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Release Date: 1/9/95

This document was reviewed following the procedures described in WHC-CM-3-4 and is:

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FIRE HAZARD ANALYSIS

FOR THE

WESTINGHOUSE HANFORD COMPANY

MANAGED LOW-LEVEL MIXED WASTE

TRENCH 31 AND 34

WHC-SD-WM-FHA-006 Rev. 0

Prepared for:

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December 15, 1994

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Fire Hazard Analysis
for the
Westinghouse Hanford Company
Managed Low-Level Mixed Waste
Trench 31 and 34

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ABBREVIATIONS, ACRONYMS, AND INITIALISMS

A	Area
ALARA	As low as reasonably achievable
ASTM	American Society for Testing and Materials
BTU	British Thermal Unit(s)
cc	cubic centimeter(s)
Ci	Curies
dia.	diameter
DOE	U.S. Department of Energy
FHA	Fire Hazards Analysis
ft	feet or foot
ft²	square feet
ft³	cubic feet
g	gram(s)
gph	gallons per hour
G	gravitational constant
GJ	giga-joules
HDPE	high-density polyethylene
HFD	Hanford Fire Department
HP	horse power
h, hr	hour(s)
in.	inch(es)
gal	gallon(s)
kg	kilogram(s)
km	kilometer
L	liter
lb	pound(s)
lbf	pounds-feet
LEL	Lower Explosive Limit
m	meter(s)
m²	square meters
m³	cubic meter(s)
MCFL	Maximum Credible Fire Loss

mi	mile(s)
min	minute(s)
MJ	megajoules
MPFL	Maximum Possible Fire Loss
mph	miles per hour
NFPA	National Fire Protection Association
RF	release fraction
RLID	Richland Operations Office (RL) Implementing Directive
s	second(s)
sq	square
Westinghouse Hanford	Westinghouse Hanford Company
yr	year(s)

1.0 INTRODUCTION

This Fire Hazards Analysis (FHA) is to assess comprehensively the risk from fire within the new lined landfills, provided by Project W-025 designated Trench 31 and 34 of Burial Ground 218-W-5. For the purposes of this analysis, the two trenches are identical. They are located in the 200 West area of the 1450 sq km (560 sq mi) United States Department of Energy (DOE) Hanford Site, Figure 1.

This FHA was prepared for Westinghouse Hanford Company (Westinghouse Hanford) by Columbia Energy and Environmental Services, Inc. under purchase order M-293887, Task Order 94-15. Elements within the FHA make recommendations for minimizing risk to workers, the public and the environment from fire during the course of the operations activity. Transient flammables and combustibles present that support the operations activity are considered and included in the analysis.

The Hanford Site was created by the United States federal government in 1943 to produce and process weapons grade plutonium. The 100 Area, at the north end of the site, housed production reactors. Processing facilities were located in the 200 East Area and 200 West Area, roughly in the center of the Hanford Site. Research and Development facilities were constructed in the 300 Area, just a few miles north of Richland, Washington.

Major facilities within 200 West are T Plant, coal-fired power plant, U Plant, REDOX, and Z Plant. Within 200 West there are identified burial management areas. Trench 31 and 34 are located just northwest of Dayton Avenue and 23rd Street in the northwest portion of 200 West, Figure 2.

The FHA will appraise Trench 31 and 34 in relation to existing or proposed fire protection to ascertain whether the objectives of DOE Order 5480.7A Fire Protection are met. A graded FHA shall contain, but not be limited to, the following elements:

- Description of construction,
- Protection of essential safety class equipment,
- Fire protection features,
- Description of fire hazards,
- Life safety considerations,
- Critical process equipment,
- High value property,
- Damage potential: Maximum Credible Fire Loss (MCFL) and Maximum Possible Fire Loss (MPFL),
- Fire Department/Brigade response,
- Recovery potential,
- Potential for a toxic, biological and/or radiation incident due to a fire,
- Emergency planning,
- Security considerations related to fire protection,
- Natural hazards (earthquake, flood, wind) impact on fire safety, and
- Exposure fire potential, including the potential for fire spread between fire areas.

NOTE: The 600 Area consists of all portions of the Hanford Site not otherwise designated.

200 WEST AREA

The objectives of DOE Order 5480.7A are to:

- Minimize the potential for the occurrence of a fire,
- Ensure that fire does not cause an on-site or off-site release of radiological and other hazardous material that will threaten the public health and safety or the environment,
- Establish requirements that will provide an acceptable degree of life safety to DOE and contractor personnel and that there are no undue hazards to the public from fire and its effects in DOE facilities,
- Ensure that process control and safety systems are not damaged by fire or related perils,
- Ensure that vital DOE programs will not suffer unacceptable delays as a result of fire and its effects, and
- Ensure that property damage from fire and related perils does not exceed an acceptable level.

While not specifically directed by the DOE Order, consideration of cost is innately part of any engineering analysis. Solutions to complex engineering problems must be justified in terms of benefits as defined in objectives against the cost of providing the benefit.

2.0 SUMMARY AND CONCLUSIONS

This FHA is the result of reviewing DOE Orders 5480.7A and 6430.1A, the DOE RLID 5480.7, Westinghouse Hanford documents, National Fire Protection Association (NFPA) Codes and Standards, reference material, and interviews with key personnel. Several walk downs of the landfill were conducted as well as consultation with wheel loader manufacturer representatives. Wheel Loader, when written with initial capitals, refers to the specific piece of equipment that will be used in Trench 31 and 34.

Waste by itself residing in Trench 31 or 34 given the planned timely covering with backfill is not postulated to be a fire risk. There is no plausible ignition source of the waste dwelling in the landfill without the introduction of people or equipment. Use of the Wheel Loader in the landfill introduces a low probability ignition source. There are a limited number of common sense and easily implemented recommendations to create greater fire safety during the operational phase of the landfills. Recommendations are made in the text of this report and printed in **bold type**. All recommendations are repeated in a list in Section 18.0.

3.0 DESCRIPTION OF CONSTRUCTION AND OPERATION

Trench 31 and 34 are designed and constructed to receive low level mixed waste. Waste will be in a variety of containers including 208 L (55 gal) drums, metal burial boxes of 1.2 by 1.2 by 2.1 m (4 by 4 by 7 ft), or 1.2 by 1.2 by 2.4 m (4 by 4 by 8 ft) plywood burial boxes. Bulk waste, possibly as soil and irregular waste, possibly in the form of large components or concrete may also be placed in the trenches. The rectangular landfill configuration will be approximately 76 by 30 m (250 by 100 ft) at the base and between 7.6 and 9.1 m (25 and 30 ft) deep. The side slope ratio is 3 horizontal to one vertical.

Unplanned transient combustibles that may be present in the trenches are tumble weeds.

RECOMMENDATION

Tumble weeds or any other unplanned transient combustible that enters the trenches shall be removed or covered daily if there is uncovered waste present. If all waste in the landfill is covered, there is no need to remove or cover the tumble weeds or other unplanned transient combustibles. There should be a written procedure to remove or cover tumble weeds or other unwanted transient combustibles. This recommendation is in keeping with the Westinghouse Hanford goal of keeping transient combustibles as low as reasonably achievable (ALARA).

Support facilities consist of a control building, unloading pad, access ramp, storage area, and leachate management system, Figure 3. The leachate management system includes liners, collection piping, drain field, leachate level sensors, recessed sump pump, and above ground facilities to handle collection and temporary storage of leachate material. A separate FHA (WHC-SD-WM-FHA-005) has been completed for the Leachate Tank Enclosure.

The floor of the trench is sloped a minimum of two percent to a depressed section at the east end that will house the leachate collection sump. A series of compacted bentonite clay admixture layers, geomembranes, drainage gravel, pumps, piping, tank, and controls are designed to prevent leachate from draining into the local ground water and, thus, entering the environment. From top to bottom the liner system incorporates the following layers:

- Operations layer - 0.9 m (3 ft) of backfill
- Primary leachate collection system
 - Geotextile,
 - Drainage gravel,
 - Geonet/geotextile geocomposite material,
 - Primary High Density Polyethylene (HDPE) Geomembrane, and
 - Admix of 0.46 m (1.5 ft) of soil and bentonite clay (eight to 10 percent) mixture.

- **Secondary leak detection system**
 - Geotextile,
 - Drainage gravel,
 - Geonet/geotextile geocomposite material,
 - Secondary HDPE geomembrane, and
 - Admix of 0.9 m (3 ft) of soil and bentonite clay (eight to 10 percent) mixture.

Refer to Figure 4 for a schematic representation of the liner system.

A dual pump system in the primary leachate collection system is designed to move leachate from the trench collection sump to the above ground leachate tank. Tank capacity is 37,800 L (10,000 gal). The low-capacity 0.0004 m³/s (7-gal/min) primary pump moves leachate from the sump to the tank. A high-capacity 0.01 m³/s (150 gal/min) is expected only to operate during or after periods of heavy precipitation. Additionally, this high capacity pump acts as a backup to the primary pump.

A low-capacity pump in the secondary leak detection system is designed to move any leachate infiltration to the above ground leachate tank. Leachate level sensors are required for monitoring both the primary and secondary collection systems.

An 8.5-m (28-ft) wide access ramp to the floor of the trench is sloped at eight percent. Waste will be moved from the crest to the base of the landfill on this ramp. As the trench is filled, the ramp will be covered. A perimeter access road surrounds the landfill basin.

RECOMMENDATION

Maintain a minimum 9.1 m (30 ft) wide path free of vegetation and other combustibles between the crest of the landfill and local vegetation. This expanse will act as a fire break between possible range fires and material in the trench or trench operations equipment. This recommendation should be implemented by written procedure. Refer to NFPA 299.

After waste has been procedurally accepted at the trench, material that does not require placement by riggers and crane will be placed using a Caterpillar 936F Wheel Loader or equivalent. For the purposes of this FHA, the Caterpillar 936F will be analyzed; however, the analysis will be valid for any similar sized diesel powered wheel loader. The Wheel Loader operator will place waste on the operating floor of the trench.

RECOMMENDATION

Written procedures should require the Wheel Loader operator to have current training in the following areas:

TRENCH 31, CROSS SECTION LINER SYSTEM DETAILS

- Use of this type of heavy off-road equipment,
- Use of hand held fire extinguishers, and
- Response in the event of a fire.

RECOMMENDATION

Written procedure should prescribe that a means of communication such as telephone, cellular phone, radio, fire alarm pull station, or other be readily available to workers at Trench 31 and 34 in the event of an emergency.

The control building has a footprint of approximately nine ft by twelve feet and is constructed with metal walls and roof. A four in. thick reinforced concrete slab on grade is the floor of the structure. Electrical panels, equipment controllers, and monitoring equipment is housed in the building.

Backfilling and covering the waste will occur at specific operating points as defined in the *Solid Waste Plant Operating Procedure, System: Burial and Waste*. These operating points are:

- Cover waste, waste containers any time when the horizontal depth of the frontloader reach with the bucket attachment installed is attained, using the frontloader with the bucket attachment installed, fill material should be at two-ft minimum depth.
- Cover waste, waste containers with fill material by the end of the day/shift, under specified conditions:
 - When adequacy of containment is doubtful,
 - When dose rate reaches 100 mRem/hr at edge of trench,
 - When animal waste has been buried,
 - When containers are unweighted or light weight and could be scattered by wind, and
 - When waste is classified.

Reach of the Wheel Loader bucket at a 45 degree discharge angle, 2.13 m (7 ft) clearance above grade, with front wheels against the waste, is 1.49 m (4 ft 11 in.). Waste will be left uncovered up to a maximum of the width of the trench of 91 m (300 ft). Because of the limited reach of the Wheel Loader, the horizontal depth of uncovered waste is assumed to be two drums, one metal burial box, or one plywood burial box. Other waste would be left exposed in different configurations limited by the reach of the Wheel Loader. All waste will be covered to a minimum depth of two ft.

RECOMMENDATION

Written procedures should require the Wheel Loader to be normally parked, when not in use, at least 9.1 m (30 ft) from any exposed waste. This will

minimize the potential for the Wheel Loader becoming an exposure fire hazard to uncovered waste.

RECOMMENDATION

Written procedures should require all attachment changing done to the Wheel Loader to be performed at least 9.1 m (30 ft) from any uncovered waste. This will minimize the potential for the Wheel Loader becoming an exposure fire hazard to uncovered waste.

RECOMMENDATION

A written procedure for refueling the Wheel Loader should be drafted. The procedure should follow the Wheel Loader manufacturer instructions for refueling. This will minimize the potential for the Wheel Loader becoming an exposure fire hazard to uncovered waste.

4.0 FIRE PROTECTION FEATURES

The operations layer of 0.9 m (3 ft) of backfill will protect the primary, high-density polyethylene (HDPE) liner from fire. There is an additional layer of drainage gravel above the primary HDPE liner providing further fire separation. As the landfill is filled, waste and backfill will add to the fire separation between the HDPE liner and the operating surface where the newly arrived waste is being placed.

Trench 31 and 34 have a perimeter access road at the crest of the landfill. If this road is maintained free of vegetation and other combustibles for a minimum width of 9.1 m (30 ft), it will act as a fire break between a range fire and uncovered material and equipment in the trench.

Waste in the trench will be covered with a minimum of two ft of backfill at specific operating points as discussed in Section 3.0. This procedure will minimize the amount of uncovered waste and, thus, minimize the amount of fuel available for a fire.

The nearest fire hydrant is located behind one fence approximately 640 m (2100 ft) to the south of Trench 34, adjacent to Dayton Avenue.

The Wheel Loader will be equipped with a hand held fire extinguisher. This will allow for the possibility of early manual suppression of small fires.

5.0 DESCRIPTION OF FIRE HAZARDS

Operation of Trench 31 and 34 is intrinsically fire safe given the limited number of ignition sources.

The control building represents little fire risk because of its noncombustible construction and minimal fuel loading.

Range fires occur at the Hanford Site. With a 9.1 m (30 ft) fire break maintained at the crest of the landfill, this potential ignition source will be minimized.

RECOMMENDATION

If a range fire is threatening the 200 West Area, all waste in the trench should be covered with backfill and operations halted until the range fire threat is over. A written procedure should be created to implement this recommendation.

The potential exposure-fire hazard of tumble weeds or other unwanted transient combustibles will be controlled by the recommended procedure to remove or cover them on a daily basis if uncovered waste is present in the trench. Tumble weeds, if allowed to accumulate into a drift, are fuel for a fast developing hot fire. They contain a very large surface area and the volume of the fuel package has plenty of entrained combustion air. Plants adapted to dry growing conditions tend to have low moisture content and high oil content to minimize water loss.

During placement of waste in the landfills by crane and riggers, a load could be dropped rupturing the waste container. If a fire would result, it would be bounded by fire involving the Wheel Loader and waste in plywood burial boxes.

Fuel consists of uncovered waste in the landfill. Worst case scenario is 1.2 m by 1.2 m by 2.4 m (4 by 4 by 8 ft) plywood burial boxes. However, all surfaces of wooden burial packages shall be treated for fire retardation prior to the boxes arriving at Trench 31 or 34. The fire-retardant treatment material on the wood will create a maximum flame-spread index of 25 when tested to American Society for Testing and Materials (ASTM) Standard E-84-89a, Test Method for Surface Burning Characteristics of Building Materials. Drums, metal burial boxes, bulk waste, and irregular waste all represent less of a fire hazard since they would be less likely to propagate a fire. For the waste in the landfill to burn, an exposure fire would have to be present.

The Wheel Loader presents fuel and ignition sources. See Appendix A for heat content assumptions. Fuel on a Caterpillar 936F Wheel Loader consists of the following:

Table 5.0**HEAT CONTENT OF FUEL**

FUEL	VOLUME	HEAT CONTENT
Diesel Fuel	200 L (52.8 gal)	7.08 GJ (6.71 x 10 ⁶ BTU)
Hydraulic Oil	146 L (38.5 gal)	5.86 GJ (5.56 x 10 ⁶ BTU)
Lube Oil		
Motor	20.0 L (5.3 gal)	
Transfer Case	29.9 L (7.9 gal)	
Front Differential	23.8 L (6.3 gal)	
Rear Differential	27.6 L (7.3 gal)	
Total Lube Oil	101.3 L (26.8 gal)	4.08 GJ (3.87 x 10 ⁶ BTU)
Tires (4)	590 kg (1300 lb)	19.1 GJ (18.1 x 10 ⁶ BTU)
Foam in tires	1905 kg (4200 lb)	45.5 GJ (43.2 x 10 ⁶ BTU)
Total Fuel Available		81.6 GJ (77.4 x 10 ⁶ BTU)

The above is based on a tire size of 20.5 by 25 12PR(L-2). Other tire sizes are available as options. Tires are supplied as pneumatically inflated. When a wheel loader is used in a landfill operation and subject to tire puncture, the tires are frequently filled with polyurethane foam to mitigate the problem. This is an option available at the purchaser's discretion. Objects that could cause a puncture problem to the tires of the Wheel Loader are pipe, concrete reinforcing bar, and large irregular components.

Sheepsfoot type steel wheels are not appropriate for a wheel loader. A Soil Compactor or a Landfill Compactor with steel wheels could be ordered, but other operational problems would be caused.

There are other minor fuel packages on the Wheel Loader such as wire insulation and flex hoses. It is assumed that these miscellaneous fuel packages can be ignored in the analysis.

While the tires and possibly the polyurethane foam in the tires are substantial fuel packages, an exposure fire would be necessary to start them burning.

Low combustible hydraulic oil is available and is usually specified for equipment used in steel mills or foundries. This special hydraulic oil would minimize the possible fire from hot slag dropping onto the hydraulic system of the Wheel Loader. Low combustible hydraulic oil would not significantly reduce the

fire hazard for the Wheel Loader in a landfill operation and would cause special maintenance needs and therefore is not recommended.

Fire suppression systems are installed on bus engine compartments, military vehicles, and off-road heavy equipment. Typical applications for fire suppression systems on off-road heavy equipment are lumber mills that generate combustible dust that would build up on oily surfaces or high value units with replacement cost of \$1 million or more. Assuming use by a trained operator and proper refueling procedures, a vehicle fire suppression system would not significantly reduce the fire hazard in a landfill operation, would add to the original cost of the Wheel Loader, and would incur increased maintenance costs over the life of the vehicle; therefore, it is not recommended.

Historically, off-road heavy equipment has been subject to hydraulic system failure, fuel system failures, fuel handling incidents, and wild land fires that lead to an equipment fire. With the recommended procedures to mitigate fuel handling and range fires, the Trench 31 and 34 Wheel Loader should have a fire risk rate lower than the a wheel loader used in the average landfill.

RECOMMENDATION

Written procedures should require the Wheel Loader to be maintained according to the manufacturer's recommendations. This will minimized the risk of hydraulic or fuel system failures that could lead to a fire.

Refueling and routine lubrication operators introduces and additional ignition source via the two trucks and potentially considerable fuel. The Wheel Loader is expected to consume fuel at the rate between 9.5 L/hr (2.5 gph) to 23 L/hr (6 gph). Assuming refueling and lubrication will take place when the fuel tank is one quarter full and an average consumption rate of 15 L/hr (4gph), these operations will take place every ten hours of operation as indicated by the following:

$$[(200 \text{ L})(0.75)]/(15 \text{ L/hr}) = 10 \text{ hours of operation.}$$

See Table 5.1 for an estimate of the heat content available on the refueling and lubrication vehicles.

Table 5.1

MAXIMUM QUANTITIES ON THE REFUELING AND LUBE TRUCKS

Fuel	Volume	Heat Content
Diesel Fuel Storage	5680 L (1500 gal)	201 GJ (191x106 BTU)
Diesel Fuel Tanks	760 L (200 gal)	27 GJ (26x106 BTU)
Unleaded Fuel Storage	5680 L (1500 gal)	179 GJ (170x106 BTU)
Motor Oil Storage	1250 L (330 gal)	50 GJ (47x106 BTU)
Other	700 L (185 gal)	28 GJ (27x106 BTU)
Total Fuel Available		485 GJ (460x106 BTU)

Having written refueling procedures and following the Wheel Loader manufacturers instructions will control the risk of fire during refueling operations.

Built up vapors in the leachate tank are addressed in *Fire Hazard Analysis for Leachate Tank Enclosure 200 West Area / 218-W-5 Burial Ground*, WHC-SD-WM-FHA-005. That analysis applies to the vapors in the man hole of the trench since both the leachate tank and the man hole contain leachate from the same source. The calculated time required to reach lower explosive limit (LEL) of hydrogen in the leachate tank is 106.8 years.

6.0 PROTECTION OF ESSENTIAL SAFETY CLASS SYSTEMS

Trench 31 and 34 do not contain any essential safety class systems.

7.0 LIFE SAFETY CONSIDERATIONS

Since Trench 31 and 34 are not designed for human occupancy, NFPA 101, *Code of Safety to Life from Fire in Buildings and Structures* does not apply. Egress out of the trenches is normally via the access ramp, but the side slope ratio of 3 to 1 of the sides of the landfills also allows egress if the ramp were unavailable for any reason.

8.0 CRITICAL PROCESS EQUIPMENT

Trench 31 and 34 do not contain any critical process equipment.

9.0 HIGH VALUE PROPERTY

Trench 31 and 34 do not contain any high value property. High value property is defined as property with worth of \$500,000 or more.

10.0 DAMAGE POTENTIAL

10.1 MAXIMUM CREDIBLE FIRE LOSS (MCFL)

DOE Order 5480.7A defines MCFL as the property damage that would be expected from a fire, assuming that:

- All installed fire protection systems function as designed.
- The effect of emergency response is omitted except for post-fire actions such as salvage work, shutting down water systems, and restoring operation.

Since Trench 31 and 34 do not have any active fire protection systems nor is it expected that the Wheel Loader will have automatic fire suppression, the Maximum Credible Fire Loss equals the Maximum Possible Fire Loss (MPFL). See Section 10.2 following for MPFL.

10.2 MAXIMUM POSSIBLE FIRE LOSS (MPFL)

DOE Order 5480.7A defines MPFL as the value of property, excluding land, within a fire area, unless a fire hazards analysis demonstrates a lesser (or greater) loss potential. This assumes the failure of both automatic fire suppression systems and manual fire fighting efforts.

Detailed data on the annual probability of fire in wheel loaders or other off-road heavy equipment is not kept by the Hanford Fire Department (HFD), Westinghouse Hanford Safety Analysis Group, equipment manufacturer, or National Safety Counsel. Analysis will be based on a discussion of intangible factors and data available on truck accidents.

Range fires occur on the Hanford Site. Recommendations advise removing or covering tumble weeds or other unwanted transient combustibles on a daily basis if uncovered waste is present in the trench. Additionally, recommendations advise covering all waste and ceasing operations if a range fire threatens the 200 West Area. This procedure would park the Wheel Loader inside the 9.1 m (30 ft) fire break of the trench. While not eliminating the risk of range fire brands being the ignition source of a Wheel Loader fire, the risk is tolerable.

Fire risk in Trench 31 and 34 is considerably lower than a typical landfill or civil construction operation. The Wheel Loader operator will be specifically trained in the use of off-road heavy equipment and be aware of the job specific risks. There will be only one piece of equipment operating in the trench at a time. The operating surface of the landfill and each additional lift is almost dead flat.

There are no vertical drop offs. Sides of the trench with a slope of 3 to 1 does not present a hazard to the Wheel Loader. Procedures are in place to handle waste that would overload the capacity of the piece of equipment. This is a landfill operation and not a lumber mill or agricultural operation that generates combustible dust that would build up on the oily surfaces of the Wheel Loader.

Power to weight ratio of the wheel loader is approximately 1 to 90 HP/kg (1 to 200 HP/lb) unloaded and would have the accordingly low acceleration potential. Relatively large rotating mass represented by the tires/wheel assemblies and optional foam fill would further reduce acceleration potential. The Wheel Loader has a theoretical top speed of 46.7 km/h (29.0 mph) but with the low acceleration and limited straight line distance in the trench of approximately 82 m (270 ft), actual top speeds would be considerably less. Robust construction of the Wheel Loader and low kinetic energy potential would minimized the seriousness if an accident were to occur.

An estimate of the annual probability of fire in the Wheel Loader based on fires in trucks follows.

Annual availability of the Wheel Loader is estimated to be 250 days based on five working days per week and ten holidays per year. This is very conservative since it assumes maintenance and refueling is completed off hours, with no down days due to weather, equipment failure, operator availability, and/or availability of waste to place in the trench. At times the Wheel Loader will not be used at all when waste is placed in the trench using a crane and riggers.

Daily availability of the Wheel Loader is estimated to be 4.5 hours based on a eight-hour shift less two hours for mobilization of crew at the start of shift, demobilization of crew before lunch, mobilization after lunch, and demobilization of crew at the end of the day; less 0.8 hr for checking Wheel Loader at beginning of shift, warm up at beginning of shift, idling before shut down before lunch, warm up after lunch, and idling before shut down at end of the shift; less 0.5 hr for two 0.25 hr breaks; and less 0.2 hr for attachment change outs. This is a conservative estimate for daily availability since no down time is assumed for waiting for trucks to move additional waste or additional backfill material to be made available to the Wheel Loader.

Cycle time for one load of the Wheel Loader is estimated to be 1.8 minutes or 33 cycles per hour. This is based on 0.5 minutes for load, dump, four reversals of direction, full cycle of hydraulics, 1.0 minute for two trips of an average travel distance of 50 m (164 ft) each, and a job efficiency of 83 percent. Data from the *Caterpillar Performance Handbook* was used for estimating cycle time.

Annual travel distance of the Wheel Loader is estimated to be:

$$(250 \text{ days})(4.5 \text{ hr/day})(33 \text{ cycles/hr})(100 \text{ m/cycle}) = 3710 \text{ km/yr} (2310 \text{ mi/yr})$$

Applying the annual truck accident rate of $1.6 \times 10^{-6}/\text{km}$ and rate of 1.3 percent of the accidents result in fires, the annual probability of the Wheel Loader fire is:

$$(3710 \text{ km/yr}) (1.6 \times 10^{-6}/\text{km}) (1.3\%) = 7.7 \times 10^{-5}/\text{yr}.$$

In a very broad terms, roughly 50 percent of the time the Wheel Loader will be hauling waste and 50 percent of the time the Loader will be hauling backfill. Of the time the Wheel Loader is placing waste, half the time or 25 percent of the total time waste will be carried by the Wheel Loader since the return trip will be empty.

Detailed analysis of the geometry of the landfill, waste, and Wheel Loader bucket provides more exact ratios of the total time the Wheel Loader is carrying waste. The following assumptions are made:

- Two feet of back fill cover is required,
- Angle of repose (slope stability) of backfill is 45 degrees,
- Wheel Loader bucket capacity is 2.3 m^3 (3 yd^3), and
- Bucket fill factor is 90 percent.

If all the waste being placed is in drums, for each trip with a drum, 0.7 trips are made with backfill.

If all the waste being placed is in 1.2 m by 1.2 m by 2.1 m (4 ft by 4 ft by 7 ft) metal burial boxes, for each trip with a metal box, 4.2 trips are made with backfill.

If all the waste being placed is in 1.2 m by 1.2 m by 2.4 m (4 ft by 4 ft by 8 ft) plywood burial boxes, for each trip with a plywood box, 4.8 trips are made with backfill, Table 10.2.

Table 10.2

**PERCENT OF OPERATING TIME WHEEL LOADER
CARRYING WASTE BY CATEGORY**

Category	Time (Percent)
Drums	29
Metal Burial Boxes	10
Plywood Burial Boxes	9

Note: The remainder of the time the Wheel Loader is empty or carrying backfill. No allowance is made for Wheel Loader attachment changes (conservative).

Worst case scenario is for a fire to occur while the Wheel Loader is placing the last plywood burial box in a row on the top of the landfill. The landfill at this point is 91 m (300 ft) wide allowing thirty-seven 1.2 by 2.4 m (4 by 4 by 8 ft) plywood burial boxes to be placed end to end. Burial boxes would have to be placed end to

end to insure coverage with backfill material due to the limited reach of the Wheel Loader bucket. Once the fire is started, it is postulated to burn through all 37 burial boxes in the row. Any other waste in the vicinity of the toe of the landfill would already be covered with backfill. Backfill cover would prevent the fire from spreading into buried waste.

Fire could be started by a fuel or hydraulic system pressure boundary failure causing hydraulic oil or diesel fuel to be ejected onto hot engine surfaces, the turbo charger, or exhaust system. The plywood box has the greatest volumetric capacity to carry waste and the least fire resistance.

Losses caused by the fire are complete destruction of the Wheel Loader and cost of cleaning up the waste spread by the fire. Area of clean up is based on the following assumptions:

- Plywood burial box volume is 3.6 m^3 (128 ft^3),
- 100 percent of the box contents are consumed in the fire,
- Strontium 90 at maximum concentration limit of $1.5 \times 10^4 \text{ Ci/m}^3$ in the waste,
- Release Fraction (RF) is 1.0×10^{-4}
- Contamination is spread to a depth of one centimeter,
- Density of soil to be cleaned up is 1.5 g/cc , and
- Strontium 90 is evenly spread over the cleanup area at exactly the concentration requiring cleanup of $2.8 \times 10^{-9} \text{ Ci/g}$. No contamination is spread outside the cleanup area. This is an incredible event (conservative).

$$A = [(1.5 \times 10^4 \text{ Ci/m}^3)(3.6 \text{ m}^3/\text{box})(37 \text{ box})(1 \times 10^{-4} \text{ RF})] / [(2.8 \times 10^{-9} \text{ Ci/g})(1.5 \times 10^4 \text{ g/m}^2)]$$

$$= 4.8 \times 10^6 \text{ m}^2$$

This clean-up area bounds the fire event. A plume model of the maximum fire and resulting deposition would yield a smaller zone requiring clean up.

Assuming cleanup costs of $\$5.49/\text{m}^2$,

$$\begin{aligned} \text{MPFL} &= \text{Cost of Wheel Loader} + \text{Cost of Cleanup} \\ &= \$150,000 + (4.8 \times 10^6 \text{ m}^2)(\$5.49/\text{m}^2) \\ &= \$150,000 + \$26,350,000 \\ &= \$26,500,000 \end{aligned}$$

$$\text{Use MPFL} = \underline{\underline{\$27,000,000}}$$

DOE Order 5480.7A Section 9.b (3) (b) requires complete automatic fire suppression if the MPFL exceeds \$1,000,000.

RECOMMENDATION

As complete automatic fire suppression is not feasible for Trench 31 and 34, an exemption from RL from DOE Order 5480.7A Section 9.b (3) (b) should be sought.

Since complete automatic fire suppression cannot be utilized at Trench 31 and 34, a reasonable alternative is to provide a means that will make manual fire fighting efforts more productive. Fire hydrants would insure that manual fire fighting endeavors would proceed in a timely and efficient manner.

RECOMMENDATION

Fire hydrants should be installed at Trench 31 and 34 using DOE Order 6430.1A, Section 02664-4, System Design Consideration as the design criteria. These fire hydrants will ensure that manual fighting efforts will have an adequate water supply.

11.0 FIRE DEPARTMENT/BRIGADE RESPONSE

The HFD consists of four fire stations covering the 1450 sq km (560 sq mi) Hanford Site. These stations are strategically located across the site to ensure minimum response time to all facilities. Front-line engines in all stations are aerial device/pumpers, with additional pumpers for backup. HFD maintains 39 vehicles representing a diversified range of capabilities. Of these, 29 are specifically equipped fire/emergency response apparatus, 24 are first-line apparatus, and five are listed as backup (reserve) apparatus.

The 200 Area Fire Station is the closest to Trench 31 and 34. This station is located midway between 200 West Area and 200 East Area. Estimated response time, from the time the alarm is received at the central dispatch/communications center until the time the first piece of fire apparatus arrives on the scene of an incident northwest of the intersection of Dayton Avenue and 23rd Street, is eight minutes. This response time assumes the fire fighters are in the 200 Area Fire Station and normal road and traveling conditions exist.

The present scenario for a Hanford Site Fire Emergency Response is to dispatch a single aerial device/pumper from the fire station closest to the incident with a backup aerial device/pumper from the next closest fire station to the incident. This provides a two-engine response. The first engine due constitutes what is termed "Initial Attack Response Capability."

First response will be for fire unless the initial alarm or call to HFD indicates another emergency. Other responses are for a medical emergency or for a hazardous material emergency.

HFD has an established mutual/automatic aid agreement with the surrounding jurisdictions. The agreement enables (and obligates) the HFD to augment its own fire and emergency medical resources in case of large fires, conflagrations, or other disasters. This agreement, known as the "Tri-Cities Mutual Aid Agreement," has been in existence at least since 1985 and includes the cities of Richland, Kennewick and Pasco and the Fire Protection Districts of Benton County #1, Benton County #2, Benton County #3, Benton County #4, Benton County #5, Benton County #6, Franklin County #3 and Walla Walla County #5. Participation in the agreement is delivered using existing labor and equipment.

12.0 RECOVERY POTENTIAL

If a fire were to occur in Trench 31 or 34, any debris from the fire may be buried along with other waste in the trenches. Residual hydrocarbons from the Wheel Loader may have to be analyzed for compatibility with the landfill liner.

13.0 POTENTIAL FOR A TOXICOLOGICAL, BIOLOGICAL, AND/OR RADIOLOGICAL INCIDENT DUE TO A FIRE

Low-level mixed waste is buried in Trench 31 and 34 so a hazardous or radiological incident due to a fire is possible. A fire involving waste only is not postulated. An exposure fire would have to be present to cause a hazardous or radiological incident. Precautions in the form of procedures or recommendations in this report are advised to minimize the exposure fire hazard risk to waste. Safeguards to eliminate or minimize an incident due to a fire include:

- Only a limited amount of waste is left uncovered,
- A fire break is maintained between the landfill and the range,
- Tumbleweeds are controlled in the landfill,
- Operations personnel have training to minimize the risk of fire, and
- The Wheel Loader, which is the sole ignition source in the landfill, is only near the waste during operations. For refueling, changing attachments, or when not in use it is a safe distance away from uncovered waste.

Dose impact to the public and onsite workers is addressed in *Solid Waste Burial Grounds Interim Safety Analysis*, WHC-SD-SARR-028, Rev.0, Section 6.3.1.5.1, "Bulldozer Accident with Ensuing Fire." The MPFL fire of Trench 31 and 34 is bounded by the 1413 drum fire analyzed in the ISA.

14.0 EMERGENCY PLANNING

The Building Emergency Plan for Burial Acceptance and Receiving Trenches (WHC-IP-0263-BART) was reviewed for this report and no discrepancies were noted.

15.0 SECURITY AND SAFEGUARDS CONSIDERATIONS RELATED TO FIRE PROTECTION

No security or safeguard barriers or procedures were noted that might compromise fire safety for these landfills; therefore, there are no security or safeguard issues related to fire protection for Trench 31 or 34. Classified waste is covered by the end of each shift. This action enhances fire safety.

16.0 NATURAL HAZARDS IMPACT ON FIRE SAFETY

16.1 FLOODS

The 200 West Area is located on a plateau 53 to 69 m (175 to 225 ft) above the highest elevation of the probable maximum flood postulated by the U. S. Army Corp of Engineers. The probable maximum flood in this situation requires severe climatic conditions in combination with a breach of Grand Coulee Dam. This breach scenario for the Grand Coulee Dam is from a hypothetical nuclear attack and is not projected to occur from any known natural event. It would result in a brief duration maximum flow of 227,000 m³/s (8,000,000 ft³/s) and flood elevations of 143 to 148 m (469 to 486 ft) in the 100 Areas. The 100 and 300 Areas as well as downstream cities along the Columbia River would be flooded. However, the 200 Area plateau would not be affected. With the 200 Area Fire Station on the 200 Area plateau, there is no postulated flood that would compromise fire safety.

16.2 TORNADOES

Hanford Meteorological Station and the National Severe Storm Forecast Center database list 21 tornadoes within a 161-km (100-mi) radius of the Hanford Site between 1916 and 1982. The recurrence interval cited is one per 146,000 yr. However, at least two tornadoes have been sited within a 161-km (100-mi) radius since 1982. Maximum wind speeds for a design basis tornado used at the site are 145 km/h (90 mi/h). The differential pressure is equivalent to a 0.75 lbf/in² ambient pressure drop in three seconds, held for one second and returned to ambient at the same rate.

With the low frequency of tornadoes on the Hanford Site and the robust design and construction of Trench 31 and 34, no additional fire safety precautions are warranted to protect against tornadoes.

16.3 EARTHQUAKES

The Design Basis Earthquake (DBE) is taken to have a return period of 1000 yrs, which means the annual occurrence is 1.0×10^{-3} . The repository siting group selected an application that gave 0.25 and 0.40 G as suggested preliminary maximum horizontal peak accelerations with 50 percent and 16 percent exceedance levels for use in preliminary design estimates. The Hanford Plant Standards specify a 0.13-G horizontal acceleration for the design basis earthquake for nonreactor structures having a moderate- or low-hazard safety classification.

Near-surface liquefaction is not expected as a result of a lack of saturated surface materials and the grading and compaction techniques that have been used. Landslides have and may continue to occur in the neighboring anticlines, but there is no evidence of this type of activity in the vicinity of Trench 31 and 34.

No additional fire protection measures are needed to mitigate the threat of earthquakes.

17.0 EXPOSURE FIRE POTENTIAL

Range fire is the only postulated exposure fire potential to Trench 31 and 34. Exposure fire potential risk is controlled by:

- Maintenance of the perimeter road effectively making a 9.1 m (30 ft) minimum fire break at the crest of the landfill,
- Controlling tumble weeds and other unwanted transient combustibles in the trench,
- Only allowing a limited amount of uncovered waste,
- Covering all waste and halting operations if a range fire threatens the 200 West Area, and
- Other fire protection measures.

18.0 RECOMMENDATIONS

1. Tumble weeds or any other unplanned transient combustibles that enters the trenches shall be removed or covered daily if there is uncovered waste present in the trench. If all waste in the landfill is covered, there is no need to remove or cover the tumble weeds or other unplanned transient combustibles. There should be a written procedure to remove or cover tumble weeds or other unwanted transient combustibles. This recommendation is in keeping with the Westinghouse Hanford goal of keeping transient combustibles ALARA. (Rec. 3-1)

2. Maintain a minimum 30-ft wide fire break free of vegetation and other combustibles between the crest of the landfill and local vegetation. This expanse will act as a fire break between possible range fires and material in the trench or trench operations equipment. This recommendation should be implemented by written procedure. Refer to NFPA 299. (Rec. 3-2)
3. Written procedures should require the Wheel Loader operator to have current training in the following areas:
 - Use of this type of heavy off-road equipment,
 - Use of hand held fire extinguishers, and
 - Response in the event of a fire. (Rec. 3-3)
4. Written procedure should prescribe that a means of communication such as telephone, cellular phone, radio, fire alarm pull station, or other be readily available to workers at Trench 31 and 34 in the event of an emergency. (Rec 3-4)
5. Written procedure should require the Wheel Loader to be normally parked, when not in use, at least 9.1 m (30 ft) from any exposed waste. This will minimize the potential for the Wheel Loader becoming an exposure fire hazard to uncovered waste. (Rec. 3-5)
6. Written procedure should require all attachment changing to the Wheel Loader to be performed at least 9.1 m (30 ft) from any uncovered waste. This will minimize the potential for the Wheel Loader becoming an exposure fire hazard to uncovered waste. (Rec. 3-6)
7. A written procedure for refueling the Wheel Loader should be drafted. The procedure should follow the Wheel Loader manufacturer instructions for refueling. This will minimize the potential for the Wheel Loader becoming an exposure fire hazard to uncovered waste. (Rec. 3-7)
8. If a range fire is threatening the 200 West Area, all waste in the trench should be covered with backfill and operations halted until the range fire threat is over. A written procedure should be created to implement this recommendation. Section 0266-4, System Design Considerations. (Rec. 5-1)
9. Written procedures should require the Wheel Loader to be maintained according to the manufacturer's recommendations. This will minimize the risk of hydraulic or fuel system failures that could lead to a fire. (Rec. 5-2)
10. As complete automatic fire suppression is not feasible for Trench 31 and 34, an exemption from RL from DOE Order 5480.7A Section 9.b (3) (b) should be sought. (Rec. 10.2-1)

11. Fire hydrants should be installed at Trench 31 and 34 using DOE Order 6430.1A, Section 02664-4, System Design Considerations as the design criteria. These hydrants will ensure that manual fighting efforts will have an adequate water supply. (Rec. 10.2-2)

19.0 REFERENCES

19.1 DOCUMENTS

- WHC, 1994, *Building Emergency Plan for Burial Acceptance & Receiving Trenches*, WHC-IP-0263-BART, Draft 09/15/94, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1994, *Fire Hazards Analysis for Leachate Tank Enclosure 200 West Area / 218-W-5 Burial Ground*, WHC-SD-WM-FHA-005, Rev.0, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1994, *Solid Waste Burial Grounds Interim Safety Analysis*, WHC-SD-WM-SARR-028, Rev.0, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1992, *Mixed Waste Lined Landfill (Project W025) Preliminary Safety Analysis Report*, WHC, SD-W025-PSAR-010, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1994, *Solid Waste Plant Operating Procedure, System: Burial and Waste, Trench 31, Radioactive Mixed Waste Land Disposal Facility, Waste Receipt, Placement and Backfill Operation*, SW-000-001, Draft A-0, Westinghouse Hanford Company, Richland, Washington.
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- WHC, 1994, *Environmental Compliance*, WHC-CM-7-5 Release 2, Westinghouse Hanford Company, Richland, Washington.

19.2 WESTINGHOUSE HANFORD COMPANY CONTROL MANUALS

- WHC, 1992, *Fire Protection Program Manual*, WHC-CM-4-41 Rel. No. 9, Westinghouse Hanford Company, Richland, Washington.

19.3 U. S. DEPARTMENT OF ENERGY ORDERS

- DOE Order 5480.7A, *Fire Protection*, U.S. Department of Energy, Washington, D.C.
- DOE Order 6430.1A, *General Design Criteria*, U.S. Department of Energy, Washington D.C.

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19.4 OTHER

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APPENDIX A**HEAT CONTENT ASSUMPTIONS
OF MATERIAL IN CATERPILLAR 936F WHEEL LOADER**

Diesel Fuel	43.2 MJ/kg (18,600 BTU/lb)
Unleaded Gasoline	46.8 MJ/kg (20,200 BTU/lb)
Hydraulic Oil	46.4 MJ/kg (20,000 BTU/lb)
Lube Oil	46.4 MJ/kg (20,000 BTU/lb)
Tires	32.2 MJ/kg (13,900 BTU/lb)
Foam in tires (polyurethane)	23.9 MJ/kg (10,300 BTU/lb)