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Abstract: This document identifies the potential impact of critical component failures during waste feed delivery to the Waste Treatment Plant. New equipment is recommended for development to support preventive maintenance and for reducing the duration of recovery operations.

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Executive Summary

This report represents an initial effort to identify maintenance equipment needed to support critical components used for delivery of waste feed to the WTP. Rough estimates of cost benefits for selected maintenance capabilities are provided. A follow-on to this report should include a detailed cost analysis showing cost benefits and tradeoffs in selection and development of specific maintenance capabilities.

Critical component failures during delivery of waste feed from the DSTs to the WTP have the potential to idle WTP facilities if the duration of the recovery operations are long enough to allow the WTP to exhaust a planned 60-day lag storage capacity for waste feed. If a critical component within the transfer route fails, current planning does not provide for an alternative HLW feed source.

Critical components with relatively high failure frequencies and recovery times are identified, along with a summary of documentation regarding historical maintenance and recovery operations and planning. Components, such as mixer pumps and transfer pumps, are estimated to have relatively long recovery times due, in part, to the current practice of sending spare pumps, when needed, off-site to a remote location, for vendor refurbishment and testing prior to installation in a tank. No capability is provided on-site for pump "run-in". As neither the spare pumps in storage, installed pumps, or other critical components are subjected to periodic preventive maintenance, and these critical components are planned to be operated intermittently over a long period of time, component failures are to be expected.

Recommendations are made for further analysis to identify specific equipment cost benefits, development costs, and tradeoffs in selection of alternatives. This new equipment will provide capabilities for component storage and maintenance in line with vendor recommendations, reduce the duration of recovery operations, and support personnel training and procedure development.

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DST System Maintenance and Recovery Needs Report

1 INTRODUCTION

This report identifies the potential impact of critical component failures during Waste Feed Delivery (WFD) operations and provides recommendations for the development of new equipment to perform preventive and corrective maintenance to mitigate the risk of these failures. The timely completion of waste feed deliveries is a key focus for WFD operations in order to avoid costly downtime at the Waste Treatment Plant due to lack of available waste from the Tank Farm Contractor (TFC). Failures at critical times, such as in preparation for and during waste feed deliveries have the potential to create significant delays in feed delivery.

The current planning for waste feed delivery during the Initial Quantity period per *Tank Farm Contractor Operation and Utilization Plan*, HNF-SD-WM-SP-012, provides no backup feed source for the HLW (see HNF-SD-WM-SP-012, Assumption A9.5). With no alternative HLW feed source planned, improving the reliability of critical components and reducing the duration of recovery operations for failed components are crucial to mitigate the impact to waste feed deliveries.

This report will address preventive maintenance on installed components and those in long-term spare storage as part of improved reliability considerations. In addition, recommendations are provided for new maintenance equipment needed to support and/or reduce the duration of recovery operations, including equipment for preparing, testing, and transporting spare components.

Consideration for maintenance and recovery equipment needs are justified as delays in delivering waste feed beyond the Waste Treatment and Isolation Plant (WTP) feed-forward storage capacity could result in idle WTP facilities with associated costs estimated at over $600,000 per day (derived from the *River Protection Project - Project Management Plan*, DOE/ORP-2000-06, summary cost estimates of $880 million for waste treatment for FY 2007-2011). Additional cost impacts to the TFC would result from both the recovery operations and as a result of any interruptions in tank farm operations during this recovery period.

In summary, this report will provide the following:

- Identification of critical component failures that have a potential of shutting down waste feed delivery to the WTP
- Evaluation of potential maintenance and recovery equipment needs
- Recommendations for new maintenance and recovery equipment

1.1 Background

Waste Feed Delivery System Phase 1 Preliminary RAM Analysis, HNF-2863 identified several risks to meeting planned waste feed deliveries which are increased due to the current plans for operation as noted below:

- For HLW feed delivery to the WTP there is no planned alternate feed source for delivery from an alternate tank
- Currently there are no plans for redundant critical components that, upon failure, have relatively long recovery times (e.g., redundant transfer pumps with the staging tanks or a backup Caustic and Diluent System to support flushing operations if a failure occurs)
- Currently there are no predictive maintenance (i.e., surveillance) programs for mixer pumps and transfer pumps
- Currently there are no plans to reduce recovery times through activities as noted below:
  (1) preplanning and expedited review of work packages;
  (2) organizing specific recovery teams and providing hands-on training for recovery;
  (3) constructing mock-ups of critical facilities for rehearsing recovery actions;
  (4) ensuring spares are readily obtainable (note that the reliability predictions made in the RAM analysis of HNF-2683 assumed that a spares management and maintenance program would be in place to support WFD).

1.1.1 WTP Feed-Forward Capacity

The WTP feed-forward capacity provides a performance bound for corrective maintenance activities. Any recovery activity that delays feed delivery long enough for the WTP to exhaust their lag storage of waste feed would result in idle WTP facilities. The feed-forward or "lag storage" of both HLW and LAW is defined in the WTP contract and interface control documents (ICDs) as the feed remaining in the WTP facility on the waste transfer date (WTD) as follows:

- 500,000 gallons of LAW per *ICD 19 - Interface Control Document for Low-Activity Waste Feed*, 24590-WTP-ICD-MG-01-019 (Note that this equates to approximately 100 days of feed forward capability, assuming WTP LAW processing rates of 1,100 units per year, and approximately 300 units of sodium within the 500,000 gallons of waste stored in the WTP facility)
- 60 days of feed forward capability of HLW per *ICD 20 - Interface Control Document for High-Level Waste Feed*, 24590-WTP-ICD-MG-01-020

1.1.2 Equipment Condition Assessments Regarding Maintenance/Spares

A review of recent reports of equipment assessments for 3 tank farms indicates the need for implementation of a spare parts management system. Several components critical to the feed delivery, such as pumps, valves, ventilation system components, etc., are "lacking sufficient surveillance and/or preventive maintenance" as noted in *AP Tank Farm Equipment Condition Assessment,* RPP-8350. A subset of recommendations from RPP-8350 are summarized as follows:

- Develop specific predictive maintenance measures

- Evaluate adequacy of existing spare parts storage facilities in terms of space and storage (e.g., climate control) requirements
- Re-evaluate pump storage practices
- Develop and implement preventive maintenance procedures for spare equipment.
- Develop spare parts management program (i.e., control of spares procurement and inventory, identification of who performs required maintenance of spares).
- For transfer and mixer pumps, perform periodic preventive maintenance for pump installations and spares, develop predictive measures on operating pumps.
- For valves, perform periodic preventive maintenance to actuate/cycle valves.
- For ventilation systems, expand preventive maintenance to test the heater, cooling fans, and the temperature settings and alarms in order to extend the life of filters and the Continuous Air Monitors (CAMs).

Similar recommendations were noted in *AW Tank Farm Equipment Condition Assessment*, RPP-8594 and *SY Tank Farm Equipment Condition Assessment*, RPP-8784.

1.1.3 Operations and Maintenance Philosophy

The *Operations and Maintenance Philosophy*, HNF-4553 identified equipment capabilities that are yet to be specified or implemented as noted below:

- Pump run-in capability shall be provided.
- Spare pump long-term vertical storage capability shall be provided.
- If waste preparation systems must be installed early, a program to exercise the moving parts and prevent binding shall be implemented (i.e., motor "bumping")
- Establishment of an integrated inventory that will provide planning personnel with an accurate spare-parts inventory and current material procurement status.
- Depending on the predicted failure rate, enough replacement parts shall be on hand so that system restart is not dependent upon the delivery date of the vendor.
- Development of parts standardization, in order to minimize one-of-a-kind procurement scenarios (i.e., systems and components shall be of a generic design and be standardized as much as possible).

1.1.4 Maintenance Planning Discussions

A summary of discussions with operations, engineering, and project personnel regarding maintenance planning and activities currently in place led to the following conclusions:

- minimal preventive maintenance is currently being performed on installed/stored pumps or valves
- no well-defined spares program in place for tracking, storing, maintaining spares
- no capability exists on-site to perform pump "run-in" tests (i.e., when needed spare pumps are shipped to remote vendors for refurbishment and testing)
- alternative strategies (between operations and projects) are planned regarding pump replacement and disposal (i.e., failed transfer pumps are cut up using hydraulic shears by Operations, however Project W-211 plans for disposal involve use of a burial box sized to accept the pump in one piece)

2 Process/Methodology

The identification of potential specifications for maintenance and recovery focused on the need for specialized tools, equipment, and facilities to best support waste feed delivery activities. Although administrative processes are also critical to maintenance and recovery, these types of process upgrades are assumed to be developed by other Tank Farm programs. The methodology of this study focused on "hardware" related items that directly support the life extension (via periodic maintenance) and recovery of failed operational equipment (via corrective maintenance) in the field, and where specifications can be developed to establish performance criteria.

The methodology used in the identification of hardware related maintenance and recovery specifications utilized a three-part approach to gather information as described below:

(1) The first effort focused on the identification of critical components and systems based on their potential for delaying feed deliveries given that they fail. HNF-2863 and the supporting RAM model provided the primary basis for this determination. Components most likely to fail and/or with the longest recovery times were identified as candidates for requiring specialized maintenance equipment.

(2) The second effort provided potential items to consider for specification through a review of technical documentation. A number of documents related to design, operations, and maintenance philosophy and planning, and system condition assessment were reviewed to gather background information regarding component failure history, vendor recommendations, and recovery operations and durations.

(3) The third effort included interviewing selected Tank Farms engineering, operations and maintenance personnel to determine current maintenance activities and future planning.

This information was then used to derive recommendations for new maintenance and recovery equipment capabilities along with estimates of cost benefits for this new equipment.

2.1 Waste Feed Delivery Critical Components

The reliability, availability, and maintainability (RAM) model analysis identified in HNF-2863 was completed in 2000 as the waste feed delivery designs neared maturity. The objective of this preliminary RAM analysis was to guide the collection and use of site-specific RAM performance data to provide practical information in maintenance and operational planning efforts. The RAM model evaluated the probability of various failure modes of individual pieces of equipment used to support waste feed delivery. The model then quantifies the impact of those failures in terms of their potential create delay

during waste feed deliveries. One of the primary products of the RAM analysis was a set of critical items lists (CILs). The CILs provide a valuable foundation for the development of tank farm maintenance and recovery specifications by ranking components and systems according to their potential to cause delay during waste feed delivery operations.

For this analysis, the CILs were condensed into tables of single components and component types. The components and component types near the top of each list were selected for further review to determine if maintenance and recovery specifications could help minimize the impact of their failure during waste feed delivery.

The following three (3) metrics were used in the RAM Model:

- contribution to the number of feed delivery delaying events,
- expected (average) contribution to feed delivery schedule delay and
- maximum recovery time for the potential component failure modes.

The relationship among these metrics and the identification of maintenance and recovery needs is as follows:

Sorting by Schedule Delay Events
When the component list is sorted by the contribution to the number of delaying events, it provides information about the components that fail the most often during the mission. These components might be good candidates for procuring as part of the local spare inventory.

Sorting by Expected Schedule Delay
Contribution to schedule delay ranks the components based on their contribution to risk of incurring delay costs. Components high in this ranking might require special attention regarding recovery strategies and spares determination to minimize potential delays.

Sorting by Recovery Time
Rank ordering by maximum recovery time provides insight into those situations where long recovery times can induce programmatic impacts. Components ranked high on this list might be good candidates for special recovery planning efforts.

A summary of the major contributors to equipment failures and schedule delays from the RAM Model is provided in Table 1 (by component) and Table 2 (by component type). The two tables provide different insights for maintenance and recovery planning. Failures and/or delays by component (Table 1) can provide information on individual components that have the greatest impact on feed delivery activities. For example, this information can assist with the development of spares lists for specialized components such as waste transfer pumps. Failures and delays by component type (Table 2) supports ranking like components together to assist with spare parts determinations, potential maintenance staffing strategies or other planning efforts.

Table 1. Potential Failure and/or Delays by Component

System	Component Description	Contribution to Schedule Delay Events[1]	Contribution to Expected Schedule Delay[2]	Greatest Mean Recovery Time[3]
Waste Transfer System	Mixer Pumps	X	X	X[4]
	Transfer Pump	X	X	X[4]
	Pipe Segment			X[4]
	Nozzle			X
	Ball Valve			X
	Check Valve			X
	Jumper			X
	Flow Element			X
	Level Detector Element			X
	Pressure Element			X
HVAC Primary	Recirculation Condenser Cooling Pump	X	X	
	High Efficiency Mist Eliminator	X	X	X
HVAC Annulus	Exhaust Fan		X	
Diluent/Flush System	Diluent/Flush Delivery Pump	X	X	
	Diluent/Flush Preparation Pump	X		

Table Notes:
[1]components with greater than 5% contribution to schedule delay events.
[2] components with greater than 2% contribution to expected schedule delay.
[3] components with greater than 200 hours of recovery time.
[4] components with greater than 1500 hours of recovery time.

Table 2. Potential Failure and/or Delays by Component Types

System	Representative Component Description	Contribution to Schedule Delay Events[1]	Contribution to Expected Schedule Delay[2]	
Waste Transfer System	Mixer Pumps	X	X	
	Transfer Pump	X	X	
	Manual Valves	X	X	
	Variable Frequency Drive, Mixer Pump	X	X	
	Temperature Instrumentation	X	X	
	Pressure Element			
	Level Instrumentation (Diluent and other)	X	X	
	Current/Voltage Instrumentation	X	X	
	Panelboards/Switches	X		
	Flow Instrumentation		X	
	Jumper Assemblies		X	
	Nozzle		X	
	Position Instrumentation		X	
HVAC Primary	High Efficiency Mist Eliminator	X	X	
	Recirculation Condenser Cooling Circuit Breaker	X	X	
	Pressure Instrumentation (Ventilation and Support)	X	X	
	Temperature Instrumentation	X	X	
	Radiation Instrumentation	X	X	
	Exhaust Condenser Cooling Control Panel(All)	X	X	
	Air Cooled Chiller	X	X	
	HEGA Filter	X	X	
	Event/State Switch	X		
HVAC Annulus	Ventilation Dampers	X	X	
	Exhaust Fans	X	X	
	Flow Instrumentation	X	X	
	Filters (Ventilation)	X	X	
Diluent/Flush System	Pumps (Other)	X	X	
	Failure Alarm	X	X	
	Pressure, Flow, Position, Temperature Instrumentation	X		
	Manual Valves (Diluent)	X	X	
	Strainer	X		
	Heater	X		
Confinement System	Pressure Instrumentation	X	X	
	Leak Detection Instrumentation	X	X	

Table Notes:
[1]component types with greater than 0.0% contribution to schedule delay events.
[2]component types with greater than 0.1% contribution to expected schedule delay.

The following RAM Model definitions apply to Table 1 and Table 2 column headings:

Contribution to Schedule Delay Events
The number of schedule delay events is the relative frequency that a component failure mode being evaluated is expected to occur per performance of the associated schedule activity evolution. The term "relative" is used because failure rate units, λ, and exposure units, E, are coupled and depend on the failure mode being analyzed. For example, if we are quantifying the relative frequency of a valve failing to open on demand, then the units of λ are failure events per demand, and the units of E are demands per activity. If we are quantifying the relative frequency of a pump to run for its specified mission time, the units of λ are failure events per operating hour, and the units of E are operating hours per activity.

Contribution to Expected Schedule Delay
The expected delay caused by a component failure is equal to the relative frequency of the failure times the mean recovery time. For each component, the expected schedule delay for each failure mode is summed to provide a component level composite value.

Greatest Mean Recovery Time
The recovery time for a component failure is an estimate based on a number of factors including where the component is located, whether it requires breaking of the primary tank containment boundary, the type of component and others. The recovery time also includes planning and testing efforts. Each component failure mode has an associated recovery time. For each component, the greatest mean recovery time among the different failure modes is listed.

The critical components types from Tables 1 and 2 were grouped into the following general categories for subsequent discussions (see Table 3-1):

Large pumps (i.e., mixer pumps, transfer pumps)
Process Related Instruments in Pits/Tanks
Safety Related Instruments in Pits/Tanks
Process Support Pumps (i.e., flush/diluent solution and chemical pumps)
Process Valves (including waste transfer valves and valve manifolds)
Process Piping (i.e., pipes, jumpers, nozzles in pits)
Active Ventilation Equipment
Ventilation Condensate Handling Equipment
Process Monitoring and Control

2.2 Documentation Review

Although there are a number of technical areas still under refinement, the waste feed delivery designs are nearing maturity. A large amount of information exists in technical baseline documentation that relates to operations and maintenance philosophies, strategies and practices. This analysis sought to consolidate a number of significant items related to components and systems that might contribute to the development of

maintenance and recovery specifications. The items selected provide additional evidence for maintenance and recovery needs for components identified in the critical items list as well as additional items.

Table 2.2 Documentation Review Summary

Significant Items That Support Selection of Maintenance Capabilities	Reference Document
References to vendor recommendations regarding periodic maintenance of installed pumps to include periodic operation and checks of motor winding insulation resistance	HNF-SD-W320-PROC-002, Rev. 1, *Project W320 Tank 241-C-106 Pump/Winch Maintenance Procedure*
Capability needed to support pump run-in, spare pump long-term vertical storage, and program to exercise moving parts to prevent binding for installed pumps and valves	HNF-4553, Rev. 0, *Operations and Maintenance Philosophy*
Historical reference for transfer pump failures. Provides recommendations for pump preventive maintenance. Identifies lost of capability to test tank farm transfer pumps due to the closure of the 272E Pipe Shop facility in FY 1996. Estimates that medium life of failed pumps is 3.5 million gallons.	HNF-3218, Rev. 0, *DST Transfer Pump History and Reliability Report, 1998*
Reference to plans for transfer pump removal and replacement. Pump testing involved sending 2 pumps to vendor for refurbishing, modification (shortening shaft length), run-in, and acceptance testing. Also included plans for pump disposal of failed transfer pump.	RPP-6869, Rev. 0, *Engineering Task Plan for AW-104 Waste Transfer Project*
Reference for projected costs for transfer pump replacement, summarized as follows: Partial costs/duration projected included : AW-104 Procurement/Installation $2,508,000 over 8-month duration AW-104 Disposal $291,000, over 3-month duration Also, various alternatives for pump disposal defined.	RPP-6128, Rev. 0, *AW-104 Waste Transfer Tank Project Plan*
Plans for mixer pump removal and replacement included the following activities/durations: -run-in tests for new pump at MASF, 5 to 6 weeks - failed pump removal and disposal, 11 to 12 weeks - new pump installation, 4 to 5 weeks	HNF-SD-WM-SDD-052, Rev. 0-C, May 26, 1998, *First Spare Mixer Pump and Installation Equipment System Design Description for 241-SY-101 Waste Tank*
Recommendations for the design of DST Subsystems. Recommendations regarding spare parts management, test and run-in facilities to support component acceptance and preparation for recovery actions/training of crews to remove and replace pumps.	HNF-5141, Rev. 0, *Reliability, Availability, and Maintainability Recommendations for the Design of DST Components*
Description of potential longer-term uses of the cold test facility that may include "run-in" tests of new transfer and mixer pumps during WFD.	RPP-5566, Rev. 1, *Cold Test, Training, and Mockup Facility Functions and Requirements*
Recommendations regarding predictive maintenance, preventative maintenance, and spares from tank farm equipment assessments in July 2001	RPP-8350, Rev. 0, *AP Tank Farm Equipment Condition Assessment;* RPP-8594, *AW Tank Farm Equipment Condition Assessment;* RPP-8784, Rev. 0, *SY Tank Farm Equipment Condition Assessment*
Recommended set of responses to a pipeline plug to reduce the duration of the recovery effort.	RPP-10905, Rev. 0, *Recommended Responses to a Postulated HLW Feed Delivery Pipeline Plug*

2.3 Expert Elicitation

A number of experts within the Tank Farms engineering and O&M staff were consulted in order to elicit ideas and facts that provide additional support for the components and systems selected for the development of maintenance and recovery specifications. The information gained during this phase of the analysis provided valuable information regarding how maintenance is performed in the tank farms complex under current, safe-storage conditions. Even more valuable were ideas that could support the development of maintenance and recovery specifications for future, production oriented operations. Expert elicitation information is not shown separately here but instead was used to assist in the development of the table in Section 3. This table lists the components and systems to consider for maintenance and recovery specifications.

3 MAINTENANCE AND RECOVERY EQUIPMENT NEEDS

The information gathered from the RAM Analysis, technical documents and from discussions with Tank Farms operations and maintenance experts was analyzed and consolidated into Table 3-1. This table provides recommendations for maintenance and recovery specifications that are related to each critical component. The approach utilized in the table starts with a component type grouping and a specific representative component/subsystem that might be a candidate for a maintenance and recovery specification. A short description is then given for the basis for selecting the components. This is followed by a general statement regarding a logical repair/maintenance philosophy for the components.

The general philosophies are derived from HNF-4553, *Operations and Maintenance Philosophy*, as well as from discussions with tank farms O&M experts. The table then provides general recovery requirements for the selected components related to what is required from a practical repair perspective or from a logical extension of the recovery philosophy. There may be several requirements for each selected component. Based on the identified maintenance and recovery requirement, a repair or maintenance concept is identified. A given requirement might have both repair and maintenance concepts associated with it. For each maintenance and recovery related concept, a potential specification or capability is identified that might assist with its implementation. The potential specifications identified might be equipment related or administrative related. Only equipment related specifications are further detailed in this report. Figure 3-1 provides a graphical representation of the specification/capability identification process used in this analysis.

Table 3-1. Recommendations for Maintenance and Recovery Specifications.

COMPONENT GROUP	COMPONENT	BASIS FOR SELECTION	REPAIR/MAINTENANCE PHILOSOPHY	RECOVERY REQUIREMENTS	REPAIR CONCEPT	MAINTENANCE CONCEPT	SPECIFICATION/ CAPABILITY NEEDED
Large Pumps In Pits	**Mixer Pumps, Transfer Pumps**	RAM model critical component; long recovery time; vendor recommendations	Replace failed units; repair motors above grade; receipt and pre-installation testing; functional test of installed pumps; ensure spares are available locally; anticipate pending failures	**Pit entry needed**	Minimize pit entry planning and preparation time		Long Length Contaminated Equipment (LLCE) handling equipment
					Crane extraction, LLCE handling		Decontaminate equipment during removal from tank
				Minimize replacement part receipt time	Spare pump(s) in storage in local warehouse		Storage for easy removal, Vertical storage for life extension
							Transport from storage to work site
						Regular rotation of motor/shaft bearings	Manual and/or electric rotation capability
						Test run of newly received pumps, or prior to installation	Facility to handle and test pumps on receipt
					Spare motor(s) (mixer pump only) in storage in local warehouse		Storage for easy removal
						Regular rotation of motor bearings	Manual and/or electric rotation capability
					Specialized parts and fittings identified and in local spare storage		Administrative: Spare parts management system
				Anticipate pending failures		Predictive maintenance testing	Test equipment

Table 3-1. Recommendations for Maintenance and Recovery Specifications.

COMPONENT GROUP	COMPONENT	BASIS FOR SELECTION	REPAIR/MAINTENANCE PHILOSOPHY	RECOVERY REQUIREMENTS	REPAIR CONCEPT	MAINTENANCE CONCEPT	SPECIFICATION/ CAPABILITY NEEDED
							Administrative: PDM training
				Dispose of failed parts	Disposal containers		Disposal containers to support receipt of LLCE, interim storage, and MW treatment options (grouting)
Process Related Instruments In Pits/Tanks	Pressure, flow, density, and other sensors	RAM model critical components; long recovery times; unique components	Replace failed units; no or minimum calibration required; remote functional testing; provide functional redundancy	Pit entry needed	Minimize pit entry planning and preparation time		Speed time for cover block removal
				Remote maintenance for small parts	Remote repair utilizing extended tool fittings	Remote maintenance utilizing extended tool fittings	Specialized tools for extended reach remote maintenance and repair identified, designed, and procured
				Minimize replacement part receipt time	Specialized parts and fittings identified and in local spare storage		Administrative: Spare parts management system
Safety Related Instruments In Pits/Tanks	Leak and level detectors	RAM model critical components; long recovery times	Replace failed units; minimum calibration required; remote functional testing; provide functional redundancy	Pit entry needed	Minimize pit entry planning and preparation time		Speed time for cover block removal
	Temperature and pressure sensors			Remote maintenance for small parts	Remote repair utilizing extended tool fittings	Remote maintenance utilizing extended tool fittings	Specialized tools for extended reach remote maintenance and repair identified, designed, and procured
				Minimize replacement part receipt time	Specialized parts and fittings identified and in local spare storage		Administrative: Spare parts management system
Process Support Pumps	Flush/diluent solution and chemical pumps	Long recovery times; expensive recovery actions (potential plugging events)	Repair failed units	Minimize failure impact on critical transfers	Ensure failure of diluent supply pumps cannot induce pipe plugging events		Provide portable diluent supply pump
	Service water pumps						Provide diverse diluent/flush supply source

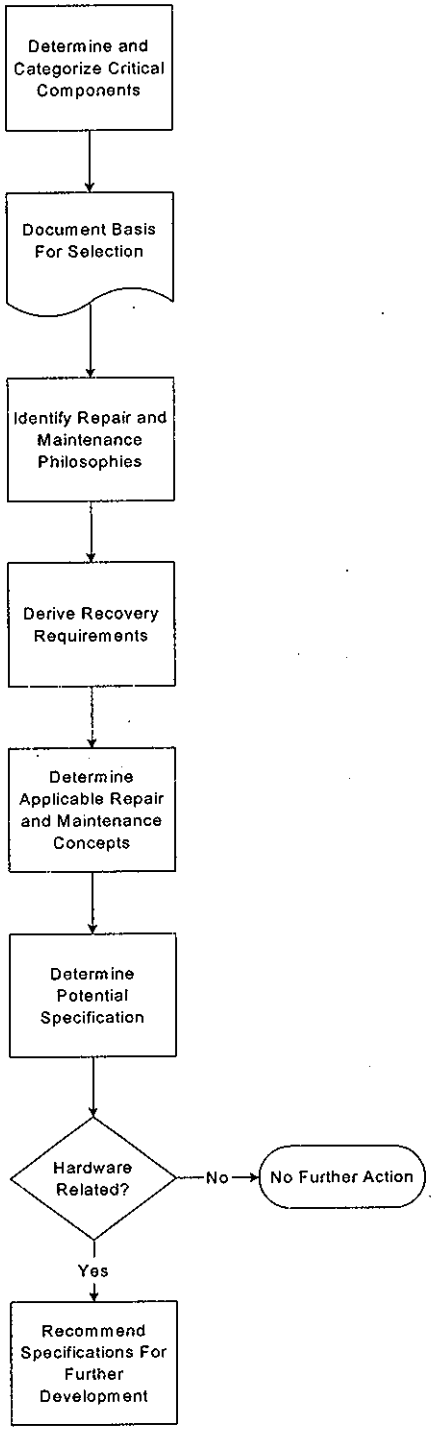
Table 3-1. Recommendations for Maintenance and Recovery Specifications.

COMPONENT GROUP	COMPONENT	BASIS FOR SELECTION	REPAIR/MAINTENANCE PHILOSOPHY	RECOVERY REQUIREMENTS	REPAIR CONCEPT	MAINTENANCE CONCEPT	SPECIFICATION/ CAPABILITY NEEDED
Process Valves	**Waste Transfer Valves and valve manifolds**	RAM model critical components; long recovery times; unique components	Replace failed items; ensure spares available locally	**Pit entry needed**	Minimize pit entry planning and preparation time		Speed time for cover block removal
				Minimize process critical failures	Ruptured/leaking valves		Provide local spares for timely replacement of unique, frequently used manifold assemblies
						Prevent standby failures	Provide equipment to exercise valves between transfers
Process Piping	**Pipes; jumpers and nozzles in Pits**	RAM model critical components; long recovery times; unique components	Replace failed items; remove plugs; ensure spares available locally	**Pit entry needed**	Minimize pit entry planning and preparation time		Speed time for cover block removal
				Minimize process critical failures	Provide mechanical/chemical unplugging capability		Mechanical uplugging equipment/device
							Administrative: Pre-planned chemical flushing recovery procedures tailored to tank specific transfer parameters
					Repair ruptured/leaking piping		Provide local spares for timely replacement of unique, frequently used jumpers
							Provide equipment and specialized pipe repair components designed for replacing failed pipe sections
Active Ventilation Equipment	**Ventilation fans**	RAM model critical components	Repair failed equipment; ensure critical spares available locally	**Anticipate pending failures**		Predictive maintenance testing for rotating equipment	Predictive maintenance test equipment
							Administrative: Predictive maintenance training
				Minimize replacement part receipt time	Specialized parts and fittings identified and in local spare storage		Administrative: Spare parts management system

Table 3-1. Recommendations for Maintenance and Recovery Specifications.

COMPONENT GROUP	COMPONENT	BASIS FOR SELECTION	REPAIR/MAINTENANCE PHILOSOPHY	RECOVERY REQUIREMENTS	REPAIR CONCEPT	MAINTENANCE CONCEPT	SPECIFICATION/ CAPABILITY NEEDED
Ventilation Condensate Handling Equipment	High Efficiency Mist Eliminator	RAM model critical components; long recovery times	Repair failed equipment; ensure critical spares available locally	Cell entry needed	Minimize cell entry planning and preparation time		Speed time for cell entry
				Anticipate pending failures		Condition monitoring	Remote condition monitoring of HEME vessel
	HLW condensate drainage			Minimize process critical failure impact			
				Minimize process critical failure impact	Repair plugging/overflow incidents		Mechanical unplugging equipment/device
							Administrative: Pre-planned chemical flushing recovery procedures tailored to condensate chemistry
Process Monitoring and Control	TMACS	Continuous availability required; no automatic redundancy	Replace failed units	Maximize operational availability	Provide automatic redundancy		Provide backup computer servers
					Reduce impacts of loss of power incidents		Provide uninterruptible power supply
				Prevent obsolescence	Replace/upgrade software and embedded systems		Adminstrative: Ensure software and embedded systems vendors can continue support
							Administrative: Plan for regular replacement/upgrade of control system software

Figure 3-1. Process Used to Identify Equipment Needed to Support Maintenance Activities



4 RECOMMENDATIONS/PATH FORWARD

For success in completing waste feed delivery the recommendation is to develop new equipment which provides the capabilities summarized in Table 4-1. Several recommendation for maintenance to support waste feed delivery have already been identified in various documents (i.e., the *O&M* Philosophy) as noted herein. In order to reduce risk to waste feed deliveries, many of these recommendations should be implemented.

Table 4-1. Summary of Recommended New Equipment Capabilities

Maintenance/Recovery Needs – New Equipment Capability	**Estimated Cost/Benefit**
Large pump equipment supporting large pump storage, maintenance, testing, transport, and installation - vertical storage resulting in component life extension due to meeting vendor recommendations for vertical storage - transport capabilities reducing time to move pump from storage to emplacement location, thus reducing overall pump recovery time - pump run-in prior capability at Hanford, to avoid recovery delays due to current practice of shipping pump off-site to remote vendor for testing to ensure readiness for emplacement - mockup equipment/facilities for training/developing procedures to support safe and efficient failed pump removal, preparation for disposal, and emplacement of new pump	Estimates from recent operations (see RPP-6869) indicate a minimum 3 month duration required to prepare a spare pump for installation (i.e., with the current practice of sending the pump to a Portland, Oregon vendor for refurbishment, testing, then shipment back to Hanford), the capabilities for storage, transport, run-in, and mockup equipment are estimated to reduce this time to approximately 5 weeks (estimated time for mixer pump run-in tests per HNF-SD-WM-SDD-052). Using these estimates, new equipment capabilities could reduce the overall recovery time by 7 weeks at a savings of approximately $600,000/day (i.e., for each day in recovery beyond the initial 60-day feed-forward capacity of the WTP from Section 1) for each failed pump. With the adverse impact of intermittent pump operation and no preventive maintenance (see HNF-3218 regarding transfer pumps), and current plans that exceed operational design life by a factor of 4 and exceed waste exposure design life by a factor of 3 (see Draft RPP-10150 regarding AZ-101 mixer pumps), a significant number of large pumps should be expected to fail.
Valve/Pump Pit Component Access - Equipment supporting remote access to critical components within pump/valve pits used to speed up recovery operations in high radiation environments	RPP-10905 estimated valve pit access operations requiring an average of 49 days. Use of remotely operated equipment could serve to reduce this duration and limit radiation exposure to maintenance personnel. The cost basis is TBD pending evaluation of "Pit Viper" equipment capabilities currently under development.

Maintenance/Recovery Needs – New Equipment Capability	Estimated Cost/Benefit
Pipeline Plug Recovery - Pipeline unplugging equipment used to locate and remove pipeline plugs used to speed up recovery by providing means to locate and clear blockage. - mockup equipment/facilities for training/developing procedures to support safe and efficient pipeline unplugging operations	Estimates for recovery from a pipeline plug using this new equipment (see RPP-10905) bound recovery from a pipeline plug within 146 days, while next the planned feed source may not be available to support HLW feed delivery for 1 to 3 years. At an estimated cost of $600,000/day this could reduce the overall pipeline plug recovery duration by at least 219 days (i.e. 365-146). The assumption is that there is no alternative route around the plugged pipeline and that no alternative feed source is available for a minimum of 365 days (see HNF-SD-WM-SP-012, Mission Summary Diagram).
Equipment/facilities supporting spare parts storage - support spare part storage, staging, and maintenance, thus reducing recovery times by having ready replacements for failed critical components	Procurement of long-lead critical components upon failure could delay recovery operations. The cost benefit is directly related to the time it takes to procure an acceptable replacement component. This translates into a $600,000/day savings for critical components in which the recovery is delayed beyond the 60-day WTP lag storage capabilities (as is expected for large pumps and any component requiring pit access). As an example, discussions with Project W-211 indicate that Mixer Pump procurement is estimated to take at least 1 year.
HVAC Primary maintenance - Equipment for remote monitoring of HEME conditions to avoid feed delivery interruptions	Estimated recovery time from a failed HEME is approximately 300 hours from the RAM model. This monitoring capability would be used to predict and schedule corrective maintenance around planned waste transfers from the AY/AZ tank farms.
Notes: TBD = to be determined	

Path Forward

The recommended path forward to initiate action regarding development and procurement of this new equipment is as follows:

Perform Decision Analyses to support equipment selection and bound equipment performance by identifying detailed cost benefits, development costs, and tradeoffs for maintenance of the critical components identified in Tables 1 and 2. These analyses should weigh vendor recommendations and industry practices as applicable to Hanford operations regarding preventive maintenance, predictive maintenance, and other processes which extend the component operating life, and prevent interruptions of waste feed delivery.

Revise the Maintenance and Recovery Specification to focus on critical waste feed delivery needs as noted herein.

In addition to the hardware specifications, the TFC should address administrative issues that could significantly shorten the recovery time for a critical component failure as noted below:

Support Operations development of maintenance procedures (preventive, and corrective) and training programs to reduce the overall time required to perform corrective maintenance, particularly in valve/pump pits.

Support development of a surveillance program that gathers data used to predict pending failures and identifies critical maintenance needed to avoid component failure during waste feed delivery.

Identify and initiate USQ's or potential safety issues to avoid potential impacts of resolving those issues.

Provide recommendations for reducing the administrative delays in developing Work Packages.

Assist Maintenance in identifying additional process improvements including spare parts inventory management, parts standardization, and predictive maintenance.

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