THOR Treatment Technologies, LLC

ART Phase II Project Briefing

Paul Rutland, Project Manager

October 23, 2007

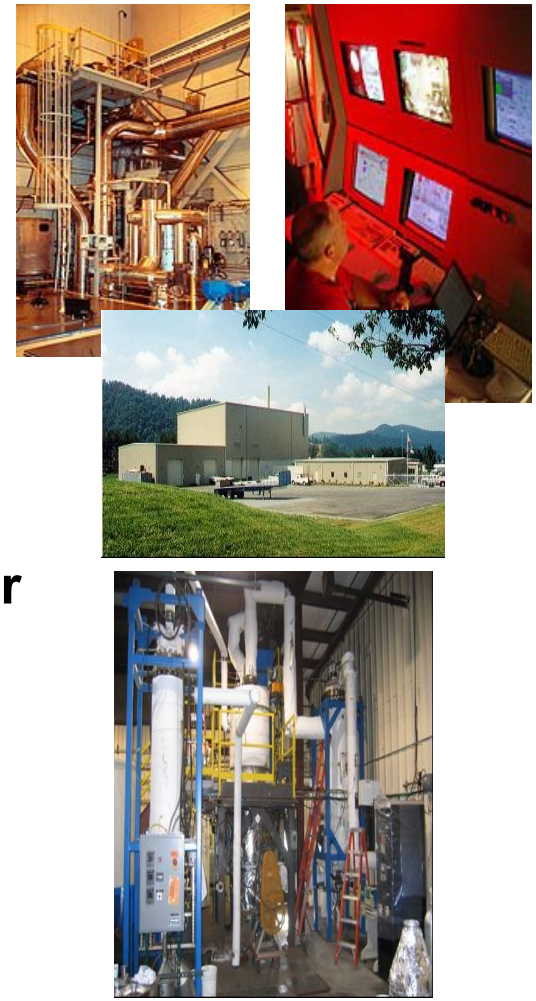
THOR Treatment Technologies℠

Agenda

- **Introduction**
- **Technology Overview**
- **ART Phase I – Results**
- **ART Phase II Project**
- **Project Objectives**
- **Scope of Work**
  - ESTD Testing
  - BSR Testing
- **Schedules**
- **Deliverables**
- **Schedule Status**
- **Discussion**

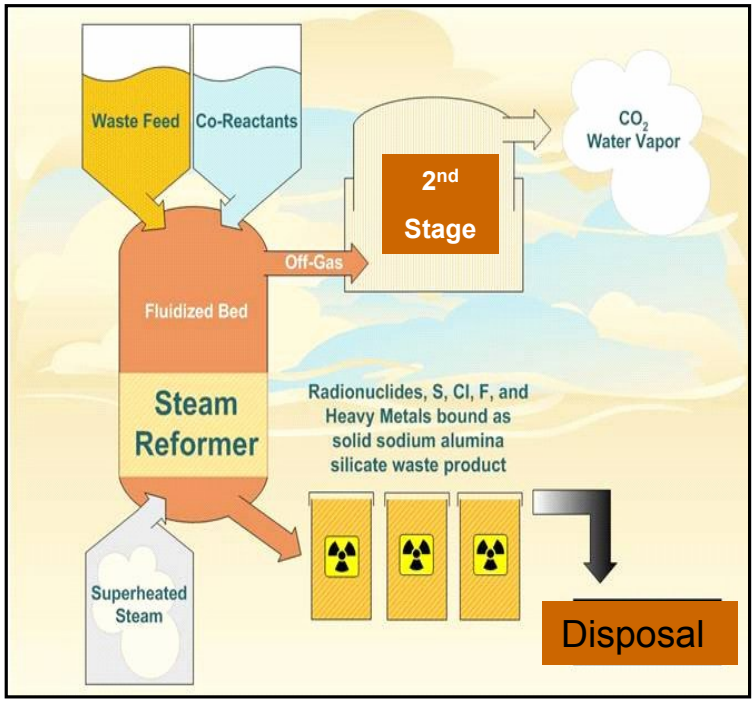
Steam Reforming Overview

- **Used extensively in the US and abroad for thermal treatment processes**
  - Biomass gasification
  - Syngas production
  - Metal reduction
  - Chemical processes
  - Petroleum refinery applications
  - Pulp and paper industry
- **Successfully deployed on commercial nuclear production scale**
  - Studsvik Processing Facility
    - Erwin, Tennessee



THOR® - A Purpose-Built Fluid Bed/Steam Reforming Technology

- **Can Accommodate Widely Varying Input Waste Streams**
  - No pre-treatment required
  - Solid, Liquid, Sludges or Gases
  - High or Low pH (no adjustment required)
  - Organic or Inorganic Materials
  - High Cl, F, P, SO_4
  - Reactive and Corrosive Chemicals
  - High iron and metal content (process not limited)
  - Reactive metals
- **Moderate Temperature (600-750 ^{o}C)**
  - Does not volatize Cs and Re/Tc
    - Less complex offgas system
    - Eliminates secondary waste
  - Reduces high temp corrosion concerns



- Fluid bed agitated by low pressure steam
- Energy produced by carbon reductant and oxygen (autothermal steam reforming)

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THOR® - A Purpose-Built Technology

- **Single Step Denitration Process**
  - Direct conversion of nitric acid, nitrates and nitrites to N_2 (No restrictions)
  - No NOx abatement system required
- **Zero-liquid release from Process**
- **Halides and Heavy Metals captured in primary product**
  - Cl, F, SO_4 retained in solid product
  - No off gas scrubber required
- **Output Product**
  - Retains >99% of activity in primary product (except H^3, C^{14} and some I^{129})
  - Stable mineral product for disposal
  - Other specialty products can be formed

Developed in 1990's for commercial radiological waste utilizing lessons learned in competitive marketplace

Adapted for DOE tank waste in 2002

Demonstrated in Long Term Commercial Operation

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Steam Reforming Treatment Products

Solid Products

Constituent	CO_2 In-Bed Additive	Clay Additive
Alkali Metals	Carbonate or Aluminate	Alkali Aluminosilicate (NAS)
Inorganic Metals	Oxides, Spinels	Spinels and Oxides bound in NAS matrix
Cl, S, F, P	Alkali Salt	Bound in NAS matrix
Radionuclides	Oxides or Carbonates	Spinels and Oxides bound in NAS matrix

Mineral Waste Form

THOR^{sm} Monolith

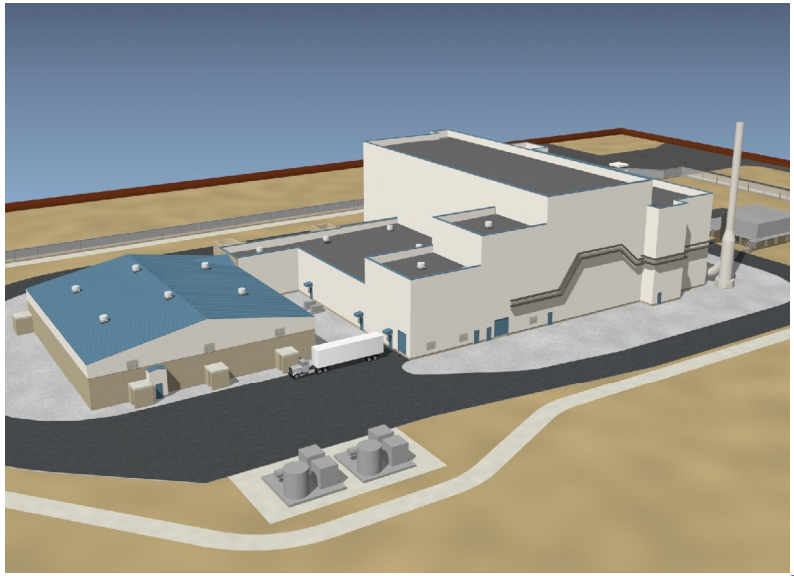
THOR Treatment Technologies$_{sm}$

Studsvik Processing Facility

- **Full-scale facility treats commercial power plant waste**
  - **Radionuclide retention in solid product >99.99%**
  - **>200,000 cu ft of LLW processed**
  - **>1,600 shipments**
  - **LLW dose rates up to 500 R/hr (Cs, Co)**
  - **Over 8 years LLRW operations**
  - **Waste feed: ion exchange resins, plastics, cellulose, carbon, oils:**
    - **High salt content waste**
    - **High organic content**
  - **Developed mineralization additives**
  - **28 months from start of design to LLW operations**
  - **Air permit (State of TN)**
  - **Radioactive materials license (State of TN)**

Studsvik Processing Facility, Erwin TN

INTEC –IWTU Facility For Sodium Bearing Waste Treatment



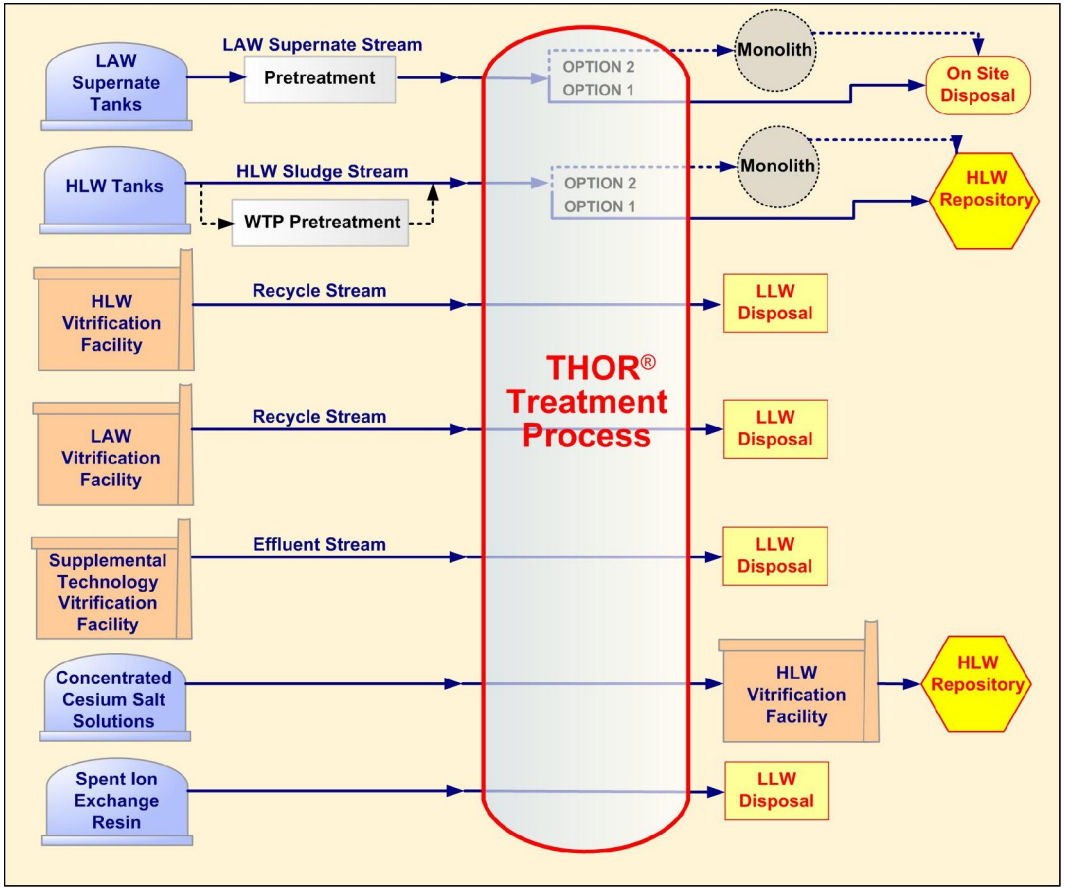
- CD – 3 Approved
- Project On Schedule for Startup in 2009

Phase I Results: Technology Demonstration Gaps for Hanford LAW

- **Waste form qualification and performance**
  - Radionuclide leachability (expand and validate database)
  - Long term waste form performance in disposal facility
  - Tc and I Retention and Volatility
- **Regulatory acceptance**
  - Fate of Tc-99 and I in mineral waste form
  - Waste form performance comparison to borosilicate glass
- **Qualify production scale parameters**
  - Throughput
  - Optimization of monolith waste loading
  - Validate life cycle cost estimates

Phase I: Applications for THOR® At Hanford

- Tank LAW –accelerate the overall risk reduction at Hanford
- Early LAW and WTP Recycle –significantly increase the glass waste loading thereby reducing final LAW container count
- Transuranic Mixed (TRUM) tank waste – direct treatment
- K-Basin Sludge – can be effectively treated in a simple THOR® drum autoclave system
- Organic solvents and ion exchange resins
- Drummed wastes (LLMW and TRU) thermal treatment



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Phase I Demonstration Results

Demonstrated:	Hanford LAW	Idaho SBW		SRS Tank 48H
	Mineral Product	Mineral Product	Carbonate Product	Carbonate Product
>99.999% Cs retention	♦	♦	♦	♦
>99.99% Tc retention (Re surrogate)	♦	♦	N/A	N/A
MACT Compliant Offgas	♦	♦	♦	♦
Zero liquid discharge	♦	♦	♦	♦
>99.999% DRE of organic constituents	♦	♦	♦	♦
Metals and non-volatiles captured in waste form	♦	♦	♦	♦
Basic chemistry and operational efficacy of DMR	♦	♦	♦	♦
Waste form qualification	Needed	In progress	♦	♦
Regulatory acceptance	Needed	In progress	♦	♦

N/A = Not Applicable

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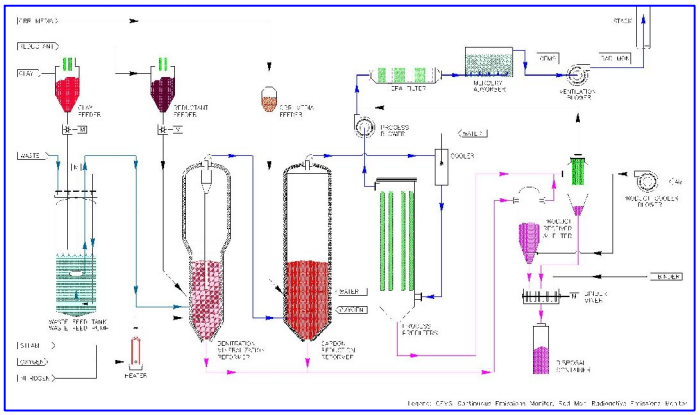
ART Phase II – Mission Objectives

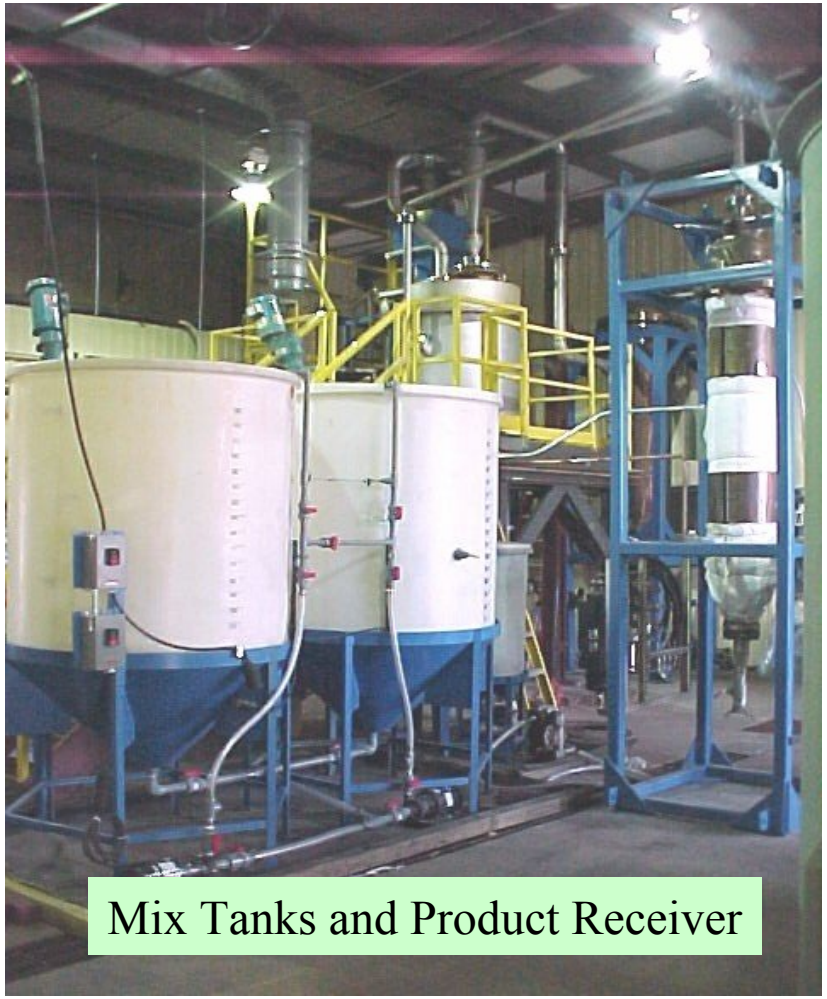
- **DOE Technology Needs At Hanford**
  - Supplemental treatment technology needed to meet milestones
  - Alternatives to "vitrification" may be required
  - Early LAW Recycle Treatment
  - Technology needed to treat WTP recycle to increase throughput
- **THOR® Steam Reforming**
  - Previously Demonstrated for Idaho and Savannah River Waste
  - Demonstration needed for Hanford Waste Treatment
- **Hanford Demonstration Requirements**
  - Produce mineralized product in laboratory sized system with actual Hanford LAW for analysis to confirm "better than WTP" glass properties for radionuclide isolation and validate that Tc is non-volatile
  - Produce mineralized product in engineering scale sized system from Hanford LAW surrogate for analysis to confirm "better than WTP glass" properties
  - Produce monolithic mineralized product
  - Confirm process throughput, off gas emissions, out put product volume and other process parameters to enable life cycle cost analysis to be performed and scale up to full scale



Phase II – Hanford LAW Surrogate ESTD

- **Perform tests at Hazen in Golden, Colorado**
- **Gather technical data to support permitting, design, and operations**
- **Produce a mineralized alkali-aluminosilicate-based product using the LAW waste surrogate.**
- **Produce a waste monolith that meets the Waste Acceptance Criteria (WAC) to be used for vitrified LAW disposal at Hanford.**
- **Demonstrate correlation of product results between previous demonstration tests on Hanford LAW**
- **Determine state of Tc in mineral and validate use of Re as surrogate**
- **Demonstrate offgas emissions are compliant with MACT and other environmental standards**
- **Establish technical parameters for design and operation of the full-scale facility**
  - Optimization of throughput, consumables, utilities and waste volume reduction
- **Demonstrate in-container monolith techniques**
- **Demonstrate long-term process operation**
- **Confirm waste form performance with results from BSR test using actual Hanford LAW**
- **Demonstrate EVMS Application Consistent with DOE O 413.3 and EVMS Application Guide**

IWTU Engineering Scale Demonstration



IWTU Engineering Scale Demonstration

CRR Reformer Lower Section

CRR Reformer and Off-Gas Cooler

Phase II: Bench Scale Reformer Demonstration

- **Treat actual Hanford Waste**
  - Testing performed at Hanford (222-S or PNNL)
- **Objectives**
  - Confirm the partitioning of radionuclides from 1 to 5 liters of Hanford LAW Waste
  - Produce actual waste product for analysis to demonstrate waste form performance to Hanford WAC
  - Demonstrate the correlation of surrogate waste formulations and previous demonstration results to actual waste at Hanford to further validate the data base
- **Use system based on design of previously proven apparatus at SRNL**

Bench Top System Developed at Savannah River

Important for regulatory acceptance and validation of surrogate demonstration results

Bench-Scale Demonstration Systems

SRNL
Bench-Top Steam Reformer

ART Phase II Implementation Schedule

Advanced Remediation Technology Phase II

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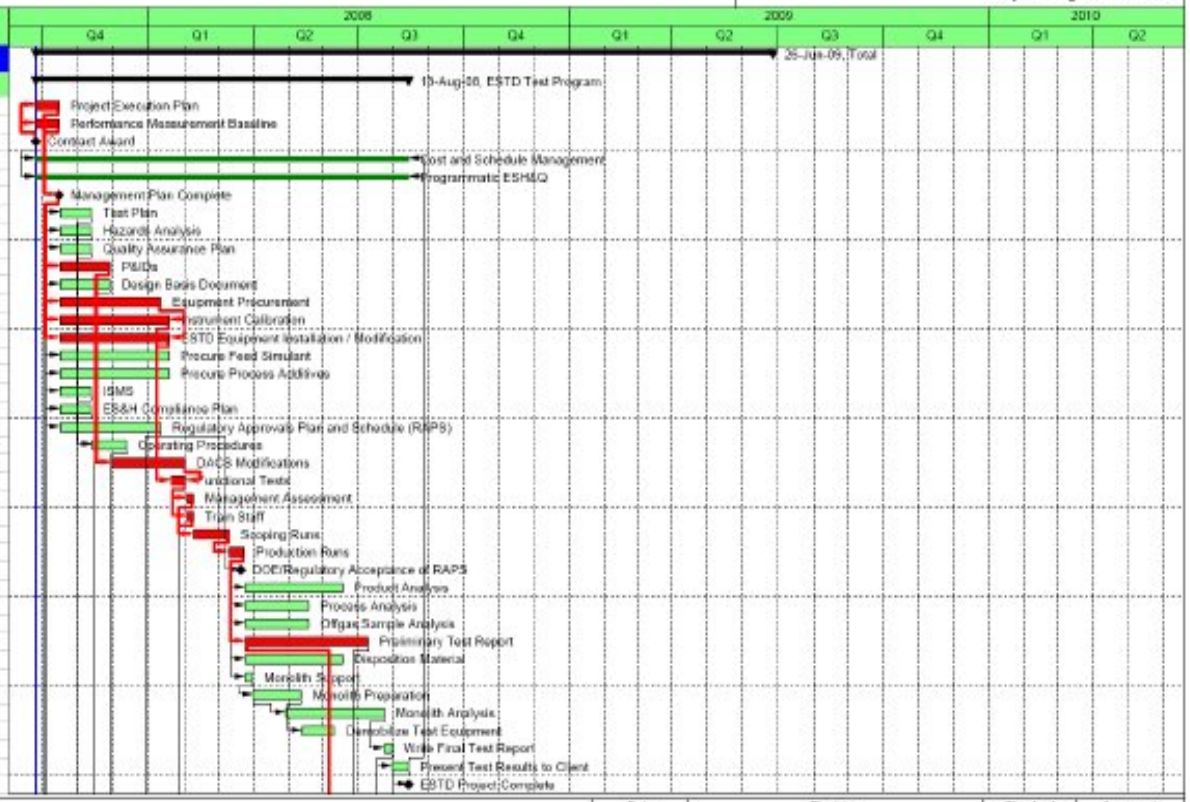
10-Oct-07 15:11

Project Manager: Paul Rutland

Activity ID	Activity Name	Duration (Weeks)	Start	Finish
Total		89.4	25-Sep-07	26-Jun-09
ESTD Test Program		45.2	25-Sep-07	13-Aug-08
10010	Project Execution Plan	3.0	25-Sep-07	15-Oct-07
10020	Performance Measurement Baseline	3.0	25-Sep-07	15-Oct-07
10000	Contract Award	0.0	25-Sep-07	
10350	Cost and Schedule Management	45.2	25-Sep-07	13-Aug-08
10360	Programmatic ESH&Q	45.2	25-Sep-07	13-Aug-08
10070	Management Plan Complete	0.0		15-Oct-07
10030	Test Plan	4.0	16-Oct-07	12-Nov-07
10050	Hazards Analysis	4.0	16-Oct-07	12-Nov-07
10060	Quality Assurance Plan	4.0	16-Oct-07	12-Nov-07
10080	P&IDs	6.0	16-Oct-07	26-Nov-07
10100	Design Basis Document	6.0	16-Oct-07	26-Nov-07
10110	Equipment Procurement	12.0	16-Oct-07	11-Jan-08
10040	Instrument Calibration	13.0	16-Oct-07	18-Jan-08
10120	ESTD Equipment Installation / Modifica...	13.0	16-Oct-07	18-Jan-08
10160	Procure Feed Simulant	13.0	16-Oct-07	18-Jan-08
10170	Procure Process Additives	13.0	16-Oct-07	18-Jan-08
10310	ISMS	4.0	16-Oct-07	12-Nov-07
10320	ES&H Compliance Plan	4.0	16-Oct-07	12-Nov-07
10330	Regulatory Approvals Plan and Sched...	12.0	16-Oct-07	11-Jan-08
10090	Operating Procedures	4.0	13-Nov-07	12-Dec-07
10130	DACS Modifications	9.0	29-Nov-07	01-Feb-08
10140	Functional Tests	2.0	31-Jan-08	01-Feb-08
10150	Management Assessment	1.0	04-Feb-08	08-Feb-08
10190	Train Staff	1.0	04-Feb-08	08-Feb-08
10200	Scoping Runs	6.2	09-Feb-08	10-Mar-08
10210	Production Runs	2.8	11-Mar-08	24-Mar-08
10340	DOE/Regulatory Acceptance of RAPS	0.0		31-Mar-08
10240	Product Analysis	12.0	25-Mar-08	17-Jun-08
10250	Process Analysis	8.0	25-Mar-08	19-May-08
10260	Offgas Sample Analysis	8.0	25-Mar-08	19-May-08
10270	Preliminary Test Report	15.0	25-Mar-08	09-Jul-08
10380	Disposition Material	12.0	25-Mar-08	17-Jun-08
10390	Monolith Support	1.0	25-Mar-08	31-Mar-08
10220	Monolith Preparation	6.0	01-Apr-08	12-May-08
10230	Monolith Analysis	12.0	29-Apr-08	23-Jul-08
10280	Demobilize Test Equipment	4.0	13-May-08	10-Jun-08
10290	Write Final Test Report	1.0	24-Jul-08	30-Jul-08
10300	Present Test Results to Client	2.0	31-Jul-08	13-Aug-08
10370	ESTD Project Complete	0.0		13-Aug-08



- Remaining Level of Effort
- Actual Level of Effort
- Actual Work
- Remaining Work
- Critical Remaining Work
- Milestone
- Summary

Advanced Remediation Technology (ART) Phase II

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Date	Revision	Checked	Approved
11-Oct-07	ART Phase II Baseline Schedule		

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ART Phase II Implementation Schedule

Advanced Remediation Technology Phase II

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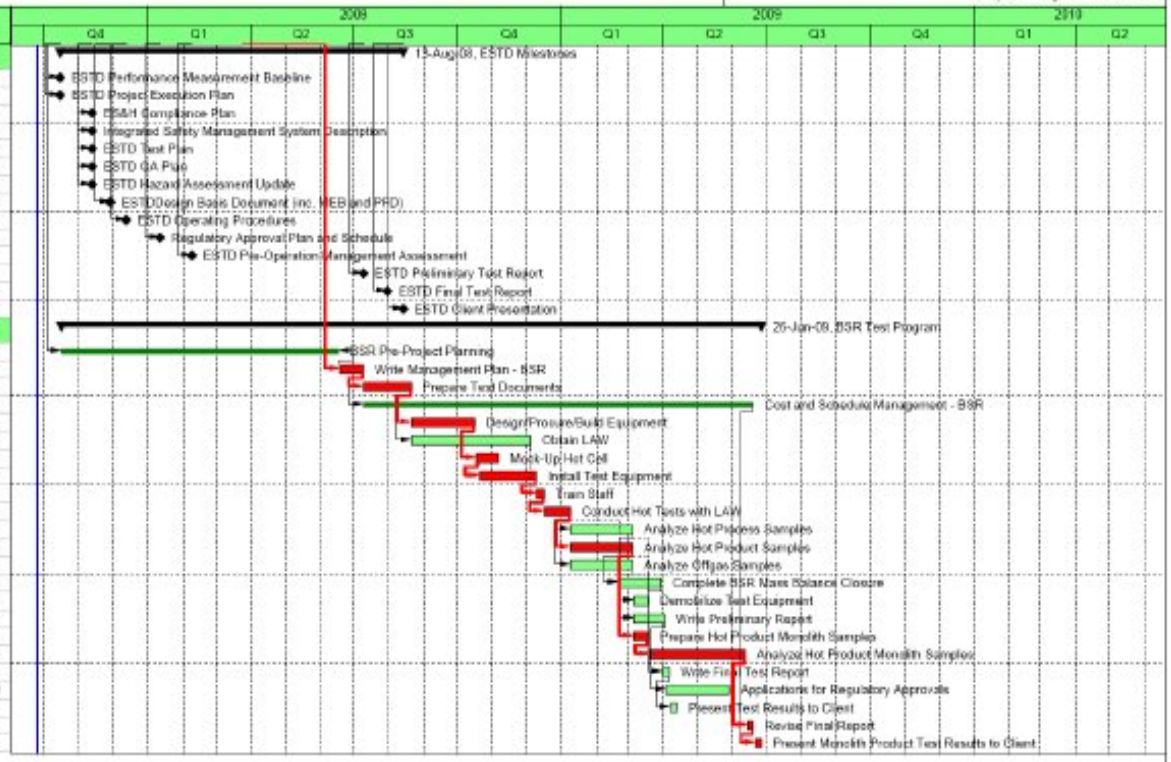
Project Manager: Paul Ratland

Activity ID	Activity Name	Duration (Weeks)	Start	Finish
ESTD Milestones		42.2	15-Oct-07	13-Aug-08
M-002	ESTD Performance Measurement Bas...	0.0		15-Oct-07
M-001	ESTD Project Execution Plan	0.0		15-Oct-07
M-003	ES&H Compliance Plan	0.0		12-Nov-07
M-004	Integrated Safety Management System...	0.0		12-Nov-07
M-014	ESTD Test Plan	0.0		12-Nov-07
M-024	ESTD QA Plan	0.0		12-Nov-07
M-034	ESTD Hazard Assessment Update	0.0		12-Nov-07
M-044	ESTDDesign Basis Document (inc. MEB...	0.0		28-Nov-07
M-054	ESTD Operating Procedures	0.0		12-Dec-07
M-064	Regulatory Approval Plan and Schedule	0.0		11-Jan-08
M-074	ESTD Pre-Operation Management Ass...	0.0		08-Feb-08
M-084	ESTD Preliminary Test Report	0.0		09-Jul-08
M-094	ESTD Final Test Report	0.0		30-Jul-08
M-104	ESTD Client Presentation	0.0		13-Aug-08
BSR Test Program		86.4	16-Oct-07	26-Jun-09
B1080	BSR Pre-Project Planning	34.2	16-Oct-07	17-Jun-08
B1010	Write Management Plan - BSR	3.0	18-Jun-08	09-Jul-08
B1020	Prepare Test Documents	6.0	10-Jul-08	20-Aug-08
B1015	Cost and Schedule Management - BSR	48.2	10-Jul-08	19-Jun-09
B1030	Design/Procure/Build Equipment	8.0	21-Aug-08	16-Oct-08
B1050	Obtain LAW	14.6	21-Aug-08	04-Dec-08
B1040	Mock-Up Hot Cell	3.0	17-Oct-08	06-Nov-08
B1060	Install Test Equipment	7.0	20-Oct-08	09-Dec-08
B1070	Train Staff	1.0	10-Dec-08	16-Dec-08
B1100	Conduct Hot Tests with LAW	3.0	17-Dec-08	08-Jan-09
B1110	Analyze Hot Process Samples	8.0	09-Jan-09	05-Mar-09
B1120	Analyze Hot Product Samples	8.0	09-Jan-09	05-Mar-09
B1140	Analyze Offgas Samples	8.0	09-Jan-09	05-Mar-09
B1160	Complete BSR Mass Balance Closure	5.4	20-Feb-09	30-Mar-09
B1130	Demobilize Test Equipment	2.0	06-Mar-09	19-Mar-09
B1150	Write Preliminary Report	4.0	06-Mar-09	02-Apr-09
B1290	Prepare Hot Product Monolith Samples	2.0	06-Mar-09	19-Mar-09
B1300	Analyze Hot Product Monolith Samples	12.0	20-Mar-09	12-Jun-09
B1170	Write Final Test Report	1.0	31-Mar-09	06-Apr-09
B1330	Applications for Regulatory Approvals	8.0	03-Apr-09	29-May-09
B1180	Present Test Results to Client	1.0	07-Apr-09	13-Apr-09
B1310	Revise Final Report	1.0	15-Jun-09	19-Jun-09
B1320	Present Monolith Product Test Results ...	1.0	22-Jun-09	26-Jun-09



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Advanced Remediation Technology (ART) Phase II

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Date	Revision	Checked	Approved
11-Oct-07	ART Phase II Baseline Schedule		

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ART Phase II: ESTD Deliverables

Deliverable	Internal	DOE	Date
Management Plan •Project Execution Plan (Rev. 0) •Performance Measurement Baseline (Rev. 0)		X	10/15/07 Complete on 10/12/07
ES&H Compliance Plan	X		11/12/07
ISMS Plan	X		11/12/07
Test Plan		X	11/12/07
Hazards Assessment	X		11/12/07
Design Basis Document	X		11/12/07
ESTD Operating Procedures	X		12/12/07
Regulatory Approval Plan and Schedule		X	1/11/08
Management Assessment, Pre-op	X		2/08/08
Preliminary Test Report	X		7/09/08
Final Test Report		X	7/30/08
Client Presentation		X	8/13/08
Monthly Report		X	12th Working Day

ART Phase II: BSR Deliverables

Deliverable	Internal	DOE	Date
Management Plan •Project Execution Plan (Rev. 1) •Performance Measurement Baseline (Rev. 1)		X	7/09/08
Test Plan		X	11/12/07
Hazards Assessment	X		TBD Under Management Plan
Design Basis Document	X		TBD Under Management Plan
Operating/Test Procedures	X		TBD Under Management Plan
Facility/BSR Interface Document	X		TBD Under Management Plan
Petitions for Regulatory Approvals		X	TBD Under Management Plan
Management Assessment, Pre-op	X		TBD Under Management Plan
Preliminary Test Report	X		TBD Under Management Plan
Final Test Report		X	TBD Under Management Plan
Client Presentation		X	TBD Under Management Plan
Monthly Report		X	12th Working Day

Phase II Schedule Status

- **Management Plan Complete**
  - Project Execution Plan
    - Tailored to DOE O 413.3
  - Performance Measurement Baseline
    - Earned management system established
      - EIA-748 Applied
      - DOE Earned Value Management Guide (Draft)
      - NDIA PMSC EVMS Application Guide
- **Test Plan Initiated**
- **Subcontracts Initiated for Work Execution**
- **All Activities on or ahead of schedule**
- **SPI 1.12**

Summary/Conclusions

- **Phase II**
  - Approach provides a logical scientific and technical basis to gather and document information required for production scale LAW remediation facility at Hanford
    - Demonstrate required quality of mineral product over a wider range of operating conditions
    - Enlarge database for long-term leach performance of monolithic mineral waste forms from LAW surrogates with a wider range of compositions
    - Validate that Tc behaves like Re and that Tc is non-volatile and is fully mineralized with leach resistance that is better than glass
    - Confirm that no liquid secondary wastes will be generated when processing Hanford LAW wastes. (Zero-liquid release facility with S, Cl, and F being retained in the mineral product so that no off-gas scrubber system is required)
    - Confirm that no NOx treatment is required in the steam reformer off-gas

Discussion

- **Questions**