM RECOVERY FROM DSS/DSSF  
CASE 2  
THREE COLUMN MERRY-GO-ROUND

DDW  
4/23/91

PRE-TREATMENT ALTERNATIVES FOR CESIUM REMOVAL FROM DSS AND DSSF



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