RCRA PART B PERMIT

FOR THE

IDAHO NATIONAL

ENGINEERING AND ENVIRONMENTAL LABORATORY

Volume 18 – Idaho Nuclear Technology and Engineering Center

ATTACHMENT 6

Debris Treatment Processes
Holdup and Collection Tanks
CPP-659/-1659 Storage
CPP-666 FDP Cell Container Storage Area
Radioactive Mixed Waste Staging Facility (CPP-1617)
Hazardous Chemical and Radioactive Waste Storage Facility (CPP-1619)

Sections F-3 through F-5

Procedures to Prevent Hazards

Modified Date: November 18, 2003

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F-3a(1) Internal Communications [IDAPA 58.01.05.008; 40 CFR 264.32(a)]

FAST (FDP Cell)

The FAST building is equipped with communication devices (i.e., telephones, two way radios, etc.) capable of summoning emergency assistance. The personnel involved in the operation have immediate access to emergency communication devices. If the work requires a cell entry, a second person is stationed outside the cell to summon emergency personnel and provide assistance as required. If there is ever just one employee at the TSD while the unit is operating, that employee will be provided immediate access to a communication device for summoning emergency assistance.

NWCF

The NWCF building is equipped with communication devices (i.e., telephones, two way radios, etc.) capable of summoning emergency assistance. The personnel involved in the operation have immediate access to emergency communication devices. If the work requires a cell entry, a second person is stationed outside the cell to summon emergency personnel and provide assistance as required. If there is ever just one employee at the TSD while the unit is operating, that employee will be provided immediate access to a communication device for summoning emergency assistance.

RMWSF and HCRWSF

The RMWSF (CPP-1617) and the HCRWSF (CPP-1619) are equipped with communication devices (e.g., telephones, two way radios, etc.) capable of summoning emergency assistance. The personnel involved in the operation have immediate access to emergency communication devices.

F-3a(2) External Communications [IDAPA 58.01.05.008; 40 CFR 264.32(b)]

The INTEC communication devices provide direct access to external emergency response agencies.

F-3a(3) Emergency Equipment [IDAPA 58.01.05.008; 40 CFR 264.32(c)]

Exhibits G-1, G-2, G-3, and G-4 in the contingency plan, Attachment 7 Section G, of this permit, identify the evacuation routes and locations of safety equipment for the NWCF. Exhibits G-5, G-6, G-7, G-8, and G-9 in the contingency plan identify evacuation routes and locations of safety equipment for the FAST facility. Exhibits G-10 and G-11 in the contingency plan identify evacuation routes and locations of safety equipment for the RMWSF and HCRWSF. Examples of safety equipment available for spill control at FAST, NWCF, RMWSF, and HCRWSF may include the following:

- Acid boots
- Acid suits
- Acid gloves (neoprene)
- Absorbents
- Face shields or Splash goggles
- Radiation rope or ribbon
- Plastic buckets
- Spill control pillows
- Spill control pillows
- Hazardous waste bags
- Safety rope
- Signs
- pH paper
- Duct tape
- Shovel (flat head)
- Smear paper and envelopes
- Pencils, grease pencils
- Radiological tags/signs
- Acid/caustic neutralizers

During monthly inspections, if any equipment is missing or out-of-date it is replaced. The safety and emergency equipment listed below are located in occupied areas at FAST, NWCF, RMWSF, and HCRWSF:

- Fire sprinkler systems
- Portable fire extinguishers
- Safety showers and eye washes (Portable eye wash at CPP-1617 when required)
- Spill control cabinets
- Plant voice paging and evacuation alarm system
- Communication devices.

The FAST facility and the NWCF have wet sprinkler systems for fire protection in the occupied areas of the buildings. These systems are connected to alarms at the Fire Alarm Center, located at the Central Facilities Area (CFA). Portable fire extinguishers are located throughout the buildings. The calciner cell (Room 214), decon cell (Room 308), and filter handling cell (Room 309) at the NWCF have in-cell wet sprinkler systems. The NWCF is equipped with fire hose connections to handle emergencies in the cells and rooms not protected by a sprinkler system. Fire hoses are provided by fire department response personnel.

RMWSF (CPP-1617) and HCRWSF (CPP-1619) have dry-pipe sprinkler systems for fire protection. These systems are connected to alarms at the Fire Alarm Center located at CFA. Portable fire extinguishers are located at these buildings.

F-3a(4) Water For Fire Control [IDAPA 58.01.05.008; 40 CFR 264.32(d)]

The INTEC fire water system is supplied by two insulated fire water supply tanks with capacities of 600,000 gal each. Water is pumped from wells to maintain the tanks at maximum volume. Pumps are located on the outlets of these tanks to supply water for hose streams and automatic sprinklers at adequate volume and pressure. The pumps are supplied with standby power by a power generator.

F-3b. Aisle Space Requirement [IDAPA 58.01.05.008; 40 CFR 264.35]

Container storage consists of a stacking arrangement of no more than three containers high, no more than two containers wide, with adequate aisle space maintained between rows of containers in container storage areas addressed in this permit. In Room 205 at the NWCF and the FDP cell, adequate aisle space cannot be maintained, due to the configuration of the waste containers and the amount of wastes stored in these areas. ALARA concerns and other personnel safety issues associated with the handling of mixed waste and/or mixed debris within the areas without undue radiological exposure of personnel preclude the arrangement of mixed waste and/or mixed to provide adequate aisle space.

HEPA filters stored in Room 205 will be transferred to Room 309 for treatment in the HFLS. The requirement for adequate aisle space is for the movement of emergency equipment in the storage area and inspection. No emergency equipment will be used in Room 205. No liquids will be stored or introduced in Room 205, and the containers will not be exposed to any other factors that may induce deterioration. Therefore, aisle space will be kept at a minimum to allow for the maximum of area for waste storage. Inspections using television cameras will be adequate to detect deterioration.

In the FDP cell, containers are currently stored on grating at the -13'- 0" level. Containers will be stored on grating at the 0'- 0" level also. The requirement for adequate aisle space is for the movement of emergency equipment in the storage area and inspection. No emergency equipment will be used in the FDP cell. No liquids will be stored or introduced in the FDP cell, and the containers will not be exposed to any other factors that may induce deterioration. Therefore, aisle space will be kept at a minimum to allow for the maximum of area for waste storage. Inspections from the shielded windows will be adequate to detect deterioration.

Containers are currently stored at the RMWSF with approximately 6 in. between boxes in a row and a minimum aisle space of 24 in. Due to the nature of the RMWSF, unobstructed movement of emergency equipment to any area of facility operation is not needed. Emergency response actions could be initiated either outside the fenced boundary and directed at the area of concern, or in the case of a leak or spill, boxes would be moved to allow for appropriate response actions. The 24-in. aisle spacing was established solely to support the inspection of boxes. This inspection allows for identification of an adverse condition such as a leak or degradation of containers containing hazardous and mixed waste. Recovery actions would require the movement of boxes in order to appropriately manage the specific box(s) that were involved.

Also, at the RMWSF, a 1-ft space will be maintained along the entire length of the cargo containers to facilitate inspections. No containers shall touch the side of the cargo container and at least 1 in. shall be maintained between the container and the wall of the cargo container. Cargo containers with double doors for access will maintain a 6-ft aisle space outside the end to allow the doors to be opened.

Containers with the longest dimension of 4 ft or less are considered small containers, while containers with the longest dimension greater than 4 ft are considered large containers. Large containers that are positioned laterally (long axis perpendicular to the length of the cargo container) shall be separated with 6 in. between each container. Large containers positioned longitudinally (lengthwise) shall be separated with 2 in. between the ends of each container. Large containers may include B-25 bins, TX-4 boxes, 4 ft X 4 ft X 8 ft boxes. Small containers may include 55-gallon drums, 85 gallon overpack drums, and 4 ft X 2 ft X 4 ft boxes and shall be separated from other containers by at least 2 in. unless stored on pallets.

Containers stored at the HCRWSF are configured to allow unobstructed movement of personnel, fire protection equipment, spill control equipment, and decontamination equipment.

F-4. Preventive Procedures, Structures, and Equipment

The NWCF and the FAST facility were designed so that process and storage area cells are maintained at a negative pressure. The HVAC systems in these buildings were designed for the air flow to originate in the areas with the least negative pressure and flow to the areas with a higher negative pressure. Thus, air flows from areas with less potential for contamination to areas with greater potential for contamination. The designs of the HVAC systems and buildings work together to contain wastes and prevent the wastes from making contact with the environment.

Storage and treatment areas may have remote capabilities, such as overhead cranes, electromechanical manipulators, and/or master/slave manipulators, for operational requirements and the movement of wastes as necessary. The NWCF and the FAST facility were constructed with shielding walls to limit personnel exposure to radiation and hazardous wastes.

F-4a. Unloading Operations [IDAPA 58.01.05.012; 40 CFR 270.14(b)(8)(I)]

Trucks, forklifts, or other equipment are used to deliver hazardous and/or mixed waste and debris for storage or treatment in the units addressed in this permit. In addition, some debris items to be treated will be hand-carried. Ramps and loading docks are provided for the NWCF, the FAST facility, and HCRWSF (CPP-1619) to facilitate the off loading of waste. At NWCF and FAST, remotely operated equipment such as overhead cranes, electromechanical manipulators, and master/slave manipulators may be used to transport the waste to the storage or treatment areas.

The loading dock at the HCRWSF (CPP-1619) is used to transfer waste containers to and from the various bays at the HCRWSF. The dock may be serviced by a forklift. The loading dock can be accessed by a concrete ramp with rails, steps, or two truck unloading areas.

Containers in the RMWSF (CPP-1617) and the HCRWSF (CPP-1619) are moved on pallets, handcarts, or pallet jacks. Containers and drums are secured as needed prior to movement by forklift. Cargo containers are moved with forklifts or other lifting devices. Containers at the RMWSF can also be moved using pickup trucks and portable cranes.

F-4b. Run-off [IDAPA 58.01.05.012; 40 CFR 270.14(b)(8)(ii)]

The units addressed in this permit are located within fully enclosed buildings (CPP-666, CPP-1617, CPP-1619, and CPP-659/-1659). The area surrounding each building slopes away from the building, carrying any storm water toward the streets, where the water is collected and diverted away from the building as demonstrated by Exhibit B-3. Flood protection is provided by the following features:

(1) The entryways are the only credible inlets for flooding. The elevations of the entryway inlets in Building CPP-659 are all 4,917 ft above mean sea level, which is 1 ft above the 100-year-flood elevation. The FDP Cell, which is located in CPP-666, is not within the 100-year floodplain of the Big Lost River. The ground elevation at RMWSF (CPP-1617) is 4917 ft msl, which is 1 ft above the 100-year flood elevation. The lowest entryway of HCRWSF (CPP-1619) is the loading dock, which is at an elevation of 4921 ft msl, which is 5 ft above the 100-year flood elevation. Engineering Design Files EDF-1747 and EDF-3088 in Appendices F-6 and F-7, respectively, discuss building elevations with respect to potential flooding.

(2) Diversion dams have been constructed to divert floodwater away from INEEL facilities.

(3) Natural features of the INEEL (soil infiltration capacity, arid climate, etc.) provide significant flood-regulating characteristics.

There is very little threat of contact between storm water and waste that could contaminate other areas since all wastes are contained inside buildings except during transport. During transport the waste is covered or otherwise contained to prevent contact with the environment.

The determination of the 100-year riverine floodplain is currently based on a report entitled "Flood Routing Analysis for a Failure of Mackay Dam" (EGG-EP-7184, Koslow and Van Haaften, 1986). This study assumes that 100-year peak flow and failure of Mackay Dam occur simultaneously. Floodplain determinations for buildings or facilities that contain RCRA-regulated units are made by comparing specific building elevations with the floodplain elevations discussed in the 1986 Koslow and Van Haaften report.

The RMWSF (CPP-1617) is not located within the floodplain boundary as postulated in the Koslow and Van Haaften, "Flood Routing Analysis for a Failure of McKay Dam," EGG-EP-7184, 1986. HCRWSF (CPP-1619) is a fully enclosed building that is located within the floodplain boundary as postulated by Koslow and Van Haaften. The elevation of the floor level of CPP-1619 prevents run-off of hazardous waste handling areas to other areas or the environment. The Engineering Design File (EDF-3088), provided as Appendix F-2 demonstrates that the RMWSF (CPP-1617) is outside of the boundary of the floodplain and the HCRWSF (CPP-1619) is within the boundary of the floodplain but was designed and constructed to prevent washout.

The areas surrounding RMWSF (CPP-1617) and HCRWSF (CPP-1619) are sloped away from the buildings, to direct any storm water toward the streets, where it is collected and diverted away from the building.

Skids are mounted to the bottoms of the boxes and cargo containers at the RMWSF (CPP-1617), elevating them approximately 3 inches off the ground. Wastes stored inside the HCRWSF (CPP-1619) are in an enclosed (bay 2, 2a, 3, and 4) and covered area (bay 5). There is no threat of contact between storm water and waste that could potentially contaminate other areas.

F-4c. Water Supplies [IDAPA 58.01.05.012; 40 CFR 270.14(b)(8)(iii)]

Contamination of water supplies by spills of mixed waste is prevented by building features such as high-density concrete base, stainless-steel lining, epoxy-coated walls, sloped floors, trenches, drains, doubly encased piping, and liquid collection tanks, as well as various means of leak detection.

F-4d. Equipment and Power Failure [IDAPA 58.01.05.012; 40 CFR 270.14(b)(8)(iv)]

Upon loss of commercial power, activities are stopped. Standby generators are provided to assume the electrical loads of FAST facility and NWCF systems that are maintained as standby circuits. Emergency lighting and the HVAC systems in both buildings resume operation to ensure personnel safety. When commercial power is restored, operations may continue.

Upon total loss of power (i.e., the standby generators fail to pick up the load), activities are stopped. Personnel evacuate the building as necessary. When commercial power is restored, operations may continue.

If commercial power fails, then cranes, hoists, and electromechanical manipulators will fail in a locked position.

Upon total loss of electrical power at these facilities, all activities will cease as needed and personnel will be instructed to evacuate, as necessary.

F-4e. Personnel Protection Equipment [IDAPA 58.01.05.012; 40 CFR 270.14(b)(8)(v)]

The NWCF and FAST are designed with various features that prevent undue exposure of personnel to mixed waste. The HVAC systems of these buildings are designed to provide air flow from areas with less potential for contamination to areas with greater contamination potential. Constant air monitors, remote area monitors, and RCT surveys are used to monitor all areas and aid in the detection of contamination. Operations at the NWCF, FAST, RMWSF, and HCRWSF are conducted according to written procedures. Emergency equipment such as eyewash stations, safety showers, and fire-fighting equipment are available at the RMWSF, HCWSF, NWCF, and FAST. See Section F-3a(3) of this permit for a list of equipment available for emergency use, and see exhibits G-1 through G-11 in the contingency plan for locations of this equipment.

Items with the highest radiation levels are treated remotely in shielded cells. Workers wear personal protective equipment as necessary and dictated by procedure, when handling or treating wastes, including equipment such as respirators, gloves, boots, and acid suits.

Pre-job briefings are held, as necessary, to ensure understanding of procedures, safety hazards, and radiological concerns. Job safety analyses are completed as necessary.

F-4f. Releases to the Atmosphere [IDAPA 58.01.05.012; 40 CFR 270.14(b)(8)(vi)]

In the event of an airborne release from a waste management unit addressed in this permit, the ventilation system in the building (NWCF or FAST) will direct hazardous constituents to the building's HEPA filter off-gas system, which minimizes releases to the atmosphere.

At the NWCF, air from the storage and treatment units is drawn through exhaust ducts and exhaust plenums. Each exhaust air plenum is equipped with a bank of pre-filters and two banks of HEPA filters in series. The pre-filters and HEPA filters remove particles in the exhaust air. From the exhaust plenums, the filtered exhaust air is ducted through one of the two NWCF stacks to the atmosphere.

At the FAST facility, all the HEPA filters are stored in sealed containers in order to minimize the release of hazardous constituents. In addition, a series of HEPA filters are in use at the FDP cell to ensure that release of hazardous constituents into the cell and subsequently to the atmosphere is minimized.

A container holding hazardous or mixed waste must always be closed during storage. Opening of containers will only be performed to add/remove waste, sort, segregate, or for sampling for verifying waste acceptance criteria. Containers of solid hazardous and/or mixed wastes may be consolidated into other DOT/UN containers for storage. Approved procedures and DOT/UN rules are used in conjunction with guidelines listed in 40 CFR 264, Appendix V, to determine compatibility or incompatibility of materials before consolidation is performed into approved containers for storage.

F-5. Prevention of Reaction of Ignitable, Reactive, and Incompatible Wastes

FDP Cell

Container storage of wastes in the FDP cell will be limited to non-liquid, physically solid waste forms. Waste matrices will be evaluated by INEEL facility personnel for free liquids prior to acceptance, and the point of generation facility personnel are responsible to ensure and certify that no free liquids are present.

EPA Hazardous waste numbers (HWNs) are applied to HEPA filters and other debris through the process of acceptable knowledge, which involves both process knowledge and/or chemical, physical testing of the waste. F and U HWNs have been applied, based on knowledge of the processes. The F and U HWNs have been assigned as a result of the contained in rule, as opposed to the For U-listed chemicals existing in a pure or concentrated form. In addition, only debris containing no free liquids will be accepted; thus, the wastes are neither reactive nor ignitable. Since these F or U-listed chemicals do not exist in a pure or concentrated form, the characteristics of ignitability or reactivity would not arise from these chemicals.

In some cases, due to high radiation fields associated with the wastes, the generator has assigned various characteristic HWNs in lieu of physical testing of the waste.

Individually the D, F, and U HWNs have the potential to pose an incompatible scenario, if mixed with sufficient concentration of the pure chemical and other factors such as time, mixing configuration, and containment of the chemicals. However, the HWNs have been (1) primarily assigned based on the contained in rule, (2) already have achieved chemical equilibrium and stability within the final physically solid waste form, and (3) exist in low concentrations. Any danger to (1) generate extreme heat or pressure, fire or explosion, violent reaction, (2) produce uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to pose a risk of fire or explosions, or (3) damage the structural integrity of the facility as a result of chemical reactions would have been eliminated by the following: (a) insufficient quantity of the chemicals in a pure, concentrated form to pose a problem, (b) lack of a medium to provide a mechanism for a high reaction and mixing rate, (c) a containment configuration that does not permit a pressure buildup and release if event "(a)" and "(b)" were simultaneously achieved, and (d) lack of an adequate ignition or energy source to initiate the reaction.

HEPA Filter Storage

HEPA filters by design have a poor ability to retain organic chemicals other than in trace amounts, as their primary purpose is to retain larger particles. Listed hazardous waste does not exist on the HEPA filters in either a pure, concentrated form or in more than de minimis or trace quantities. Similarly, other debris lacks the quantity of chemicals necessary to provide a vehicle for reaction to create a hazard to human health or the environment.

Debris Treatment Processes

HEPA filter and other debris treatment involves treatment of a physically solid waste form which has no associated free liquids. The HFLS process and other debris treatment involves treatment of HEPA filters and other debris by leaching the hazardous waste contaminants from the filters and other debris using water and nitric acid solutions. Highly concentrated nitric acid solutions are not employed in the leaching process. The use of these solutions in the treatment processes would not affect the chemical conditions existing in HEPA filters/other debris and are consistent with the logic stated above.

Holdup and Collection Tanks

Table F-1, below, contains the most commonly used chemicals at the decontamination facility, along with their estimated monthly usage and typical concentrations. These chemicals may potentially be mixed, when successive treatment batches are received in a common tank. INEEL technical support personnel have reviewed all decontamination chemicals to be used during debris treatment activities. Based on this evaluation and site operating experience, technical support has determined that, in the quantities and concentrations used, significant reactions between these solutions are not likely. Any reactions that might occur would be minor and non-energetic (e.g., slight temperature increase, no violent gas evolution). Reactions are mitigated by using relatively dilute decon solutions and by rinsing between different treatment operations. Typically, large volumes of rinse water are used during cleanup activities following each treatment iteration, creating very dilute solutions in the decon holdup (VES-NCD-123) and collection (VES-NCD-129) tanks. When chemical mixing does occur, it takes place at ambient temperatures in a tank with heel volumes greater than the volumes of the chemicals drained into the tank at any given time, reducing the likelihood of heat buildup. To ensure that over pressurization does not occur, the NWCF facilities were designed to manage these wastes using vented tanks under sufficient vacuum, to allow the safe removal of gaseous products.

Table F-1. Typical Decon Chemicals.

Chemical	Typical Estimated Monthly Usage	Typical Concentration, as used
Nitric Acid	200 gal	4.3 molar
Oxalic Acid	15 lb	60 g/l (6%)
Turco 4502	15 lb	60 g/l
Turco ARR	125 lb	60 g/l

Despite the fact that these solutions pose no significant compatibility concern, administrative controls and recordkeeping practices are employed to prevent undesirable chemical reactions and ensure adequate tank capacity. Debris treatment operations are administratively controlled. Procedures detail the treatment activity to be performed, decon solution makeup, and recordkeeping requirements. The type and concentration of the decon solution to be utilized is determined by supervision, with input from technical support personnel. Any unusual hazards posed by the debris type or the chemicals used and special precautions required to minimize hazards are established by environmental, safety, and health professionals and may be incorporated into safe work permits. Pre-job briefings include a review of safe work permit requirements as well as potential hazardous conditions and mitigation efforts. Atypical treatment activities involving uncommon debris items or modified decontamination solutions are evaluated by technical support personnel for impacts on treatment effectiveness and compatibility with existing solutions. Personnel are trained in the hazards associated with chemicals specified for use in these systems.

Decon area activities are recorded in a logbook. Personnel review the entries in the logbook each day for treatment status information including the types and quantities of decon solutions used. In addition, a formal turnover occurs at shift changes. Debris treatment and/or decon request forms, which identify chemical contaminants and applicable HWNs, are submitted for any treatment services required. These requests for services must be formally approved by decon facility management, or designee, before treatment activities can take place. Acceptable knowledge may be used to determine applicable HWNs assigned to HEPA filters and other debris. This knowledge includes both process knowledge and/or chemical/physical testing of the waste. Facility Personnel use data sheets to document chemical additions to the tanks as a result of debris treatment activities. The concentration of solutions utilized from the decon makeup tanks are also noted on the data sheet. Tanks VES-NCD-123 and VES-NCD-129 are sampled and analyzed for chemical constituents of concern prior to discharge for further treatment or storage. A record of the analytical results is maintained for reference.

RMWSF and HCRWSF

Incompatible wastes are segregated to ensure no adverse reactions occur. Procedures direct the packaging of wastes. US Department of Transportation (DOT) rules are used in conjunction with guidelines listed in 40 CFR 264, Appendix V, to determine compatibility or incompatibility of materials before being placed in DOT/UN approved containers for storage.

At the RMWSF (CPP-1617) and the HCRWSF (CPP-1619), "No Smoking" signs are displayed at all entrances. The north and east walls of the ignitable liquid area, bay 5, are made of wire mesh, which provides adequate ventilation to prevent concentration of fumes.

F-5a. Precautions to Prevent Ignition or Reaction of Ignitable or Reactive Waste [IDAPA 58.05.01.012 and 58.05.01.008; 40 CFR 270.14(b)(9) and 264.17(a)]

Individually the D, F, P, and U HWNs have the potential to pose an incompatible scenario if mixed with sufficient concentration of the pure chemical and other factors such as time, mixing configuration, and containment of the chemicals. However, the HWNs have been (1) primarily assigned based on the contained in rule, (2) already have achieved chemical equilibrium and stability within the final physically solid waste form, and (3) exist in low concentrations. Any danger to (1) generate extreme heat or pressure, fire or explosion, violent reaction, (2) produce uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to pose a risk of fire or explosions, or (3) damage the structural integrity of the facility as a result of chemical reactions would have been eliminated by the following: (a) insufficient quantity of the chemicals in a pure, concentrated form to pose a problem, (b) lack of a medium to provide a mechanism for a high reaction and mixing rate, (c) a containment configuration that does not permit a pressure buildup and release if event “(a)” and “(b)” were simultaneously achieved, and (d) lack of an adequate ignition or energy source to initiate the reaction.

F-5b. General Precautions for Handling Ignitable or Reactive Waste and Mixing of Incompatible Waste [IDAPA 58.05.01.012 and 58.05.01.008; 40 CFR 270.14(b)(9) and 264.17(b)]

Any danger to (1) generate extreme heat or pressure, fire or explosion, or violent reaction, (2) produce uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to pose a risk of fire or explosions, or (3) damage the structural integrity of the facility as a result of chemical reactions would have been eliminated by the following: (a) insufficient quantity of the chemicals in a pure, concentrated form to pose a problem, (b) lack of a medium to provide a mechanism for a high reaction and mixing rate, (c) a containment configuration that will not permit a pressure buildup and release if events "(a)" and "(b)" were simultaneously achieved, and (d) lack of an adequate ignition or energy source to initiate the reaction. Therefore, the wastes stored in the areas addressed in this permit do not have potential for ignition or reaction.

F-5c. Management of Ignitable or Reactive Wastes in Containers [IDAPA 58.05.01.012 and 58.05.01.008; 40 CFR 270.15 and 264.176]

As described in Section F-5, the wastes to be stored in containers are managed to prevent a threat to human health or the environment. In addition, CPP-1617 and CPP-1619 are located more than 50 feet from the INEEL boundary.

F-5d. Management of Incompatible Wastes in Containers [IDAPA 58.05.01.012 and 58.05.01.008; 40 CFR 270.15(d) and 264.177]

Only compatible wastes are stored in containers. Incompatible wastes will not be placed in the same container. Incompatible waste containers may be stored in the same area, but will be segregated, to ensure no commingling of wastes will occur.

F-5e. Management of Ignitable or Reactive Wastes in Tank Systems [IDAPA 58.05.01.012 and 58.05.01.008; 40 CFR 270.16(j) and 264.198]

Hazardous and/or mixed waste and debris to be treated in tank systems contains only de minimis quantities of residual chemicals, which are insufficient to sustain an ignitable and/or reactive chemical reaction and produce an ignitable/reactive hazard. Treatment solutions going to the holdup or collection tanks are compatible with solutions that are contained in the tanks. Therefore, the wastes stored in the tanks addressed in this permit do not have potential for ignition or reaction.

F-5f. Management of Incompatible Wastes in Tank Systems [IDAPA 58.01.05.012 and 58.01.05.008; 40 CFR 270.16(j) and 264.199]

INEEL technical support personnel have reviewed all decontamination chemicals to be used during debris treatment activities. Based on this evaluation and site operating experience, technical support personnel have determined that, in the quantities and concentrations used, significant reactions between decon solutions are not likely. Any reactions that might occur would be minor and non-energetic (e.g., slight temperature increase, no violent gas evolution). Reactions are mitigated by using relatively dilute decon solutions and by rinsing between different treatment operations. Typically, large volumes of rinse water are used during cleanup activities following each treatment iteration, creating very dilute solutions in the decon holdup (VES-NCD-123) and collection (VES-NCD-129) tanks. When chemical mixing does occur, it takes place at ambient temperatures in a tank with heel volumes greater than the volumes of the chemicals drained into the tank at any given time, reducing the likelihood of heat buildup. To ensure that over pressurization of the tanks does not occur, the NWCF facilities were designed to manage these wastes using vented tanks under sufficient vacuum, to allow the safe removal of gaseous products.

Despite the fact that these solutions pose no significant compatibility concerns, administrative controls and recordkeeping practices are employed to prevent undesirable chemical reactions and ensure adequate tank capacity. Debris treatment operations are administratively controlled. Procedures detail the treatment activity to be performed, decon solution makeup, and recordkeeping requirements.

The type and concentration of the decon solution to be utilized is determined by supervision, with input from technical support personnel. Any unusual hazards posed by the debris type or the chemicals used and special precautions required to minimize hazards are established by environmental, safety, and health professionals and may be incorporated into safe work permits. Pre-job briefings include a review of safe work permit requirements as well as potential hazardous conditions and mitigation efforts. Atypical treatment activities involving uncommon debris items or modified decontamination solutions are evaluated by technical support personnel for impacts on treatment effectiveness and compatibility with existing solutions. All decontamination personnel are trained in the hazards associated with chemicals specified for use.

Decon area activities are recorded in a logbook. Personnel review the entries in the logbook each day for treatment status information including the types and quantities of decon solutions used. In addition, a formal turnover occurs at shift changes. Debris treatment and/or decon request forms, which identify chemical contaminants and applicable HWNs, are submitted for any treatment services required. These requests for services must be formally approved by decon facility management, or designee, before treatment activities can take place. Acceptable knowledge may be used to determine applicable HWNs assigned to HEPA filters and other debris. This knowledge includes both process knowledge and/or chemical/physical testing of the waste. Decontamination facility technicians use data sheets to document chemical additions to the tanks as a result of debris treatment activities. The concentration of solutions utilized from the decon makeup tanks are also noted on the data sheet. Tanks VES-NCD-123 and VES-NCD-129 are sampled and analyzed, for chemical constituents of concern prior to discharge for further treatment or storage. A record of the analytical results is maintained for reference.

F-5g. Management of Ignitable or Reactive Wastes Placed in Waste Piles [IDAPA 58.05.01.012 and 58.05.01.008; 40 CFR 270.18(f) and 264.256]

The stored waste piles, that consist of spent HEPA filters, do not have the potential for ignition or reaction. HWNs are applied to HEPA filters and other debris through the process of acceptable knowledge, which involves both process knowledge and/or chemical, physical testing of the waste. F and U HWNs have been applied based on knowledge of the processes. The F and U HWNs have been assigned as a result of the contained in rule, as opposed to the F- or U-listed chemicals existing in the matrices in a pure, concentrated form. In addition only debris containing no free liquids will be accepted; thus, the wastes will neither be reactive nor ignitable. Since these F- or U-listed chemicals do not exist in a pure, concentrated form, the characteristics of ignitability or reactivity would not from these HWNs.

In some cases, due to high radiation fields associated with the wastes, the generator has assigned various characteristic HWNs in lieu of physical testing.

Individually the D, F, and U HWNs have the potential to pose an incompatible scenario if mixed with sufficient concentration of the pure chemical and other factors such as time, mixing configuration, and containment of the chemicals. However, the waste codes have been (1) primarily assigned based on the contained in rule, (2) already have achieved chemical equilibrium and stability within the final physically solid waste form, and (3) exist in low concentrations. Any danger to (1) generate extreme heat or pressure, fire or explosion, violent reaction, (2) produce uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to pose a risk of fire or explosions, or (3) damage the structural integrity of the facility as a result of chemical reactions would have been eliminated by the following: (a) insufficient quantity of the chemicals in a pure, concentrated form to pose a problem, (b) lack of a medium to provide a mechanism for a high reaction and mixing rate, (c) a containment configuration that does not permit a pressure buildup and release if event "(a)" and "(b)" were simultaneously achieved, and (d) lack of an adequate ignition or energy source to initiate the reaction.

HEPA filters by design have a poor ability to retain organic chemicals other than in trace amounts, as their primary purpose is to retain larger particles. Listed hazardous waste does not exist on the HEPA filters in either a pure, concentrated form nor in more than de minimis or trace quantities. Similarly, other debris, lack the quantity of chemicals necessary to provide a vehicle for reaction to create a hazard to human health or the environment.

F-5h. Management of Incompatible Wastes Placed in Waste Piles [IDAPA 58.01.05.012 and 58.01.05.008; 40 CFR 270.18(g) and 264.257]

The stored waste piles, which consist generally of spent HEPA filters, will not be stored with incompatible wastes or materials.

APPENDIX F-1. Hydrodynamic and Structural Analysis of Flood Hazards at CPP-659 During a Peak Flow in the Big Lost River

Document ID: EDF-1747
Revision ID: 0

Engineering Design File

Hydrodynamic and Structural Analysis of Flood Hazards at CPP-659 During a Peak Flow in the Big Lost River

Prepared for:
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, Idaho

INEEL
Idaho National Engineering & Environmental Laboratory
BECHTEL BWXT IDAHO, LLC

Form 412.14
10/05/99
Rev. 02

Hydrodynamic and Structural Analyses of Flood Hazards at CPP-659 During A Peak Flow in the Big Lost River

The following Engineering Design File (EDF) were prepared under the responsible charge of the Professional Engineer as indicated by the seal and signature provided on this page. The Professional Engineer is registered in the State of Idaho to practice Civil and Structural Engineering.

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1/17/2001
STATE OF IDAHO
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431.02
06/29/2000
Rev. 07

ENGINEERING DESIGN FILE

Functional File No. ________
EDF No. 1747
Page 1 of 13

1. Project File No.: ____________

2. Project/Task: CPP-659 Flood Hazard Analysis

3. Subtask: Hydrodynamic and Structural Analyses of Flood Hazards at CPP-659

4. Title: Hydrodynamic and Structural Analyses of Flood Hazards at CPP-659 During a Peak Flow in the Big Lost River

5. Summary: This summary briefly describes the problem to be addressed, gives a summary of the analyses performed in addressing the problem, and states the results, conclusions, and recommendations.

A study performed by the INEEL in 1986 estimated the flow volumes and water-surface elevations which occur during a peak flow in the Big Lost River at the INEEL. The INEEL study assumed that the 100-year peak flow and failure of Mackay Dam occur simultaneously, and estimated that the peak flow is equal to 28,500 ft^3/s at the diversion dam in the southwestern part of the INEEL. Building CPP-659–the New Waste Calcining Facility–lies within this hypothetical flood plain boundary based on the computed water elevation. The purpose of this analysis is to provide information to Idaho DEQ, in order to ensure compliance with RCRA regulations that require determination of hydrodynamic and hydrostatic forces expected to occur at the site and a description of flood protection devices at the facility and how these will prevent washout. The analysis consists of three parts: (1) A hydrodynamic analysis to compute the pressure exerted on the building by flood water; (2) A field investigation and structural analysis to determine whether the concrete foundation of CPP-659 can withstand the presence of flood water and to assess the likelihood of water infiltration; (3) A hydraulic analysis to examine the potential for sediment transport and erosion.

The results of this analysis lead to the following conclusions. Hydrostatic and hydrodynamic forces due to flood water above grade are negligible in comparison to lateral earth pressure. However, the weight of water in saturated soil considerably increases the lateral earth pressure. The lateral earth pressure of saturated soil was computed and shown to be 2 times larger than the pressure of dry soil. However, the strength of the below-grade retaining walls is adequate to support the increase in lateral earth pressure which may occur as a consequence of the flood postulated by the INEEL. Another major factor affecting the structural adequacy of the building is the method of construction, particularly the methods used to prevent water infiltration during a flood. A field investigation showed that construction of CPP-659 follows many of the methods described in the ACI Manual of Concrete Practice to assure a watertight structure. However, some minor water seepage was observed during the field investigation. Water accumulation is insignificant, which indicates that the rate of seepage is very low. Water that may seep into CPP-659 through pipe or utility penetrations is handled by flood protection devices that are designed to route water to the hot sump or valve cubicle so that water does not come into direct contact with waste piles or containerized hazardous wastes stored in the building. In particular, the flood protection devices are designed to preclude washout of hazardous waste from the building. Furthermore, a hydraulic analysis indicates that sediment transport and erosion at CPP-659 may occur. However, the likelihood of erosion is reduced by flood control devices that divert water to storage basins, asphalt and concrete that cover the gravel sediment found in the stream bed, and structures such as roads and buildings that slow and divert the flow.

6. Distribution (complete package): P. E. Murray, MS 3760; N. C. Hutten, MS 3428; S. A. Davies, MS 3650; S. A. Jensen, MS 3650; S. L. Austad, MS 3650
Distribution (summary package only): None

7. Review (R) and Approval (A) Signatures:

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Introduction

In 1986, the INEEL published a report containing calculated flow volumes and water-surface elevations which occur during a peak flow in the Big Lost River at the INEEL (1). The INEEL study included the assumption that the 100-year peak flow and failure of Mackay Dam occur simultaneously, and thereby estimated that the peak flow in the Big Lost River is equal to 28,500 ft^3/s at the INEEL diversion dam. However, there are conflicting scientific opinions regarding the magnitude of the 100-year peak flow in the Big Lost River, and the INEEL Natural Phenomena Hazards Committee is currently addressing this issue. Presently, the water surface profile associated with a 28,500 ft^3/s flow is considered to be an upper bound on potential flooding at the INEEL. The particular water surface profile obtained from the INEEL study is used as a basis for the present analysis.

In the INEEL study, 57,740 ft^3/s was estimated to occur at Mackay Dam. The flow is attenuated downstream, and the INEEL diversion dam located in the southwestern part of the INEEL was estimated to receive 28,500 ft^3/s. The diversion dam was assumed to be unable to retain that flow, and so a large part of the discharge flows onto the site. The remaining water was assumed to flow through the diversion channel and into spreading areas. A hydraulic model was used to compute the flow volumes and water elevations within a 18 mile reach downstream of the diversion dam. Building CPP-659—the New Waste Calcining Facility at INTEC—lies within the hypothetical flood plain boundary that is based on computed water elevations given in the 1986 INEEL report (1).

The purpose of this engineering analysis is to provide information to Idaho DEQ regarding the hydrodynamic and structural effects of a peak flow. This analysis is performed to ensure compliance with RCRA regulations (2) that require an "engineering analysis to indicate the various hydrodynamic and hydrostatic forces expected to result at the site as a consequence of a 100-year flood," and "structural or other engineering studies showing the design of operational units and flood protection devices at the facility and how these will prevent washout." In the RCRA regulations (2), the term "washout" is defined as "the movement of hazardous waste from the active portion of a facility as a result of flooding."

This analysis is performed to ensure compliance with the following specific requirements stemming from application for a RCRA permit for mixed hazardous waste treatment in CPP-659 and to address issues presented in the DEQ letter received 9/27/00 requesting this study:

1. A description of building CPP-659 construction parameters which prevent run-on to the units described in the Volume 18 Part B permit application;
2. A professional engineer (PE) certification that CPP-659 could withstand hydrodynamic or hydrostatic forces applied to the building as a result of the hypothetical 100-year flood event described in the 1986 INEEL report (1);
3. PE certification that the design of operational units and/or flood protection devices in CPP-659 are adequate to prevent washout;
4. A discussion of the controls within the building that provide protection against washout.

This analysis consists of three parts:

1. Hydrodynamic and hydrostatic analyses were used to compute the pressure exerted on the building by stationary and moving flood water;
2. A field investigation and structural analysis are used to determine whether the concrete foundation of CPP-659 can withstand the presence of flood water and to assess the likelihood of water infiltration;
3. A hydraulic analysis is used to examine the potential for erosion and washout of hazardous waste.

Background

Peak Flow Analysis

Koslow and Van Haaften (1) examined the consequences of a failure of Mackay Dam and performed a hydraulic analysis to determine the extent of the flood plain for several scenarios. Their analysis included a predicted 100-year flood and simultaneous piping failure at Mackay Dam, which leads to a breach of the dam, overtopping of the INEEL diversion dam, and flooding of the INEEL site. This scenario results in a peak flow released from the dam that was calculated to be 57,740 ft^3/s. This flow between Mackay Dam and the INEEL is attenuated by storage, agricultural diversion, and channel infiltration. The calculated flow at the INEEL diversion dam is 28,500 ft^3/s. Since the diversion dam is unable to retain the high flow, most of the flood water is assumed to flow onto the site.

Flow Routing Analysis

The peak flow estimated by Koslow and Van Haaften (1) was used in a flow routing analysis to determine the extent of the flood plain at the INEEL site. The geometry of the channel was determined from USGS topographical maps, and the Big Lost River stream bed was examined to determine surface roughness. The Bernoulli equation for ideal flow and the Manning relation for energy loss in open channels were used to compute the peak flow and water elevation at each cross-section. The INTEC site was surveyed by INEEL engineers to determine building and ground elevations. All vertical elevations are in reference to the National Geodetic Vertical Datum of 1929 (NGVD29). Of particular interest in this study is Building CPP-659 located at the INTEC facility. The leading edge of the flood wave is estimated to arrive at INTEC approximately 17.1 hours after breach of the dam. The peak flow is attenuated to 24,870 ft^3/s, and the peak water velocity is estimated to be 2.2 ft/s. Since the area surrounding INTEC is very flat, flood water will spread easily and so the flood plain is wide and shallow. The elevation of the stream bed is 4911 feet and the calculated water elevation is 4916 feet. The lowest ground elevation at CPP-659 is 4912.1 feet and occurs at the east side of the building. These results suggest that the depth of flood water may reach 4 feet at the building's foundation. Therefore, a water depth equal to 4 feet is used in the following hydrodynamic and hydrostatic analyses.

Koslow and Van Haaften (1) also performed an analysis to examine the potential for overland flooding due to localized heavy rain and snowmelt. It was found that localized flooding due to a 25-year peak rainfall and simultaneous snowmelt lead to a peak flow equal to 32 ft^3/s. This runoff can be accommodated by the drainage basin at INTEC and flood control devices such as culverts, dikes, and ditches. Meanwhile, flood water may collect in low-elevation areas at

INTEC. The following hydrodynamic and hydrostatic analyses of 4 feet of water at the foundation of CPP-659 may also be used to assess the effect of overland flooding due to localized precipitation.

Hydrostatic and Hydrodynamic Analyses

Hydrostatic Forces

The results of the INEEL study (1) were used to determine that the depth of flood water may reach 48 inches at the CPP-659 building foundation during a peak flow in the Big Lost River streambed adjacent to INTEC. At a depth of 48 inches, the hydrostatic pressure on the foundation is

$$P_{water} = \gamma_{water} \cdot d = 62.4\frac{lb}{ft^3} \cdot 4\ ft = 249.6\frac{lb}{ft^2},$$

where P_{water} is the hydrostatic pressure, γ_{water} is the weight of water, and d is the water depth. The resultant force per unit width of foundation is

$$F_{water} = \frac{1}{2} P_{water} \cdot d = 499.2\frac{lb}{ft},$$

where F_{water} is the resultant force that occurs at a height above grade equal to $d/3$, as is shown in Fig. 1.

The lateral earth pressure of saturated soil includes the effect of water pressure and soil pressure. The at-rest earth pressure due to the weight of soil is

$$P_{soil} = K_o(\gamma_{sat} \cdot H - \gamma_{water} \cdot H) = 0.375 \cdot \left(135\frac{lb}{ft^3} - 62.4\frac{lb}{ft^3}\right) \cdot H = 27.2\frac{lb}{ft^3} \cdot H,$$

where P_{soil} is the earth pressure, γ_{sat} is the weight of saturated soil, H is the soil depth, and K_o is the earth pressure coefficient. The at-rest earth pressure coefficient was obtained from the relation

$$K_o = 1 - \sin\phi,$$

where ϕ is the angle of internal friction which is equal to 43° according to the NWCF soils report (3). The weight of saturated soil at NWCF is assumed to be equal to the weight of dense, mixed-grain sand given by Peck et al (4). The resultant force per unit width is

$$F_{soil} = \frac{1}{2} P_{soil} \cdot H = 13.6\frac{lb}{ft^3} \cdot H^2,$$

where F_{soil} is the resultant force that occurs at a height equal to $H/3$ from the base of the retaining wall. The hydrostatic pressure due to the presence of water is

$$P_{wet\ soil} = \gamma_{water} \cdot H = 62.4 \frac{lb}{ft^3} \cdot H,$$

where $P_{wet\ soil}$ is the hydrostatic pressure. The resultant force per unit width of retaining wall is

$$F_{wet\ soil} = \frac{1}{2} P_{wet\ soil} \cdot H = 31.2 \frac{lb}{ft^3} \cdot H^2,$$

where $F_{wet\ soil}$ is the resultant force that occurs at a height equal to $H/3$ from the base of the retaining wall. The total resultant force per unit width of retaining wall is

$$F_{total} = F_{soil} + F_{wet\ soil} = 44.8 \frac{lb}{ft^3} \cdot H^2,$$

where F_{total} is the total resultant force that occurs at a height equal to $H/3$ from the base of the retaining wall, as is shown in Fig. 1.

In the case of dry soil, the resultant force per unit width of retaining wall is

$$F_{dry\ soil} = \frac{1}{2} \cdot K_o \cdot \gamma_{dry} \cdot H^2 = \frac{1}{2} \cdot 0.375 \cdot 118 \frac{lb}{ft^3} \cdot H^2 = 22.1 \frac{lb}{ft^3} \cdot H^2.$$

The density of dry soil is given in the NWCF soils report (3).

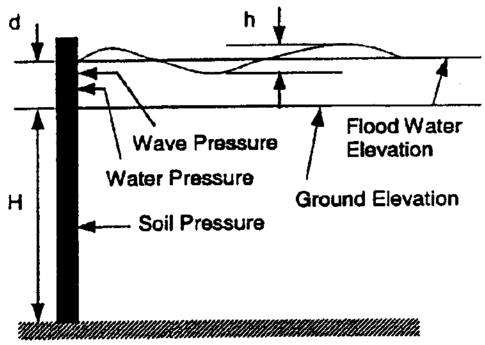

Fig. 1. Various forces acting on a retaining wall during a flood.

Hydrodynamic Forces

The force of moving flood water is calculated by considering the impact of shallow water waves caused by a high wind. A graph that shows the relation between wind velocity, water depth, wave height, and wave period is given in Fig. 10-16 on page 10-36 in Brater and King (5). Assuming a wind velocity equal to 60 mph and a water depth equal to 4 feet, the graph shows that the wave height is 2.0 feet and the wave period is 3.4 seconds. The relation between wave period and wavelength of shallow water waves is

$$\frac{L}{T}=\sqrt{g\cdot d}\,,$$

where L is the wavelength, T is the wave period, d is the water depth, and g is the gravitational acceleration. Assuming a water depth equal to 4 feet and a wave period equal to 3.4 seconds, the wavelength is

$$L=T\sqrt{g\cdot d}=3.4\,s\sqrt{32.2\frac{ft}{s^2}\cdot 4\,ft}=38.6\,ft\,,$$

and the wave velocity is

$$\frac{L}{T}=\frac{38.6\,ft}{3.4\,s}=11.35\frac{ft}{s}.$$

In comparison, the velocity of flood water as estimated by Koslow and Van Haaften (1) is 2.2 ft/sec. Therefore, the velocity of moving flood water is small in comparison to the velocity of wind-generated waves.

The resultant force per unit width of retaining wall, which is caused by wind-generated waves, is calculated from an empirical relation described on page 10-41 in Brater and King (5). Assuming a wave height equal to 2.0 feet, the pressure exerted by the wave is

$$P_{wave}=\gamma_{water}\cdot h=62.4\frac{lb}{ft^3}\cdot 2.0\,ft=124.8\frac{lb}{ft^2}.$$

According to Fig. 10-21 on page 10-42 in Brater and King (5), the pressure distribution is uniform from the ground to the still-water height, and hydrostatic from the still-water height to a height above still water equal to $1.66\cdot h$. Assuming a water depth equal to 4 feet, the force of the wave is

$$F_{wave}=P_{wave}\left(d+0.5\cdot 1.66\cdot h\right)=124.8\frac{lb}{ft^2}\left(4\,ft+0.5\cdot 1.66\cdot 2.0\,ft\right)=706.4\frac{lb}{ft},$$

and occurs at a height above grade equal to 2.9 feet, as is shown in Fig. 1.

The results of these calculations show that the hydrostatic and hydrodynamic forces are small in comparison to the lateral earth pressure. Furthermore, hydrostatic and hydrodynamic forces have a negligible effect on the overturning moment. However, a substantial increase in the earth pressure occurs when the soil becomes saturated—the dry soil force is equal to $22.1\cdot H^2$ lb/ft and the saturated soil force is equal to $44.8\cdot H^2$ lb/ft. Since the topmost 40 feet of soil at the NWCF is mostly sandy gravel that is dry and permeable (3), the assumption of saturated soil may be very conservative. Therefore, the calculated earth pressure is an upper bound on the actual earth pressure that would occur during a flood.

Structural Analysis

The second and third levels of CPP-659 are below grade and contain an inner cell structure encased in a 4 feet thick shielded concrete wall. The cell structure is surrounded by corridors and various utility rooms. The retaining walls on the second and third levels support gravel backfill and are 1 1/3 to 2 feet thick concrete. The first level is 3 feet above grade and contains a maintenance area leading to the cell structure and an outer office area built on gravel backfill. The exterior retaining wall supporting the first level is 1 1/6 feet thick concrete.

The structural features of the concrete foundation at CPP-659 were examined during a field investigation. The following features were examined: footing and foundation structures; type of concrete used during construction; soil grading and drainage systems; exterior wall construction, including joints and the method of sealing penetrations; openings such as doorways that enable water to easily infiltrate; the use of water stops and sealant to prevent water infiltration; and the occurrence of water seeping through cracks and penetrations. The ACI Manual of Standard Practices (6) provides guidance on construction of watertight concrete structures. The result of the field investigation shows that construction of the NWCF follows many of these standard practices, though some minor water seepage was observed.

The following list of construction practices were used to assure a watertight foundation and to provide adequate drainage during a flood.

(1) The retaining walls that support lateral earth pressure were made using high-density, low-permeability concrete.

(2) Soil surrounding the foundation is graded to slope away from the building.

(3) All joints are fitted with carbon steel water stops to prevent water infiltration.

(4) The first level is at an elevation higher than the flood water elevation.

(5) Visible cracks in the above-grade, exterior concrete foundation were not observed.

(6) Water entering the building drains to the hot sump tank located below the third level.

The following list of observations suggest the potential for water infiltration during a flood, particularly seepage caused by water infiltration through pipe penetrations and other openings. The field study investigated the potential for water infiltration through the utility piping tunnel, tank farm waste pipe, concrete hatches, doorways and other openings.

(1) All the INTEC utility piping is carried in an underground tunnel that sometimes contains water because the tunnel has manholes that provide an opening for runoff. Despite the presence of level alarms and a pump in the utility tunnel, the water in the utility tunnel occasionally seeps into the utility corridor located at the second level of CPP-659. Seepage occurs through pipe penetrations into the utility corridor. Seeping water is collected by a floor drain in the utility corridor and flows into VES-NCC-122—the non-fluoride hot sump tank. This tank has a maximum capacity of 4300 gallons and is equipped with level monitoring and control equipment. If seeping water enters the building as a result of a prolonged flood event, VES-NCC-122 can be sampled and its contents transferred to VES-

WL-133—the Process Equipment Waste Evaporator (PEWE) feed tank. The contents of tank VES-NCC-122 can also be transferred to VES-NCC-119—the fluoride hot sump tank–or the Tank Farm Facility if the PEWE cannot accept the liquid. Water is transferred through steam jets that have a capacity equal to 20 gal/min each.

(2) A 3 inch stainless steel pipe carrying waste from the tank farm is the only pipe that penetrates the inner cell structure. This pipe is encased in a larger pipe that is well sealed, and water infiltration through the pipe penetration has not been observed. If flood water enters the building at this location, the flood protection devices are designed to route water to a sump in the valve cubicle which is equipped with leak detection devices. From this sump the water may be pumped to a variety of other tanks, such as VES-NCC-119, VES-NCD-123, and VES-NCD-129. These tanks are equipped with level monitors and overflow alarms.

(3) Concrete hatches located in the maintenance area at the first level lead to the cell structure. These hatches are not watertight, but flood water will not reach the maintenance area since the first level is at an elevation equal to 4917 feet, which is 1 foot higher than the flood level.

(4) The lowest elevation of an entry into the building is a doorway on the north side, which is at an elevation equal to 4914.3 feet. This is 1.7 feet less than the flood water elevation. The doorway leads to the first level, which is at an elevation equal to 4917 feet. The exterior retaining wall at this doorway is located 20 feet from the closest retaining wall on the second and third levels. If a person enters the exterior door at the north side of CPP-659, he must walk up steps to an elevation of 4917 feet to reach the first level, and then walk 20 feet toward the center of the building to be above the second level. Therefore, water entering the exterior doorway may only infiltrate the gravel backfill underneath because there is no path for water to infiltrate the levels below grade.

Another important consideration is the ability of the retaining walls to withstand lateral earth pressure. In the section on hydrodynamic analysis, the at-rest lateral earth pressure of saturated soil was computed and shown to be 2 times larger than the pressure of dry soil. This particular flood hazard affects all below-grade retaining walls that support backfill. The structural design of the second and third levels of CPP-659 is complex, and the concrete retaining walls have a variable height, width, and thickness. Surcharge loads are present in addition to lateral earth pressure. Furthermore, the strength of reinforced concrete depends on the exact size, number, and placement of the steel bars. Therefore, a thorough assessment of the effect of soil saturation on the stress in retaining walls is a complex structural analysis that is beyond the scope of this study. However, the following simple calculation demonstrates that the strength of the below-grade retaining walls are more than adequate to support the increase in lateral earth pressure which may occur as a consequence of a flood.

The building structure consists of two levels below grade, and the height of each level is 17 feet. The first level is 3 feet above grade. Therefore, the depth of soil at the base of the first level retaining wall is 14 feet. Consider a concrete beam fixed at both ends and acted on by a distributed force, as is shown in Fig. 2. This particular beam loading represents the lateral earth pressure acting on a section of retaining wall, and leads to a conservative estimate of the shear force and the bending moment. To examine the loading on the weakest section of retaining wall, assume that the length of the beam is equal to 8 feet—the maximum spacing between supports—

and the thickness of the beam is equal to 16 inches—the minimum thickness of the foundation walls. Using the results calculated previously in the section entitled *Hydrostatic Forces*, the force per unit area of beam is equal to

$$P = P_{soil} + P_{wet\ soil} = 27.2\frac{lb}{ft^3} \cdot H + 62.4\frac{lb}{ft^3} \cdot H = 89.6 \cdot H\, lb/ft^2,$$

where H is measured in feet. At the base of the beam where H is equal to 14 feet, the pressure is equal to $1250\, lb/ft^2$. To examine the maximum loading on the beam, assume that this pressure is uniformly distributed on the entire length of the beam.

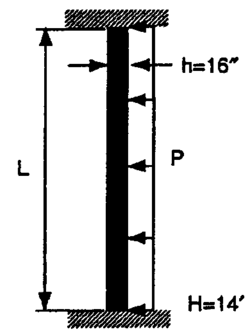

Fig. 2. Lateral earth pressure acting on a retaining wall.

The maximum shear force and bending moment occurs at the ends of the beam, and are obtained from the following formulas found in ACI 318 (7):

$$M = \frac{P L^2}{12} = 6690\frac{ft - lbs}{ft},$$

$$V = \frac{P L}{2} = 5020\frac{lbs}{ft}.$$

The actual force and moment are multiplied by a load factor equal to 1.7, as specified in ACI 318 (7), to give $M_u = 11{,}400\ lb\ ft$ and $V_u = 8{,}500\ lb$ per 1 foot width of beam.

To compute the allowable shear and moment capacity of the concrete beam, assume the minimum required reinforcement according to ACI 318-77 (7), which was the building code for reinforced concrete at the time the NWCF was built. For reinforcement with a yield strength equal to 40,000 psi, assume #4 bar spaced 8 inches center to center, and assume top and bottom covers equal to 1 inch. This meets the requirements that the area of vertical reinforcement shall not be less than 0.0015 times the wall area and the reinforcement layers shall not be placed more than 1/3 the wall thickness from the surface, as described in Sections 14.2.11 and 14.2.12 of ACI 318 (7). Furthermore, the concrete is assumed to have a compressive strength equal to 4000 psi.

The computation of moment and shear capacity are based on ACI 318 (7) and the CRSI Design Handbook (8). The shear capacity is obtained from Section 11.3.1.1 of ACI 318 (7):

$$V_c = 0.85\, 2\sqrt{f_c'}\, b\, d\,,$$

where f_c' is the compressive strength of concrete, b is the width of the beam, and d is the distance from the extreme compression fiber to the centroid of the tension reinforcement. The moment capacity for a single layer of tension reinforcement is obtained from page 5-7 in the CRSI Design Handbook (8):

$$M_n = 0.90\, A_s\, f_y\, (d - a/2),$$

where A_s is the area of tension reinforcement, f_y is the yield strength of the reinforcement, and a is the depth of the concrete compression block which is obtained from a balance of concrete compression and bar tension:

$$A_s\, f_y = 0.85\, f_c'\, b\, a\,.$$

The moment capacity and shear capacity for the concrete beam are $M_n = 13{,}100$ lb ft and $V_c = 19{,}000$ lb per 1 foot width of beam, which are larger than the factored moment and shear computed above. In fact, the retaining walls at the NWCF are stronger than this simple example indicates, owing to the presence of intersecting walls, columns, and slabs anchored to each section of retaining wall.

Hydraulic Analysis

Transport of sediment caused by moving flood water may lead to erosion of the stream bed. The type of soil needs to be known to assess the potential for erosion. A previous study (3) found that the topmost 40 feet of soil at the NWCF is mostly sandy gravel and some silt. Below the topmost layer is a 0 to 10 feet intermediate layer of clay soil containing silt and sand, and below the intermediate layer is basalt bedrock. A sieve analysis performed on the topmost layer of soil showed that the 75th percentile of the particle diameter distribution is approximately equal to 0.4 inches to 0.8 inches (3), which means that 75% of the particles by weight are that size or finer. In the case of a non-cohesive soil with a particle diameter larger than approximately 0.05 inches, the critical shear stress for sediment transport may be obtained from the following relation given on page 7-26 in Brater and King (5):

$$\tau_{critical} = 0.4 \cdot D\,,$$

where D is the 75th percentile of the particle diameter distribution measured in inches, and the critical shear stress is measured in lb/ft^2. Assuming a particle diameter equal to 0.6 inches,

$$\tau_{critical} = 0.4 \cdot 0.6\text{ in} = 0.24 \frac{\text{lb}}{\text{ft}^2}\,.$$

The shear stress due to uniform flow of water in a channel having a small slope may be obtained from the following relation given on page 7-25 in Brater and King (5):

$$\tau = \gamma_{water} \cdot d \cdot s,$$

where d is the water depth and s is the channel slope. In the Big Lost River stream bed near INTEC, the channel slope is approximately equal to 16 feet per mile. Since the flood water depth at CPP-659 is approximately equal to 4 feet, the shear stress due to moving flood water near the building is

$$\tau = 62.4\frac{\text{lb}}{\text{ft}^3} \cdot 4\ \text{ft} \cdot \frac{16}{5280} = 0.76\frac{\text{lb}}{\text{ft}^2}.$$

Since $\tau > \tau_{critical}$, compute the particle size needed to resist erosion. Assuming a particle diameter equal to 2.0 inches,

$$\tau_{critical} = 0.4 \cdot 2.0\ \text{in} = 0.80\frac{\text{lb}}{\text{ft}^2}.$$

Therefore, erosion of sand and rock with a diameter smaller than 2 inches may occur. However, the likelihood of erosion is greatly reduced because much of the sandy gravel sediment found in the stream bed has been covered with asphalt and concrete at INTEC. Furthermore, the likelihood of erosion is reduced by the presence of flood control devices that divert water to storage basins and structures such as roads and buildings that slow and divert the flow. Since the main foundations are deep and the gravel has some larger rock, erosion of the soil is not likely to cause damage to critical structural components.

Conclusions

An engineering analysis was used to calculate the various hydrodynamic and hydrostatic forces expected to result at Building CPP-659 as a consequence of a 100-year flood coinciding with a failure of Mackay Dam. A structural study was used to describe the design of CPP-659 and its flood protection devices and how these will prevent washout of hazardous waste. Specific details are given below.

An engineering analysis was used to determine whether CPP-659 can withstand a peak flow in the Big Lost River adjacent to INTEC. Hydrostatic and hydrodynamic forces due to flood water above grade are negligible in comparison to lateral earth pressure, but the weight of water in saturated soil considerably increases the lateral earth pressure. In fact, the lateral earth pressure of saturated soil was computed and shown to be 2 times larger than the pressure of dry soil. However, the strength of the below-grade retaining walls is adequate to support the increase in lateral earth pressure which may occur as a consequence of a flood.

Another major factor affecting the structural adequacy of the building is the method of construction, particularly the methods used to prevent water infiltration during a flood. A field investigation showed that construction of the NWCF follows many of the methods described in the ACI Standard Practices to assure a watertight structure. Furthermore, the field investigation examined the potential for water infiltration through the utility piping tunnel, tank farm waste pipe, concrete hatches, doorways and other openings. The first level of CPP-659 contains a pathway for water to enter the concrete hatches in the maintenance area. Since the elevation of the first level is one foot above the elevation of the hypothetical 100-year flood, water entry through these openings will not occur. However, some minor water seepage from a below-grade utility tunnel was observed during the field investigation. The rate of water seepage is very low and water accumulation is insignificant. Water that may seep into CPP-659 through pipe or utility penetrations is handled by flood protection devices that are designed to route water to the hot sump tank so that water does not come into direct contact with waste piles or containerized hazardous wastes. In particular, the flood protection devices are designed to preclude "washout" or movement of hazardous waste from the building as a result of flooding.

Another issue concerns the potential for erosion and sediment transport. The shear stress of moving flood water near CPP-659 is larger than the critical shear stress needed to cause sediment transport, and so erosion at CPP-659 may occur. However, the likelihood of erosion is greatly reduced because much of the sandy gravel sediment found in the stream bed has been covered with asphalt and concrete at INTEC. Furthermore, the likelihood of erosion is reduced by the presence of flood control devices that divert water to storage basins and structures such as roads and buildings that slow and divert the flow. Since the main foundations are deep and the gravel has some larger rock, erosion of the soil is not likely to cause damage to critical structural components.

References

1. K. N. Koslow and D. H. Van Haaften, *Flood Routing Analysis for a Failure of Mackay Dam*, EGG-EP-7184, June, 1986.
2. *Code of Federal Regulations*, 40 CFR Ch. 1, Sect. 270.14(b), Para. 11(iv) A, August 1, 2000.
3. *Soil and Foundation Investigation, Proposed New Waste Calcining Facility*, Prepared for The Energy Research and Development Administration, Fluor Contract No. 453504, Dames and Moore, 1976.
4. R. B. Peck, W. E. Hanson, and T. H. Thornburn, *Foundation Engineering*, 2nd Edition, John Wiley & Sons, NY, 1974.
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APPENDIX F-2. Hydrodynamic and Structural Analysis of Flood Hazards at CPP-1619 During a Peak Flow in the Big Lost River

Document ID: EDF-3088
Revision ID: 0
Effective Date: 02/01/02

Engineering Design File

Hydrodynamic and Structural Analyses of Flood Hazards at CPP-1619 During a Peak Flow in the Big Lost River

Prepared for:
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, Idaho

INEEL
Idaho National Engineering and Environmental Laboratory

Form 412.14
07/24/2001
Rev. 03

431.02
06/20/2001
Rev. 09

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EDF- 3088
Rev. No. 0
Page 1 of 9

1. Title:	Hydrodynamic and Structural Analyses of Flood Hazards at CPP-1619 During a Peak Flow in the Big Lost River		
2. Project File No.:	N/A		
3. Site Area and Building No.:	INTEC, CPP-1619	4. SSC Identification /Equipment Tag No.:	Building Foundation

5. Summary:

A RCRA permit application is currently being prepared for Building CPP-1619, the Hazardous Chemical and Radioactive Waste Storage Facility. A study is needed to ensure compliance with RCRA regulations that require an engineering analysis to indicate the various hydrodynamic and hydrostatic forces expected to result at the site as a consequence of a 100-year flood, and structural or other engineering studies showing the design of operational units and flood protection devices at the facility and how these will prevent washout. In RCRA regulations, "washout" is defined as the movement of hazardous waste from the active portion of a facility as a result of flooding. The objective of this study is to compute the hydrodynamic and hydrostatic forces expected to occur during a 100-year flood, and to demonstrate that the structure can withstand these forces in order to ensure that the waste will be protected from washout.

The flood information is obtained from a study by Koslow and Van Haaften, who examined four probable flood scenarios that included (1) a 25-year flood and simultaneous seismic failure of Mackay Dam, (2) a 100-year flood and simultaneous piping failure of Mackay Dam, (3) a 500-year flood and simultaneous piping failure of Mackay Dam, and (4) overtopping of Mackay Dam caused by the probable maximum flood. Since the assumptions used in scenario (2) exceed RCRA permit requirements, this scenario is referred to as the *maximum credible flood* associated with a 100-year peak flow in the Big Lost River.

Koslow and Van Haaften performed a hydraulic analysis to determine the extent of the floodplain at the INEEL site. The maximum credible flood leads to a breach of Mackay Dam, overtopping of the INEEL diversion dam, and flooding of the INEEL site. A hydraulic model was used to compute the flow volumes and water elevations within an 18-mile reach downstream of the diversion dam. A large part of INTEC lies within the flood plain boundary that is based on computed water elevations. Since there are conflicting scientific opinions regarding the magnitude of the 100-year flood in the Big Lost River and the extent of the floodplain at the INEEL site, the floodplain associated with the maximum credible flood is used as a conservative estimate of the 100-year floodplain for the purpose of RCRA permitting.

A hydrostatic analysis was used to calculate the forces expected to occur at the foundation of CPP-1619 during the maximum credible flood. A structural analysis was used to examine the design of the foundation wall, to check that the elevation of openings such as doorways and loading docks is above the floodwater elevation, and to verify that washout of hazardous waste will not occur. The following results were obtained.

1. The elevation of the concrete floor slab, exterior doorways, loading dock, and sumps is higher than the floodwater elevation. All entry paths to the waste storage area are above the floodwater elevation.
2. The building is constructed to provide adequate drainage during a storm. Drains are installed in the loading dock and are routed to two containment sumps constructed of stainless steel, and having a capacity of 275 gallons each. The concrete floor of the loading dock is sloped so that rainwater and snowmelt entering the loading dock will drain into the sumps.
3. The ground elevation surrounding the foundation walls is above the floodwater level, and so floodwater will not reach the exposed foundation wall but may saturate the soil. A hydrostatic analysis of saturated soil was used to calculate the pressure exerted on the retaining wall. A structural analysis of the retaining wall demonstrates that the wall can withstand the hydrostatic force caused by the maximum credible flood. Therefore, the enclosed waste will be protected from washout.

6. Review (R) and Approval (A) and Acceptance (Ac) Signatures:

	R/A	Typed Name/Organization	Signature	Date
Performer	R	P. E. Murray/6790	P. E. Murray	1/24/02
Checker	R	S. A. Jensen/6780	S.A. Jensen	1/25/02
Requestor	Ac	N. C. Hutten/7310	N.C. Hutten	1/30/02
Approver	A	S. A. Davies/6710	S A Davies	1/25/02
Approver	A	S. L. Austad/6780	SAustad	1/24/02

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06/20/2001
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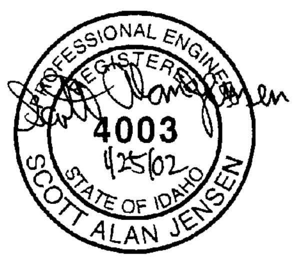

Introduction

A RCRA permit application is being developed for the INEEL Hazardous Chemical and Radioactive Waste Storage Facility, which is Building CPP-1619 located at INTEC. A study is needed to ensure compliance with RCRA regulations (1) that require an engineering analysis of the hydrodynamic and hydrostatic forces expected to occur during a 100-year flood, and analysis of the measures used to preclude washout of waste. If the elevation of the waste storage area is above the floodwater elevation and the building foundation can withstand the forces caused by a 100-year flood, the enclosed waste will be protected from washout.

Maximum Credible Flood

In 1986, Koslow and Van Haaften (2) published a report containing calculated flow volumes and water-surface elevations, which occur during a peak flow in the Big Lost River at INEEL. This study included four probable flood scenarios: (1) a 25-year flood and simultaneous seismic failure of Mackay Dam, (2) a 100-year flood and simultaneous piping failure of Mackay Dam, (3) a 500-year flood and simultaneous piping failure of Mackay Dam, and (4) overtopping of Mackay Dam caused by the probable maximum flood. Since the assumptions used in scenario (2) exceed RCRA permit requirements, this scenario is referred to as the *maximum credible flood* associated with a 100-year peak flow in the Big Lost River. Since there are conflicting scientific opinions regarding the magnitude of the 100-year flood in the Big Lost River and the extent of the floodplain at the INEEL site, the water surface profile associated with the maximum credible flood is used as a conservative estimate of the 100-year floodplain for the purpose of RCRA permitting.

The maximum credible flood results in a peak flow released from Mackay Dam that is equal to 57,740 ft^3/s. The flow between Mackay Dam and the INEEL site is attenuated by storage, agricultural diversion, and channel infiltration. The calculated flow at the INEEL diversion dam located in the southwestern part of the INEEL is equal to 28,500 ft^3/s. The diversion dam is assumed to be unable to retain the peak flow, and so most of the floodwater flows onto the site. The remaining water flows through the diversion channel and into spreading areas. The leading edge of the floodwater wave is estimated to arrive at INTEC approximately 17.1 hours after breach of the dam. The peak flow is attenuated to 24,870 ft^3/s, and the peak water velocity is estimated to be 2.2 ft/s. The elevation of the stream bed is 4911 feet and the calculated water elevation is 4916 feet, in reference to the National Geodetic Vertical Datum of 1929 (NGVD29). Since the area surrounding INTEC is very flat, floodwater will spread easily and so the flood plain is wide and shallow.

Description of Structure

Building CPP-1619 is the Hazardous Chemical and Radioactive Waste Storage Facility. This building is used to store, sort, and package hazardous waste before shipping the waste to another treatment, disposal, or storage facility. Only sealed waste containers are stored. The following is a brief description of the facility; additional information is available from INEEL Document ISD-5 (3).

Building CPP-1619 contains five storage bays and an office; the truck loading area on the south end is not part of the RCRA permitted facility. The permitted area of the building contains a concrete floor slab supported by foundation walls and backfill; there are no floors below grade. A loading dock with roll-up doors is located at the east side of the building and provides access to the storage bays. According to Drawing 169067, the elevation of the first floor slab is 4922 ft.

However, CPP-1619 was built at a time when the datum used by surveyors at the INEEL site was not NGVD29. Instead, the actual elevation is approximately one foot less, or 4921 ft in reference to NGVD29. A 6 in. curb surrounds the slab, as shown on Drawing 169065. Therefore the elevation of the exterior doors on the west side of the building is 4921.5 ft, which agrees with recent measurements made by INEEL surveyors. The elevation of the loading dock on the east side of the building is 4921 ft. Therefore all entry paths to the waste storage area are above the floodwater elevation. Drains are installed in the loading dock and are routed to two containment sumps constructed of stainless steel, and having a capacity of 275 gallons each. These sumps are located at the loading dock, and the elevation of the metal lids covering the sumps is 4918.75 ft.

A related building is CPP-1617, which is located at the Radioactive Mixed Waste Staging Facility. Building CPP-1617 is 20 ft × 40 ft, and is used for receiving, sorting, and packaging waste for temporary storage only. The Waste Staging Facility contains an asphalt pad used to store containerized waste outdoors. The ground elevation at the staging facility, which was measured at the entry gate at the north side, is 4917.0 ft. The entire facility is above the floodwater elevation and therefore CPP-1617 is not within the floodplain.

According to Drawing 169065, the ground level is 4 ft below the first floor slab, which places ground level at 4917 ft. Since the floodwater elevation is 4916 ft for the maximum credible flood, floodwater will not reach the exposed foundation wall but may saturate the soil. Since floodwater will not infiltrate Building CPP-1619, this study concerns mainly the foundation wall and its ability to withstand hydrodynamic and hydrostatic forces due to floodwater. In the following section, a hydrostatic analysis is used to compute the pressure exerted on a retaining wall by saturated soil.

Hydrostatic Forces

The lateral earth pressure of saturated soil includes the effect of water pressure and soil pressure, as is shown in Fig. 1. Using the method described in Section 2.4 in Peck et al (4), the at-rest earth pressure due to the weight of soil is

$$P_{soil} = K_o(\gamma_{sat} \times H - \gamma_{water} \times H) = 0.375 \times \left(135\frac{lb}{ft^3} - 62.4\frac{lb}{ft^3}\right) \times H = 27.2\frac{lb}{ft^3} \times H,$$

where P_{soil} is the earth pressure, γ_{sat} is the weight of saturated soil, γ_{water} is the weight of water, H is the soil depth, and K_o is the at-rest earth pressure coefficient. The earth pressure coefficient is obtained from the relation

$$K_o = 1 - \sin\phi,$$

where ϕ is the angle of internal friction which is equal to 43^o according to the INEEL soils report (5). The weight of saturated soil at the INEEL is assumed to be equal to the weight of saturated, dense, mixed-grain sand, as is given in Table 1.4 in Peck et al (4). The resultant force per unit width of retaining wall is

$$F_{soil} = \frac{1}{2}P_{soil} \times H = 13.6\frac{lb}{ft^3} \times H^2,$$

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where F_{soil} is the resultant force that occurs at a height equal to $H/3$ from the base of the retaining wall. The hydrostatic pressure due to the presence of water in the soil is

$$P_{water} = \gamma_{water} \times H = 62.4 \frac{lb}{ft^3} \times H,$$

where P_{water} is the hydrostatic pressure. The resultant force per unit width of retaining wall is

$$F_{water} = \frac{1}{2} P_{water} \times H = 31.2 \frac{lb}{ft^3} \times H^2,$$

where F_{water} is the resultant force that occurs at a height equal to $H/3$ from the base of the retaining wall. The total resultant force per unit width of retaining wall is

$$F_{sat\ soil} = F_{soil} + F_{water} = 44.8 \frac{lb}{ft^3} \times H^2,$$

where $F_{sat\ soil}$ is the total resultant force that includes the weight of soil and water.

In the case of dry soil, the resultant force per unit width of retaining wall is

$$F_{dry\ soil} = \frac{1}{2} \times K_o \times \gamma_{dry} \times H^2 = \frac{1}{2} \times 0.375 \times 118 \frac{lb}{ft^3} \times H^2 = 22.1 \frac{lb}{ft^3} \times H^2,$$

where γ_{dry} is the weight of dry soil as given in the INEEL soils report (5). These results show that a substantial increase in lateral earth pressure occurs when the soil becomes saturated. The at-rest lateral earth pressure of saturated soil is approximately two times larger than the pressure of dry soil. Since the topmost 40 feet of soil at INTEC is mostly sandy gravel that is dry and permeable (5), the assumption of saturated soil during a flood is conservative. Therefore, the calculated earth pressure is an upper bound on the actual earth pressure that would occur during a flood.

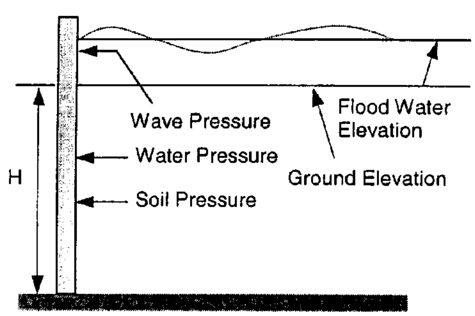

Fig. 1. The various forces acting on a retaining wall during a flood.

Structural Analysis

An important consideration in regard to flood protection is the ability of the retaining walls to withstand lateral earth pressure. In the section on hydrostatic analysis, the at-rest lateral earth pressure of saturated soil was computed and shown to be 2 times larger than the pressure of dry soil. This particular flood hazard affects all below-grade retaining walls that support backfill. The structural design of the building foundation is complex, and the concrete retaining walls have a variable height, width, and thickness. Surcharge loads are present in addition to lateral earth pressure. Furthermore, the strength of reinforced concrete depends on the exact size, number, and placement of the steel bars. Therefore, a detailed assessment of the stress in the foundation is a complex structural analysis that is beyond the scope of this study. However, the following observations suggest a simple way to assess the strength of the retaining walls and to demonstrate that the walls are more than adequate to support the increase in lateral earth pressure, which may occur as a consequence of a flood.

Building CPP-1619 has one level that is above grade and none below grade, as shown on Drawing 169059. The exterior retaining wall on the west side of CPP-1619 is 8 in. thick reinforced concrete supported by a concrete footing located 8 ft below the floor slab, as shown on Drawing 169063. The strength of the retaining wall on the west side of CPP-1619 represents the minimum strength of the entire foundation. Therefore, the following structural analysis of a concrete retaining wall uses the design of the west wall of CPP-1619 to demonstrate that the building can withstand hydrostatic forces caused by the maximum credible flood.

The following structural details are found on Drawing 169063. The height of the retaining wall is 8 ft 8 in. The distance from the base of the wall to the bottom of the floor slab is 7 ft 7 in. The thickness of the wall is 8 in. The exterior ground level is 4 ft below the top of the floor slab, as shown on Drawing 169065. Since the floor slab is 8 in. below the top of the wall, ground level is 4 ft above the base of the wall.

Consider a concrete beam pinned at both ends and acted on by hydrostatic forces, as shown in Fig. 2. This particular beam loading represents the earth pressure acting on both sides of a section of retaining wall. Simple supports are assumed since a rotation may occur at the ends of the beam where the wall is anchored to the slab and footing. The interior backfill exerts a force on the retaining wall opposite to the force of saturated soil, and this force is assumed to be equal to the at-rest earth pressure of dry soil.

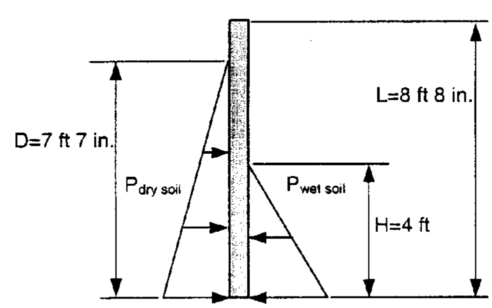

Fig. 2. Hydrostatic forces acting on a retaining wall.

Using the hydrostatic pressure calculated previously, the wet and dry soil pressures at the base of the beam are equal to

$$P_{wet} = 27.2\frac{lb}{ft^3} \times H + 62.4\frac{lb}{ft^3} \times H = 358.4\,lb/ft^2, \qquad P_{dry} = 44.3\frac{lb}{ft^3} \times D = 335.8\,lb/ft^2,$$

where $H = 4\,ft$ and $D = 7.58\,ft$. The maximum shear force and bending moment are obtained from the analytical formulas found in Roark and Young (6), Table 3, Case 2e:

$$M = \frac{P_{wet} \times (L - a_1)^2 \times a_1}{6 \times L} - \frac{P_{dry} \times (L - a_2)^2 \times a_1}{6 \times L} + \frac{P_{dry} \times (a_1 - a_2)^3}{6 \times (L - a_2)} = 881\frac{ft\,lbs}{ft},$$

$$V = \frac{P_{wet} \times (L - a_1)^2}{6 \times L} - \frac{P_{wet} \times (L - a_1)}{2} - \frac{P_{dry} \times (L - a_2)^2}{6 \times L} + \frac{P_{dry} \times (L - a_2)}{2} = 296\frac{lbs}{ft},$$

where $L = 8.67\,ft$, $a_1 = L - H = 4.67\,ft$, and $a_2 = L - D = 1.083\,ft$. The maximum shear force occurs at the base of the beam, and the maximum bending moment occurs at the point 4 ft above the base of the beam. The actual force and moment are multiplied by a load factor equal to 1.7, as specified in ACI 318 (7), to give $M_u = 1498\,lb\,ft$ and $V_u = 503\,lb$ per 1 foot width of beam.

To compute the allowable shear and moment capacity of the concrete beam, assume that the beam includes vertical reinforcement only and neglect the presence of horizontal reinforcement. The vertical reinforcement consists of one layer of #5 bar spaced 8 in. center to center, as shown on Drawing 169063. This meets the requirement that the area of vertical reinforcement shall not be less than 0.0015 times the wall area, as described in Section 14.3.2 of ACI 318 (7). Since the bar is placed in the middle of the slab, the concrete cover is equal to 4 in. The minimum 28-day compressive strength of the concrete is 4000 psi, as shown on Drawing 169063. Furthermore, the yield strength of the reinforcement bar is equal to 60,000 psi.

The computation of moment and shear capacity is based on ACI 318 (7) and the CRSI Design Handbook (8). The shear capacity is obtained from Section 11.3.1.1 of ACI 318 (7):

$$V_c = 0.85 \times 2 \times \sqrt{f_c'} \times b \times d = 0.85 \times 2 \times \sqrt{4000\,psi} \times 12\,in. \times 4\,in. = 5161\,lb,$$

where f_c' is the compressive strength of concrete, b is the width of the beam, and d is the distance from the extreme compression fiber to the center of mass of the tension reinforcement. The moment capacity for a single layer of tension reinforcement is obtained from page 5-7 in the CRSI Design Handbook (8):

$$M_n = 0.90 \times A_s \times f_y\,(d - a/2),$$

where A_s is the area of tension reinforcement, f_y is the yield strength of the reinforcement, and a is the depth of the concrete compression block which is obtained from a balance of concrete compression and bar tension:

$$A_s \times f_y = 0.85 \times f_c' \times b \times a.$$

The size and spacing of the reinforcing bars are used to calculate $A_s = 0.461\,\text{in}^2$. The depth of the compression block is

$$a = \frac{A_s \times f_y}{0.85 \times f_c' \times b} = \frac{0.461\,\text{in}^2 \times 60{,}000\,\text{psi}}{0.85 \times 4{,}000\,\text{psi} \times 12\,\text{in.}} = 0.678\,\text{in.},$$

and the moment capacity is

$$M_n = 0.90 \times A_s \times f_y\,(d - a/2) = 0.90 \times 0.461\,\text{in}^2 \times 60{,}000\,\text{psi}\,(4\,\text{in.} - 0.678\,\text{in.}/2) = 7595\,\text{lb} - \text{ft}.$$

The moment capacity of the beam is $M_n = 7595\,\text{lb ft}$ per 1 foot width of beam, which exceeds the factored moment computed above. The shear capacity of the beam is $V_c = 5161\,\text{lb}$ per 1 foot width of beam, which exceeds the factored shear computed above. In fact, the moment capacity and shear capacity in the retaining wall are greater than this simple example indicates, owing to the presence of 2-way slab action, intersecting walls, and horizontal reinforcement.

Conclusions

A 100-year flood coinciding with a failure of Mackay Dam is referred to as the maximum credible flood and is used as a conservative estimate of the 100-year flood for the purpose of RCRA permitting. A hydrostatic analysis was used to calculate the forces expected to occur at the foundation wall enclosing Building CPP-1619 during the maximum credible flood. A structural analysis was used to examine the design of the foundation wall, to check that the elevation of openings such as doorways and loading docks is above the floodwater elevation, to demonstrate that the retaining wall can withstand the hydrostatic force due to saturated soil, and to verify that washout of hazardous waste will not occur. The following results were obtained.

1. The elevation of the concrete floor slab, exterior doorways, loading dock, and sumps is higher than the floodwater elevation. All entry paths to the waste storage area are above the floodwater elevation.

2. The building is constructed to provide adequate drainage during a storm. Drains are installed in the loading dock and are routed to two containment sumps constructed of stainless steel, and having a capacity of 275 gallons each. The concrete floor of the loading dock is sloped so that rainwater and snowmelt entering the loading dock will drain into the sumps.

3. The ground elevation surrounding the foundation walls is above the floodwater level, and so floodwater will not reach the exposed foundation wall but may saturate the soil. A hydrostatic analysis of saturated soil was used to calculate the pressure exerted on the retaining wall. A structural analysis of the retaining wall demonstrates that the wall can withstand the forces caused by the maximum credible flood. Since the floodwater forces caused by the maximum credible flood are a conservative estimate of the floodwater forces caused by the 100-year flood, the enclosed waste will be protected from washout.

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1. *Code of Federal Regulations*, 40 CFR Ch. 1, Sect. 270.14(b), Para. 11(iv) A, August 1, 2000.
2. K. N. Koslow and D. H. Van Haaften, *Flood Routing Analysis for a Failure of Mackay Dam*, EGG-EP-7184, June, 1986.
3. INEEL Document ISD-5, *INTEC RCRA Interim Status Document for CPP-1617 and CPP-1619: Section A – General Description*, July 2000.
4. R. B. Peck, W. E. Hanson, and T. H. Thornburn, *Foundation Engineering*, 2nd Edition, John Wiley & Sons, NY, 1974.
5. *Soil and Foundation Investigation, Proposed New Waste Calcining Facility*, Prepared for The Energy Research and Development Administration, Fluor Contract No. 453504, Dames and Moore, 1976.
6. R. J. Roark and W. C. Young, *Formulas for Stress and Strain*, 5th Edition, McGraw-Hill, NY, 1975.
7. *Building Code Requirements for Reinforced Concrete*, ACI 318-99, American Concrete Institute, 1999.
8. *CRSI Design Handbook*, 3rd Edition, Concrete Reinforcing Steel Institute, 1978.

Drawings

1. INEEL Drawing 169059, *Hazardous Chemical Radioactive Waste Facility Architectural Floor Plan*, Rev. 5, September 1999.
2. INEEL Drawing 169063, *Hazardous Chemical Radioactive Waste Facility Foundation Plan, Sections, and Details*, Rev. 0, March 1987.
3. INEEL Drawing 169065, *Hazardous Chemical Radioactive Waste Facility Building Sections*, Rev. 0, March 1987.
4. INEEL Drawing 169067, *Hazardous Chemical Radioactive Waste Facility Wall Sections and Details*, Rev. 0, March 1987.