SANDIA REPORT
SAND98–8244
Unlimited Release
Printed June 1998

Fissile Materials Disposition Program SST/SGT Transportation Estimation

John Didlake
Department 2221
Sandia National Laboratories
Livermore, California

June 1, 1998

Sandia National Laboratories

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

Sandia is a multiprogram laboratory
operated by Sandia Corporation,
a Lockheed Martin Company, for the
United States Department of
Energy under Contract DE-AC04-
94AL85000.

Approved for public release; distribution is unlimited.

Issued by Sandia National Laboratories, operated for the United States Department of Energy by Sandia Corporation.

Printed in the United States of America. This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831

Prices available from (615) 576-8401, FTS 626-8401

Available to the public from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd
Springfield, VA 22161

NTIS price codes
Printed copy: A03
Microfiche copy: A01

Sandia National Laboratories

Table of Contents

Tables

Figures

Glossary

ANL/W	Argonne National Laboratories, West at INEEL
APSF	Actinide Packaging and Storage Facility
BWR	Boiling Water Reactor
CSMO	Central Scrap Management Office
DOE	Department of Energy
DOE/DP	DOE Assistant Secretary for Defense Programs
DOE/EM	DOE Assistant Secretary for Environmental Management
DOE/MD	DOE/Office of Fissile Materials Disposition
DWP-EIS	Disposition of Weapons-usable Plutonium Environmental Impact Statement
EIS	Environmental Impact Statement
FFTF	Fast Flux Test Fuel, fuel for the Fast Flux Test Reactor
HEU	Highly Enriched Uranium
IAEA	International Atomic Energy Agency
INEEL	Idaho National Engineering and Environmental Laboratory
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
LTA	Lead Test Assemblies
MOX	Reactor Fuel made from mixed plutonium oxide and uranium oxide, referred to as Mixed OXide fuel
MT	Metric Tons
MTHM	Metric Tons Heavy Metal
ORNL	Oak Ridge National Laboratories
PD&C	Pit Disassembly and Conversion Facility
PEIS	Programmatic Environmental Impact Statement
Pu	Plutonium
PuO_2	Plutonium Oxide
PWR	Pressurized Water Reactor
Px	Pantex
RFETS	Rocky Flats Environmental Technology Site
ROD	Record of Decision
SGT	SafeGuards Transport
SRS	Savannah River Site
SST	Safe Secure Transport
TSD	Transportation Safeguards Division
ZPPR	Zero Power Production Reactor

Executive Summary

This study was requested by the Department of Energy (DOE) Office of Fissile Materials Disposition (DOE/MD) as a basis for providing DOE Transportation Safeguards Division (TSD) with an estimation of the Fissile Materials Disposition Programs' future Safe Secure Transport/SafeGuards Transport (SST/SGT) requirements. The study includes SST/SGT disposition transportation requirements for both surplus highly enriched uranium (HEU) and surplus plutonium, but does not include transportation of waste materials containing small amounts of HEU or plutonium going to waste disposal facilities like the Waste Isolation Pilot Plant. In addition, TSD was asked to estimate costs of the plutonium transportation legs, based on the study data, in support of DOE/MD's costing of the alternatives in their Disposition of Weapons-Usable Plutonium Environmental Impact Statement DWP-EIS.

Specifically, the study is a broad-brush estimation of necessary SST/SGT loads and load mileage by year for each of the 13 DWP-EIS transportation scenarios combined with the transportation of HEU to blending. A load is defined as one SST/SGT trailer load transported from one site to another site, and the load mileage is defined as one trailer load times the distance between the sites.

The transportation for the following surplus materials is included in the study:

- HEU to blending sites: BWX Technologies, Inc., Lynchburg, Virginia or Nuclear Fuels Services, Inc., Erwin, Tennessee.
- Completion of pit transfers from Rocky Flats Environmental Technology Site (RFETS) to Pantex (Px).
- RFETS, Hanford Nuclear Site, Idaho National Engineering and Environmental Laboratory (INEEL), Savannah River Site (SRS), Lawrence Livermore National Laboratory (LLNL), and Los Alamos National Laboratory (LANL) materials to the immobilization facility.
- Pits to the pit disassembly and conversion facility.
- HEU from pit disassembly to Y-12 in Oak Ridge, Tennessee.
- Pit parts from the pit disassembly and conversion facility to LANL.
- Plutonium oxide to Mixed OXide (MOX) fabrication facility.
- MOX Lead Test Assemblies (LTAs) to a reactor.
- Fresh MOX fuel assemblies to commercial reactors.

Results are summarized by alternative in Table 1; alternative costs, not including HEU to blending costs, are summarized in Table 2.

Depending on the alternative selected, the total disposition program will require between 1100 and 2300 SST/SGT loads, which corresponds to between 1.0 and 3.3 million load miles. The peak years will occur between 2004 and 2014 with between 100 to 220 loads per year resulting in 120 to 340 thousand load miles per year. The estimated costs in constant FY97 dollars range from $20 to $80 million.

At a briefing in February 1998, Transportation Safeguards Division (TSD), indicated that the disposition alternatives presented in the study were within their projected capabilities based on projected mission requirements. Any major perturbation to projected missions, like Start III, would be addressed when it occurred. TSD recommended conducting future program updates to ensure that appropriate capabilities, especially courier services, were maintained to cover the program. Also, TSD recommended that, after one of the alternatives was selected, their operations personnel conduct a more detailed analysis of mission requirements.

Table 1. Total loads and load miles by alternative.

Alter-native	PD&C	MOX	Immobilization	SST Loads Total	SST Loads Max in a Year	Load Miles x 1000 Total	Load Miles x 1000 Max in a Year	Max Years
2	Hanford	Hanford	Hanford	2,224	194	2,698	255	2004-2015
3	SRS	SRS	SRS	2,307	215	2,844	292	2004-2015
4	Pantex	Hanford	Hanford	1,948	166	1,994	181	2004-2015
5	Pantex	SRS	SRS	2,031	187	2,524	265	2004-2015
6	Hanford	Hanford	SRS	2,307	215	3,279	337	2004-2015
7	INEEL	INEEL	SRS	2,307	215	2,938	304	2004-2015
8	INEEL	INEEL	Hanford	2,224	194	2,357	219	2004-2015
9	Pantex	Pantex	SRS	1,777	162	2,143	226	2004-2015
10	Pantex	Pantex	Hanford	1,694	141	1,562	137	2004-2015
11A	Hanford	N/A	Hanford	1,386	124	1,852	183	2004-2015
11B	Pantex	N/A	Hanford	1,110	97	1,148	116	2004-2015
12A/B	SRS	N/A	SRS	1,469	145	1,998	248	2004-2015
12C/D	Pantex	N/A	SRS	1,193	118	1,474	202	2004-2015

Note: MOX fabrication to the reactors is assumed to be 1000 miles

Table 2. Total cost for each DWP-EIS alternative's SST/SGT transportation.

	Total $M
Alternative 2:	71.73
Alternative 3:	51.70
Alternative 4:	61.10
Alternative 5:	45.83
Alternative 6:	78.01
Alternative 7:	59.73
Alternative 8:	53.46
Alternative 9:	32.19
Alternative 10:	25.91
Alternative 11A:	29.97
Alternative 11B:	19.33
Alternative 12A/B:	29.72
Alternative 12C/D:	23.85

Background

In March of 1995, the President announced that 200 metric tons (MT) of U.S. fissile material were no longer needed for U.S. defense. To ensure the safe, secure, and long-term storage and disposition of these surplus materials, the DOE Office of Fissile Materials Disposition (DOE/MD) issued an Environmental Impact Statement (EIS) for the disposition of weapons-usable Highly Enriched Uranium (HEU) and a Programmatic Environmental Impact Statement (PEIS) for the storage and the disposition of weapons-usable fissile materials. The PEIS covered the storage of weapons-usable HEU, the storage of weapons-usable plutonium, and the disposition of weapons-usable plutonium. The Record of Decision (ROD) for the Disposition of Surplus HEU EIS, issued in July 1996, stated that the DOE would blend down approximately 174 MT of surplus HEU to low-enriched uranium (LEU) either for use as feed material for reactor fuel fabrication or as waste to be discarded. The ROD for the storage and disposition PEIS, issued in January 1997, stated the DOE would pursue two technologies for the disposition of weapons-usable plutonium: irradiation of mixed plutonium oxide and uranium oxide (MOX) fuel in existing light-water reactors and the immobilization of the plutonium in either ceramic or glass.

At the present time, DOE/MD is preparing another EIS on the disposition of weapons-usable plutonium to decide on the location of the facilities necessary to irradiate and immobilize approximately 50 MT of surplus weapons-usable plutonium and the approximate split of the plutonium between the technologies. The new processing facilities that are required by the two technologies are a pit disassembly and conversion facility, a MOX fuel fabrication facility, and a plutonium conversion and immobilization facility. DOE/MD has identified four candidate sites for the location of one or more processing facilities: the Hanford Nuclear Site, Idaho Engineering and Environmental Laboratory (INEEL), Pantex (Px), and the Savannah River Site (SRS). The four candidate sites and the processing facilities under consideration at that site are depicted in Figure 1.

DOE/MD has defined 12 reasonable alternatives with regard to location of these facilities and the split of plutonium between the two technologies. The 12 reasonable alternatives, including the two "sub-alternatives," which include inter-site transportation differences, result in 13 Safe Secure Transport/SafeGuards Transport (SST/SGT) transportation scenarios because the first alternative is a "no action" alternative and thus is not analyzed in the study (see Table 3). Within the 12 reasonable alternatives there are actually 23 "sub-alternatives" that distinguish between the use of existing and new buildings on a site for the processing facilities. However, for the purposes of this study of SST/SGT transportation between sites, there are no differences in the sub-alternatives, except in the last two alternatives, Alternatives 11 and 12, which include different sites for the location of pit disassembly and conversion facility within the sub-alternatives.

The present schedule for the disposition of weapons-usable plutonium EIS (DWP-EIS) calls for the release of a draft statement in June 1998, followed by publication of the final EIS in January 1999 with a ROD in February 1999. Some of the 174 MT of surplus HEU and 50 MT of surplus plutonium will not require transport by DOE Transportation Safeguards Division (TSD) SST/SGTs. Examples of surplus HEU and plutonium that will not require shipment by SST/SGT are the HEU and plutonium that is in spent reactor fuel assemblies and in residues where the amounts of HEU or plutonium are below the safeguards

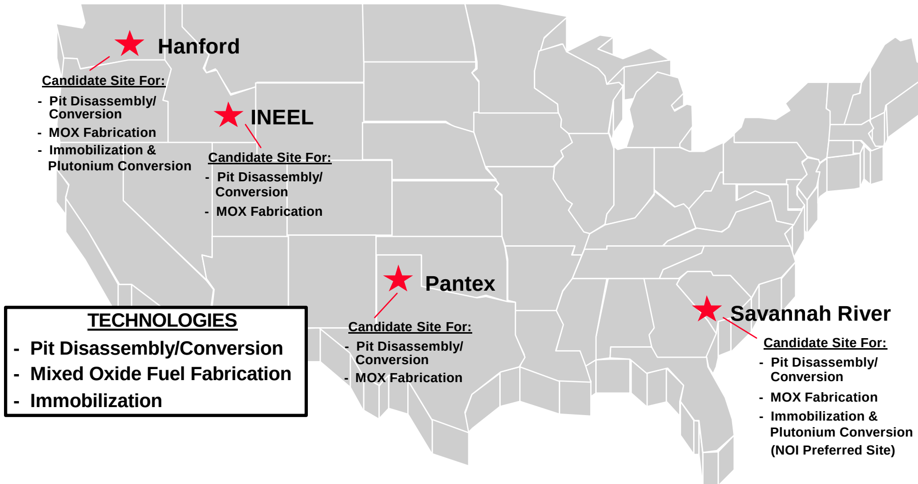

Figure 1. Facilities, locations, and candidate technologies.

termination limits. However, most of the surplus HEU and plutonium that must be moved between sites, including intermediate products such as plutonium oxide (PuO_2) and fresh MOX fuel, will require transport by SST/SGT.

Table 3. Reasonable alternatives with location of processing facilities and split of plutonium between technologies as defined in the DWP-EIS.

Alt. No.	Pit Disassembly & Conversion	MOX Plant	Pu Conversion & Immobilization	Immobilization Pu (MT)	Irradiation Pu (MT)
1	NO ACTION (not included in analysis)				
2	Hanford	Hanford	Hanford	17	33
3	SRS	SRS	SRS	17	33
4	Pantex	Hanford	Hanford	17	33
5	Pantex	SRS	SRS	17	33
6	Hanford	Hanford	SRS	17	33
7	INEEL	INEEL	SRS	17	33
8	INEEL	INEEL	Hanford	17	33
9	Pantex	Pantex	SRS	17	33
10	Pantex	Pantex	Hanford	17	33
11A	Hanford	N/A	Hanford	50	0
11B	Pantex	N/A	Hanford	50	0
12A/B	SRS	N/A	SRS	50	0
12C/D	Pantex	N/A	SRS	50	0

Introduction

The DOE/MD requested this study as a basis for providing TSD with an estimate of the Fissile Materials Disposition Programs' future SST/SGT transport requirements. As part of their request for a proposal to obtain MOX fuel fabrication and reactor irradiation services, DOE/MD will be committing TSD to the transportation of fresh MOX fuel between a MOX fuel fabrication facility and commercial reactors under tight time constraints. In addition, TSD was asked to estimate costs of the plutonium transportation legs, in support of DOE/MD's costing of the DWP-EIS alternatives.

Specifically, the study is a broad-brush estimation of the necessary number of SST/SGT loads and load mileage by year to complete the fissile materials disposition programs. In the estimate, a load is defined as one SST/SGT trailer load transported from one site to another site, and the load mileage is defined as one trailer load times the distance between the sites. The study is also a snapshot in time because on-going programmatic decisions by the DOE Assistant Secretary for Defense Programs (DOE/DP) and the DOE Assistant Secretary for Environmental Management (DOE/EM) affect the input data to the disposition programs.

The study calculates loads and load mileage for each of the 13 DWP-EIS transportation scenarios combined with the transportation of HEU to blending. Costs are provided for each of the 13 DWP-EIS transportation scenarios only.

The transportation for the following materials is included in the study:

- HEU to blending the sites, either BWX Technologies, Inc., Lynchburg, Virginia, or Nuclear Fuels Services, Inc., in Erwin, Tennessee.
- Completion of pit transfers from Rocky Flats Environmental Technology Site (RFETS) to Pantex (Px).
- RFETS, Hanford, Idaho National Engineering and Environmental Laboratory (INEEL), Savannah River Site (SRS), Lawrence Livermore National Laboratory (LLNL), and Los Alamos National Laboratory (LANL) materials to the immobilization facility.
- Pits to the pit disassembly and conversion facility.
- HEU from pit disassembly to Y-12 in Oak Ridge, Tennessee.
- Pit parts from the pit disassembly and conversion facility to LANL.
- Plutonium oxide to MOX fabrication.
- MOX Lead Test Assemblies (LTAs) to a reactor.
- Fresh MOX fuel assemblies to commercial reactors.

None of the 13 scenarios requires SST/SGT transportation of all the above materials. For example, in the scenarios where the pit disassembly and conversion facility (PD&C) is located at Pantex, SST/SGT transportation of the pits to PD&C is not required; only on-site movement of the pits from storage to the PD&C is necessary. The appropriate materials movements are included in each of the individual 13 scenarios.

In addition, data are provided to assess the effects on transportation loads of an earlier movement of RFETS materials to K reactor at the Savannah River Site followed by earlier movement of Hanford materials into the Actinide Packaging and Storage Facility (APSF) being built at Savannah River. The RFETS materials would be moved as soon as K reactor can be modified to accept the material in approximately 2000. Hanford materials would be moved as soon as APSF is ready to accept material in approximately 2002. The Savannah River Site is the preferred site for immobilization.

Assumptions

Materials Amounts

Oak Ridge, Y-12, provided the HEU amounts and the schedules for the study. For plutonium, the study uses the data provided for the DWP-EIS disposition for amounts of material and shipping containers. The DWP-EIS analyzes two scenarios with regard to the split of the 50 MT of plutonium. For a dual track disposition, 33 MT of plutonium at 3.5 MT per year will pass through the PD&C and the MOX fuel fabrication facilities to irradiation, and 17 MT of plutonium at 1.7 MT per year will be immobilized. For an immobilization only disposition, 50 MT at 5.0 MT per year is assumed.

Some minor differences exist between the draft DWP-EIS data and the study data. The study incorporates revisions to the Hanford and INEEL data that are not in the draft DWP-EIS because of time constraints. Also, slight differences occur when conservative environmental analysis and transportation philosophy lead to slightly different approaches for load calculations.

Also, it is assumed that the plutonium destined for immobilization has been processed to the DOE-STD-3013-94[1] stabilization requirements. If material is not processed to DOE-STD-3013-94 prior to shipment, or if an interim storage standard is developed, the total volume of materials transported could vary, impacting the total number of loads required for shipment.

Containers

This study uses the containers listed in the DWP-EIS for plutonium disposition and those provided by Y-12 for the HEU mission. The study baseline assumes that the containers are certified and available in sufficient quantities to meet the schedule. However, it is recognized that not all the listed containers are certified and that there may not be enough containers to support the mission. The study addresses the effects of some of the container uncertainties in the section, **Effects of Changes to Input**.

The basic assumption is that the SST/SGTs are fully loaded with containers. An exception is made of the final SST/SGT shipment if the total number of containers is not an even multiple of a trailer load. The Transportation Systems Engineering Department at Sandia National Laboratories, New Mexico, reviewed the assumptions on the maximum number of each type of container that can be loaded on an SST/SGT. In reality, the maximum number of containers that will fit in a SST/SGT varies. Not all the SST/SGTs have the same maximum load ratings. There are four types of SST and one SGT type; all five types have a slightly different rating. In addition, some container types, e.g., the 9975, come in more than one configuration resulting in total container weight differences. Nominal values are used for the number of containers in the SST/STG to average out these differences.

---

[1] DOE-STD-3013-94, December 1994,Criteria for Safe Storage of Plutonium Metals and Oxides

Missions

The study assumes that missions are balanced over a designated time from a site, i.e., if 50 loads at a site are to be moved over 10 years, they will be moved at 5 loads a year. No optimization of trips or loads is assumed, e.g., no attempt has been made to combine loads of different-category materials.

Load Mileage

The distance between DOE sites is calculated as the shortest distance by major highway rounded up to the next 50 or 100 miles, depending on the magnitude of the distance, e.g., 315 miles would be rounded to 350 miles, but 1115 miles would be rounded to 1200 miles. This rounding allows for the fact that the SST/SGTs can not always take the most direct routes. The distance between the reactors and the MOX fuel fabrication facility is estimated to be nominally 1000 miles. The DWP-EIS calculates the environmental impacts for the reactors at nominal distances of 500, 1000, and 1500 miles. The study gives the mile differential for the reactors being 500 miles closer or farther from the MOX fabrication facility; there is no change in number of loads when the nominal reactor distance changes.

Whether HEU is transported to BWX Technologies, Inc., Lynchburg, Virginia, or Nuclear Fuels Services, Inc., in Erwin, Tennessee, for blending will depend on which site is selected in a bidding process for each lot of HEU. Therefore, the study used the average distance between a site and the two blending facilities as the load mileage from that site to blending.

Input Data

Baseline Data

Baseline input data is presented in Table 4 and Table 5. The upper portions of the tables are the plutonium disposition transportation requirements while the bottom portions are for HEU disposition. Blanks in the plutonium portion of the table indicate sensitive information. Blanks in the HEU portion of Table 4 result from estimating the total number of loads from averages of the multiple material forms in the categories.

In the “Include in Alternative” section in Table 5, an “X” in the column indicates which transportation categories are required for a given alternative. For example, SST/SGT shipment of SRS plutonium materials to immobilization is required in Alternatives 2, 4, 8, 10, and 11(A and B), the alternative for which the immobilization facility is located at Hanford (see Table 3). For the other alternatives, immobilization is located at SRS, and the transport of SRS materials would be on site, not requiring SST/SGTs. Note, the transportation of HEU materials to the blending facilities is independent of the DW-EIS alternatives; therefore, it is added to each alternative to determine the total disposition program requirement.

For the plutonium materials going to immobilization, the total volume of the materials containing plutonium depends upon how the materials are processed to the DOE-STD-3013-94. The DOE/EM is responsible for processing these materials to the DOE-STD-3013-94. DOE/EM is conducting trade studies to determine the best methods to process these materials; therefore, the baseline for these materials is still changing as information is gathered and evaluated. The study input data uses the DOE/EM baseline at the time of the input to the DW-EIS.

The smaller amount of plutonium in the RFETS oxide, i.e., 2.8 kilograms versus 4.3 kilograms at other sites, results from a larger volume of bulk materials containing the PuO_2. Therefore, the average amount of plutonium in each can is limited by the volume of bulk materials containing PuO_2 and not by the DOE-STD-3013-94 plutonium material limitation of 4.3 kilograms.

The number of loads required for transportation of fresh MOX fuel assemblies to the reactors is a function of the type of reactors, boiling water reactor (BWR) or pressurized water reactor (PWR); the number of reactors; and the MOX fuel management schemes for each specific reactor. Since an irradiation contract has not been established, the commercial reactors that will be used are still an unknown; the estimated loads are based on transporting MOX fuel containing 3.5 MT of plutonium. One-third of the plutonium is assumed to go to BWRs in fuel assemblies loaded with 2.45 kilograms each. The other two-thirds goes to PWRs in fuel assemblies loaded with 18.05 kilograms each.

Table 4. Materials, containers, and load input data.

Transport									
From	To	Material Form	Quantity	Container	Amount per Container	Containers per SST	Total Loads	Site Total	Loads Per Year
LTA Fab	Rx	MOX Assemblies	8.7 MTHM[2]	MO-1	2 assy	1	8	8	4
MOX	Rx	Fresh MOX Fuel	900 MTHM	Foreign	4-8 assy	1	830	830	83
PD&C	MOX	PuO_2 Product	33 MT	SAFKEG	4.3 kg	32	254	254	25
PD&C	LANL	Piece Parts-A		UC-609			20	30	8
		Piece Parts-B		9968			10		
PD&C	Y-12	HEU to Y-12		DT-22		22	160	160	16
Sites	PD&C	Pits & Metal	33 MT	FL			530	530	53
Hanford	Immob.	Oxide	2600 cans	9975	1 can	25	104	131	26
		FFTF[3] Pins	5000 ea	M60	44 ea	9	13		
		FFTF Assys	56 ea	RRSC	4 ea	1	14		
ANL/W[4]	Immob.	ZPPR[5] Plates	29000 ea	9975	10 ea	25	116	156	17
		ZPPR Pins	20000 ea	9975	20 ea	25	40		
SRS	Immob.	SRS Materials	1200 cans	9975	1 ea	25	48	48	5
LANL	Immob.	Oxide - LANL	1 MT	SAFKEG	4.3 kg	32	7	11	11
		Metal - LANL	0.5 MT	SAFKEG	4.4 kg	32	4		
LLNL	Immob.	Various	192 cans	9975	4.3 kg	25	8	8	8
RFETS	Immob.	Oxide	2600 cans	9975	2.8 kg	25	104	104	52
RFETS	Storage	Pits & Metal		FL			16	16	16
Portsmith	Blend	HEU Oxide	7 MT	DC-1/6M			70	70	35
Y-12	Blend	HEU Logs	10 MT	ES-2M	37 kg	20	14	14	2
Y-12	Blend	HEU Oxide	3.5 MT	ES-2LM	25 kg	20	8	8	1
Y-12	Blend	Misc. HEU Metal	30 MT	ES-2M	25 kg	20	61	61	10
Y-12-IAEA[6]	Blend	HEU Logs	10 MT	ES-2M	37 kg	20	14	14	4
Y-12	Blend	Various Off-Spec	13 MT				23	23	2
SRS	Blend	Various Off-Spec	22 MT				40	40	8
INEEL	Blend	Various Off-Spec	5 MT				9	9	2
Y-12	Blend	Various Metals	5 MT	ES-2M	25 kg	20	10	10	3
Y-12	Blend	CSMO[7] HEU	2 MT				4	4	1
Y-12	Blend	Remaining HEU	36 MT				65	65	7
Sites	Blend	Remaining HEU	<2 MT				5	5	1

[2] MTHM — Metric Tons Heavy Metal
[3] FFTF — Fast Flux Test Fuel, fuel for the Fast Flux Test Reactor
[4] ANL/W — Argonne National Laboratories, West at INEEL
[5] ZPPR — Zero Power Production Reactor
[6] IAEA — International Atomic Energy Agency
[7] CSMO — Central Scrap Management Office

Table 5. Schedule and alternative input data.

Transport			When		Include in Alternative												
From	To	Material Form	Start	Finish	2	3	4	5	6	7	8	9	10	11A	11B	12A/B	12C/D
LTA Fab	Rx	MOX Assemblies	2004	2005	X	X	X	X	X	X	X	X	X				
MOX	Rx	Fresh MOX Fuel	2006	2015	X	X	X	X	X	X	X	X	X				
PD&C	MOX	PuO2 Product	2004	2013			X	X							X		X
PD&C	LANL	Piece Parts-A	2010	2013	X	X	X	X	X	X	X	X	X	X	X	X	X
		Piece Parts-B															
PD&C	Y-12	HEU to Y-12	2004	2013	X	X	X	X	X	X	X	X	X	X	X	X	X
Sites	PD&C	Pits & Metal	2004	2013	X	X			X	X	X			X		X	
Hanford	Immob.	Oxide	2005	2009		X		X	X	X		X				X	X
		FFTF Pins															
		FFTF Assemblies															
ANL/W	Immob.	ZPPR Plates	2005	2013	X	X	X	X	X	X	X	X	X	X	X	X	X
		ZPPR Pins															
SRS	Immob.	SRS Materials	2005	2013	X		X				X		X	X	X		
LANL	Immob.	Oxide - LANL	2005	2005	X	X	X	X	X	X	X	X	X	X	X	X	X
		Metal - LANL															
LLNL	Immob.	Various	2005	2005	X	X	X	X	X	X	X	X	X	X	X	X	X
RFETS	Immob.	Oxide	2002	2003	X	X	X	X	X	X	X	X	X	X	X	X	X
RFETS	Storage	Pits & Metal	1998	1998	X	X	X	X	X	X	X	X	X	X	X	X	X
Portsmith	Blend	HEU Oxide	1998	1999	X	X	X	X	X	X	X	X	X	X	X	X	X
Y-12	Blend	HEU Logs	1998	2003	X	X	X	X	X	X	X	X	X	X	X	X	X
Y-12	Blend	HEU Oxide	1998	2003	X	X	X	X	X	X	X	X	X	X	X	X	X
Y-12	Blend	Misc. HEU Metal	1998	2003	X	X	X	X	X	X	X	X	X	X	X	X	X
Y-12-IAEA	Blend	HEU Logs	1999	2002	X	X	X	X	X	X	X	X	X	X	X	X	X
Y-12	Blend	Various Off-Spec	1999	2009	X	X	X	X	X	X	X	X	X	X	X	X	X
SRS	Blend	Various Off-Spec	2004	2008	X	X	X	X	X	X	X	X	X	X	X	X	X
INEEL	Blend	Various Off-Spec	2004	2008	X	X	X	X	X	X	X	X	X	X	X	X	X
Y-12	Blend	Various Metals	2004	2007	X	X	X	X	X	X	X	X	X	X	X	X	X
Y-12	Blend	CSMO HEU	1998	2003	X	X	X	X	X	X	X	X	X	X	X	X	X
Y-12	Blend	Remaining HEU	2008	2016	X	X	X	X	X	X	X	X	X	X	X	X	X
Sites	Blend	Remaining HEU	2008	2012	X	X	X	X	X	X	X	X	X	X	X	X	X

Container Uncertainties

Uncertainties associated with several of the listed containers could have impacts on the number of loads necessary to complete the disposition missions. Most of the uncertainties concern the status of the container certification and the quantities of containers available. Time exists to resolve many of these uncertainties, as they will not become critical for several years. In addition, resolution of some of the container unknowns depends on the disposition alternative chosen; for example, resolving concerns with the FL container for shipping pits is unnecessary if the PD&C is located at Pantex. Generally, it is expected that these uncertainties, except for those with the MOX fresh fuel container, will not significantly impact the total loads required; because of certification requirements, any new container will have close to the same capabilities as the container used in the study.

Uncertainties associated with the MOX fresh fuel container have the potential of significantly increasing the 830 total loads. Presently, one U.S. container design, the MO-1, has been certified for transporting MOX fuel. The MO-1 can hold two PWR assemblies but because of weight and size constraints only one MO-1 will fit in a SST. The weight of the MO-1 with fuel assemblies is very close to the maximum load limit of the SST. In fact, the MO-1 may be limited to certain SST trailers, depending on when they were acquired. It also appears that the newer SGTs will not be able to transport a MO-1 with fuel assemblies.

There are two MO-1 containers in existence. New MO-1s can not be built and certified to the present NRC requirements. Two foreign MOX fuel containers exist: one for PWR fuel and one for BWR fuel. These containers have not been certified in the U.S. U.S. certification is assumed to be possible but, until the containers go through the process, it is not a certainty. The PWR fuel container, French FS69, like the MO-1, accepts two PWR assemblies and fits one container to a SST. The BWR fuel container is a Siemans design, fits one to a SST, and carries eight assemblies. Development work at Oak Ridge National Laboratory (ORNL) indicate that a new MOX fuel container that could hold four PWR or eight BWR assemblies and fit one to a SST could be designed and certified. The EIS assumes use of a new four-assembly PWR MOX fuel container and of a new eight-assembly BWR fuel container or the Siemans BWR fuel container. If the new four-assembly PWR fuel container is not designed, developed, and certified, and the contracted reactors are mostly PWRs, then the number of MOX fuel loads to the reactors could increase significantly. However, as discussed in the **Input Data** section, several other factors exist that could reduce the total number of MOX fuel loads.

Other container uncertainties are as follows: The SAFKEG, ES-2M, and ES-2LM containers have not yet been certified, although certification is expected. If transportation of all the surplus pits is required, it is uncertain whether the FL containers will be able to maintain their certification until they are needed in 2004 or whether the less-than-200 existing FL containers are sufficient to carry out the mission. The RRSC container is a storage cask for Fast Flux Test Fuel (FFTF) and is not likely to be certified as a transportation container. One option is to disassemble the FFTF assemblies and to place the resulting FFTF pins in M60 containers for shipment. This would reduce the number of loads required from 14 to 12.

Schedule Uncertainties

As with any program that projects 20 years into the future, schedule uncertainties exists. One schedule change under investigation is to move the RFETS materials bound for immobilization to the K reactor area at SRS as soon as possible and then move the Hanford materials to APSF at SRS as soon as it is ready to accept materials. One effect of this schedule change is provided in the **Study Results** section.

Also, the schedules for moving non-pit materials to immobilization from any of the sites are reasonable but arbitrary. The moves could be achieved earlier or later in the schedule or could be accomplished on a shorter or longer schedule. The impacts of changing these parameters can be estimated from Figures 2, 4, 6, 8, 10, 12, and 14, which depict the individual site information.

While the assumption of a uniform yearly rate of transportation of fresh MOX fuel assemblies to the reactors over a 10-year period is adequate for the level of detail for this study, it is a highly unlikely scenario. Depending on the number of reactors assigned to the disposition mission, their refueling schedules, and many other factors, there could easily be an imbalance in the number of reactors refueled each year; for example, two reactors in one year and three reactors, the next. In addition, most commercial reactors like to shut down for refueling in the spring or the fall to avoid peak electrical demand periods. Present reactor fuel usually arrives in a two-week period, 1 to 2 months before the scheduled refueling outage. DOE is requesting that the mission reactors have 90 days of fresh MOX fuel storage capability.

Study Results

Baseline

The study results are summarized in Table 6 below. Appendix A includes graphs for each alternative for loads and load miles. The graphs are stacked bars by year for each of the materials by site.

Table 6. Study results.

Alter-native	PD&C	MOX	Immobilization	SST Loads Total	SST Loads Max in a Year	Load Miles x 1000 Total	Load Miles x 1000 Max in a Year	Max Years
2	Hanford	Hanford	Hanford	2,224	194	2,698	255	2004-2015
3	SRS	SRS	SRS	2,307	215	2,844	292	2004-2015
4	Pantex	Hanford	Hanford	1,948	166	1,994	181	2004-2015
5	Pantex	SRS	SRS	2,031	187	2,524	265	2004-2015
6	Hanford	Hanford	SRS	2,307	215	3,279	337	2004-2015
7	INEEL	INEEL	SRS	2,307	215	2,938	304	2004-2015
8	INEEL	INEEL	Hanford	2,224	194	2,357	219	2004-2015
9	Pantex	Pantex	SRS	1,777	162	2,143	226	2004-2015
10	Pantex	Pantex	Hanford	1,694	141	1,562	137	2004-2015
11A	Hanford	N/A	Hanford	1,386	124	1,852	183	2004-2015
11B	Pantex	N/A	Hanford	1,110	97	1,148	116	2004-2015
12A/B	SRS	N/A	SRS	1,469	145	1,998	248	2004-2015
12C/D	Pantex	N/A	SRS	1,193	118	1,474	202	2004-2015

Note: MOX fabrication to the reactors is assumed to be 1000 miles

While the load miles are different for each scenario, several of the alternatives have similar requirements for SST/SGT load movements. First, the HEU-to-blending loads are independent of the DWP-EIS alternatives and are the same for every scenario, see Figure 2 and Figure 3. Also, if the 50-MT immobilization alternatives are viewed as a combination of a 17-MT case and a 33-MT case, the 17-MT case is the same for all scenarios, except that the immobilization facility could be located at SRS or Hanford, see Figure 4. Estimates are that it will take 83 less SST/SGT loads to move SRS materials to Hanford than it would take to move Hanford materials to SRS. Adding the 17-MT immobilization loads to the HEU-to-blending loads leads to the graph shown in Figure 5, which is common to all the scenarios.

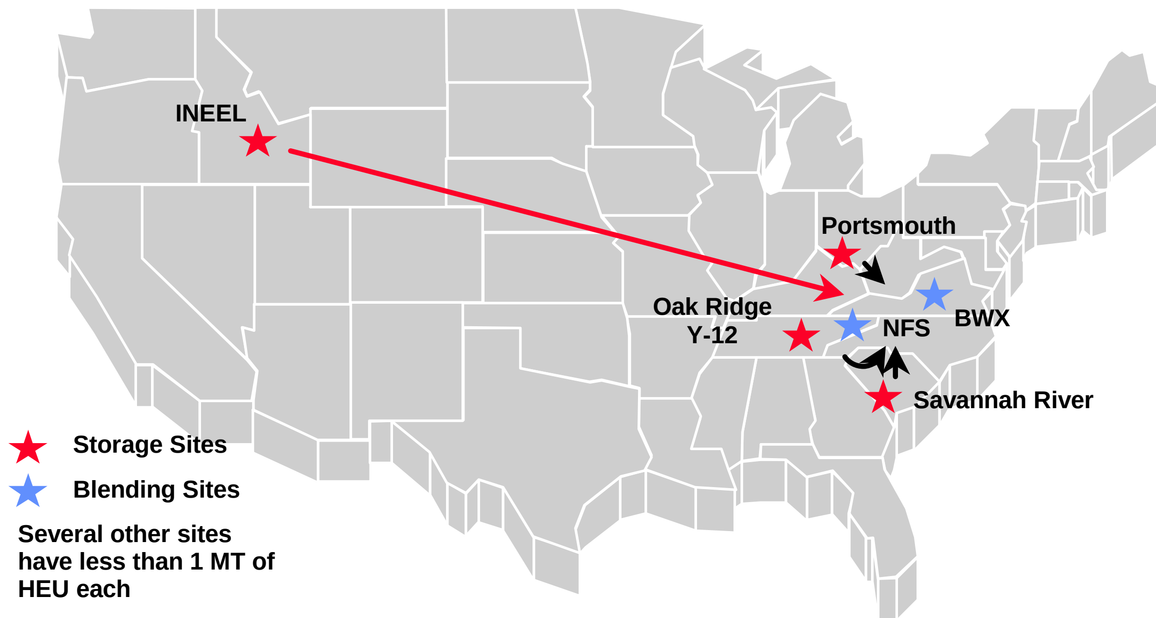

Figure 2. HEU-to-blending transportation.

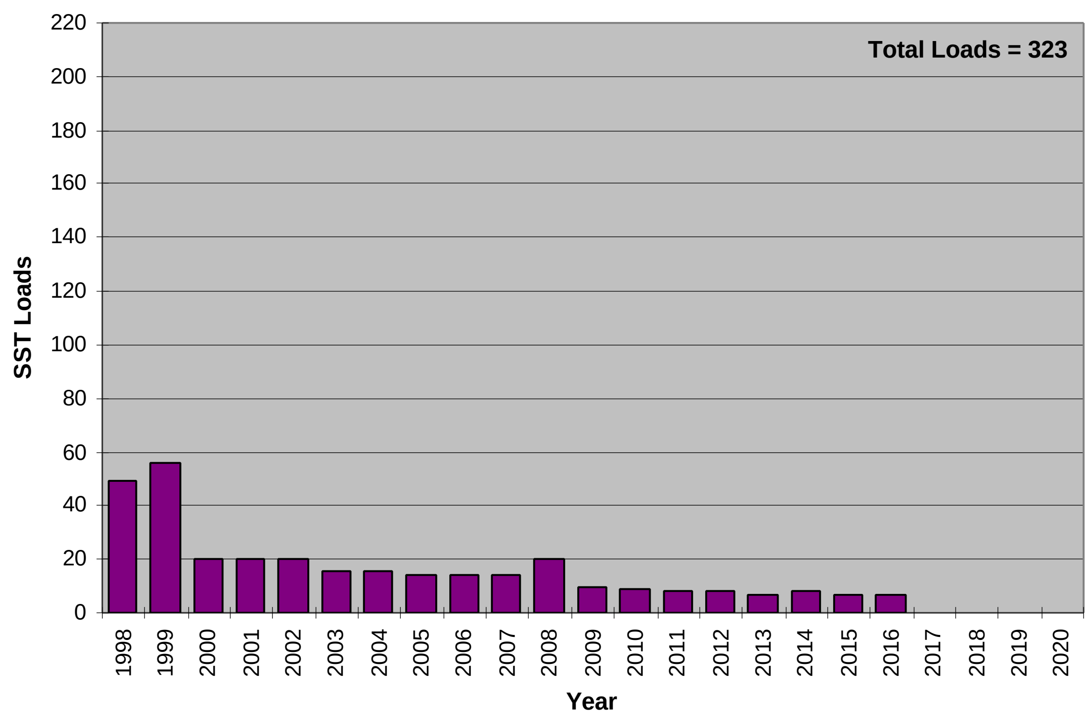

Figure 3. SST/SGT loads for HEU-to-blending.

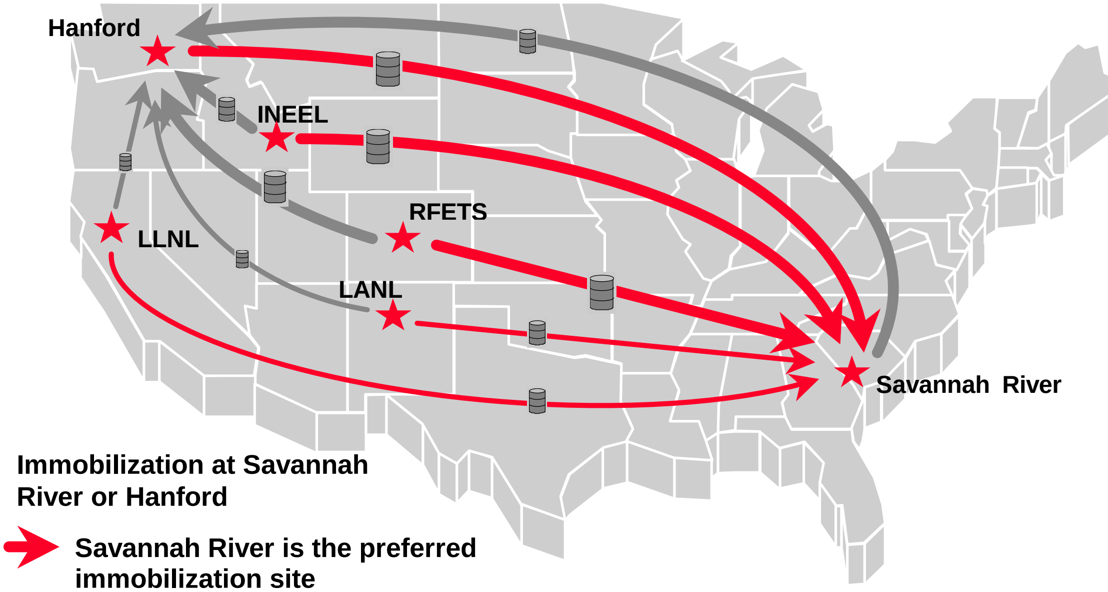

Figure 4. 17-MT immobilization transportation to SRS (red) or to Hanford (gray).

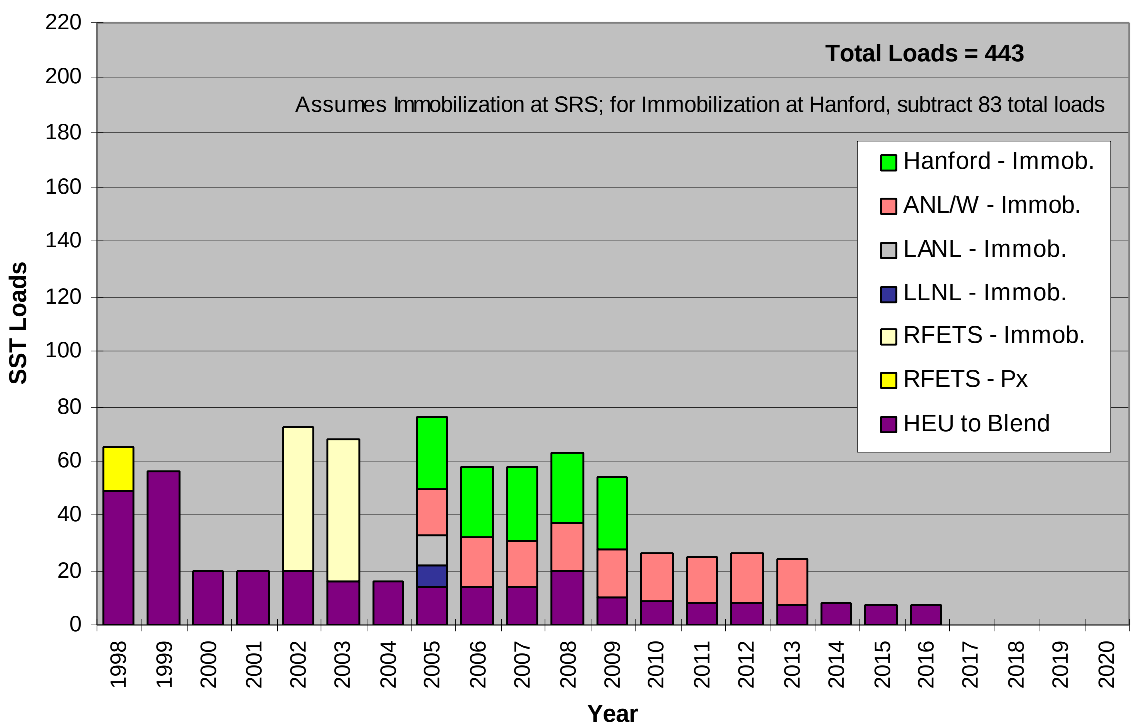

Figure 5. Immobilization and HEU to blending, common to all scenarios.

Alternatives 2, 3, 6, 7, and 8, form the first group of alternatives that share common total loads. Alternatives 2 and 8 differ by the 83 loads in the 17-MT case for immobilization at Hanford. These five alternatives have the PD&C and MOX fabrication colocated at Hanford, INEEL, or SRS. Figure 6 depicts the transportation legs for the 33 MT of plutonium in the reactor irradiation technology for these alternatives; Figure 7 shows the total transportation requirements including the HEU-to-blending load and the transport of 17 MT of plutonium to immobilization.

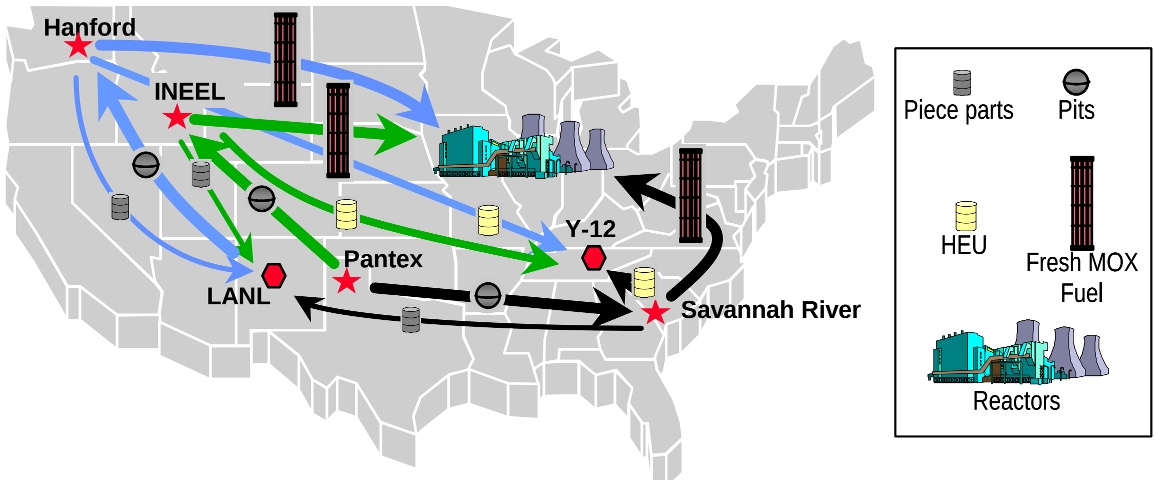

Figure 6. Transportation for 33-MT irradiation alternatives with PD&C and MOX fabrication colocated at SRS (black), INEEL (green) or Hanford (blue).

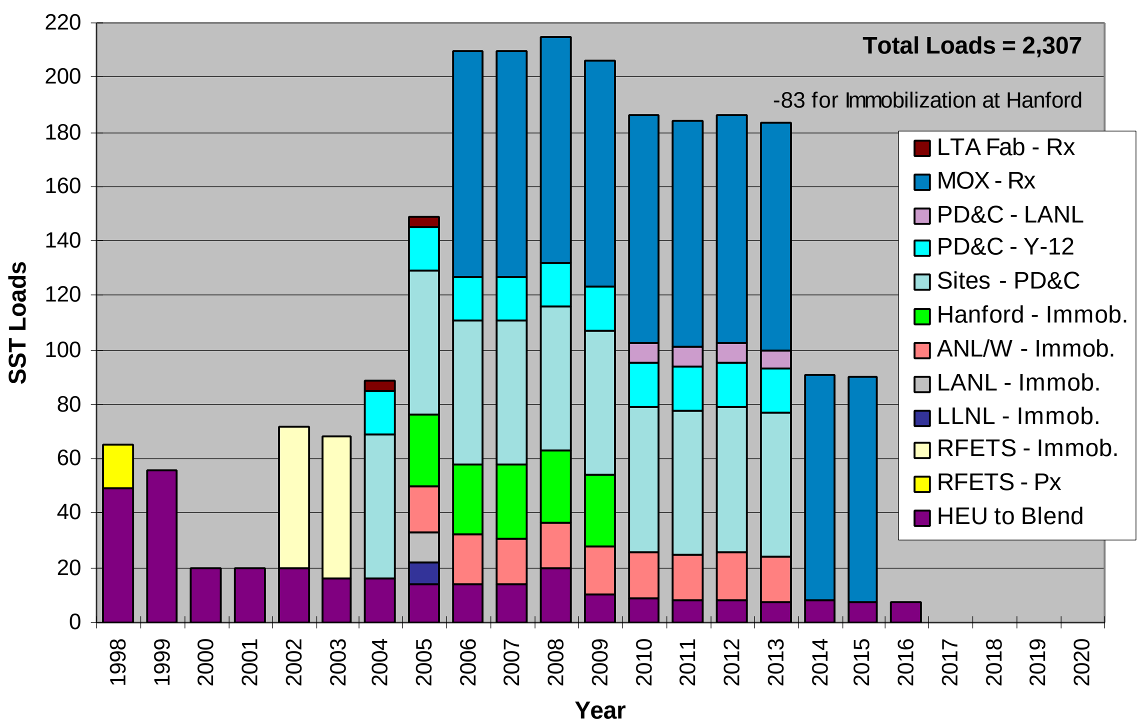

Figure 7. Group 1 (Alternatives 2, 3, 6, 7 and 8) total loads for PD&C and MOX fabrication colocated at SRS, INEEL or Hanford (including HEU and immobilization).

The second group, Alternatives 4 and Alternative 5, has PD&C located at Pantex with MOX fabrication at either Hanford or SRS. The total loads differ only in the 83 loads in immobilization. The major transportation legs for this group are PuO_2 from Pantex to MOX fabrication, fresh MOX fuel to the reactors, piece parts from Pantex to LANL, and HEU from Pantex to Y-12. Figure 8 and Figure 9 show the second group transportation legs and total loads, respectively.

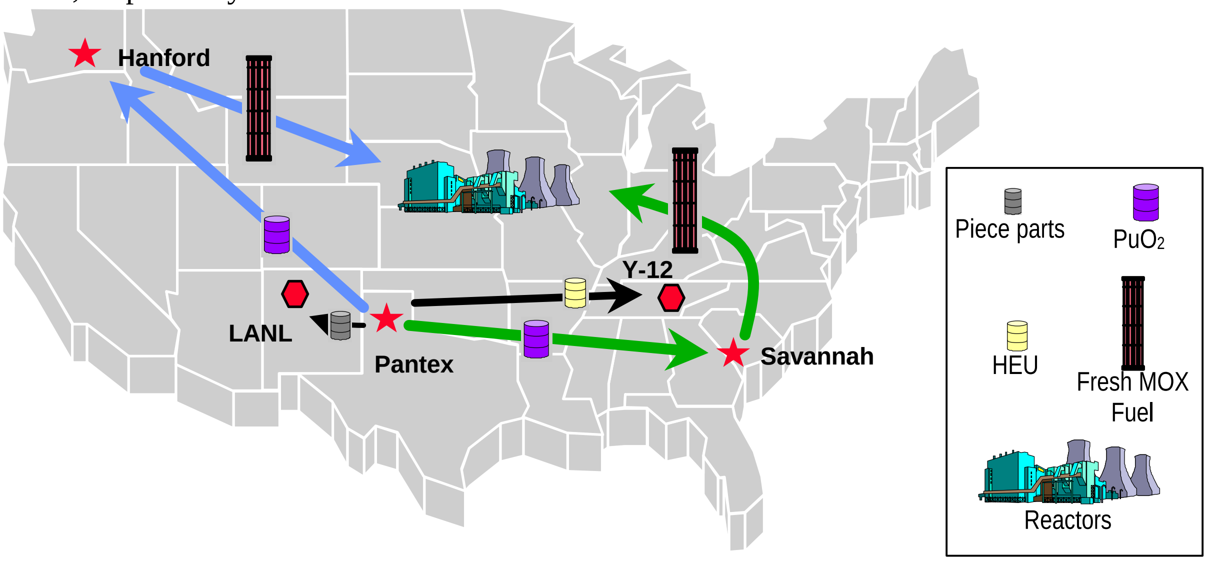

Figure 8. Transportation for 33-MT irradiation alternatives with PD&C at Pantex and MOX fabrication at SRS (green) or Hanford (blue).

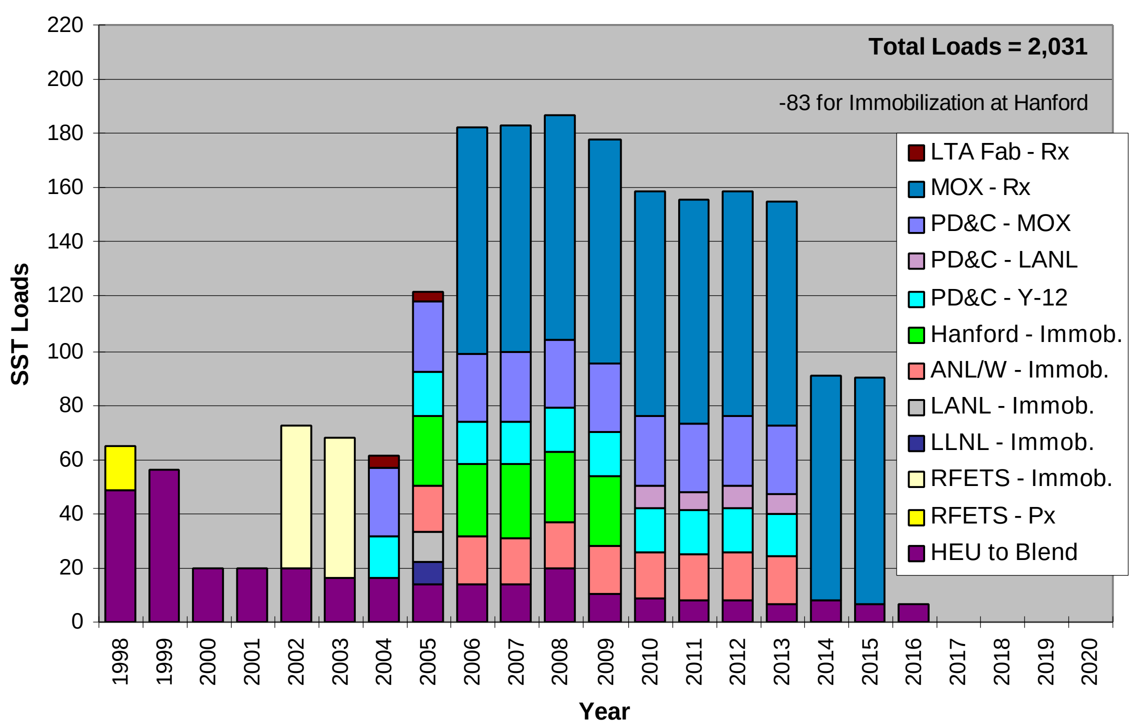

Figure 9. Group 2 (Alternatives 4 and 5) total loads for PD&C at Pantex and MOX fabrication at SRS or Hanford (including HEU and immobilization).

The third group, Alternative 9 and Alternative 10, has PD&C and MOX fabrication colocated at Pantex. Again, the total loads differ only in the 83 loads in immobilization. The major transportation legs for this group are fresh MOX fuel to the reactors, piece parts from Pantex to LANL, and HEU from Pantex to Y-12. Figure 10 and Figure 11 show the third group transportation legs and total loads, respectively.

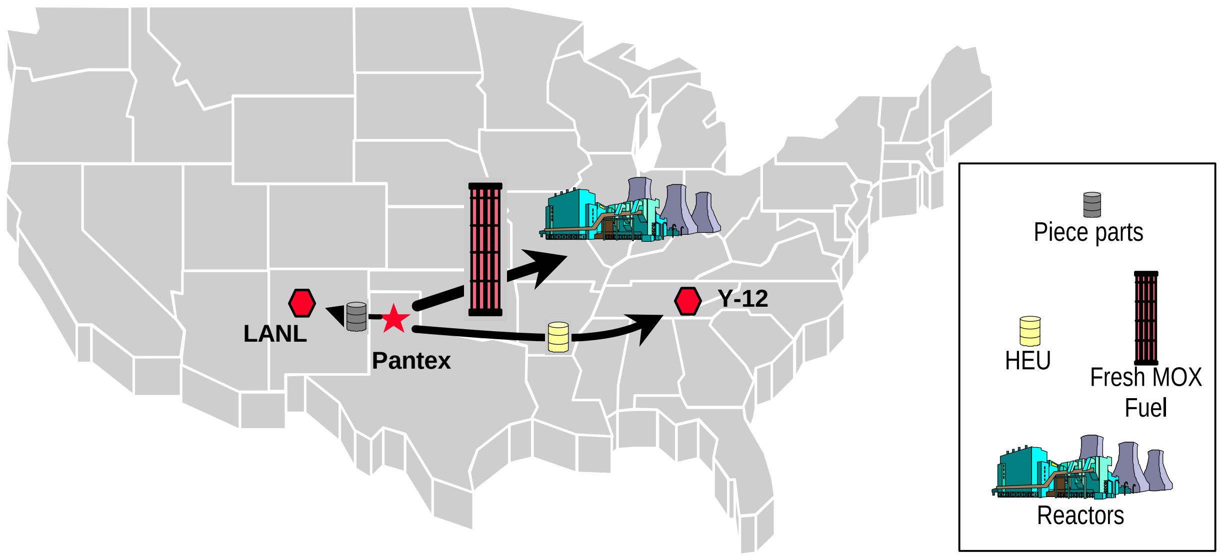

Figure 10. Transportation for 33-MT irradiation alternatives with PD&C and MOX fabrication colocated at Pantex.

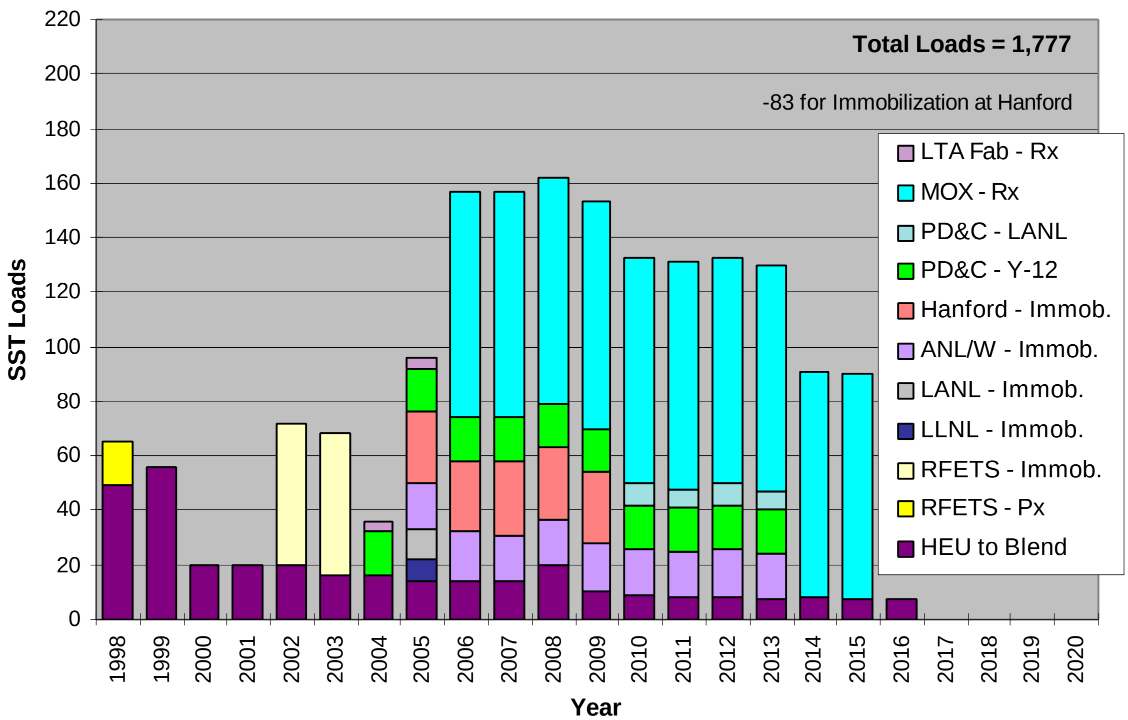

Figure 11. Group 3 (Alternatives 9 and 10) total loads for PD&C and MOX fabrication colocated at Pantex (including HEU and immobilization).

The fourth and fifth groups include the four 50-MT immobilization scenarios. The fourth group is comprised of Alternative 11A and Alternative 12A/B and has the PD&C colocated with the immobilization facility at either SRS or Hanford. As previously shown, the total loads differ only in the 83 loads in the 17 MT immobilization area. The major transportation legs for this group are pits from Pantex to PD&C, piece parts from PD&C to LANL, and HEU from PD&C to Y-12. The second group transportation legs and total loads are shown Figures 12 and 13, respectively.

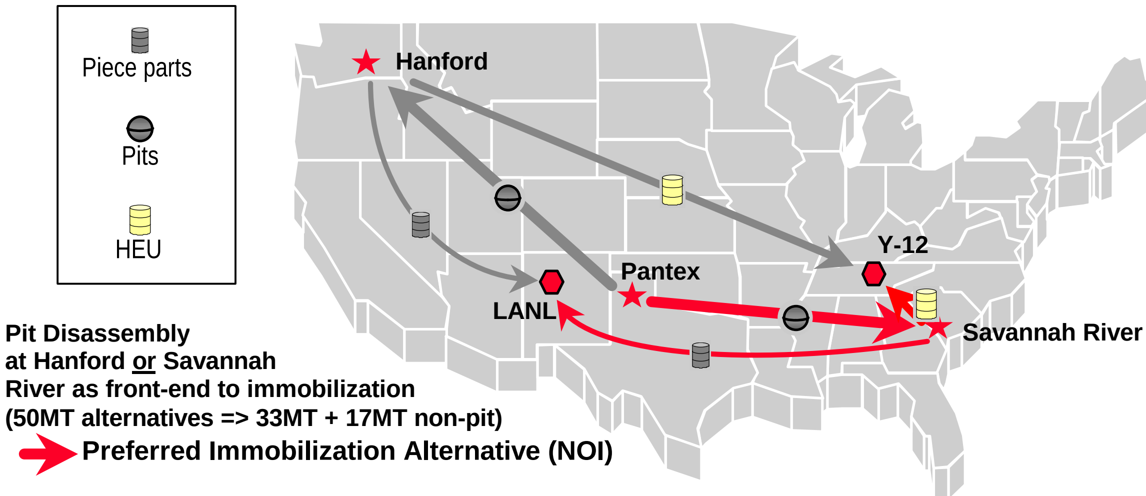

Figure 12. Transportation for 33 MT of pits and metal to immobilization, PD&C colocated with immobilization facility.

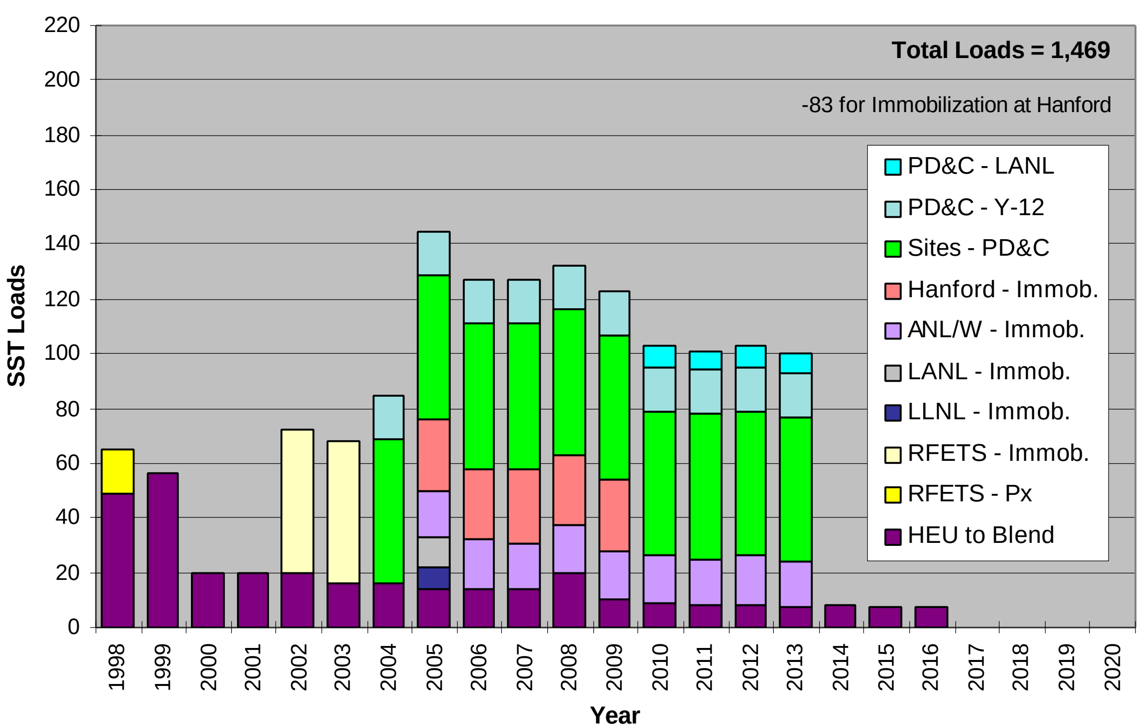

Figure 13. Group 4 (Alternatives 11A and 12A/B) total loads for 50-MT immobilization, PD&C colocated with immobilization **(including HEU).**

The fifth group, comprised of Alternative 11B and Alternative 12C/D, is the same as the fourth group except that the PD&C is at Pantex as opposed to being colocated with the immobilization facility. This group transports PuO_2 instead of pits, the piece parts from Pantex to LANL, and HEU from Pantex to Y-12. Figures 14 and 15 show the fifth group transportation legs and total loads.

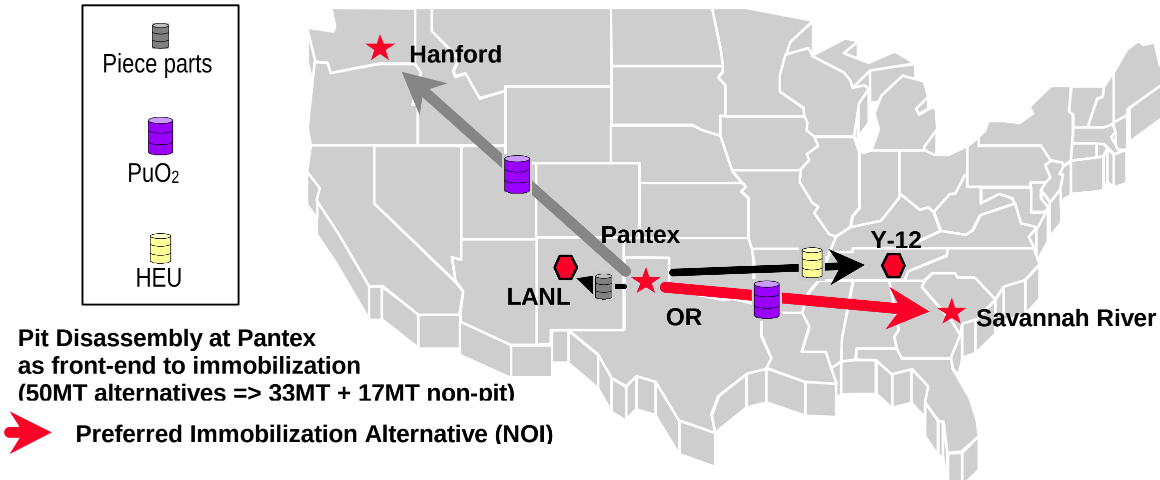

Figure 14. Transportation for 33 MT of pits and metal to immobilization, PD&C at Pantex.

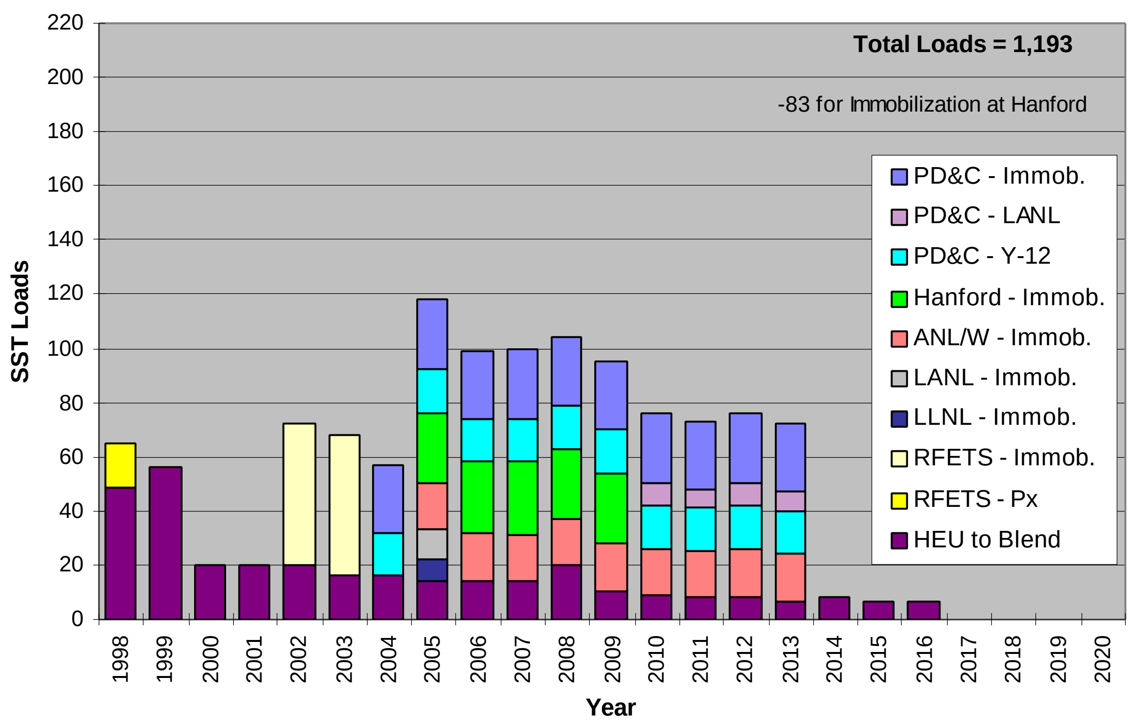

Figure 15. Group 5 (Alternatives 11B and 12C/D) total loads for 50-MT immobilization, PD&C at Pantex (including HEU to blending).

Effect of Changes to Input

As described earlier, there are uncertainties with regard to some of the containers and with the distance of the reactors from PD&C. Table 7, below, summarizes the effect of some of these uncertainties.

Table 7. Effects of changes to input.

Change	Total Loads	Loads per Year	Total Miles	Miles per Year
±500 miles from MOX Fab. to Reactors	0	0	±400 K	±40 K
Using only 9975s - Alternatives 4 & 5	+75	+8	+125 K	+14 K
Using SAFKEGs only - Immobilization SRS Immobilization Hanford	 -80 -70	 -10 -5	 -80 K –190 K	 -10 K –25 K
Using existing container for PWR fresh MOX fuel with reactors at 1000 miles (for PWR only)	+250	+25	+250K	+25 K

Effects of Early Moves from RFETS and Hanford

An early move of RFETS materials to the K reactor at SRS followed by an early move of Hanford materials into APSF at SRS, as soon as it is open, shifts load requirements from

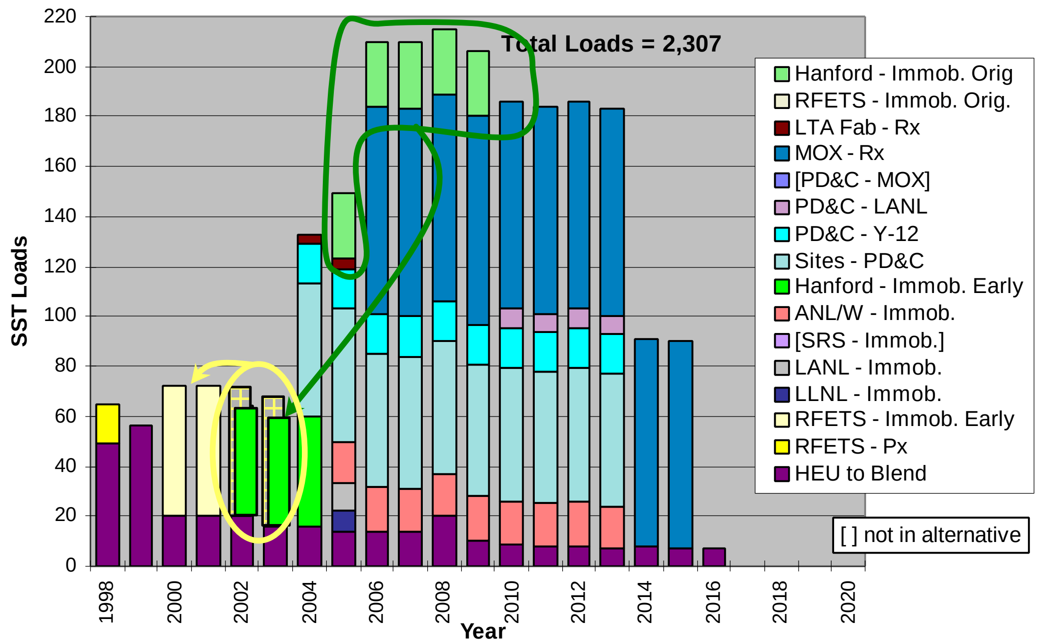

Figure 16. Effects on SST/SGT loads of early RFETS and Hanford materials moves depicted in the yellow and green loops, respectively.

the peak years of 2006 to 2009 into the 2000 and 2001 time frame. The early moves also level the load requirements from now through 2003 and reduce the small peak that was occurring between 2006 and 2008. Figure 16 shows this effect, graphically, on Alternative 3. The yellow loop and arrow show the effect of the early RFETS movement, shifting the crosshatched yellow bars in 2002 and 2003 to the solid yellow bars in 2000 and 2001. Likewise, the green loop and arrow indicate the effect of the early Hanford movement, shifting the four crosshatched green bars in 2005 to 2008 to the three solid green bars in 2002 to 2004. A similar result would occur in the other alternatives where SRS is the site for immobilization, namely Alternatives 5, 6, 7, 9, 12A/B, and 12C/D.

Costs

In support of DOE/MD's costing of the DWP-EIS alternatives, TSD was asked to provide estimated costs of the plutonium transportation legs, based on the study data. The costs provided by TSD for each individual transportation leg are provided in Table 8 and the resulting alternative cost totals in Table 9. It should be noted that Tables 8 and 9 do not include the costs for transporting the HEU to blending.

The cost calculations assume that the loads are transported by the optimum convoy size of three trailers at a time. If convoys of three trailers are not used, the estimated cost could double or triple. Also, the estimated costs for transportation of the MOX fuel to the reactors assumes that the SST/SGTs deploy from their base that is closest to the MOX fabrication site, pick up the MOX fuel, deliver the fuel to a reactor, and then return along the same route. In reality, the SST/SGTs would take the shortest route from the reactor back to their base.

Table 8. Cost data provided by TSD.

Transport		Loads	Time		Transportation Leg		Yearly Cost
From	To	Per Year	Start	Finish	From	To	($M)
MOX	Rx	83.0	2006	2015	Pantex	Rx*	1.42
					SRS	Rx*	2.20
					INEEL	Rx*	3.16
					Hanford	Rx*	4.18
PD&C	MOX or Imm.	25.4	2004	2013	Pantex	SRS	.58
					Pantex	Hanford	.76
PD&C	LANL	7.5	2010	2013	Pantex	LANL	.06
					SRS	LANL	.25
					INEEL	LANL	.18
					Hanford	LANL	.29
PD&C	Y-12	16.0	2004	2013	Pantex	Y-12	.33
					SRS	Y-12	.13
					INEEL	Y-12	.66
					Hanford	Y-12	.83
Sites	PD&C	53.0	2004	2013	Pantex	SRS	1.17
					Pantex	INEEL	.83
					Pantex	Hanford	1.53
Hanford	Immob.	26.2	2005	2009	Hanford	SRS	1.43
ANL/W	Immob.	17.3	2005	2013	ANL/W	SRS	.59
					ANL/W	Hanford	.50
SRS	Immob.	5.3	2005	2013	SRS	Hanford	.32
LANL	Immob.	11.0	2005	2005	LANL	SRS	.35
					LANL	Hanford	.30
LLNL	Immob.	8.0	2005	2005	LLNL	SRS	.37
					LLNL	Hanford	.22
RFETS	Immob.	52.0	2002	2003	Rocky Flats	SRS	1.65
					Rocky Flats	Hanford	1.16

Table 9. Total SST/SGT transportation costs by alternative.

	Total $M
Alternative 2:	71.73
Alternative 3:	51.70
Alternative 4:	61.10
Alternative 5:	45.83
Alternative 6:	78.01
Alternative 7:	59.73
Alternative 8:	53.46
Alternative 9:	32.19
Alternative 10:	25.91
Alternative 11A:	29.97
Alternative 11B:	19.33
Alternative 12A/B:	29.72
Alternative 12C/D:	23.85

Conclusions

Depending on the alternative selected, the total disposition program will require between 1100 and 2300 SST/SGT loads, which in turn result in a total of between 1.0 and 3.3 million load miles. The peak years will occur between 2004 and 2014 with between 100 to 220 loads per year and a total of 120 to 340 thousand load miles per year. The estimated costs in constant FY97 dollars range from $20 to $80 million. See Table 6 for a detailed breakdown of loads and load-miles by alternative and Table 9 for detailed costs.

Transportation Safety Division (TSD), at a briefing in February 1998, indicated that the alternatives presented were within their projected capabilities based on projected mission requirements. Any major perturbation to projected missions, like Start III, would be worked and addressed when it occurred. They recommended conducting future disposition program interface updates to ensure that appropriate capabilities were maintained, especially courier services, to cover the program. Also, TSD recommended that, after selection of one of the alternatives, their operations personnel conduct a more detailed analysis of mission requirements.

Appendix A — Results by Alternative

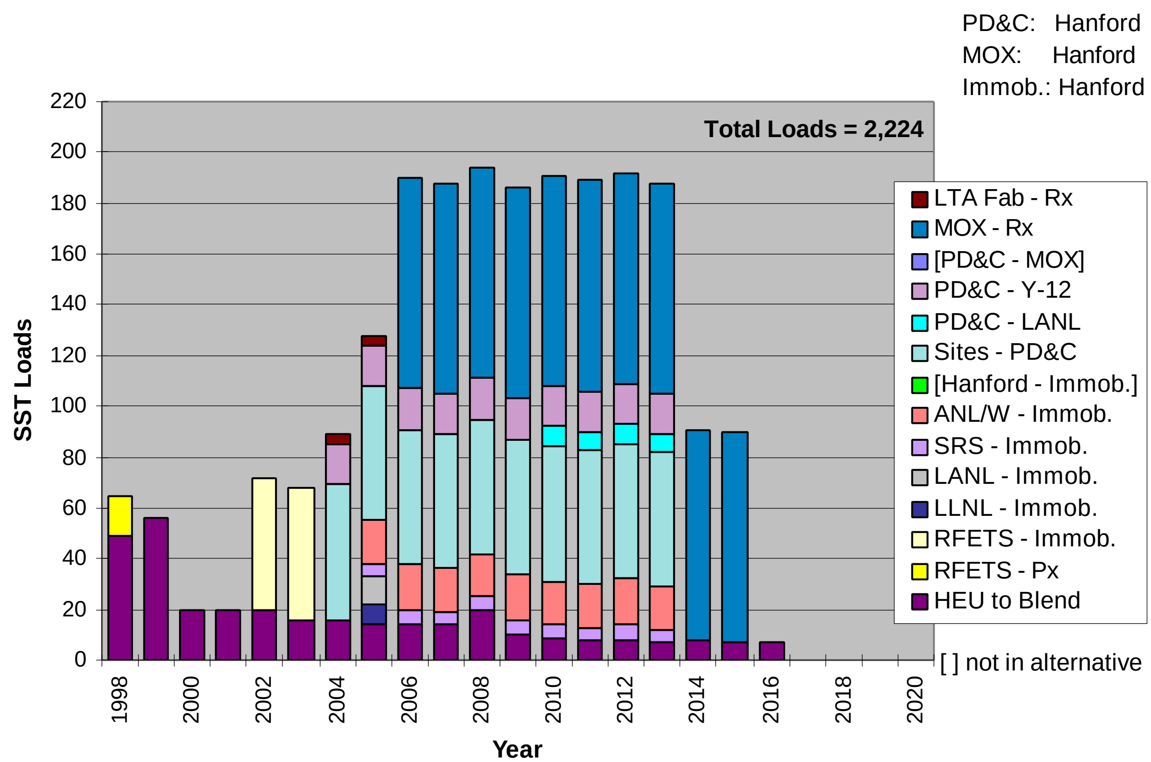

Figure 17. Alternative 2 estimated SST/SGT loads.

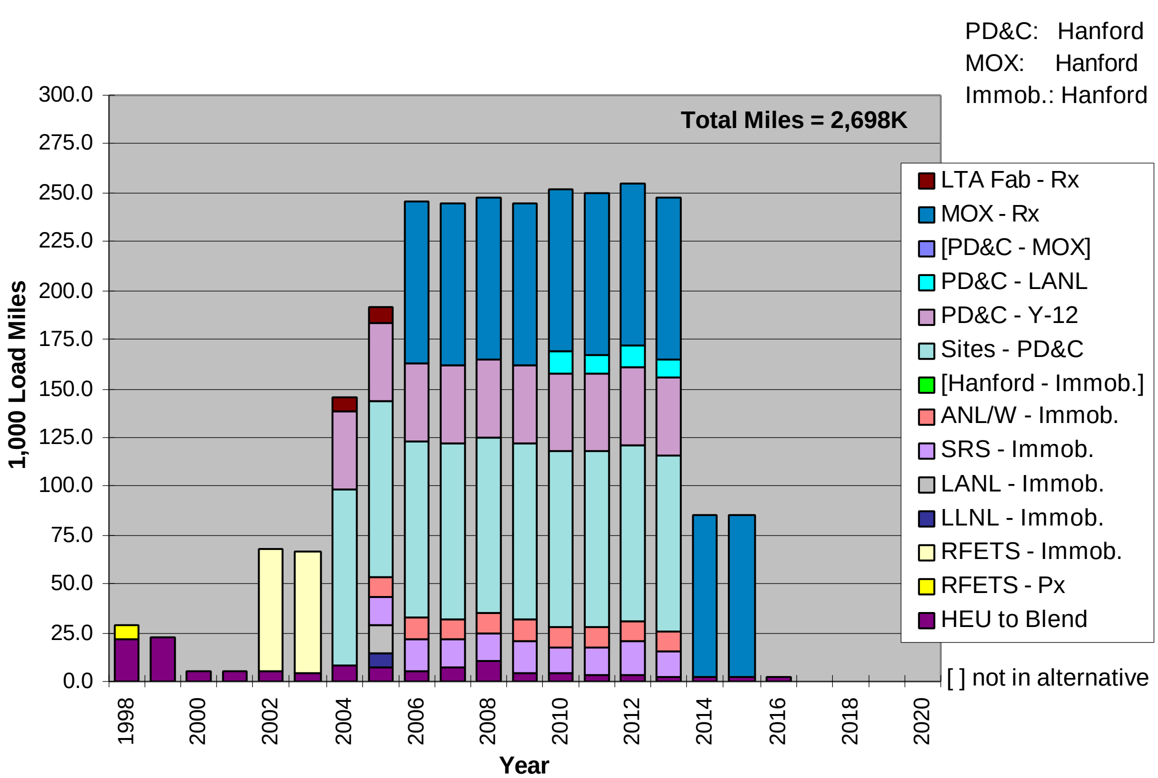

Figure 18. Alternative 2 estimated load miles.

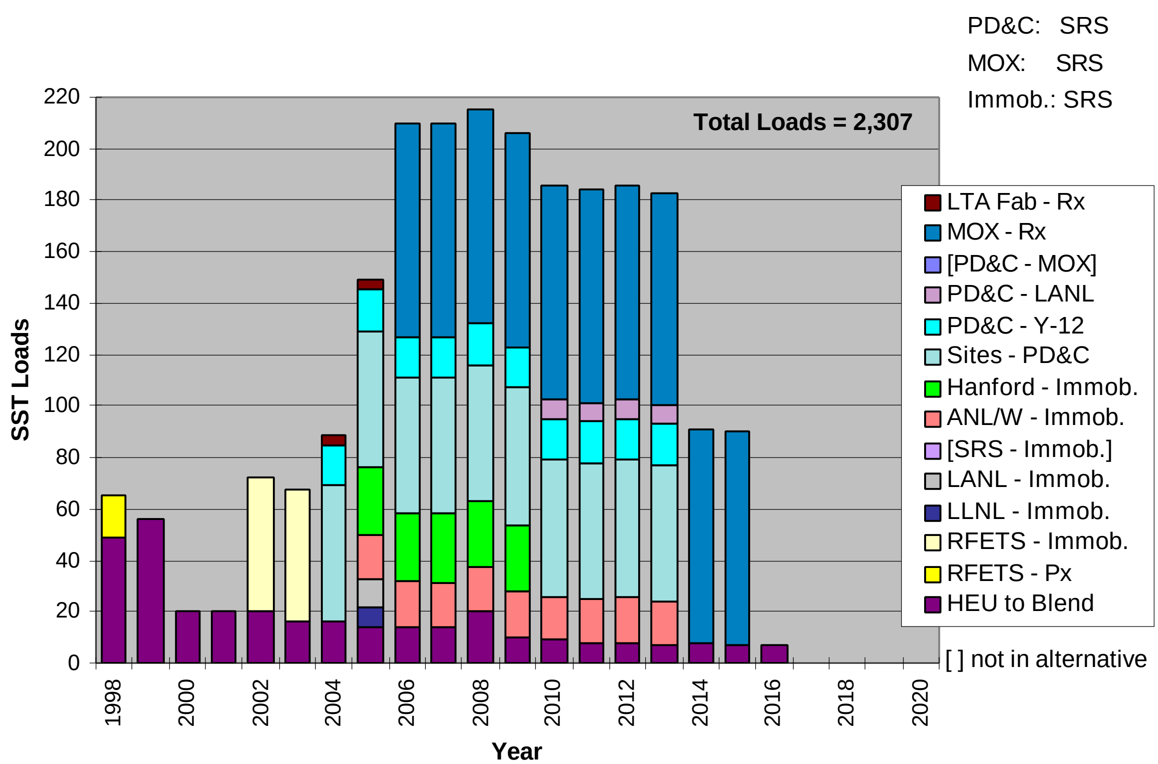

Figure 19. Alternative 3 estimated SST/SGT loads.

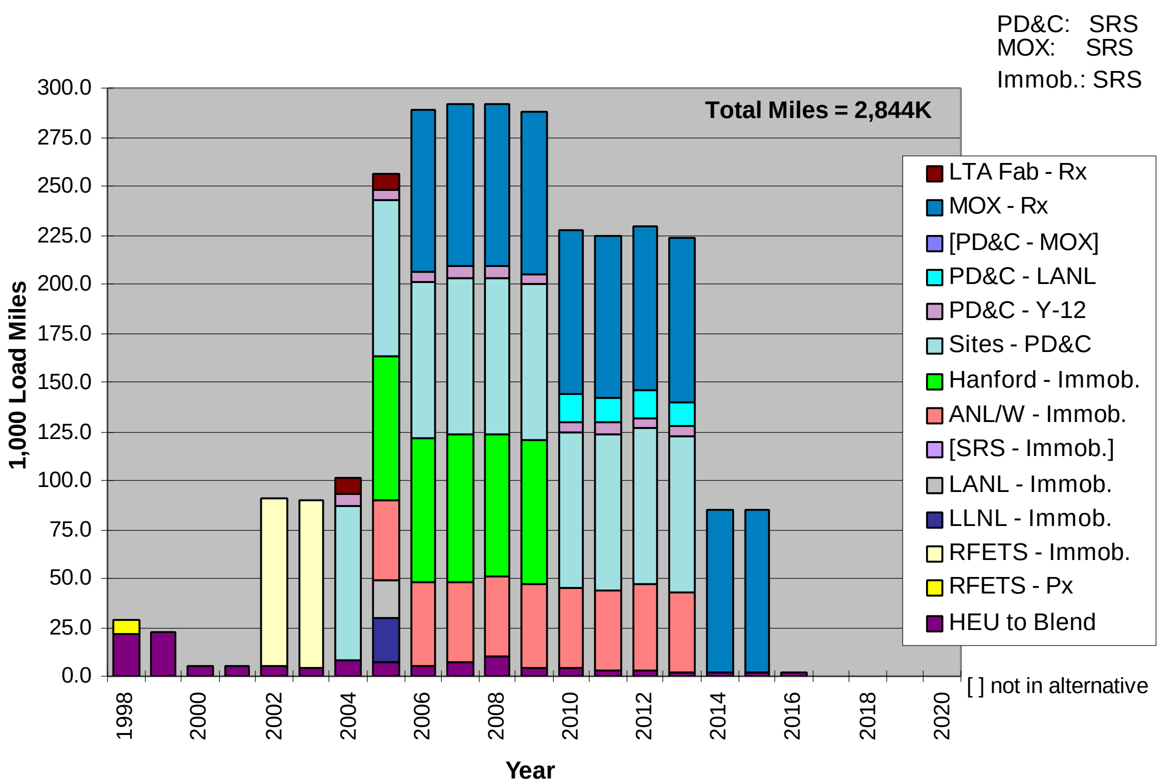

Figure 20. Alternative 3 estimated load miles.

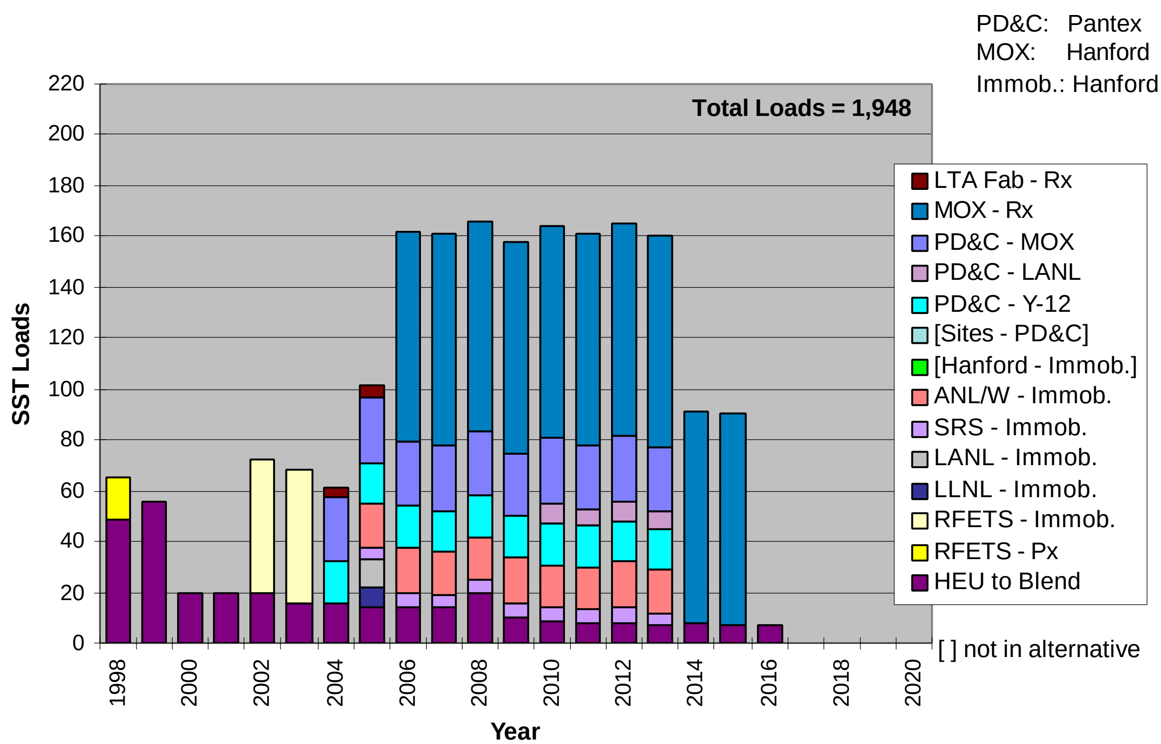

Figure 21. Alternative 4 estimated SST/SGT loads.

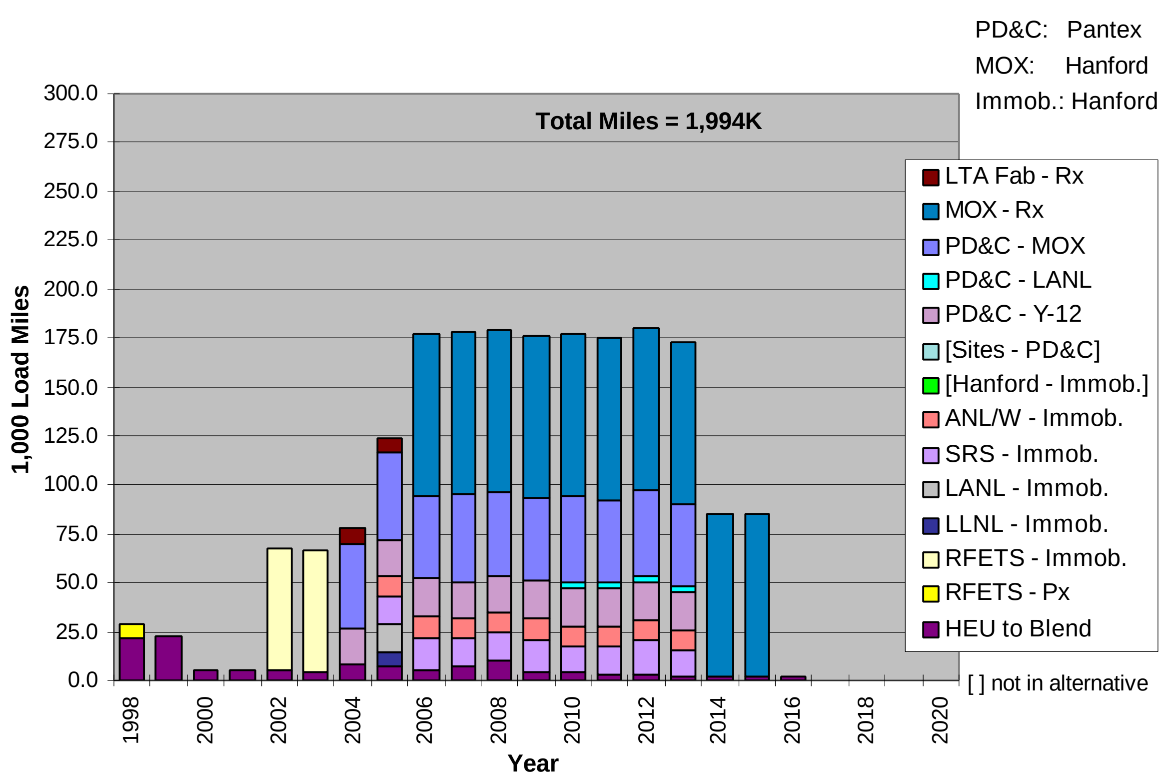

Figure 22. Alternative 4 estimated SST/SGT load miles.

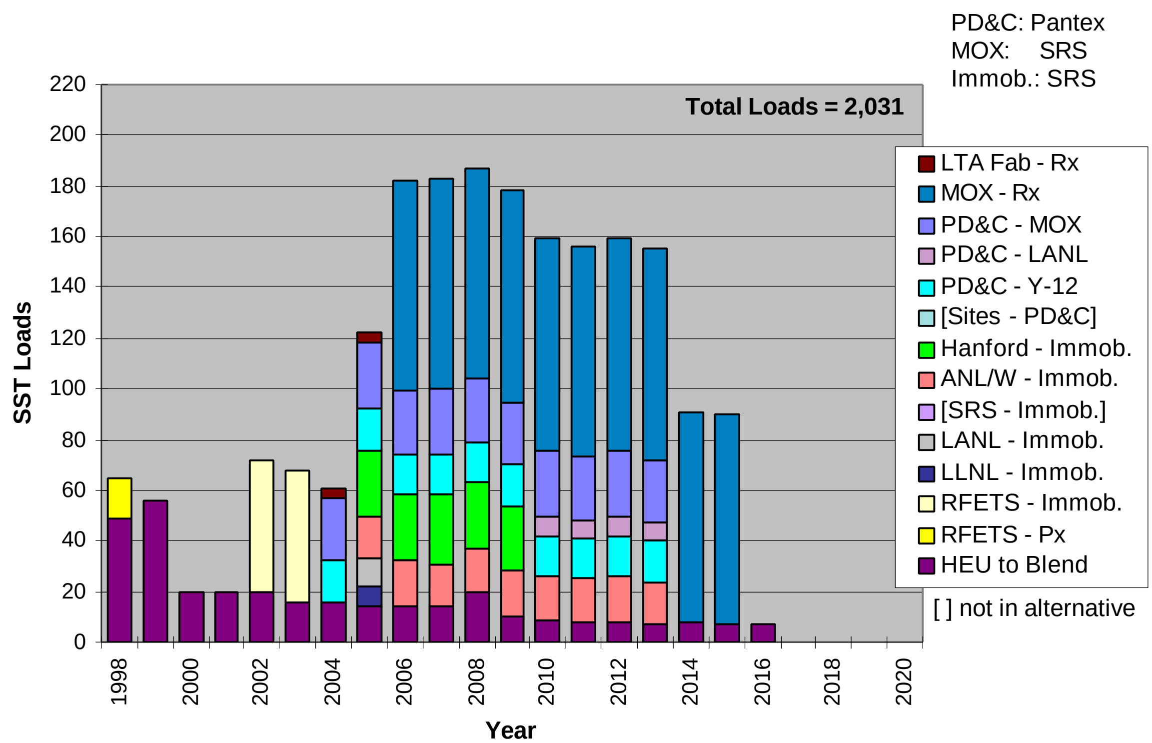

Figure 23. Alternative 5 estimated SST/SGT loads.

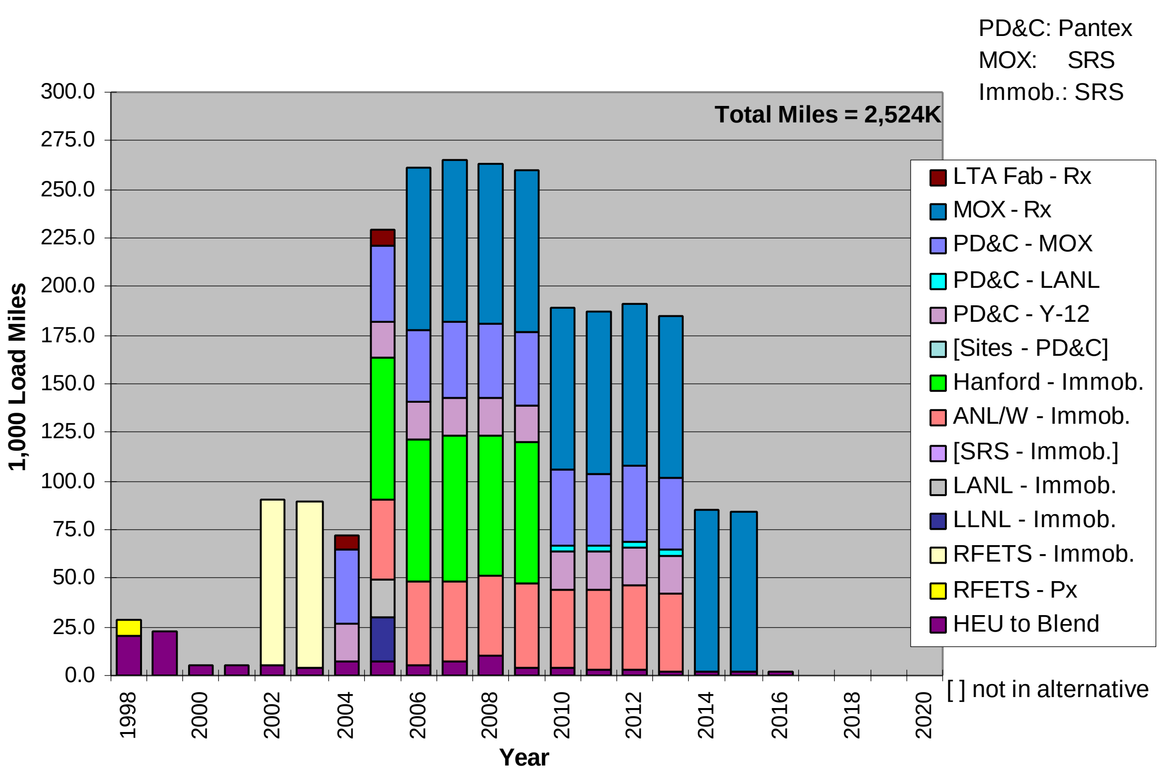

Figure 24. Alternative 5 estimated SST/SGT load miles.

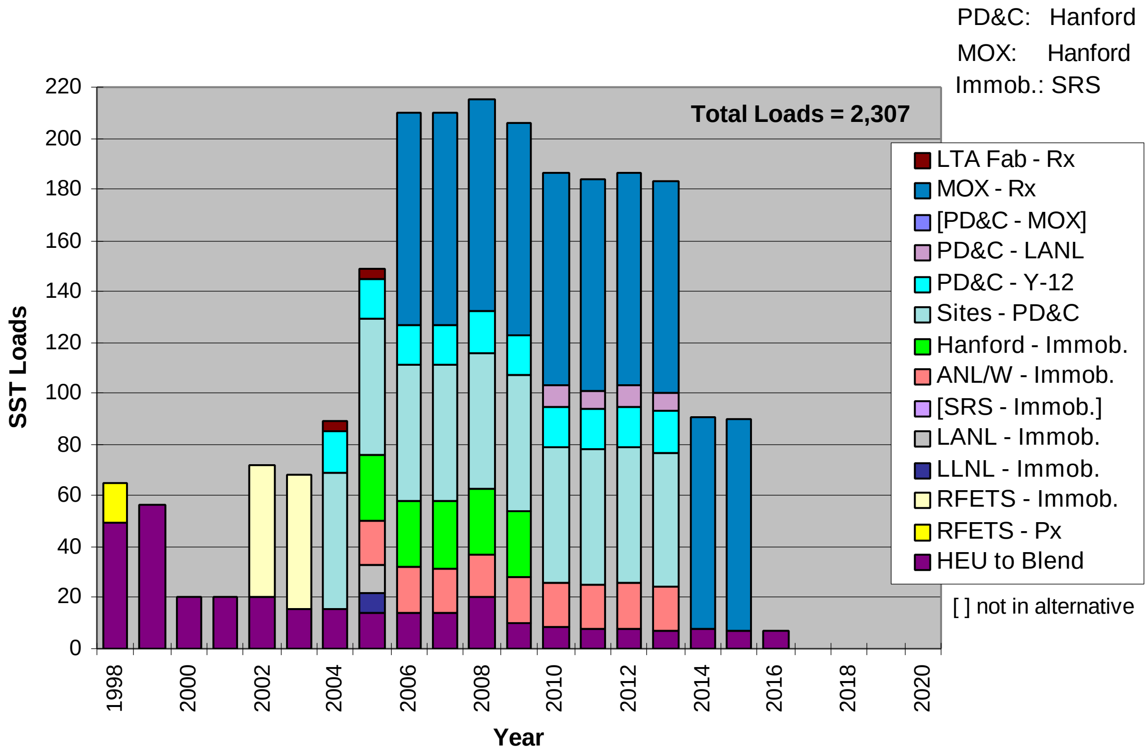

Figure 25. Alternative 6 estimated SST/SGT loads

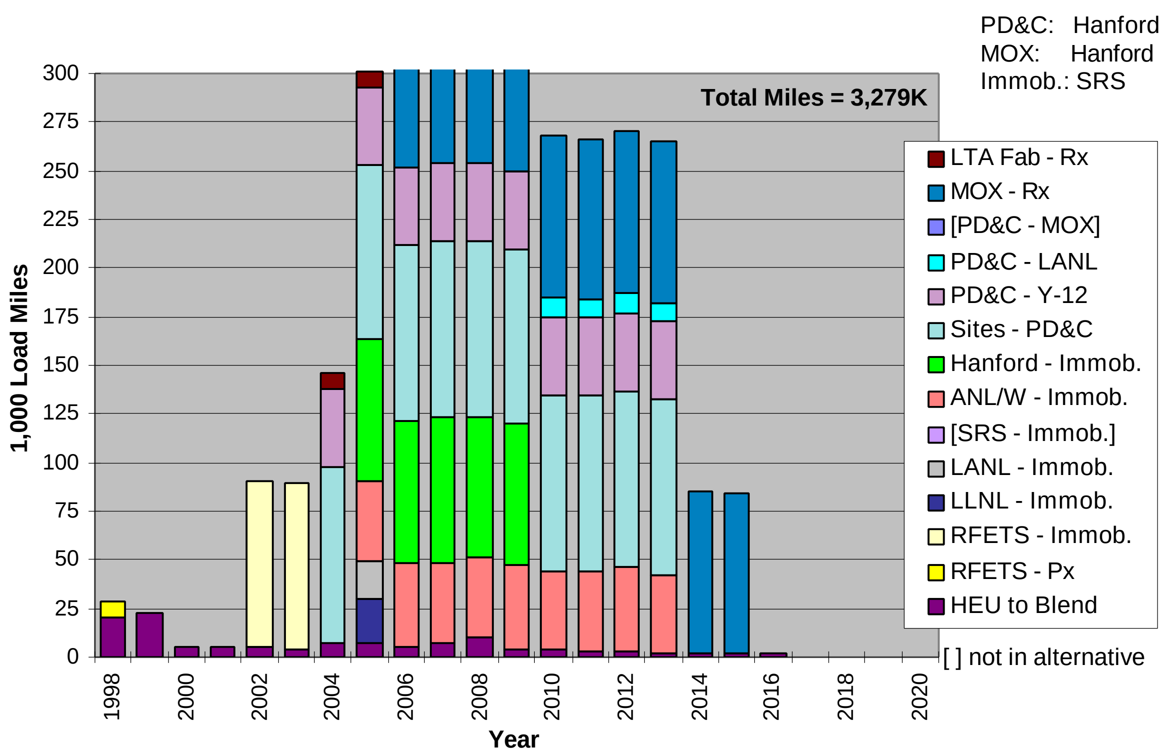

Figure 26. Alternative 6 estimated SST/SGT load miles.

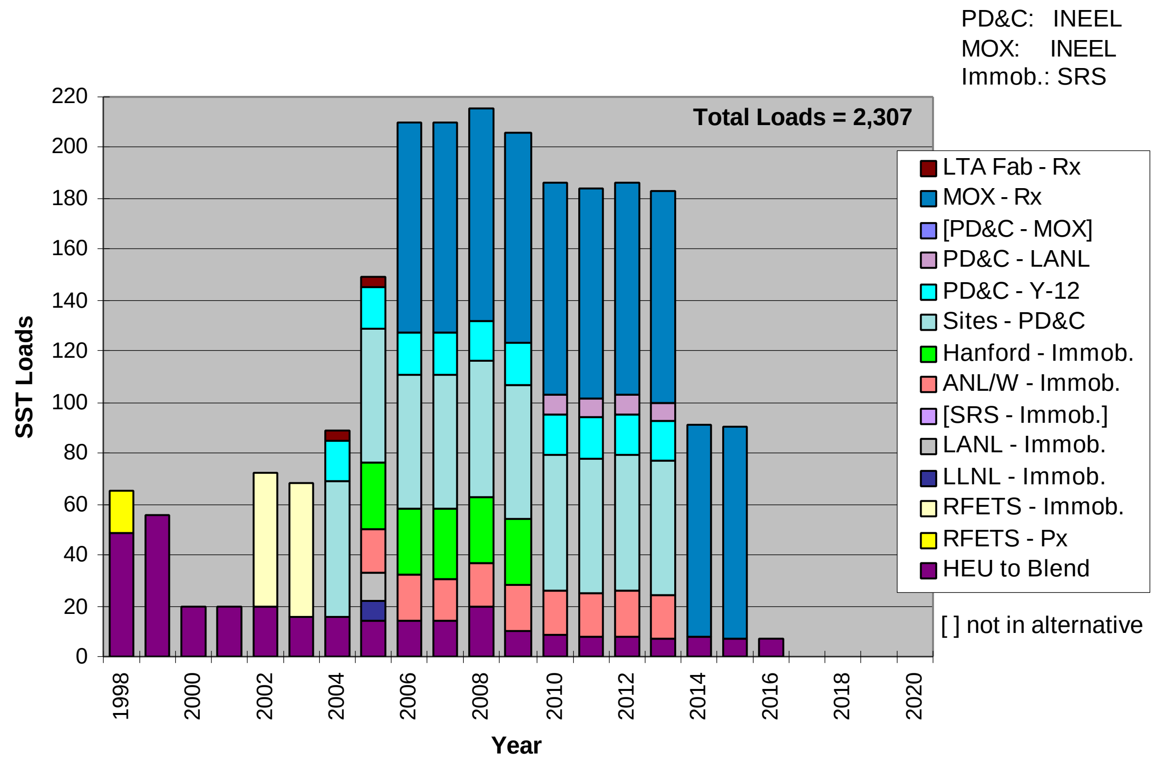

Figure 27. Alternative 7 estimated SST/SGT loads.

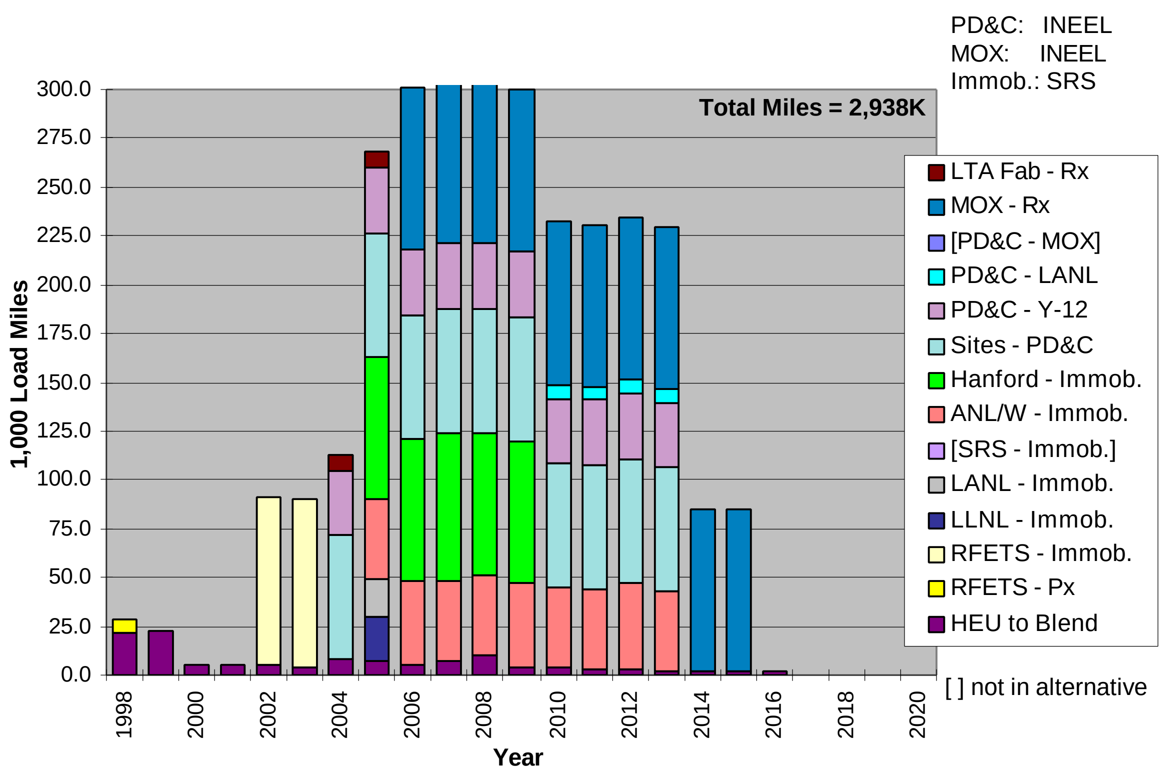

Figure 28. Alternative 7 estimated SST/SGT load miles.

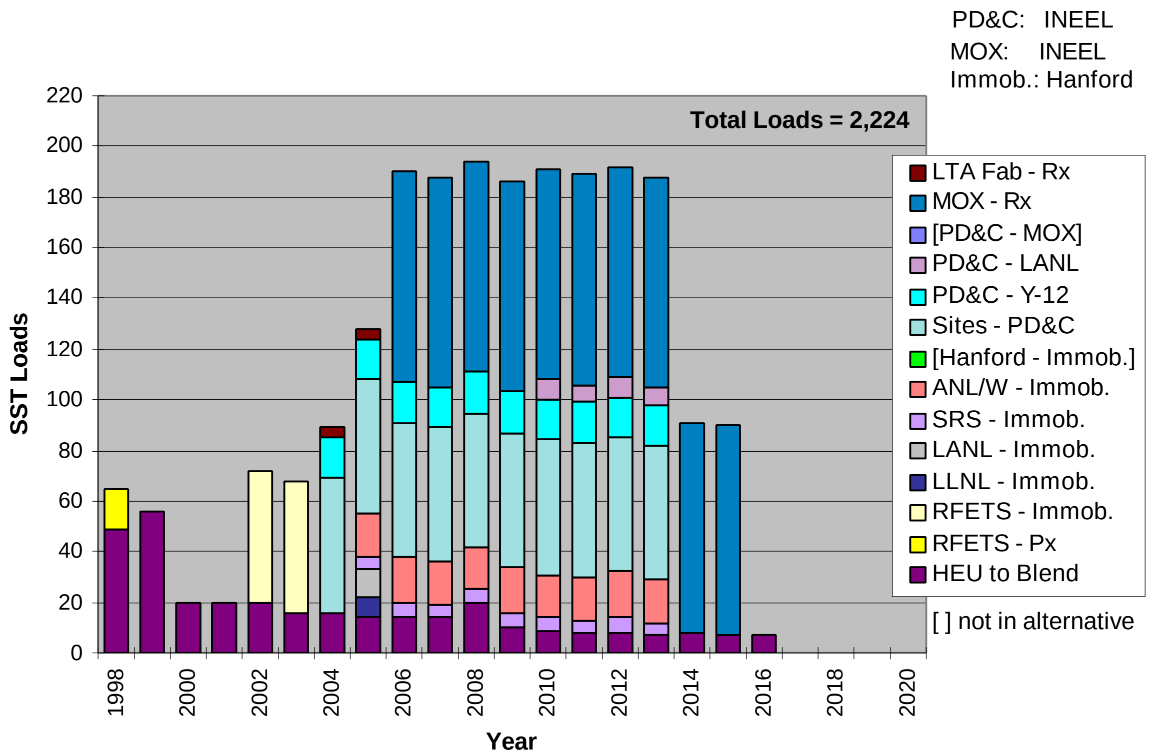

Figure 29. Alternative 8 estimated SST/SGT loads.

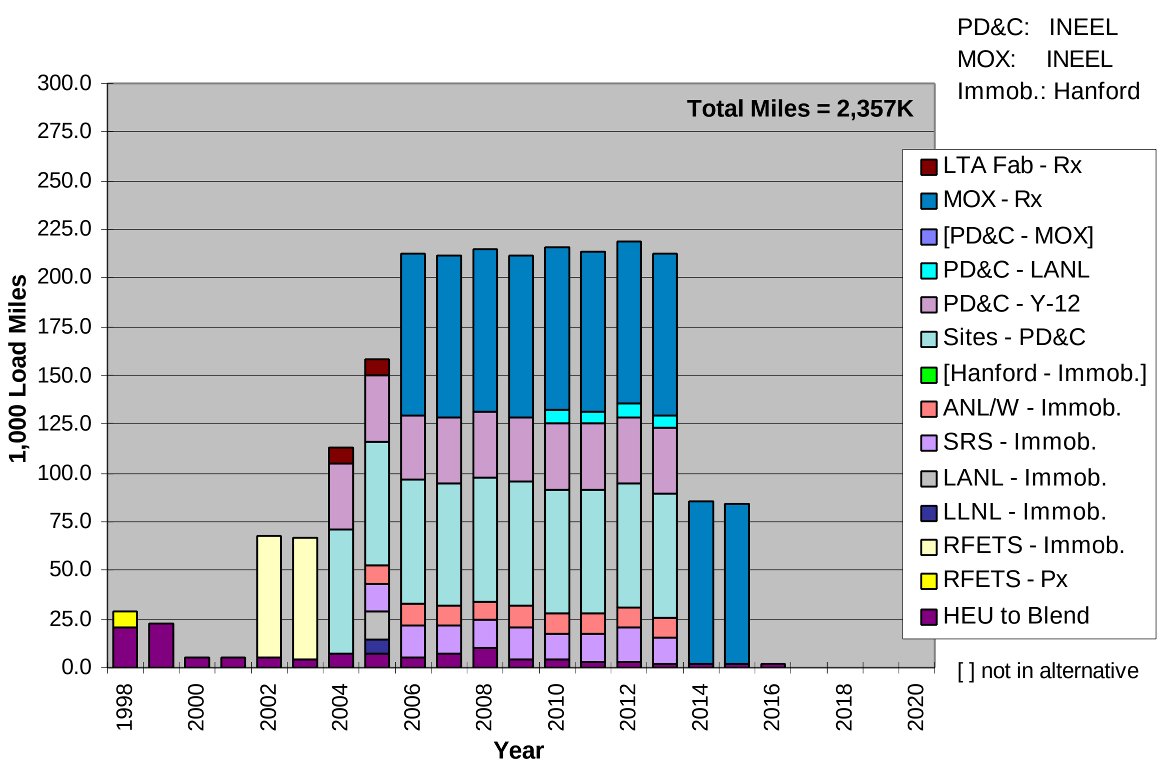

Figure 30. Alternative 8 estimated SST/SGT load miles.

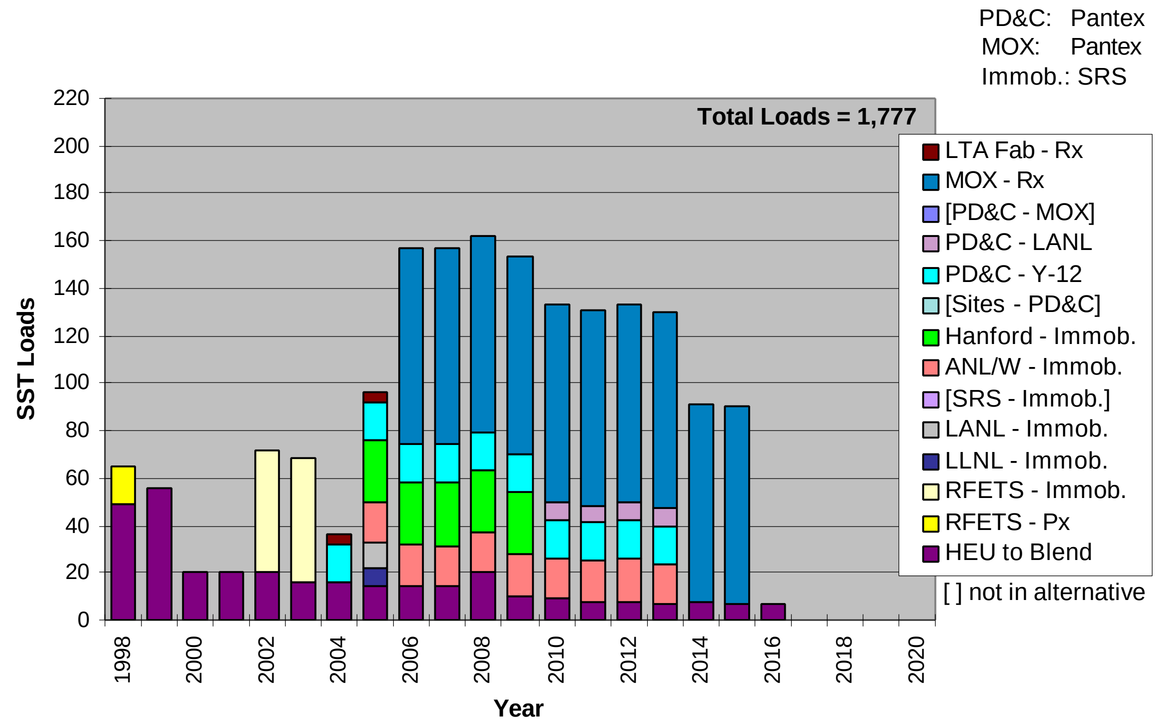

Figure 31. Alternative 9 estimated SST/SGT loads.

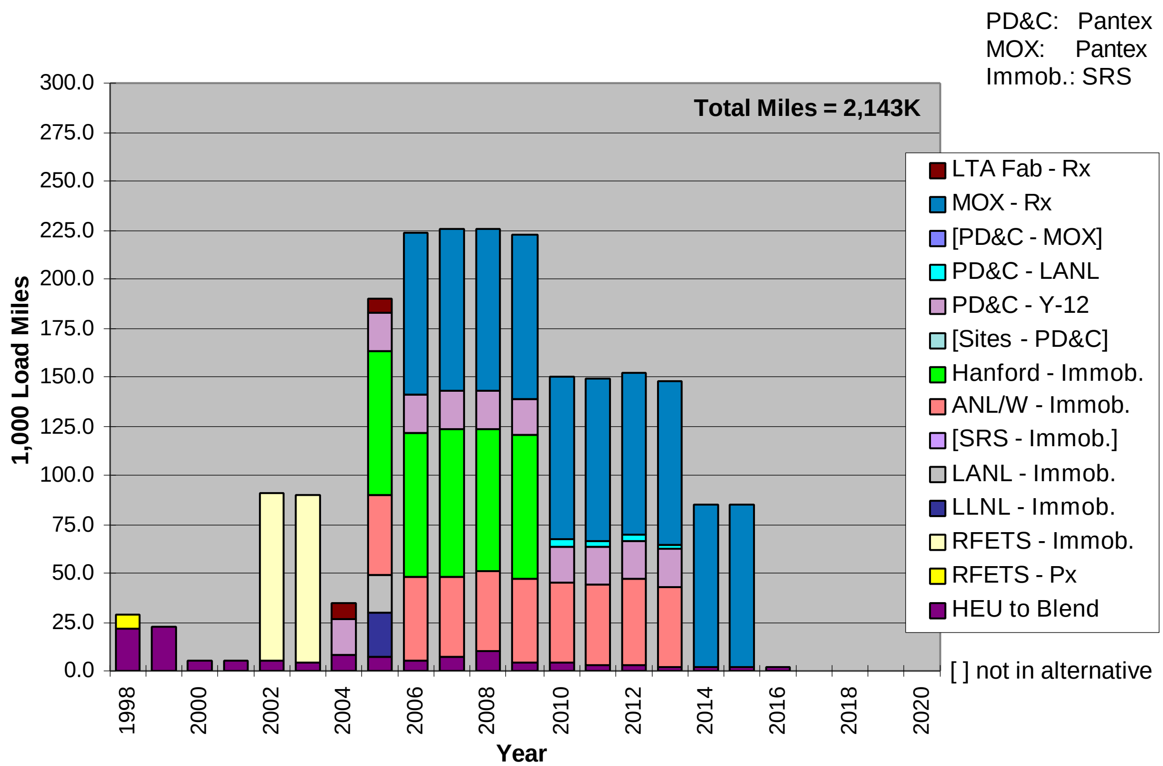

Figure 32. Alternative 9 estimated SST/SGT load miles.

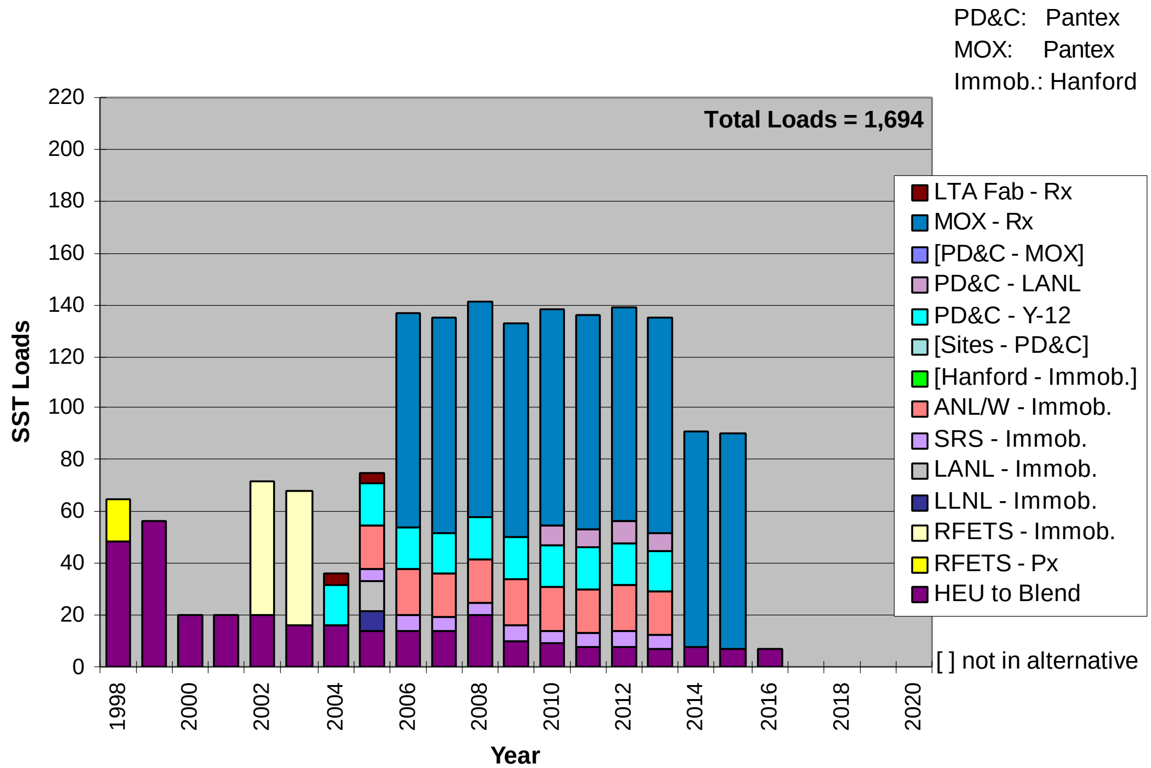

Figure 33. Alternative 10 estimated SST/SGT loads.

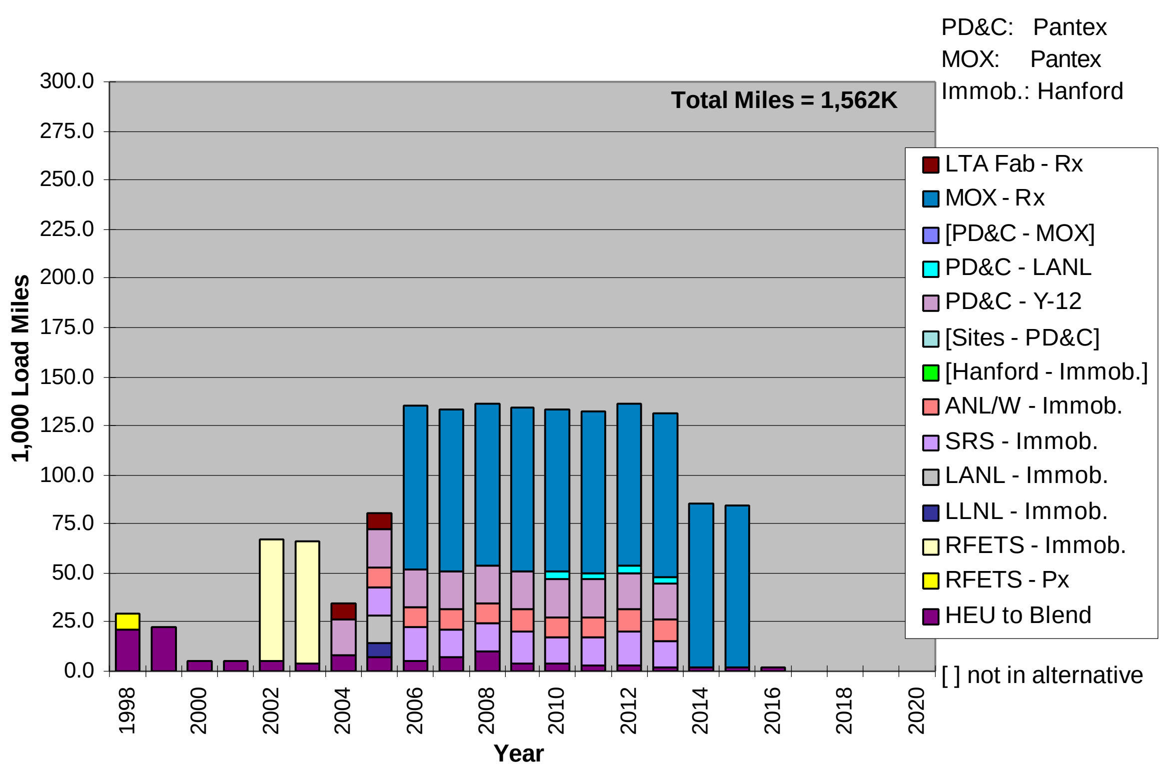

Figure 34. Alternative 10 estimated SST/SGT load miles.

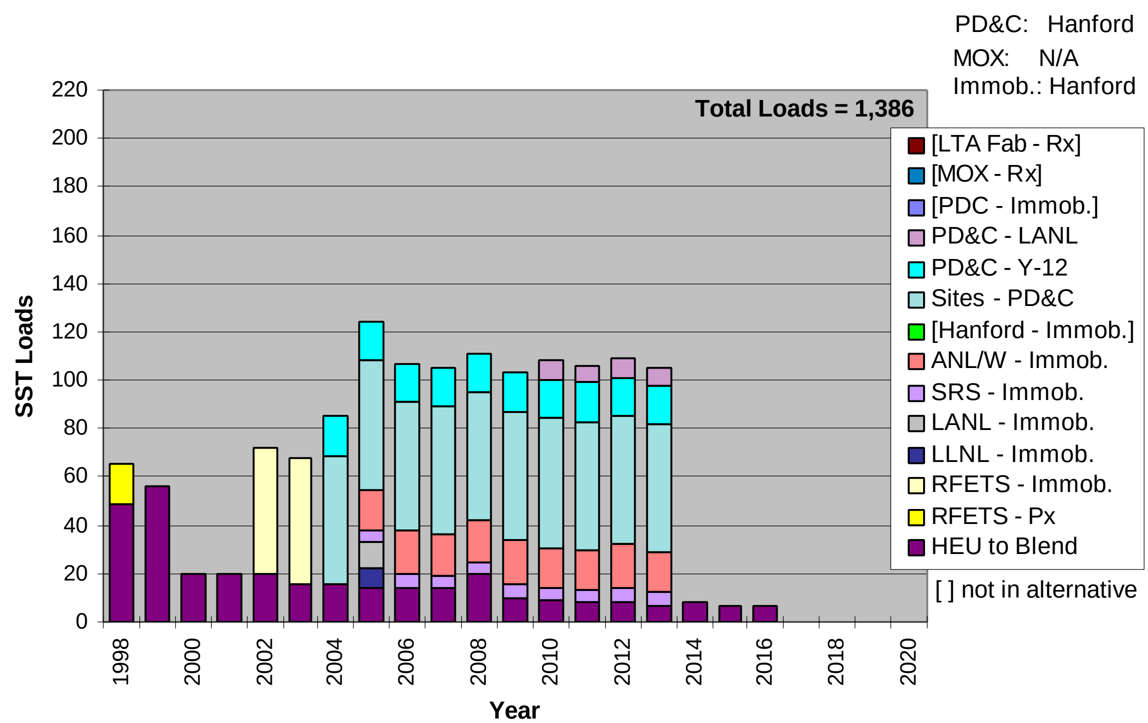

Figure 35. Alternative 11A estimated SST/SGT loads.

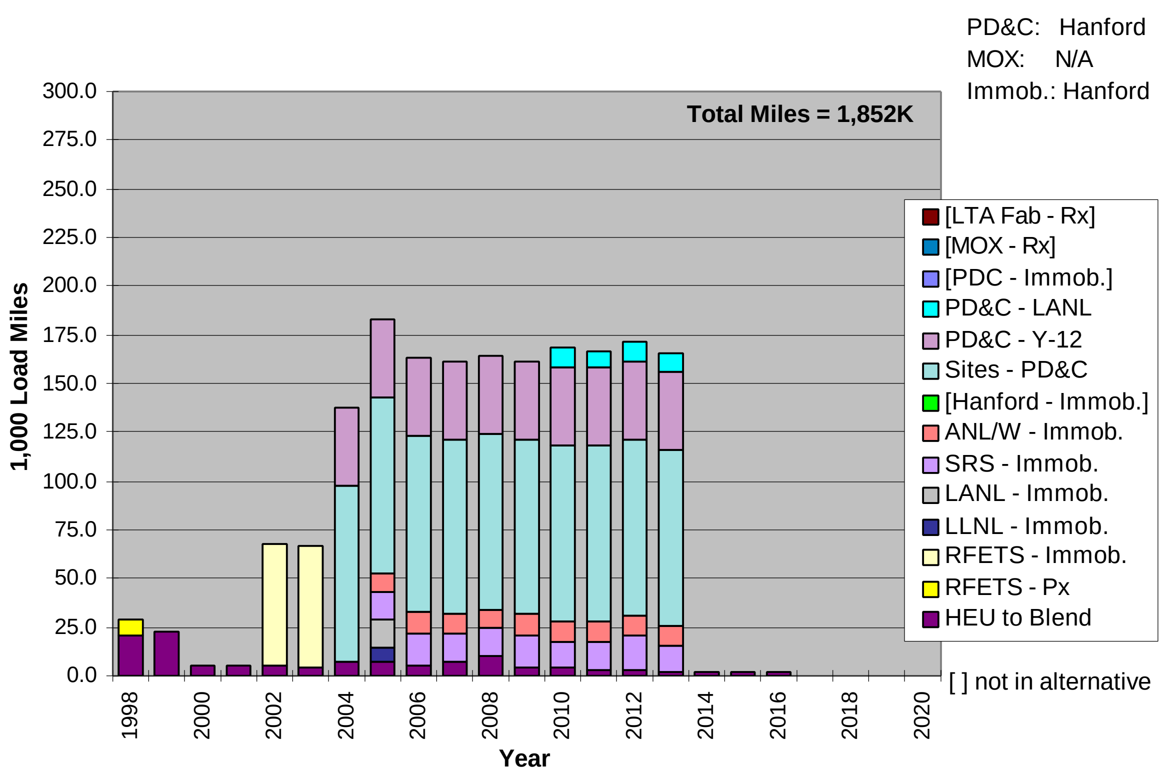

Figure 36. Alternative 11A estimated SST/SGT load miles.

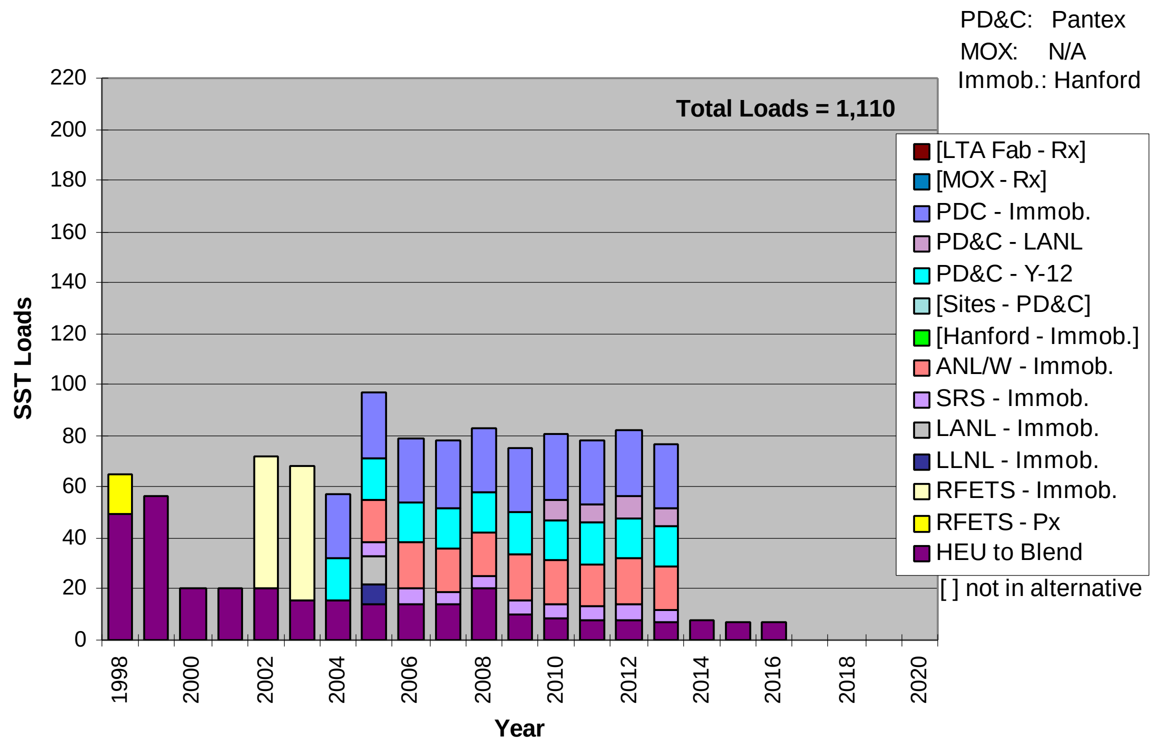

Figure 37. Alternative 11B estimated SST/SGT loads.

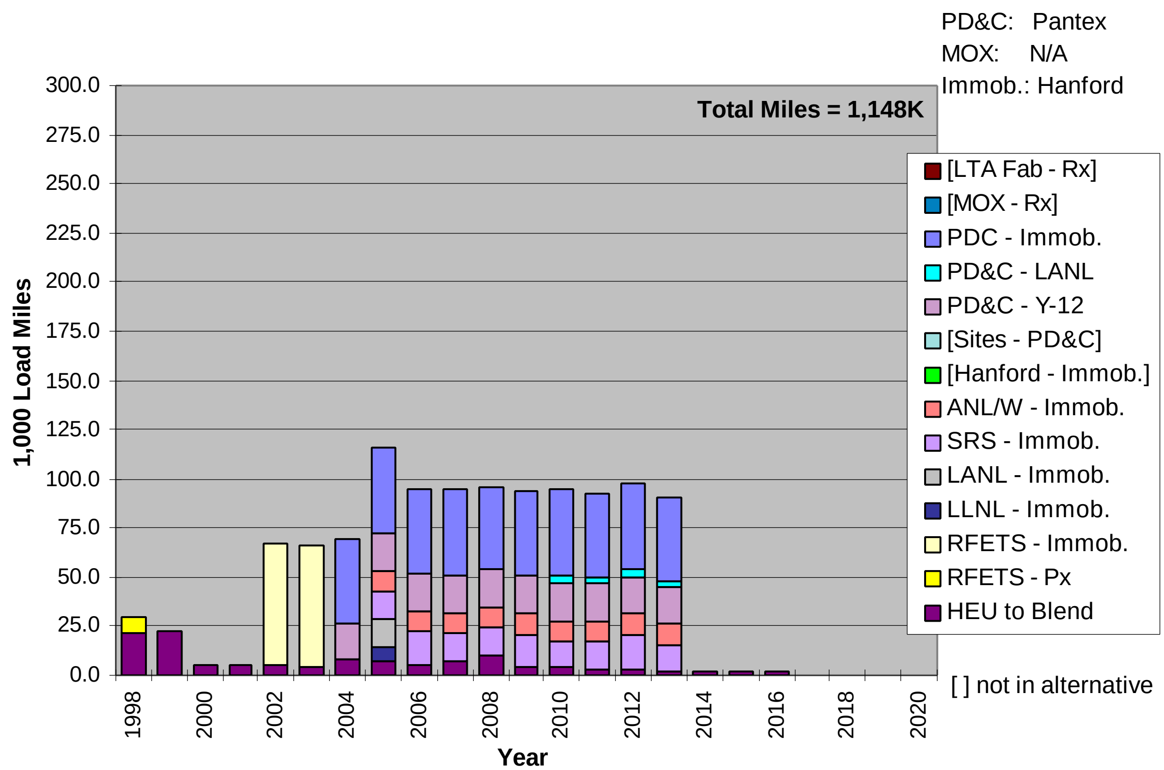

Figure 38. Alternative 11B estimated SST/SGT load miles.

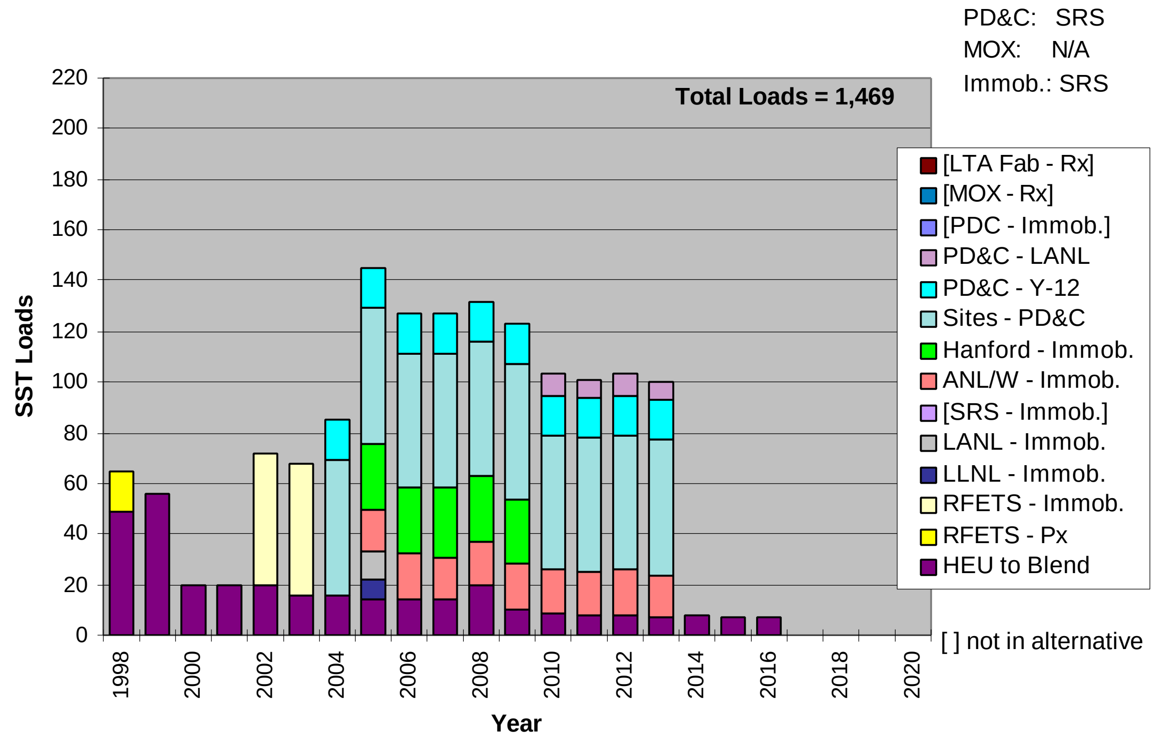

Figure 39. Alternative 12A/B estimated SST/SGT loads.

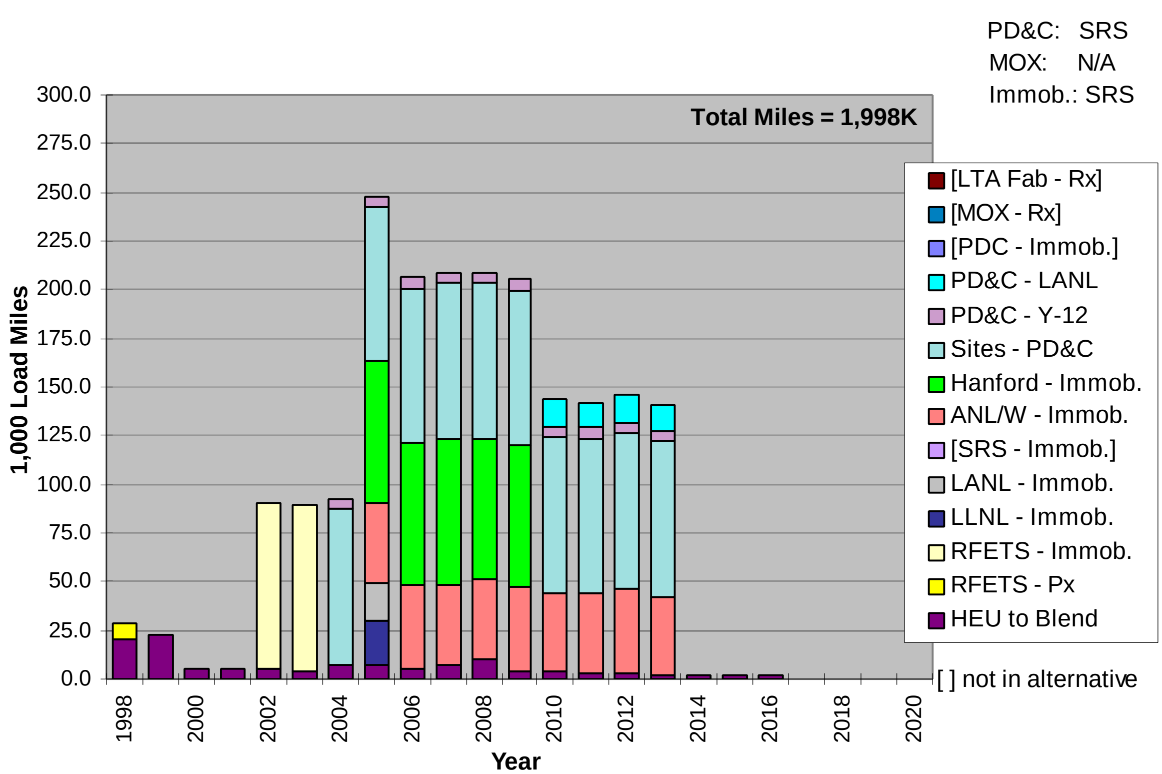

Figure 40. Alternative 12A/B estimated SST/SGT load miles.

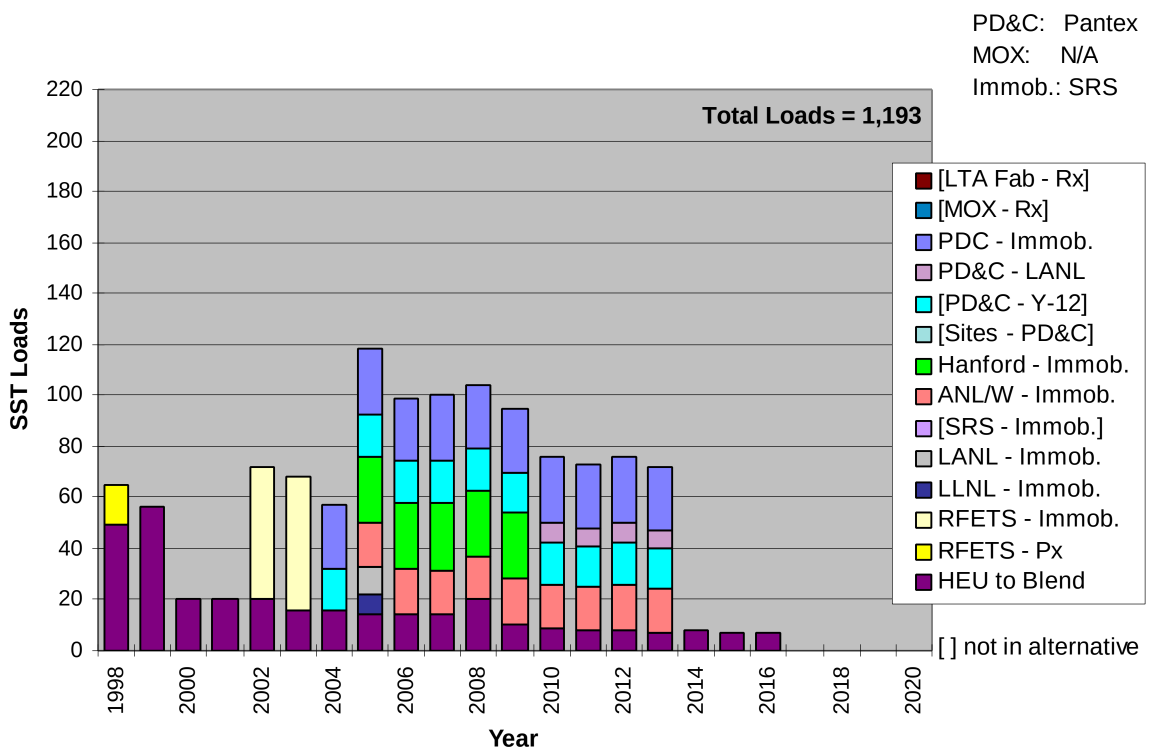

Figure 41. Alternative 12C/D estimated SST/SGT loads.

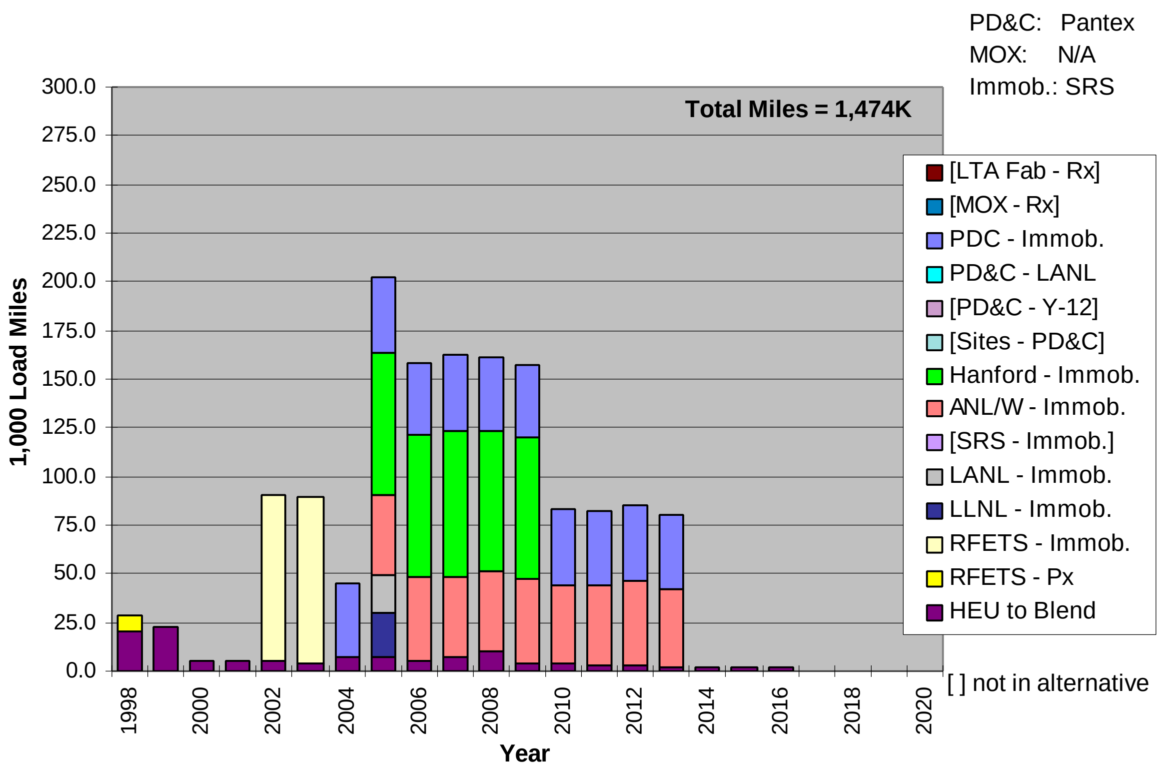

Figure 42. Alternative 12C/D estimated SST/SGT load miles.

Appendix B — Mileage

From	To	Mileage
Hanford	INEEL	600
Hanford	LANL	1300
Hanford	LLNL	900
Hanford	Pantex	1700
Hanford	RFETS	1200
Hanford	Reactors	1000
Hanford	SRS	2800
Hanford	Y-12	2500
INEEL	Blend[8]	2300
INEEL	LANL	900
INEEL	Pantex	1200
INEEL	Reactors	1000
INEEL	SRS	2400
INEEL	Y-12	2100
LANL	Pantex	400
LANL	SRS	1800
LLNL	SRS	2800
LTA	Reactors	1000
Pantex	RFETS	500
Pantex	Reactors	1000
Pantex	SRS	1500
Pantex	Y-12	1200
Portsmith	Blend[9]	500
RFETS	SRS	1650
SRS	Blend[10]	200
SRS	Reactors	1000
SRS	Y-12	350
Y-12	Blend[11]	250

[8] INEEL to BWX is 2400 and to NFS is 2200.

[9] Portsmith to BWX is 700 and to NFS is 500.

[10] SRS to BWX is 150 and to NFS is 250.

[11] Y-12 to BWX is 350 and to NFS is 150.

Distribution:

14 Howard R. Canter (1)
Andre I. Cygelman (1)
J. Dave Nulton (1)
G. Bert Stevenson (6)
William J. Danker (1)
Damian Peko (1)
Patrick T. Rhoads (1)
Joseph P. Bozik (1)
Dean R. Tousley (1)

U.S. Department of Energy
Office of Fissile Materials Disposition, MD-3
1000 Independence Ave. S.W.
Washington, DC 20585-0114

5 Albert E. Whiteman (1)
Nazir S. Khalil (1)
Paul T. Dickman (1)
Paul T. Mann (1)
Martin D. Centala (1)

Department of Energy
Albuquerque Operations Office
Pennsylvania & H Street
Kirtland Air Force Base
Albuquerque, NM 87116

1 Department of Energy, Albuquerque Operations
TSD, Operations Branch
Attn: Everett R. Goodman
P.O. Box 5400
Albuquerque, NM 87185-5400

1 Oak Ridge National Laboratory
Attn: Sherrell R. Greene, MS 8057
P.O. Box 2009
Bldg. 9104-1
Oak Ridge, TN 37831-8057

1 Oak Ridge National Laboratory
Attn: Scott B. Ludwig, MS 6495
130 Mitchell Road
Oak Ridge, TN 37831-6495

1	Lockheed Martin Energy Systems, Y-12 Attn: Dave J. Snider, MS 8207 P.O. Box 2009 Bldg. 9113 Oak Ridge, TN 37831-8207	
1	Los Alamos National Laboratory Attn: Randall M. Erickson, MS F660 P.O. Box 1663 Los Alamos, NM 87545	
1	Lawrence Livermore National Laboratory Attn: Lee M. MacLean, L-186 P.O. Box 808 Livermore, CA 94551	
1	Science Applications International Corporation Attn: Gary M. DeMoss 20201 Century Boulevard, Third Floor Germantown, MD 20874	
1	Amarillo National Research Center for Plutonium Attn: Richard S. Hartley 600 South Tyler, Suite 800 Mail Box 12098 Amarillo, TX 79101	
1	MS 9005	James B. Wright, 2200
1	MS 9014	William G. Wilson, 2221
1	MS 9014	Linda K. Groves, 2221
1	MS 1213	Dennis L. Mangan, 5214
1	MS 0766	Ajoy K. Moonka, 6303
1	MS 0790	Joseph J. Roesch, 6313
1	MS 0775	Richard C. Beckmann, 6315
1	MS 0727	Thomas L. Sanders, 6406
1	MS 9201	Patricia K. Falcone, 8114
3	MS 9018	Central Technical Files, 8940-2 (3)
4	MS 0899	Technical Library, 4916
1	MS 9021	Technical Communications Department, 8815/ Technical Library, MS 0899, 4916
2	MS 9021	Technical Communications Department, 8815 For DOE/OSTI