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Defense Nuclear Facility Safety Board Requirements for Low-Level Burial Grounds Closure/Postclosure

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Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

Approved for public release

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WHC Information Release Administration Specialist:

Christine Willingham — 9/22/97

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DEFENSE NUCLEAR FACILITY SAFETY BOARD REQUIREMENTS FOR THE LOW-LEVEL BURIAL GROUNDS CLOSURE/POSTCLOSURE

SUMMARY

This report addresses the Defense Nuclear Facility Safety Board requirements for the Low-Level Burial Grounds Closure/Postclosure as required by certain sections of the U.S. Department of Energy Order 5820.2A. This report is divided into sections beginning with a facility description identification of the applicable requirements of DOE Order 5820.2A and how the LLBG will meet these requirements, a reference section, and supporting appendices. The preparation of this report used several documents that address the requirements of DOE Order 5820.2A. Where possible, text from these documents was used to prepare this report.

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METRIC CONVERSION CHART

Into metric units			Out of metric units		
If you know	Multiply by	To get	If you know	Multiply by	To get
Length			**Length**		
inches	25.40	millimeters	millimeters	0.03937	inches
inches	2.54	centimeters	centimeters	0.3937	inches
feet	0.3048	meters	meters	3.2808	feet
yards	0.9144	meters	meters	1.0936	yards
miles	1.6094	kilometers	kilometers	0.62137	miles
Area			**Area**		
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092	square meters	square meters	10.7639	square feet
square yards	0.8361274	square meters	square meters	1.19599	square yards
square miles	2.59	square kilometers	square kilometers	0.386102	square miles
acres	0.404687	hectares	hectares	2.47104	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.03527	ounces
pounds	0.4536	kilograms	kilograms	2.2046	pounds
short ton	0.9071847	metric ton	metric ton	1.1023	short ton
Volume			**Volume**		
fluid ounces	29.57353	milliliters	milliliters	0.03	fluid ounces
quarts	0.9463529	liters	liters	1.05671	quarts
gallons	3.7854	liters	liters	0.26418	gallons
cubic feet	0.02832	cubic meters	cubic meters	35.3147	cubic feet
cubic yards	0.7645549	cubic meters	cubic meters	1.308	cubic yards
Temperature			**Temperature**		
Fahrenheit	subtract 32 then multiply by 5/9ths	Celsius	Celsius	multiply by 9/5ths, then add 32	Fahrenheit
Force			**Force**		
pounds per square inch	6.894757	kilopascals	kilopascals	1.4504×10^{-1}	pounds per square inch

Source: *Engineering Unit Conversions*, M. R. Lindeburg, PE., Second Ed., 1990, Professional Publications, Inc., Belmont, California.

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1.0 FACILITY DESCRIPTION

The active Low-Level Burial Grounds (LLBG) are a land-based unit consisting of eight burial grounds located in the 200 East Area and 200 West Area of the Hanford Site, Richland, Washington. Seven of the original eight burial grounds (218-E-10, 218-E-12B, 218-W-3A, 218-W-3AE, 218-W-4C, 218-W-5, and 218-W-6) contain or will contain mixed waste that is subject to Washington Administrative Code (WAC) 173-303 *Dangerous Waste Regulations*. In addition, portions of the 218-E-10, 218-E-12B, 218-W-3A, 218-W-3AE, 218-W-4C, and 218-W-5 Burial Grounds are designated as solid waste management units (SWMUs). One other burial ground (218-W-4B) within the LLBG is now designated completely as SWMU (DOE/RL-88-20).

Mixed waste is and has been received from onsite generating units and from offsite generators and is and will be disposed in mixed waste trenches. Leachate collected from lined trenches is transferred to leachate collection tanks that are located in proximity to the lined trenches.

Low-level radioactive waste and transuranic waste continues to be placed in the SWMU portions of the LLBG. Transuranic mixed waste has not been placed in the LLBG since August 19, 1987 [effective date for the Washington State Department of Ecology (Ecology) to regulate the dangerous waste component of mixed waste]. Soil is placed over some of the waste containers to provide radiological protection. Transuranic waste was placed in a manner that allows for retrieval and/or removal in the future if necessary. Any waste retrieved and/or removed will be processed and disposed in accordance with current federal and state requirements.

The 218-E-10 and 218-E-12B Burial Grounds are located in the 200 East Area (Figure 1-1). The 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, 218-W-5, and 218-W-6 Burial Grounds are located in the 200 West Area (Figure 1-2). The LLBG consist of various sizes and depths of lined and unlined disposal trenches. All mixed waste destined for disposal will meet land disposal restriction (LDR) requirements [WAC 173-303-140 and 40 Code of Federal Regulations (CFR) 268] or other regulatory alternatives. The lined trenches have leachate collection and removal systems. The less-than-90-day leachate collection tanks are operated in accordance with the generator provisions of WAC 173-303-200. The less-than-90-day leachate collection tanks have a current design capacity of 37,850 liters; however, future leachate collection tank capacity might change to accommodate various sized lined trenches.

Future mixed waste trench development and configuration within a burial ground are subject to change as disposal techniques improve or as waste management needs dictate. Mixed waste is disposed in lined or in unlined trenches. Disposal of mixed waste in unlined trenches requires an exemption from the liner/leachate collection system requirements [the *Hanford Facility Dangerous Waste Permit Application, Low-Level Burial Grounds* (DOE/RL-88-20, as revised) includes an exemption request for trench 94 for the disposal of U.S. Navy defueled reactor compartments].

The following provides a brief description and identifies the generic types of waste disposed in the LLBG. An electronic database (Solid Waste Information and Tracking System) is maintained that documents each waste receipt, type of waste, and disposal location.

- The 218-E-10 Burial Ground is approximately 36.1 hectares in size (Figure 1-3) and began receiving waste in 1960. Examples of waste placed in this burial ground include failed equipment, rags, paper, rubber gloves, disposable supplies, broken tools, and post-August 19, 1987 *Resource Conservation and Recovery Act* (RCRA) and state-only designated mixed waste.

- The 218-E-12B Burial Ground is approximately 68 hectares in size (Figure 1-4) and began receiving waste in 1967. Examples of waste placed in this burial ground include defueled reactor compartments (trench 94), low-level waste, and retrievable transuranic waste.

- The 218-W-3A Burial Ground is approximately 20.4 hectares in size (Figure 1-5) and began receiving waste in 1970. Examples of waste placed in this burial ground include ion exchange resins, failed equipment, tanks, pumps, ovens, agitators, heaters, hoods, jumpers, vehicles, accessories, retrievable transuranic waste, and post-August 19, 1987 RCRA and state-only designated mixed waste.

- The 218-W-3AE Burial Ground is approximately 20 hectares in size (Figure 1-6) and began receiving waste in 1981. Examples of waste placed in this burial ground include rags, paper, rubber gloves, disposable supplies, broken tools, and post-August 19, 1987 RCRA and state-only designated mixed waste.

- The 218-W-4B Burial Ground is approximately 3.5 hectares in size (Figure 1-7) and began receiving waste in 1968. Examples of waste placed in this burial ground include rags, paper, rubber gloves, disposable supplies, broken tools, alpha caissons, and retrievable transuranic waste.

- The 218-W-4C Burial Ground is approximately 20 hectares in size (Figure 1-8) and began receiving waste in 1978. Examples of waste placed in this burial ground include contaminated soil, decommissioned pumps, pressure vessels, post-August 19, 1987 RCRA and state-only designated mixed waste, and retrievable transuranic waste.

- The 218-W-5 Burial Ground is approximately 37.2 hectares in size (Figure 1-9) and began receiving waste in 1986. Examples of waste placed in this burial ground include rags, paper, rubber gloves, disposable supplies, broken tools, and post-August 19, 1987 RCRA and state-only designated mixed waste. This burial ground currently contains double-lined mixed waste trenches (trenches 31 and 34). Trenches 31 and 34 also are designated as a greater-than-90-day container storage. Waste to be placed in trenches 31 and 34 for storage purposes predominately will be macro-encapsulated long-length contaminated equipment and other containerized waste that has been treated to meet LDR requirements. Adjacent to the double-lined mixed waste trenches are leachate collection tanks. Examples of waste to be disposed in the double-lined mixed waste trenches include mixed waste that has been treated to meet LDR requirements (including bulk waste), macro-encapsulated long-length contaminated equipment, etc.

- The 218-W-6 Burial Ground is approximately 16 hectares in size (Figure 1-10), has not received any waste, and is reserved for future mixed waste disposal.

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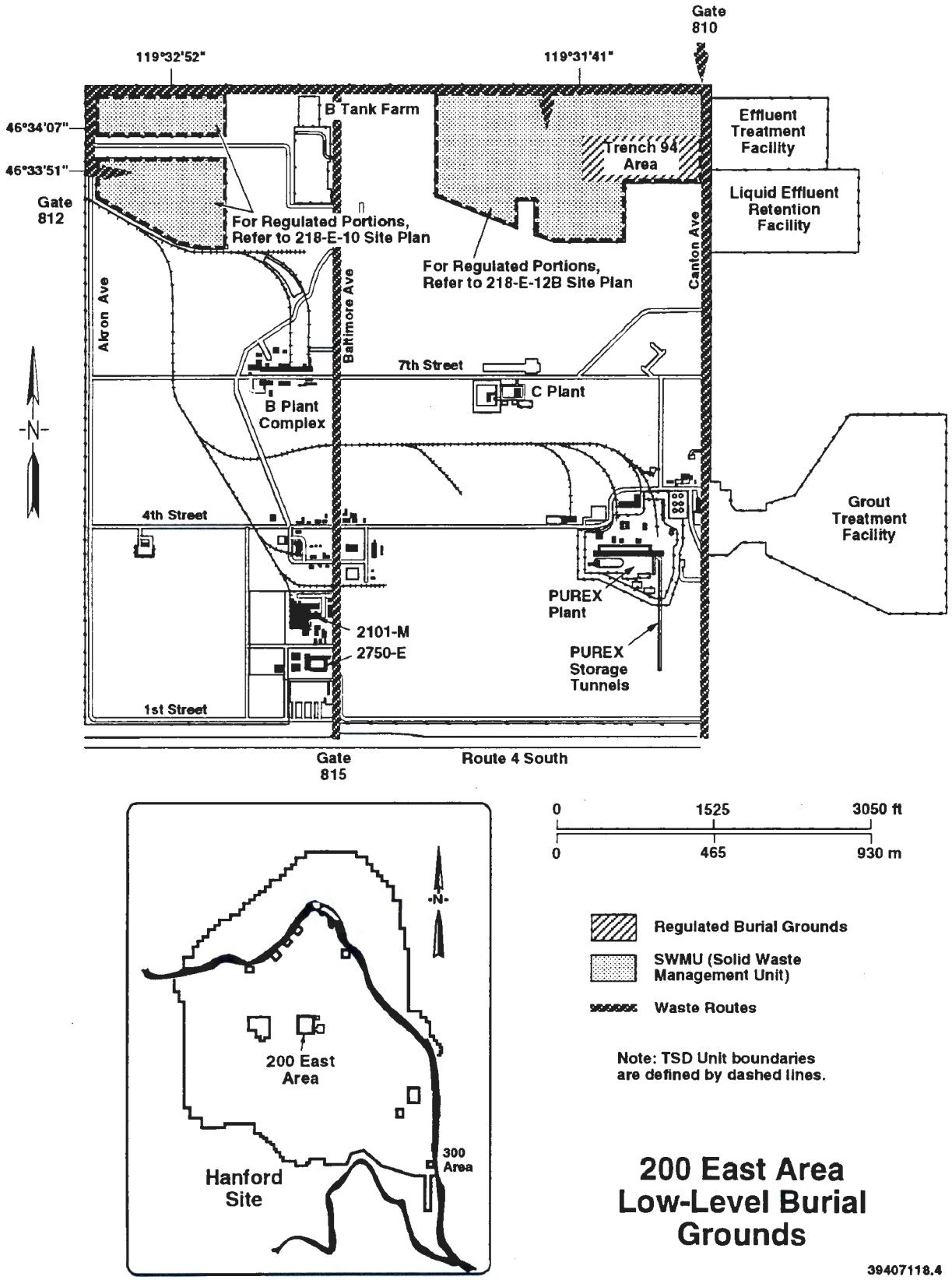


Figure 1-1. 200 East Area.

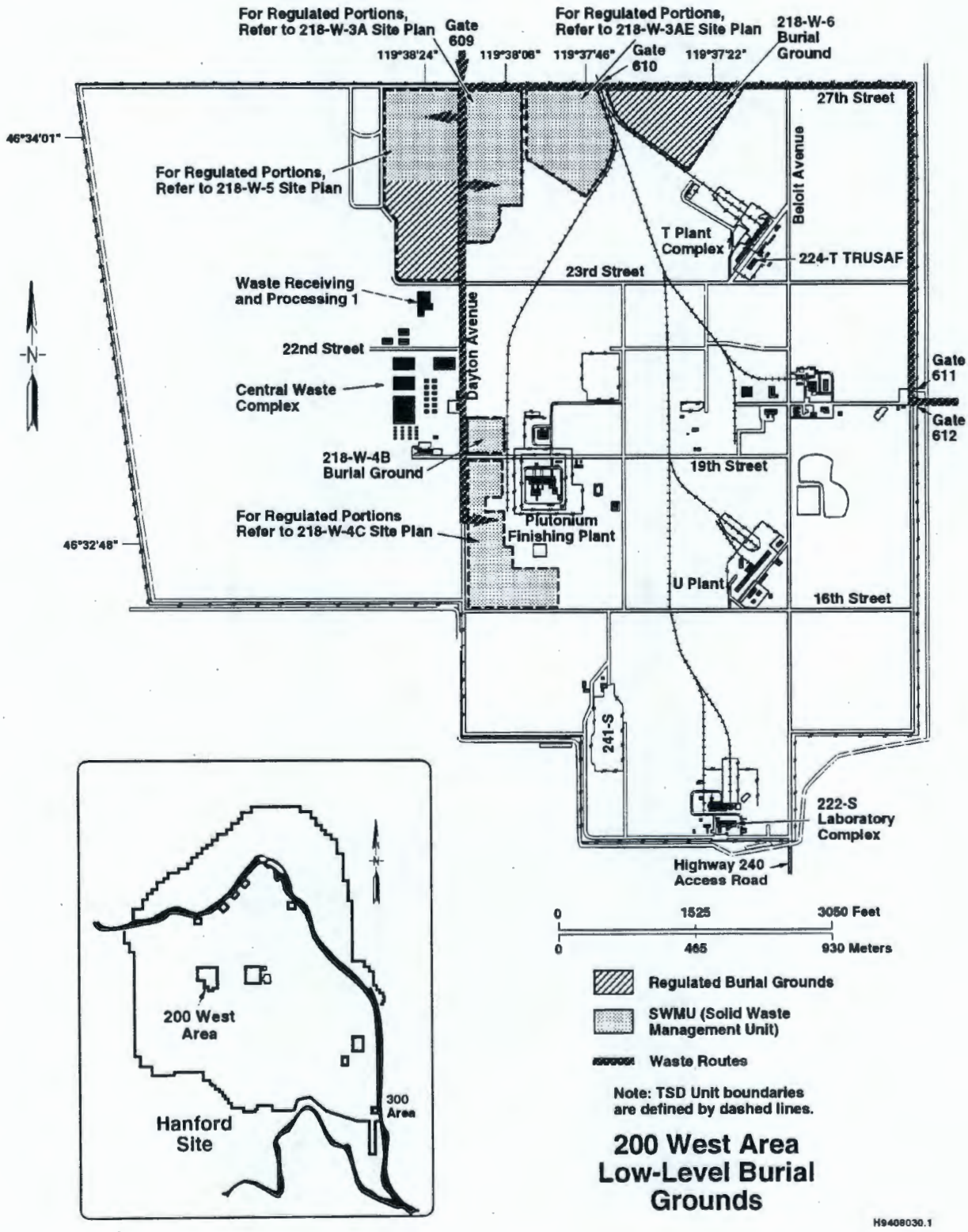


Figure 1-2. 200 West Area.

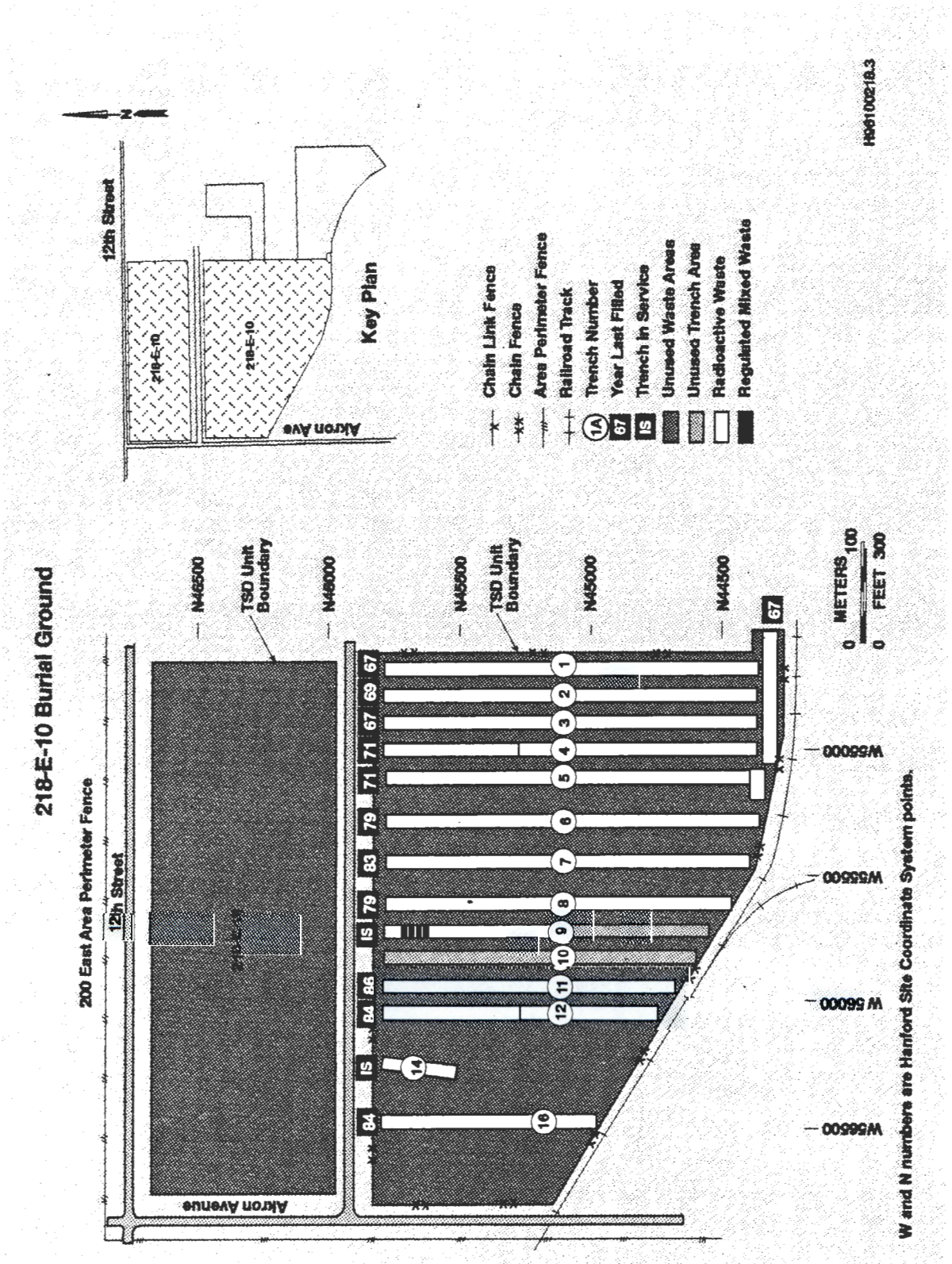


Figure 1-3. 218-E-10 Burial Ground.

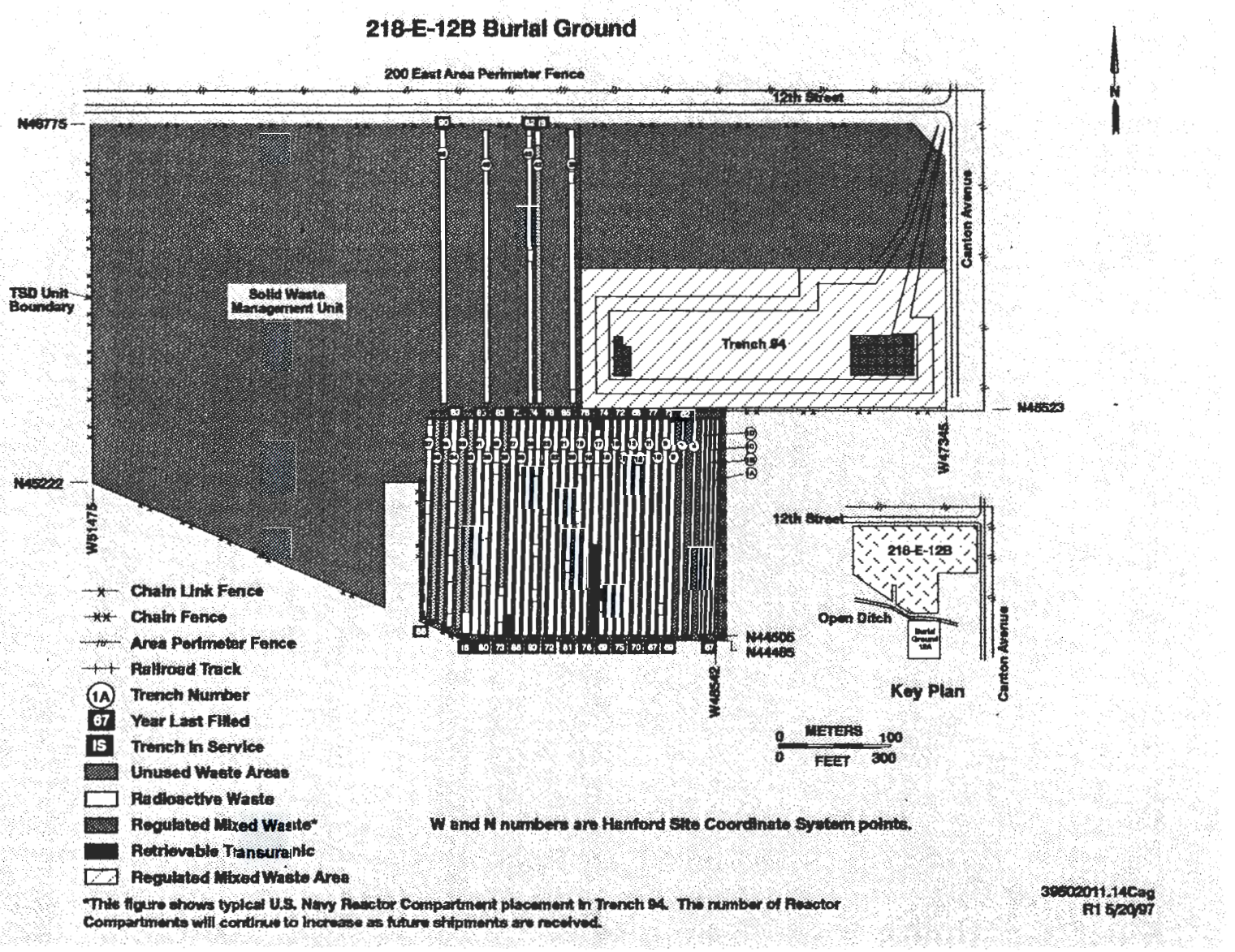
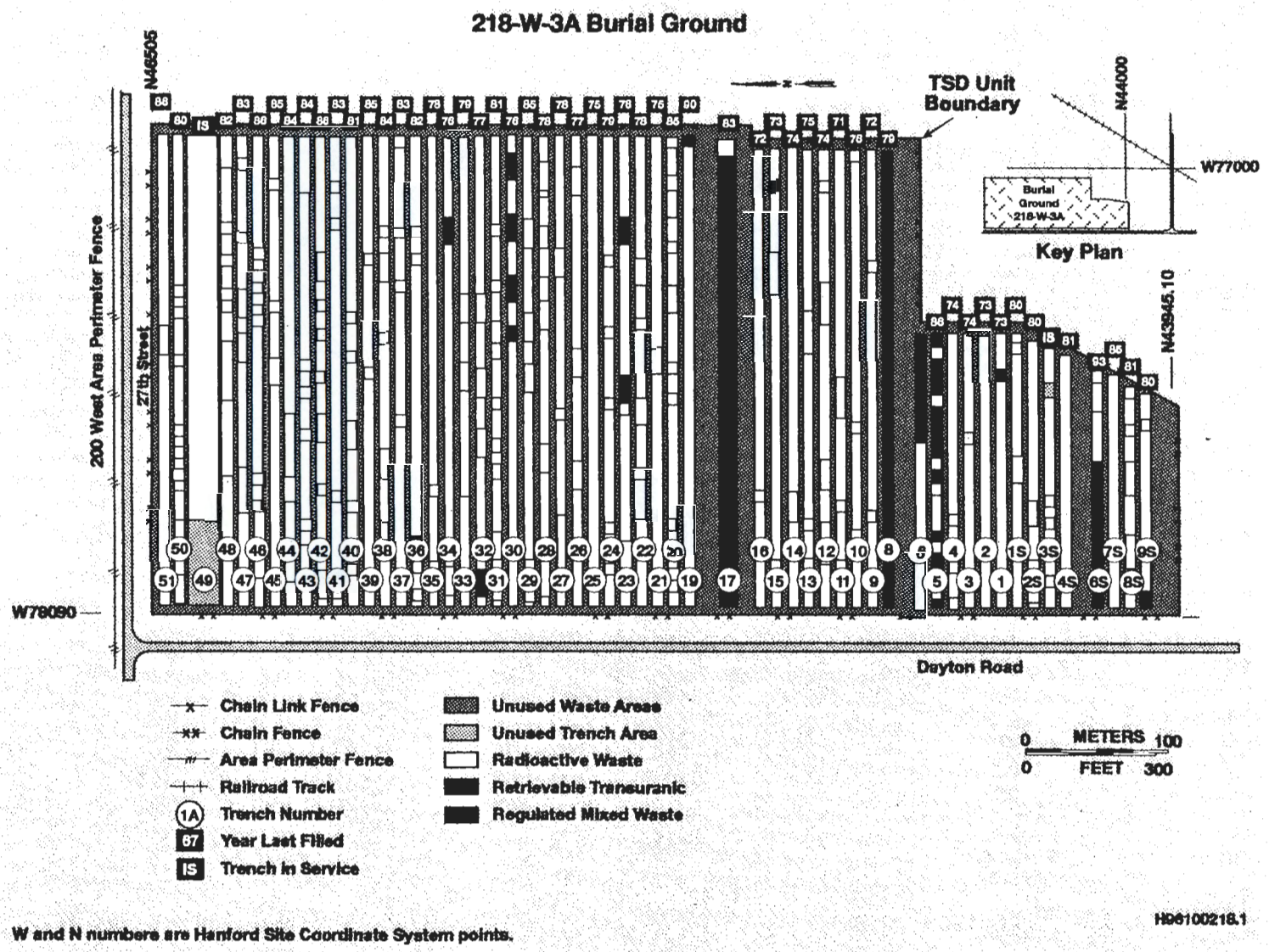


Figure 1-4. 218-E-12B Burial Ground.



W and N numbers are Hanford Site Coordinate System points.

Figure 1-5. 218-W-3A Burial Ground.

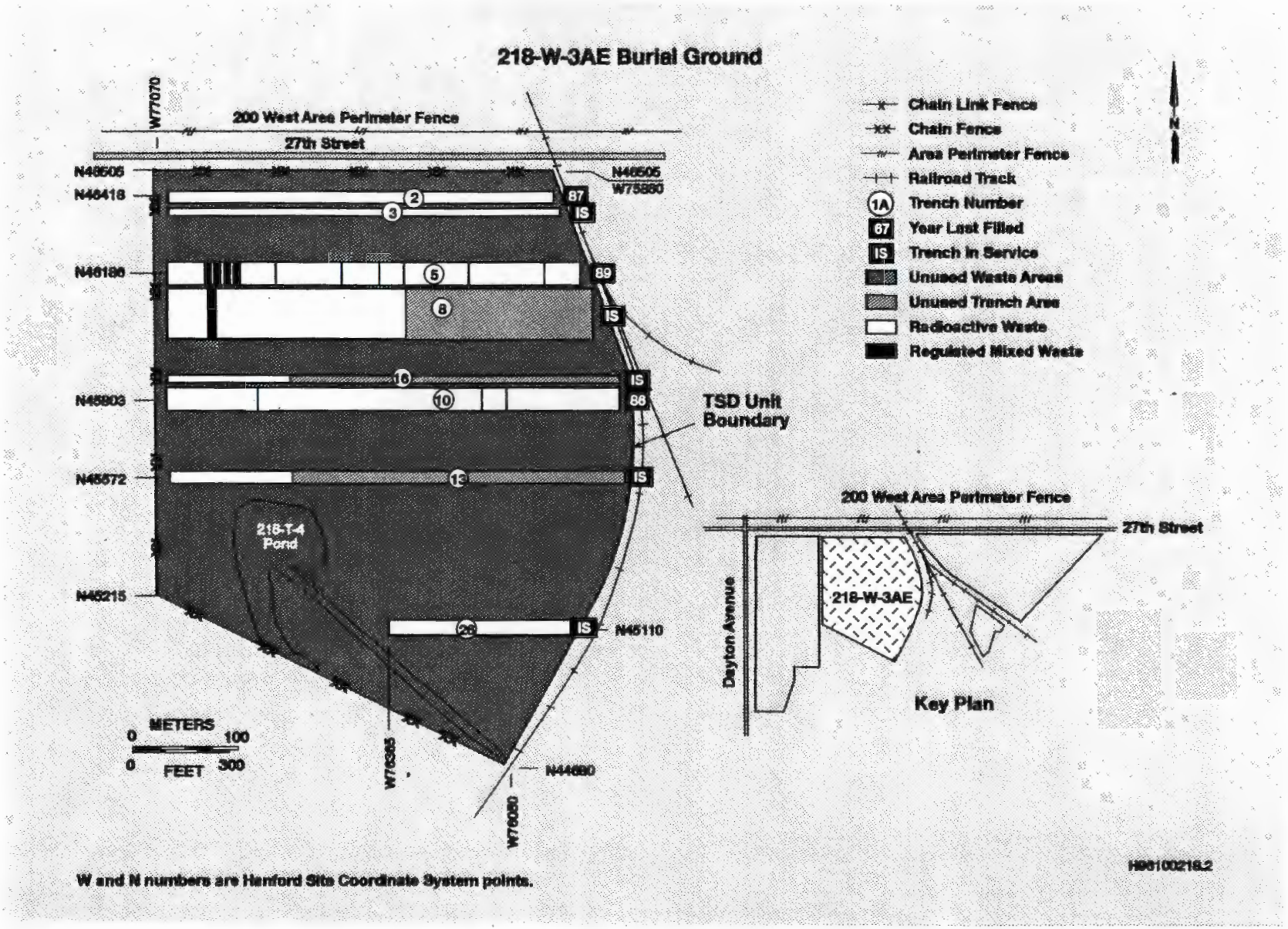


Figure 1-6. 218-W-3AE Burial Ground.

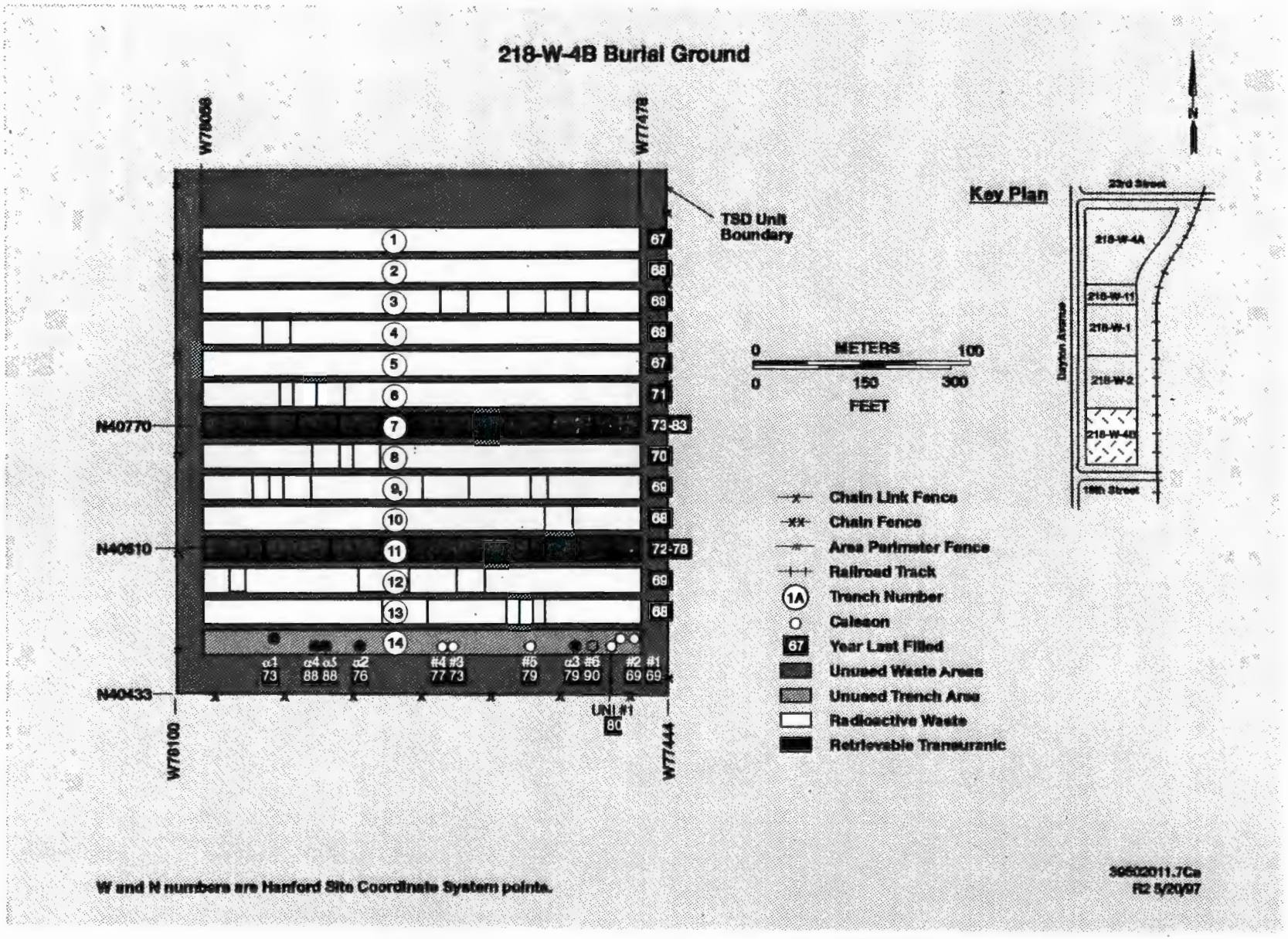


Figure 1-7. 218-W-4B Burial Ground.

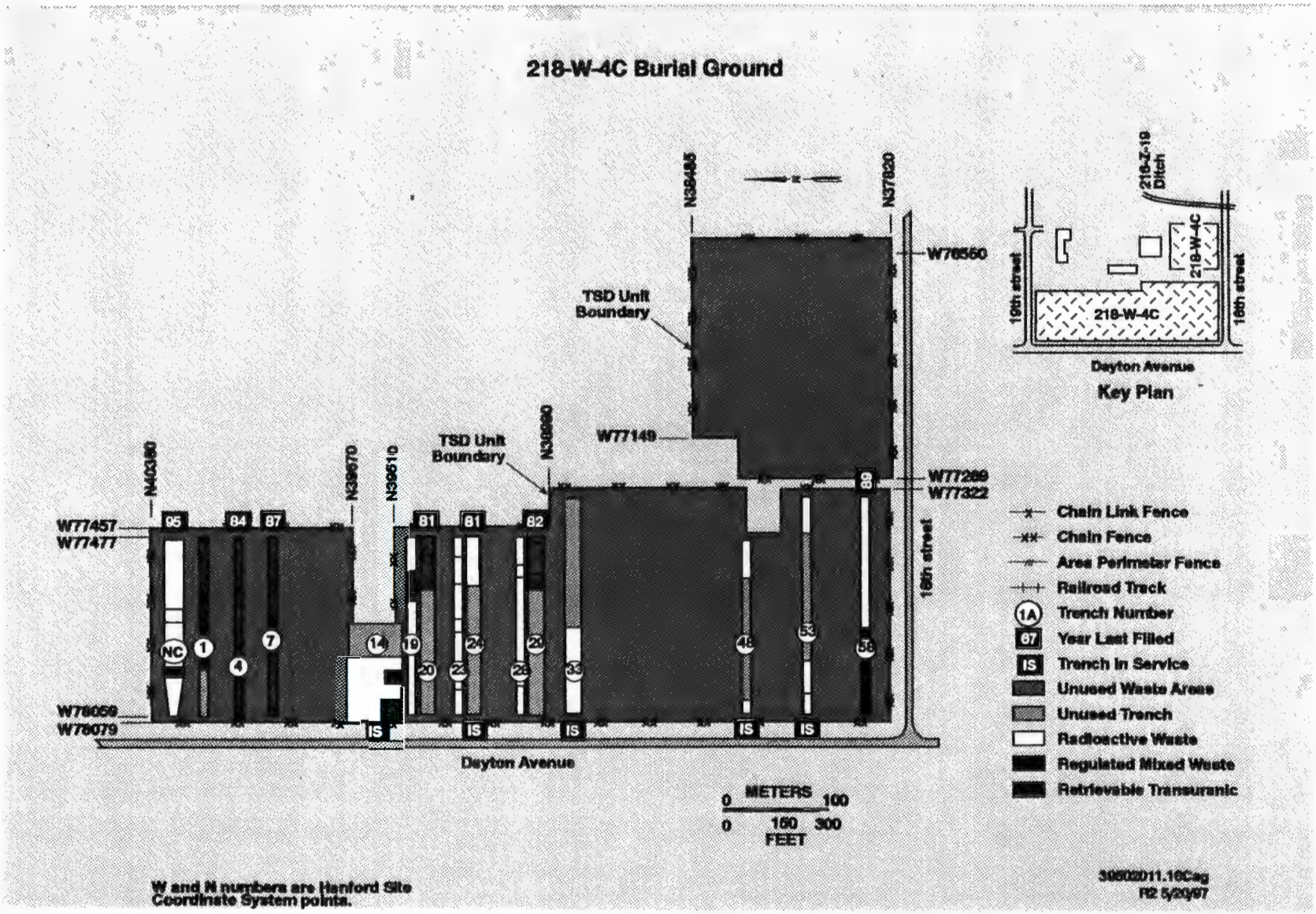


Figure 1-8. 218-W-4C Burial Ground.

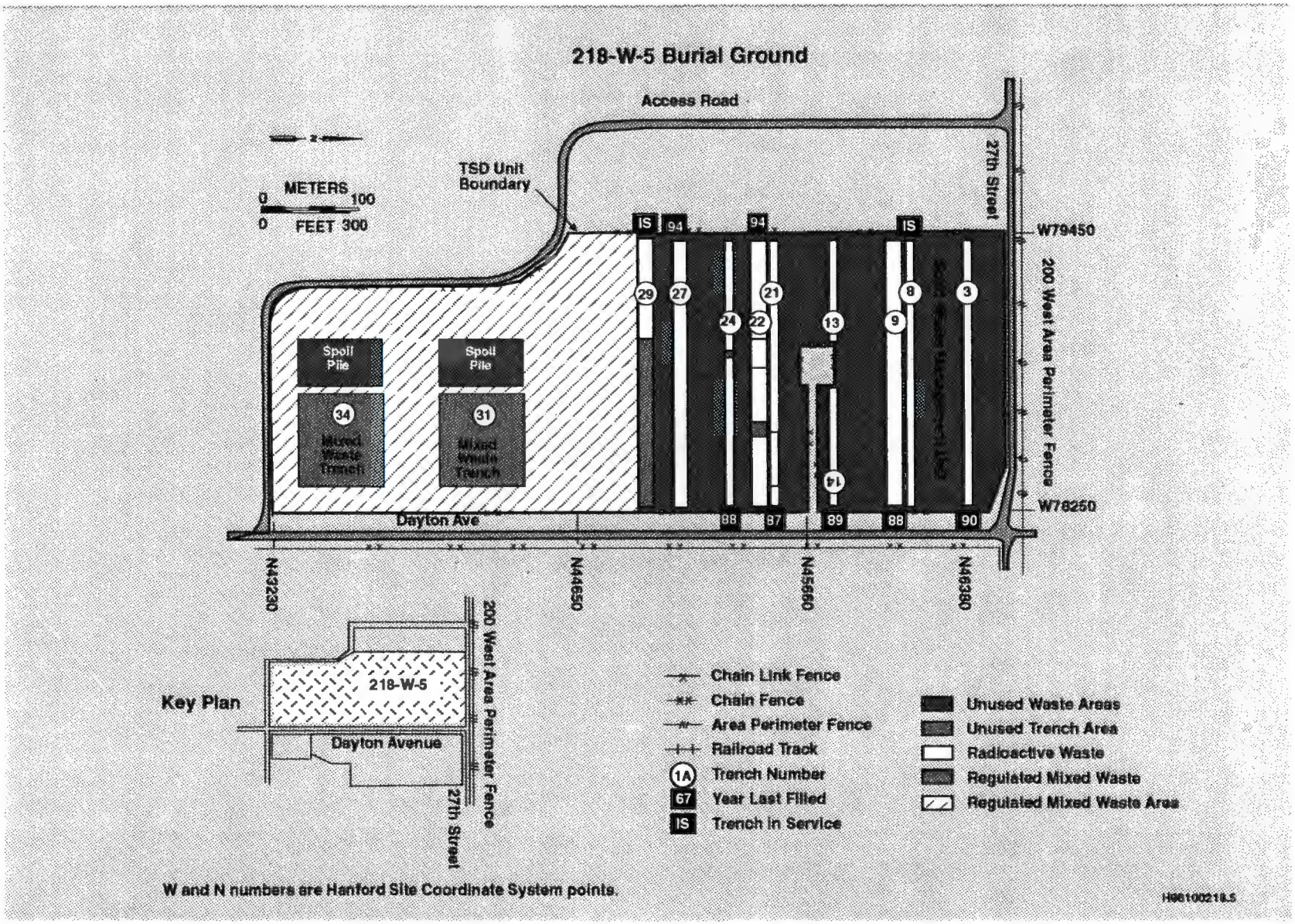


Figure 1-9. 218-W-5 Burial Ground.

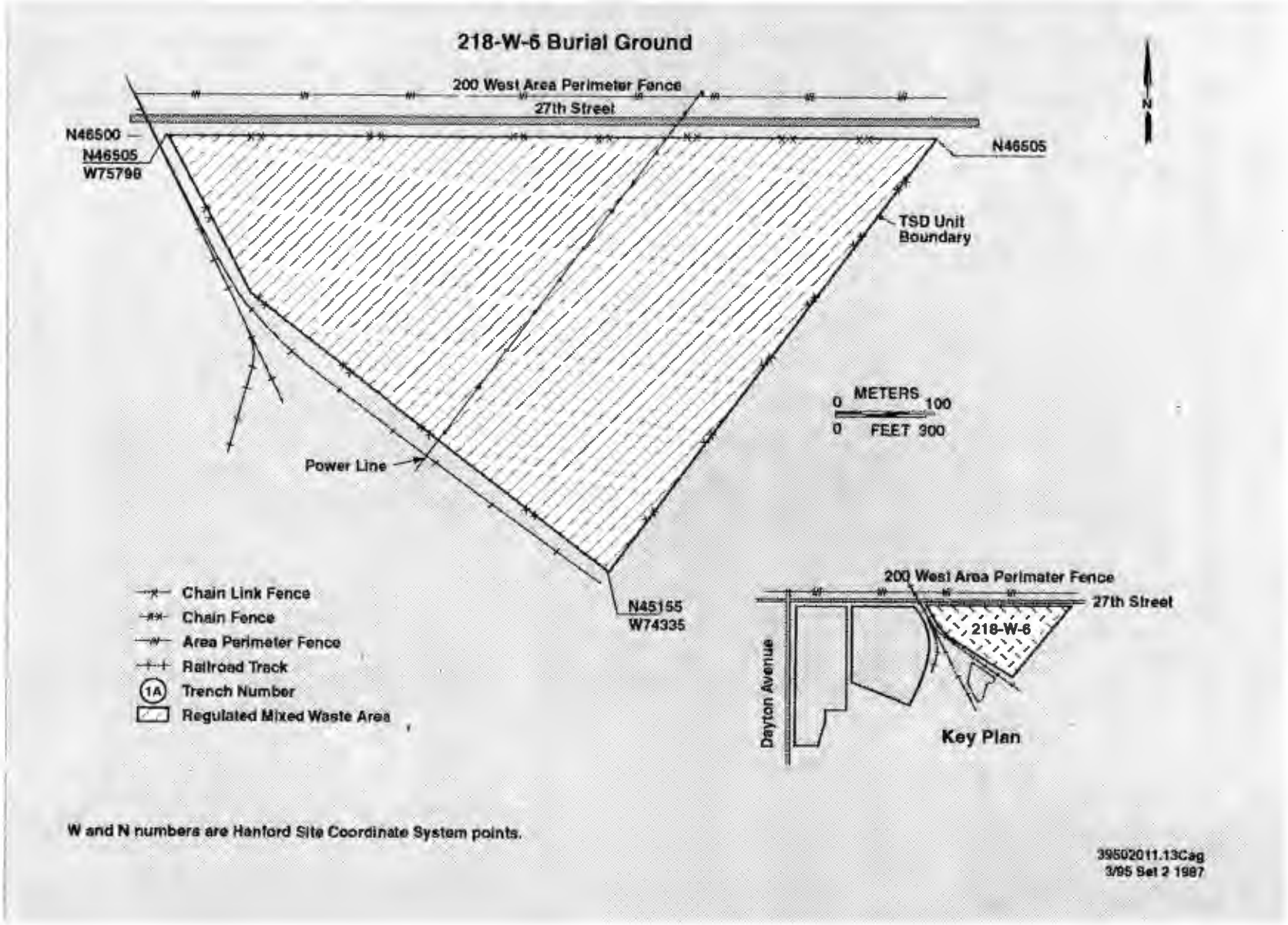


Figure 1-10. 218-W-6 Burial Ground.

2.0 U.S. DEPARTMENT OF ENERGY ORDER 5820.2A

The following sections of U.S. Department of Energy Order 5820.2A are addressed to support the Defense Nuclear Facility Safety Board (DNFSB) requirements for the Low-Level Burial Grounds (LLBG) closure/postclosure.

2.1 DOE ORDER 5820.2A, SECTION III.J. DISPOSAL SITE CLOSURE/POSTCLOSURE

(1) Field organizations shall develop site-specific comprehensive closure plans for new and existing operating low level waste disposal sites. The plan shall address closure of disposal sites within a 5-year period after each is filled and shall conform to the requirements of the National Environmental Policy Act process. Performance objectives for existing disposal sites shall be developed on a case-by-case basis as part of the National Environmental Policy Act process.

2.1.1 Closure/Postclosure Plan for the Low-Level Burial Grounds

Closure and postclosure of the LLBG will be a complex activity. In an effort to understand how the LLBG eventually will be closed, a brief description of the current operational and regulatory status of the various burial grounds must be understood. The following discusses the current status of each burial ground.

- The 218-E-10 Burial Ground, with the exception of a few small areas that contain post-August 19, 1987 RCRA/WAC 173-303 regulated waste, is a SWMU and continues to receive only low-level waste.

- The 218-E-12B Burial Ground with the exception of trench 94, contains no RCRA/WAC 173-303 regulated waste. The majority of this burial ground, with the exception of trench 94, is a SWMU and continues to receive only low-level waste. This burial ground also contains retrievable transuranic waste. This transuranic waste eventually will be removed and the trenches will be used only for low-level waste disposal.

- The 218-W-3A Burial Ground, with the exception of a few small areas that contain post-August 19, 1987 RCRA/WAC 173-303 regulated waste, is a SWMU and continues to receive only low-level waste. This burial ground also contains retrievable transuranic waste. This transuranic waste eventually will be removed and the trenches will be used only for low-level waste disposal.

- The 218-W-3AE Burial Ground, with the exception of a few small areas that contain post-August 19, 1987 RCRA/WAC 173-303 regulated waste, is a SWMU and continues to receive only low-level waste. This burial ground also contains retrievable transuranic waste. This transuranic waste eventually will be removed and the trenches will be used only for low-level waste disposal.

- The 218-W-4B Burial Ground contains no RCRA/WAC 173-303 regulated waste. This burial ground is full and no longer receives waste. However, this burial ground also contains retrievable transuranic waste. This transuranic waste eventually will be removed and the trenches will be used only for low-level waste disposal.

- The 218-W-4C Burial Ground, with the exception of a few small areas that contain post-August 19, 1987 RCRA/WAC 173-303 regulated waste, is a SWMU and continues to receive only low-level waste. This burial ground also contains retrievable transuranic waste. This transuranic waste eventually will be removed and the trenches will be used only for low-level waste disposal.

- The 218-W-5 Burial Ground contains RCRA double-lined leachate collection and removal system trenches (trenches 31 and 34). Trenches 31 and 34 are located in the southern one-third portion of this burial ground. There are two small areas in the northern two-thirds portion of this burial ground that contains post-August 19, 1987 RCRA/WAC 173-303 regulated waste. The majority of this burial ground is a SWMU and continues to receive only low-level waste.

- The 218-W-6 Burial Ground has yet to be used. This burial ground, in its entirety, is identified for future disposal of RCRA/WAC 173-303 regulated mixed waste.

2.1.1.1 Closure Plan. The LLBG RCRA-regulated areas will be closed according to the applicable dangerous waste regulations, U.S. Department of Energy requirements, and the best management practices available at the time of closure.

The cover(s) will be designed and located so that the cover(s) passively isolate the recognized hazard and properly protect human health and the environment. The cover(s) will conform to the requirements of WAC 173-303-610. The specification and/or variation for other cover designs will be provided at the time of closure once the hazard(s) have been defined. Although a final detailed cover design cannot be provided for all applications at this time, at closure, all covers will be designed to adequately protect human health and the environment.

2.1.1.2 Pre-closure Activities. A complete list of partial closure activities has not been defined. It is assumed that pre-closure activities could include, at a minimum, placing interim or final covers over the lined mixed waste trenches once these trenches are no longer receiving waste. Placement of covers over individual trenches might be deferred until closure of the entire LLBG. Once a decision is made to construct final covers over the various burial grounds, a cover will be designed based on the hazard to be isolated. A closure cover design that satisfies the dangerous waste disposal requirements as defined in WAC 173-303 will be placed over the lined mixed waste trenches at the time of closure.

This closure plan does not address the closure of adjacent waste management areas (e.g., CERCLA operable units, other TSD units, etc.). However, this closure plan does address some of the parameters that will have to be evaluated when a burial ground is filled and ready for closure

(Figure 2-1). In addition, this closure plan does not address activities outside the present scope and operation of the LLBG that might impact future disposal activities across the Hanford Facility.

Current waste management operations require that when a trench is filled with only low-level waste, the trench is backfilled with soil to match the surrounding topography, which is predominately flat. This cover is compacted by track-walking (e.g., weight of dozer) to stabilize and minimize subsidence. A maintenance and inspection program is implemented during this interim period to control erosion (e.g., the planting of shallow-rooted plants; an ongoing ocular monitoring program to remove any deep rooted plants; and filling in areas of subsidence, correcting any wind or water erosion if observed, and burrowing animals and insect intrusion) and other natural deterioration that could compromise human health or the environment. A chain-link fence might be erected around the perimeter of a backfilled burial ground for safety. On filling an entire burial ground, a detailed analysis might be necessary to determine the best method for final closure.

As stated previously, the majority of the LLBG are used only for low-level waste disposal (SWMU) and this disposal is outside the regulatory scope of RCRA and WAC 173-303. However, the low-level portions do impact the ability to perform final closure of the RCRA portions of the LLBG. Another significant impact affecting closure of the LLBG is integration with nearby CERCLA operable units, operating TSD units (e.g., Double-Shell Tank System and active burial grounds), roads, rails, and utility lines. Depending on how the LLBG are closed, closure caps for the low-level portions and the RCRA portions could cover, partially cover, or impact these structures in an adverse manner. A combined approach to address the radioactive and RCRA/WAC 173-303 portions might be necessary (Table 2-1).

The LLBG are located in an arid climate. To date, no known releases (radioactive and/or mixed waste) have been detected from the LLBG. As stated previously, as a trench is filled, soil is added to make the trench match the surrounding topography and a program of erosion prevention is initiated. An exception is trench 94 of the 218-E-12B Burial Ground. To maximize the disposal capacity of this trench, the best operating method is to delay backfilling until the trench is filled with defueled reactor compartments. Other exceptions for delay would depend on best waste management practices.

2.1.1.4 Maximum Extent of Operation. The design capacity of the LLBG for mixed waste conservatively is calculated to be 174 hectare meters. The design capacity of the LLBG for low-level waste is estimated to be in excess of 6,000 hectare meters. In addition, the expansion area of 218-W-5 could provide a disposal capacity for low-level waste in excess of 15,000 hectare meters (Appendix A, LLBG topographic map).

2.1.1.5 Removing Dangerous Waste. Transuranic waste has been placed in various trenches of the LLBG since May 1970. Transuranic waste containers were placed on asphalt pads on the bottom of the trenches or placed in plywood-lined trenches. An earthen cover, where appropriate, was placed over the trenches to provide radiological protection. This waste was placed in a manner that allows for retrieval and/or removal in the future if necessary. No transuranic mixed waste has been placed into the LLBG since August 19, 1987. This waste eventually will be retrieved, processed, and disposed in accordance with current federal and state requirements. The low-level portion

of the transuranic waste will be disposed of as low-level waste. This disposal could take place in the trenches in which the transuranic waste was removed. The pre-August 19, 1987 mixed waste portion of the transuranic waste will be disposed in lined trenches. The transuranic portion will be processed and prepared for offsite disposal. It is assumed that the retrieval of transuranic waste will be conducted and completed during the operational phase of the LLBG.

2.1.1.5.1 Retrievable Transuranic Waste. Transuranic waste has been placed in several different configurations (WHC-EP-0225, WHC-EP-0226, WHC-EP-0245, and WHC-MR-0008). All transuranic waste packages placed in the LLBG were free of external contamination at the time of emplacement and were designed to maintain integrity for a minimum of 20 years. It is assumed that retrieval of this waste can be accomplished without generating an airborne release of radioactivity.

Where retrievable transuranic waste has been covered with soil, conventional excavating equipment could be used to remove the bulk of the fill soil, taking care not to damage the waste containers. If necessary, manual removal of soil could be required from around the waste containers. If the structural integrity of a container is questionable, additional precautions will be exercised that could include, but are not limited to, wrapping with polyethylene sheets, overpacking the container to prevent airborne release during subsequent handling operations, or retrieval would be conducted inside a full-containment structure to minimize the risk of an environmental release and to protect personnel.

It is assumed that the retrieval of transuranic waste would be completed during the operational phase of the LLBG. As such, this activity would not be subject to requirements contained in WAC 173-303-610.

2.1.1.5.2 Gas Sampling. In most transuranic waste areas, polyvinylchloride tubes were installed downward through the temporary waste area cover and operational cover into the waste zone for ambient air sampling. The tubes were installed and samples were taken periodically from the early 1970s through the mid-1980s. The primary objective of this testing program was to determine if the concentration of hydrogen gas generated by radioactive decay was sufficient to be of concern during retrieval operations and to determine moisture content. Although the results indicated that generation of hydrogen gas would not be of concern, additional confirmatory sampling will be conducted before retrieval.

The gas sampling system will be removed during retrieval of transuranic waste. Because these systems will be removed before closure, removal of these systems will not be subject to WAC 173-303-610.

2.1.1.6 Decontaminating Structures, Equipment, and Soil. All equipment used during waste sampling or retrieval will be decontaminated as required to ensure the safety of personnel. Decontamination also will be performed before the use of such equipment in a subsequent retrieval operation to prevent cross-contamination. If required, radiological decontamination will be performed before nonradiological decontamination. Although certain types of materials will require special chemical or other decontamination procedures, routine decontamination generally will be accomplished by one of the following:

- Washing the items in nonphosphate detergent and tap water
- Rinsing or washing down three times with tap water
- Wiping with nonflammable, nontoxic cleaning solution.

If, after decontamination activities, waste retrieval equipment or structures are shown to have contamination above the established decontamination standards, the use of such items will be restricted or discontinued. The overburden soil once removed will be carefully managed and stockpiled for future use. This soil could be used to cover waste that is disposed in the LLBG.

Equipment and structures that cannot be decontaminated to operational standards and contaminated soils, pavements, and waste residuals will be disposed in accordance with WAC 173-303-610(5).

2.1.1.7 Closure of Landfill Units. Closure of the LLBG will be consistent with the closure requirements specified in WAC 173-303-665(6) where appropriate.

The cover design(s) that will be used at the time of closure will satisfy the requirements for dangerous waste disposal as defined by WAC 173-303 and 40 CFR 264. Two designs are considered for this report: a proposed preliminary final cover for trenches 31 and 34 (Appendix B) and a conceptual cover design (Appendix C).

2.1.1.8 Schedule for Closure. As stated previously, closure of the LLBG will be a complex process. Closure of the various burial grounds that comprise the LLBG is not expected to occur within the next 30 or more years. A disposal strategy document (WHC-SD-WM-ES-355) addresses the filling sequence of various trenches and provides an estimate as to when a burial ground will be filled. This document, addressing both mixed and low-level waste, is based on waste forecasts and is designed to be modified to account for the constantly changing waste forecasts. However, the majority of waste identified in this document is low-level only. This document projects to the year 2023. Therefore, in an effort to account for the uncertainty of a closure date for the various burial grounds, 10 years have been added to the dates identified in this document:

- 218-E-10 Burial Ground estimated date of closure 2033
- 218-E-12B Burial Ground estimated date of closure 2033
- 218-W-3A Burial Ground estimated date of closure 2033
- 218-W-3AE Burial Ground estimated date of closure 2033
- 218-W-4B Burial Ground estimated date of closure 2033 (Note: although this burial ground is full, retrievable transuranic waste will allow for future disposal of only low-level waste)
- 218-W-4C Burial Ground estimated date of closure 2033
- 218-W-5 Burial Ground estimated date of closure 2033
- 218-W-6 Burial Ground estimated date of closure 2033.

As stated, closure of various burial grounds of the LLBG is not anticipated to occur for more than 30 years.

2.1.2 National Environmental Protection Act

Currently a comprehensive solid waste environmental impact statement (which includes the LLBG) is being prepared. This EIS will address operations, expansions, closure, etc., of the LLBG. A record of decision is not anticipated for at least 2 years from the date of this report.

2.2 DOE ORDER 5820.2A, SECTION III.J. DISPOSAL SITE CLOSURE/POSTCLOSURE

(2) During closure and postclosure, residual radioactivity levels for surface soils shall comply with existing DOE decommissioning guidelines.

All burial grounds that comprise the LLBG are considered an active operating disposal unit. Closure of various burial grounds of the LLBG is not anticipated to occur for more than 30 years. Closure/postclosure activities will be in compliance with existing decommissioning guidelines for residual radioactivity levels for surface soils. Refer to Section 2.1 for discussion on how the LLBG could be closed.

2.3 DOE ORDER 5820.2A, SECTION III.J. DISPOSAL SITE CLOSURE/POSTCLOSURE

(3) Corrective measures shall be applied to new disposal sites or individual disposal units if conditions occur or are forecasted that could jeopardize attainment of the performance objectives of this Order.

The LLBG are located in a arid climate with a negative evapotranspiration rate. To date, no known releases (radioactive and/or mixed waste) have been detected from the LLBG since the installation of the groundwater monitoring network. Current waste management operations require that when a trench is filled with only low-level waste, the trench is backfilled soil to match the surrounding topography, which is predominately flat. This cover is compacted by track-walking to stabilize and minimize subsidence. An exception is trench 94 of the 218-E-12B Burial Ground. To maximize the disposal capacity of this trench, the best operating method is to delay backfilling until the trench is filled with defueled reactor compartments (Ecology has agreed to this approach). Other exceptions for delay would depend on best waste management practices. A maintenance and inspection program is implemented during this interim period to control erosion and other natural deterioration that could compromise human health or the environment (refer to Section 2.1.1.2). A chain-link fence might be erected around the perimeter of a backfilled burial ground for safety. On filling an entire burial ground, a detailed analysis might be necessary to determine the best method for final closure. Refer to Section 2.2 for transitioning a burial ground to inactive status and Section 2.1 for closure.

In addition, stringent controls on waste acceptance at the LLBG help ensure that mixed waste and/or radioactive constituents will not migrate from

the LLBG into the environment. These controls are accomplished by the Hanford Site Waste Acceptance Criteria (WHC-EP-0063-4) as well as the Waste Analysis Plan for the LLBG (HNF-SD-EN-WAP-002, as amended). The waste acceptance criteria addresses all waste types that the LLBG accepts for disposal [e.g., low-level, mixed (Class I or III)]. Each onsite and offsite generator that transfers or ships waste to the LLBG for disposal is provided with a copy of this waste acceptance criteria to assist them in making their waste acceptable for disposal in the LLBG. The waste analysis plan specifically focuses on mixed waste. This waste analysis plan discusses waste streams, verification rates, and acceptable and nonacceptable waste forms. The controls from these two documents ensure that the potential for mixed waste and/or radionuclide migration out of the LLBG is minimized and/or eliminated.

2.4 DOE ORDER 5820.2A, SECTION III.J. DISPOSAL SITE CLOSURE/POSTCLOSURE

> *(4) Inactive disposal facilities, disposal sites, and disposal units shall be managed in conformance with the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation, and Liability Act, and the Superfund Amendments and Reauthorization Act, or, if mixed waste is involved, may be included in permit applications for operation of contiguous disposal facilities.*

As identified in Section 2.1, a RCRA/WAC 173-303 dangerous waste permit application for the LLBG (DOE/RL-88-20, Revision 1) has been submitted to Ecology. Currently, the LLBG are operating under interim status (WAC 173-303-400). The LLBG are anticipated to be under final status January 1, 1997.

2.5 DOE ORDER 5820.2A, SECTION III.J. DISPOSAL SITE CLOSURE/POSTCLOSURE

> *(5) Closure plans for new and existing operating low-level waste disposal facilities shall be reviewed and approved by appropriate field organization.*

As identified in Section 2.1, a closure plan has been developed for the LLBG that meets the requirements of WAC 173-303. This closure plan has been reviewed by Ecology, U.S. Department of Energy, Richland Operations Office (DOE-RL), as well as several other organizations to ensure that this plan meets the regulations as well as operating parameters of the LLBG. Because the LLBG dangerous waste permit application documentation is a 'living document', the closure plan is subject to constant review and/or modification to reflect current dangerous waste regulations, DOE Orders, etc. Closure of the various burial grounds is not expected to occur within the next 30 or more years and closure activities will be consistent with regulations at the time of closure. The cover design(s) that will be used at the time of closure will satisfy the requirements for dangerous waste disposal as defined by WAC 173-303 and 40 CFR 264.

2.6 DOE ORDER 5820.2A, SECTION III.J. DISPOSAL SITE CLOSURE/POSTCLOSURE

(6) Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.

Dangerous waste regulations (WAC 173-303) require landfills to continue with a groundwater monitoring program for 30 years after closure. Also, during the postclosure period, surveillance and maintenance will continue on the closure caps, and for precipitation run-off control systems, animal intrusion, etc. Closure of the various burial grounds is not expected to occur within the next 30 or more years (refer to Section 2.1). Conformance with this DOE Order will be addressed at the time of closure.

As a result of direction from DOE/RL via letter [J.D. Wagoner, DOE-RL, to W.J. Madia, Pacific Northwest National Laboratory (PNNL), and A.L. Trego, Westinghouse Hanford Company, "Single Groundwater Project for the Hanford Site" dated September 5, 1996 (Appendix D)], groundwater monitoring responsibilities, in their entirety (e.g., installation of new wells, maintenance of new wells, sampling, reporting, and recordkeeping, etc.) resides with Bechtel Hanford, Inc. and PNNL. PNNL is responsible for all RCRA groundwater monitoring activities on the Hanford Site.

This section of DOE Order 5820.2A will be complied with if it is determined that termination of monitoring (e.g., expiration of required monitoring period) and maintenance are no longer necessary to protect human health and the environment.

2.7 DOE ORDER 5820.2A, SECTION III.K. ENVIRONMENTAL MONITORING

(1) Each operational or non-operational low-level waste treatment, storage, and disposal facility shall be monitored by an environmental monitoring program that conforms with DOE 5484.1 and, at a minimum, meet the requirements of paragraph 3K(2) through 3K(4).

DOE Order 5484.1, Chapter III has been deleted. The Effluent and Environmental Monitoring Program Requirements are provided in DOE 5400.1, General Environmental Protection Program, specifically Chapter IV.

The following sections discus environmental monitoring for the LLBG.

2.7.1 Air Monitoring

The LLBG are identified as a fugitive source of emissions (refer to the Hanford Site Air Operating Permit Application, DOE/RL-95-07). Past air sampling activities at the LLBG have determined that emissions have been below established regulatory thresholds for both radioactive and toxic air pollutants. Air sampling activities continue to be conducted periodically. In addition, the Hanford Site has a continuous air sampling program in place to monitor for particulates, radionuclides, and toxic air pollutants.

2.7.2 Groundwater Monitoring

A interim status groundwater monitoring plan as required by 40 CFR 265 for the LLBG has been developed. This interim status groundwater monitoring plan is included as Appendix E. A final status groundwater monitoring report currently is being developed.

The LLBG are not a source of effluent discharges subject to National Pollutant Discharge Elimination System (NPDES) permitting. The LLBG does have storm water discharges and as such is subject to WAC 173-218 and the LLBG is included in *Miscellaneous Waste Streams Report* (DOE/RL-95-82) to address this activity. Before discharge of storm water effluent to the environment, screening is performed to ensure that discharge limits are within regulatory thresholds.

As a result of direction from DOE/RL via letter (J.D. Wagoner, RL, to W.J. Madia, PNNL, and A.L. Trego, WHC, "Single Groundwater Project for the Hanford Site" dated September 5, 1996 (Appendix D) groundwater monitoring for the LLBG is the responsibility of PNNL (refer to Section 2.6).

2.7.3 Radiological Monitoring

Radiological monitoring for the LLBG is addressed in the Solid Waste Burial Grounds Interim Safety Analysis, WHC-SD-WM-SARR-028, as amended.

2.8 DOE ORDER 5820.2A, SECTION III.K. ENVIRONMENTAL MONITORING

(2) The environmental monitoring program shall be designed to measure: (a) operational effluent releases; (b) migration of radionuclides; (c) disposal unit subsidence; and (d) changes in disposal facility and disposal site parameters which may affect long-term site performance.

The following sections discuss the environmental monitoring program for the LLBG.

2.8.1 Operational Effluent Releases

Waste management operations at the LLBG do not produce any effluent discharges subject to NPDES permitting. The LLBG does have storm water discharges and as such is subject to and is included in Miscellaneous Waste Streams Report (DOE/RL-95-82).

As a result of direction from DOE/RL via letter (J.D. Wagoner, RL, to W.J. Madia, PNNL, and A.L. Trego, WHC, "Single Groundwater Project for the Hanford Site" dated September 5, 1996 (Appendix D) groundwater monitoring for the LLBG is the responsibility of PNNL (refer to Section 2.6). This responsibility also includes the management and disposition of purge water generated during sampling of groundwater monitoring wells. Note: To date, there have been no known releases (radioactive and/or mixed waste) from the LLBG.

2.8.2 Migration of Radionuclides

To date, no known releases (radioactive and/or mixed waste) have been detected from the LLBG since the installation of the groundwater monitoring network. Current waste management operations require that when a trench is filled with only low-level waste, the trench is backfilled with soil to match the surrounding topography, which is predominately flat. This cover is compacted by track-walking to stabilize and minimize subsidence. Past air sampling activities at the LLBG have determined that emissions (both radiological and toxic) have been below established regulatory thresholds.

Radiological monitoring for the LLBG is addressed in the Solid Waste Burial Grounds Interim Safety Analysis, WHC-SD-WM-SARR-028, as amended.

2.8.3 Disposal Unit Subsidence

Current waste management operations require that when a trench is filled with only low-level waste, the trench is backfilled with soil to match the surrounding topography, which is predominately flat. This cover is compacted by track-walking to stabilize and minimize subsidence. A maintenance and inspection program is implemented during this interim period to control erosion (refer to Section 2.1.1.2). A chain-link fence might be erected around the perimeter of a backfilled burial ground for safety. On filling an entire burial ground, a detailed analysis might be necessary to determine the best method for final closure.

2.8.4 Changes in Disposal Facility and Disposal Site Parameters that could Affect Long-Term Site Performance

Although changes will occur to the LLBG site parameters during the operational life, these changes are not anticipated to affect long-term site performance.

2.9 DOE ORDER 5820.2A, SECTION III.K. ENVIRONMENTAL MONITORING

(3) Based on the characteristics of the facility being monitored, the environmental monitoring program may include, but not necessarily be limited to, monitoring surface soil, air, surface water, and in the subsurface, soil and water, both the saturated and the unsaturated zones.

The following sections discuss environmental monitoring of the LLBG

2.9.1. Surface Soil Monitoring

Radiological monitoring for the LLBG is addressed in the Solid Waste Burial Grounds Interim Safety Analysis, WHC-SD-WM-SARR-028, as amended.

2.9.2 Air Monitoring

Refer to Section 2.7.1 for discussion on air monitoring.

2.9.3 Surface Water Monitoring

There are no surface waters within the vicinity of the LLBG. The nearest surface water is the Columbia River. The Columbia River is approximately 8.0 kilometers from the 218-E-12B Burial Ground in the 200 East Area and 6.4 kilometers from the 218-W-5 Burial Ground in the 200 West Area.

2.9.4 Groundwater Monitoring

Refer to Section 2.7.2 for discussion on groundwater monitoring.

2.10 DOE ORDER 5820.2A, SECTION III.K. ENVIRONMENTAL MONITORING

(4) The monitoring program shall be capable of detecting changing trends in performance sufficiently in advance to allow application of any necessary corrective action prior to exceeding performance objectives. The monitoring program shall be able to ascertain whether or not effluents from each treatment, storage, or disposal facility or disposal site meet the requirements of applicable EH Orders.

Monitoring activities for the LLBG are established to measure release of contaminants as near as possible to a burial ground so that corrective action can be taken. However, releases from the LLBG are expected to be an extremely slow process, or nonexist. It is recognized in DOE Order 5820.2A that monitoring activities are likely to provide little indication of contamination release.

LLBG monitoring for radionuclide release currently is oriented toward worker safety and groundwater monitoring. As with all radiation zones, direct radiation level monitoring is conducted routinely in the LLBG to ensure worker safety. Other monitoring devices are operated in the vicinity of the LLBG as part of a site-wide monitoring program. A network of groundwater monitoring wells, air samplers, and thermoluminescent dosimeters are operated throughout the Hanford Site. The unconfined aquifer is the primary target of groundwater monitoring, and stack emissions from units are the primary target of air sampling. Surface waters, natural vegetation, soils, and animal parts are periodically collected and analyzed. Data collected from these monitoring devices are reported at least annually (e.g., PNNL-11139, DOE/RL-96-01, and WHC-EP-0573-4). The only real observation of radionuclide release from the LLBG, based on the current monitoring program, is the occurrence of contaminated tumbleweeds whose roots have penetrated the interim soil cover overlying the waste volume and come in contact with the waste.

The current site-wide monitoring system is capable of measuring environmental contamination generated by past soil column liquid discharges from cribs, ponds, ditches, and air emissions from reprocessing units. These events, largely discontinued, discharged relatively large amounts of

radioactivity into the environment at a rapid rate. It is not likely that this system is adequate to detect early radionuclide releases from the LLBG that might ultimately result in long-term environmental contamination (e.g., unconfined aquifer). It is estimated that any contaminates derived from the LLBG are unlikely to appear in the aquifer for many decades, even with conservative assumptions. These predictions are fundamentally a result of site hydrogeologic and meteorologic conditions coupled with the fact that the small mass of mobile radionuclides in the LLBG inventory, make for near-release detection extremely difficult.

However, as noted previously, the LLBG are located in an arid climate. Discharges of liquid effluent nearly have been eliminated on the Hanford Site. Also, waste acceptance criteria, double-lined mixed waste trenches, and interim covers after a trench has been filled (e.g., backfilled) all contribute to reducing and/or eliminating the release to the environment of radionuclides and/or mixed waste.

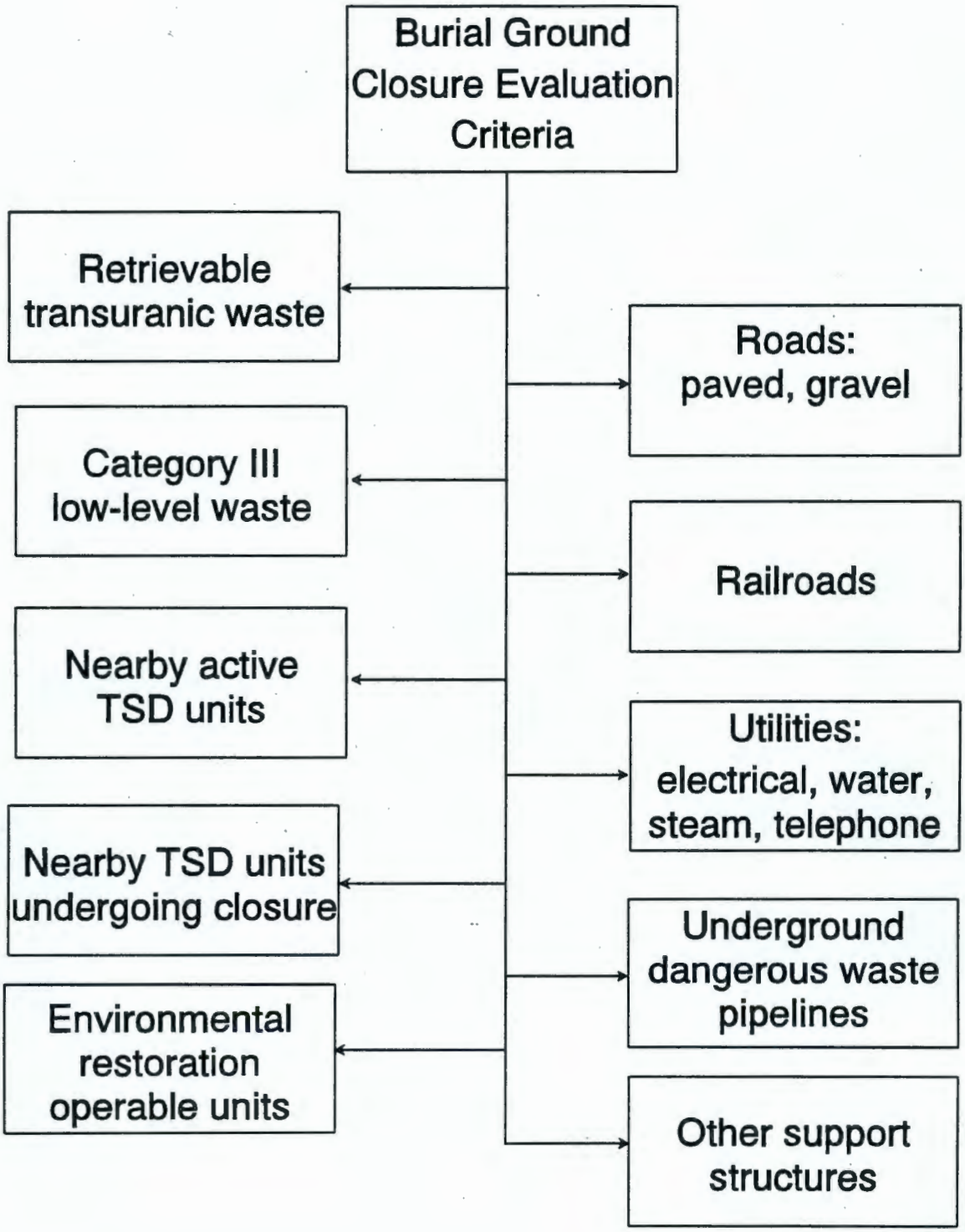


Figure 2-1. Low-Level Burial Grounds Closure Evaluation Process.

Table 2-1. Potential Interferences/Integration Opportunities With Closure Cap.

Burial ground	Predominant waste received	Land area used as of 01/97 (percent)	Contains retrievable transuranic waste	Contains Category III low-level waste	Active TSD units in vicinity	Operable unit	Roads	Railroads	Utilities	Environmental impacts (affected flora/fauna)
218-E-10	Low-level	60	No	Yes	No	200-BP-10	Akron Avenue 12th Street	Yes	Electrical	TBD
218-E-12B	Low-level, defueled reactor compartments (mixed waste)	20	Yes	Yes	No	200-PO-6	Canton Avenue 12th Street	No	Electrical Telephone	TBD
218-W-3A	Low-level	99	Yes	Yes	218-W-3AE 218-W-5	200-ZP-3	Dayton Avenue 27th Street	No	No	TBD
218-W-3AE	Low-level	30	No	Yes	218-W-3A 218-W-6	200-ZP-3 200-TP-3	27th Street	Yes	No	TBD
218-W-4B	Low-level	100	Yes	No	218-W-4C	200-ZP-3	Dayton Avenue 19th Street	Yes	Electrical	TBD
218-W-4C	Low-level	26	Yes	Yes	218-W-4B	200-ZP-3 200-ZP-1 200-UP-1	Dayton Avenue 16th Street 19th Street	Yes	Pump and treat Electrical	TBD
218-W-5	Low-level, mixed waste	20	No	Yes	218-W-3A WRAP 1	200-ZP-3	Dayton Avenue 23rd Street	No	Electrical Telephone	TBD
218-W-6	Future mixed waste	0	No	No	218-W-3AE	200-ZP-3	27th Street	Yes	Electrical	TBD

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APPENDIX A

TOPOGRAPHIC MAPS

APPENDIX A

H-13-000259, Rev. 0	200 East Area Low-Level Burial Grounds.
H-13-000260, Rev. 0	200 West Area Low-Level Burial Grounds.

APPENDIX B

COVER DESIGN FOR TRENCH 31 AND TRENCH 34

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APPENDIX B

COVER DESIGN FOR TRENCH 31 AND TRENCH 34

This appendix contains a description of the proposed final cover that might be constructed over trenches 31 and 34. A cross-section of the proposed cover design is shown in Figure 1 and includes: a low-permeability composite soil/bentonite layer, a low-permeability geomembrane layer, a high permeability drainage layer to channel infiltration to the margins of the cover; and an overlying surface soil layer designed to retain and recycle most precipitation to the atmosphere via evapotranspiration under the arid conditions on the Hanford Facility.

Maintenance needs will be minimized through low cover slope angles; limited length drainage paths, including a gravel admix to the surface soil layer to minimize eolian erosion; armoring the sideslope treatment with riprap; and revegetating the surface soil layer with shallow-rooted perennial grasses. The grasses and surface soil layer are expected to reduce liquid migration through the cover and help protect the cover against erosion. The surface slope will be designed to ensure adequate liquid run-off while minimizing surface erosion. The low slope angles, small cover size, and revegetation will minimize the visual impact of the cover and return the land to the general appearance and use of the surrounding area.

Existing waste materials might be stabilized as required through dynamic compaction and/or grouting to provide a stable foundation for the cover. Where the cover is placed over lined trenches, the cover will be designed to have a permeability less than or equal to that of the liner system, thereby avoiding ponding of water by the liner. The uppermost cover layer will consist of a silty, sandy soil with sufficient thickness to afford frost protection. This layer will be fine grained to enhance moisture retention in the shallow root zone of the perennial grasses where moisture will be available for evapotranspiration.

1.0 GENERAL DESCRIPTION

The landfill cover consists of several layers of soil and geosynthetic materials. Over the waste, the cover or grade layer (coarse) will be sloped at 3 percent to accommodate minor amounts of long-term settlement and facilitate drainage without causing excessive erosion. At the edge of the waste, the cover slope will be increased to 3H (horizontal):1V (vertical) to reduce the lateral extent and volume of material required to bring the cover to existing grade. A drainage ditch will be constructed around the perimeter of the cover to collect and discharge drainage (run-off). The drainage ditch will be sized to handle the run-off from a 50-year, 24-hour storm combined with a rapid snowmelt. Surface water run-on from areas adjacent to the cover and run-off from the cover itself will be controlled by this drainage ditch.

Gas generation is not expected to be significant, because the amount of organic material in the LLBG is relatively limited. In lined trenches, the

gas will vent through the primary leachate collection system. Consequently, no other gas venting systems will be required.

The riser pipes for the leachate collection and removal systems will penetrate the closure cover to allow for leachate monitoring and removal during the postclosure period. Penetrations through those cover components will not compromise the effectiveness of the cover. Access to the riser pipes for monitoring, maintenance, and leachate removal will be provided by roadways designed to prevent damage to the cover. Penetration and roadway details will be determined as part of the final design process.

Many details of the final cover design will depend on site-specific conditions and decisions made at the time of closure, particularly the local topography and the properties of the soil components used to construct the cover. These details are deferred until the final design. Construction procedures, particularly compaction requirements, also will depend on the actual material properties of the soils used for the cover. In this context, the procedures and design specifications are subject to change and cannot be finalized until material sources have been identified and tested. In practice, the processes of final design, material selection, construction specification, and cover performance assessment will be iterative. Nevertheless, general approaches can be identified at the present time based on current design/construction practice and reasonable assumptions concerning material properties. Example calculations have been performed to evaluate critical factors such as surface drainage and surface erosion. Detailed engineering support calculations will be prepared as part of the final design process.

2.0 COVER COMPONENTS

A cross-section of the cover is shown in Figure 1. The cover will be constructed on a soil grade layer that will be overlain by a soil/bentonite layer, a flexible membrane liner, a geocomposite drainage layer, a surface soil layer, and a vegetative cover. Riprap will be used as the sideslope treatment around the periphery of the cover. Material specifications, construction procedures, and quality assurance and quality control will be similar to those described for the lined landfill in Chapter 4.0.

2.1 GRADE LAYER

The upper surface of the waste will be compacted and contoured (graded) at 3 percent to provide the required slope for the overlying cover. Where needed, additional soil will be placed over the waste zone to achieve the required cover grade. The grade layer will taper from zero thickness near the edge of the outermost trench (the cover boundary) to a maximum of 3 meters at the center of the cover; the nominal thickness will depend on the lateral dimensions of the final cover design.

The grade layer will be constructed from soils obtained near the LLBG. This material will be sufficiently well graded to allow effective compaction. Field studies will be performed to identify suitable borrow sites. These studies will consist of evaluating existing geologic data pertaining to

surficial deposits, surface mapping and sampling, test pits, laboratory testing, and possibly surface geophysics or limited drilling.

The grade layer generally will be placed in uniform horizontal lifts, except near the edges of the cover where soil thickness will be tapered to meet grade specifications after compaction. The optimum lift thickness will depend on the soil and equipment characteristics and will be determined by constructing a test pad before cover construction. To minimize settlement, the grade layer will be compacted to 95 percent of maximum density as determined by ASTM D 1557 [modified proctor (ASTM 1993)] or other method such as M41-10, Section 2-03.3(14)C (WSDOT 1991), as applied during the construction of the prototype barrier (DOE/RL-94-76). Compaction will be accomplished with a large, smooth drum vibratory roller or similar piece of equipment, sized to prevent damage to underlying liner system components if present.

Before cover construction, a full-scale test pad will be constructed using the proposed soil material, construction equipment, and placement techniques. Density measurements of the placed grade layer will be taken periodically by bulk sampling and volume measurement techniques (e.g., ASTM D 4914). This testing will be used to determine the need for moisture conditioning, time constraints for placement, the optimum lift thickness, the required number of passes to achieve compaction, and other information necessary to establish quality control specifications.

2.2 SOIL/BENTONITE LAYER

A 61-centimeter-thick layer of soil mixed with bentonite will be placed over the grade layer to minimize vertical infiltration of water. This layer will serve as a barrier to long-term infiltration, should the overlying geomembrane be damaged or deteriorate. Using a low-permeability soil/bentonite layer combined with a flexible membrane liner is consistent with EPA recommendations for RCRA cover design (EPA-530-SW-89-047).

The soil component will consist of well-graded silt or silty sand from a suitable borrow source or screened from native soils. The maximum particle size generally will be 4.75 millimeters (no. 4 sieve) to exclude larger particles that might reduce the overall permeability of the mixture or puncture the overlying geomembrane. This soil will be mixed with enough bentonite to lower the hydraulic conductivity of the mixture to 1×10^{-7} centimeter per second or less at a readily achievable degree of compaction. The optimum percentage of bentonite will depend on the properties of both the soil and the bentonite itself and will be determined by laboratory testing of candidate mixtures. However, previous studies (Daniels 1988) indicate that approximately 10 percent bentonite should provide satisfactory performance.

The soil/bentonite material will be mixed (e.g., by disking or in a pugmill) at a location close to the cover and will be stockpiled to minimize moisture changes. If necessary, the surface of the grade layer will be moistened and proof rolled immediately before placing this admixture. To meet permeability specifications, the soil/bentonite layer will be placed in 15-centimeter-thick lifts and compacted with a self-propelled sheepsfoot compactor. The first lift could be somewhat thicker depending on compactor

and grade layer characteristics to prevent the soil/bentonite from being driven into the underlying layer. In-place densities will be measured with a sand cone or other direct method or a nuclear density gage calibrated to the specific mixture used for the cover. Permeability will be measured on thin-walled tube samples in the laboratory. The sample holes in the cover will be carefully backfilled and compacted by hand. Material that does not have an in-place hydraulic conductivity of $1x10^{-7}$ centimeters per second or less will be recompacted or replaced as appropriate, and the permeability test will be repeated. The top surface of the soil/bentonite layer will be rolled with a smooth drum roller to provide a flat, even surface for the overlying geomembrane. The moisture content of the admix surface will be maintained by sprinkling, covering, or other means to prevent drying and desiccation. Potential concerns regarding desiccation also will be mitigated by installing the other layers of the cover as soon as possible after the admix layer has been placed.

Before cover construction, a full-scale test pad will be constructed using the proposed soil/bentonite mixture, construction equipment, and placement techniques. This testing will be used to determine the time constraints for placement, the optimum lift height, the required number of passes to achieve compaction, the permeability-density relationships, and similar information necessary to establish quality control specifications. On one or more of the test pads, a sealed double ring infiltrometer test (ASTM D 5093) will be performed to verify that a large-scale portion of the cover can satisfy the permeability requirement.

2.3 FLEXIBLE MEMBRANE LINER

A flexible membrane liner (or geomembrane) will be placed over the soil/bentonite layer as a barrier to surface water infiltration. Using a flexible membrane liner is consistent with EPA guidance for RCRA cover design (EPA-530-SW-89-047).

The geomembrane will consist of a 40-mil sheet of HDPE, very-low-density polyethylene (VLDPE), or other suitable material. The 40-mil thickness is twice that recommended by the EPA (EPA-530-SW-89-047), but is considered appropriate to reduce the risk of damage during construction and subsequently during the postclosure period from such potential hazards as settlement, roots, and burrowing animals. The composition of the geomembrane will be selected for high resistance to normal weathering and chemical deterioration, including any fertilizers and herbicides that might be used to establish the vegetative cover. Physical and mechanical properties of the geomembrane, such as thickness, strength, and density, will be verified by conformance testing (to ASTM and other standard tests as appropriate) on samples of material received at the site. A flexible membrane liner that does not meet manufacturer's or design specifications will be rejected.

The geomembrane will be placed on the prepared soil/bentonite surface with several centimeters of overlap between adjacent sheets and, in most cases, the seams running downslope. Sheets will be joined by fusion or extrusion welding. Samples for destructive seam-strength tests will be taken every few hundred meters to ensure adequacy of the welding process, and the sample locations will be patched. Nondestructive tests such as vacuum box or pressure testing (the type of test will depend on the welding method) will be

performed along the entire length of all seams to ensure total seam integrity. Any part of a seam that fails these tests will be repaired or removed and patched as appropriate. Flexible membrane liner installation will be performed by specialists experienced in this technology and will be conducted under detailed quality assurance/quality control procedures to be developed as part of the final cover design.

Depending on construction staging, sandbags will be placed on the flexible membrane liner to prevent damage from wind uplift before the overlying layers are placed. Design methods, such as those described by Wayne and Koerner (1988), will be used to estimate more precisely the sandbag requirements. The sandbags will be removed before placing the drainage layer.

2.4 DRAINAGE LAYER

The drainage layer will conduct any water that percolates through the overlying surface soil layer laterally to the drainage ditch. Thus, the drainage layer will prevent hydraulic pressure from building up directly on the flexible membrane liner, and thereby will eliminate one set of forces that would drive moisture through the flexible membrane liner and underlying soil/bentonite layer.

The drainage layer will be a geocomposite consisting of a geonet with a geotextile thermally bonded to the upper side. The geocomposite will have a transmissivity equivalent to a 30.5-centimeter-thick soil layer that has a hydraulic conductivity of at least 1×10^{-2} centimeters per second. The geonet will be manufactured from HDPE or other suitable material commercially available.

The geotextile will prevent fine material in the overlying surface soil layer from washing into and clogging the drainage layer. The geotextile will consist of either a woven or non-woven fabric with sufficient permittivity (hydraulic conductivity across the plane of the fabric) to accommodate the maximum expected water flow through the surface soil layer. In addition, the pore size of the fabric will be appropriate to retain the fine materials in the overlying soil without long-term fabric clogging. Finally, the geotextile will be compatible with the components of its chemical environment such as soil chemistry, fertilizers, and herbicides. The geotextile will be selected during detailed cover design when the characteristics of the surface soil layer have been fully determined.

The geocomposite will be placed directly on the geomembrane, with several centimeters of overlap between adjacent sheets and, in most cases, the seams running downslope. Sheets will be joined by sewing or heat seaming, depending on the material selected. Installation will be performed by specialists experienced in this technology and will be conducted under detailed quality assurance/quality control procedures to be developed as part of the final cover design. If necessary, sandbags will be placed on the geocomposite to prevent wind damage before placing the overlying soil. The sandbags will be removed before placing the surface soil layer.

2.5 SURFACE SOIL LAYER

A 0.9-meter-thick layer of surface soil (91.5 centimeters) will be placed over the geotextile to prevent damage to the underlying cover components from erosion or other mechanical processes. The surface soil also will protect the soil/bentonite layer from freezing, which could disrupt its internal structure and significantly reduce its effectiveness as a moisture barrier. The soil will retain a significant fraction of normal precipitation for evaporation and (via the vegetative cover) transpiration back into the atmosphere. Finally, the surface soil layer will provide a suitable medium for plant growth. To prevent wind and water erosion, pea gravel will be added to the surface soil layer. Based on tests performed on the Hanford Facility, approximately 15 percent by weight will be added. A pug mill will be used to mix the gravel and soil. The pea gravel could be mixed in the top two lifts of the soil layer (top 30 centimeters) or could be mixed throughout.

Laboratory tests (particularly grain size distribution, moisture-density, and permeability) will be conducted during final cover design to support geotextile selection for the geocomposite. The results of these tests also will be used to establish compaction requirements to optimize erosion control (balancing the amount of infiltration versus surface run-off) and vegetation support.

The surface soil layer will be placed in 15-centimeter-thick lifts, except for the lowest lift, which will be 30.5-centimeter thick to avoid damage to the underlying geosynthetic layers. The soil will be dumped and carefully spread in the upslope direction by small, low-ground-pressure bulldozers using placement techniques that will avoid dragging the soil across the geocomposite. The surface soil will be compacted to about 85 percent maximum dry density as determined by ASTM D 698 [standard proctor test (ASTM 1993)] using sheepsfoot or rubber tire rollers or possibly by 'track walking' with a low-ground-pressure bulldozer. This compaction specification is tentative and could change as a result of the laboratory testing described previously. The uppermost lift of the surface soil will be 'track walked' only to facilitate establishing the vegetative cover. Fertilizers and/or herbicides also could be added to the soil in the upper lift at this time.

2.6 VEGETATIVE COVER

The vegetative cover will perform three functions. First, the plants will return water stored in the surface soil back to the atmosphere, significantly decreasing net infiltration and reducing the amount of moisture available to penetrate the cover. Second, the vegetation will help stabilize the surface soil component of the cover against wind and water erosion. Finally, the vegetative cover will restore the appearance of the land to a more natural condition. During final design, suitable species for the area, such as wheatgrasses, will be identified. The selection of the cover crop will be based on Hanford Facility experience.

Before seeding, the uppermost portion of the surface soil layer will be loosened by disking or other means. Fertilizer and/or herbicide will be added as appropriate; the need for these will be determined by experience and germination tests in the surface soil selected for the cover. The soil will be moistened before or immediately after seeding. Mulch could be used to

prevent excessive moisture loss. Wheatgrasses will be planted in the fall. If, due to scheduling, a cover is completed in the winter or spring, an annual cereal ryegrass mixture could be planted to control wind erosion during the summer. At the present time, irrigating the vegetation after seeding is not considered necessary, although a dry winter or other unforeseen conditions could require reseeding until the vegetative cover is established.

3.0 SIDESLOPE TREATMENT

A discussion of the proposed sideslope treatment is outlined in the following sections.

3.1 RIPRAP BEDDING LAYER

On the 3H:1V sideslopes, a 30.5-centimeter-thick bedding layer will be placed on the geotextile to serve as a foundation for the overlying riprap layer. The bedding layer also will serve to protect the geotextile from puncture by angular riprap, and consequently will help maintain the integrity of the drainage layer.

The riprap bedding layer will consist of native material ranging in size from coarse sand to fine gravel (0.5 centimeter to 2.54 centimeters in dimension). The grading will be suitable to provide a firm foundation for the overlying riprap layer and to prevent the underlying soil from washing out. The grading will be determined during final cover design after the riprap material has been characterized. It is anticipated that the riprap bedding layer could be produced by screening material from gravel pits located near the 200 Areas.

The riprap bedding layer will be placed in a single 30.5-centimeter lift to minimize the possibility of damage to the underlying geocomposite. The material will be dumped and carefully spread in the upslope direction by small, low-ground-pressure bulldozers using placement techniques that will avoid dragging the material across the geocomposite. No specific degree of compaction is required for this material, and 'track walking' should be adequate to prepare the bedding layer for the overlying material.

3.2 RIPRAP LAYER

On the 3H:1V sideslopes, a 61-centimeter-thick riprap layer will be placed over the riprap bedding layer to prevent erosion and gullying of these slopes from surface run-off. This layer also will prevent animals from burrowing laterally into these slopes.

The riprap layer will consist of native materials greater than 5.1 centimeters in dimension. This material should be readily available as a byproduct of preparing the bedding layer described previously. Because the cobble-sized material on the Hanford Facility generally appears to be subrounded, the material might need to be crushed to form a sufficiently stable slope. The need for crushing will be determined by characterizing the actual material and applying accepted design methodology. Precise grading

requirements for the riprap material will be determined during the detailed design process. Adequacy of riprap design will be verified by constructing a simulated test slope and subjecting it to the maximum expected run-off.

The riprap layer will be placed in a single lift. The material will be dumped and carefully spread in the upslope direction by small, low-ground-pressure bulldozers using placement techniques that will avoid dragging the material along the bedding layer. 'Track walking' is expected to adequately compact the riprap layer.

4.0 COVER DRAINAGE

Drainage of any precipitation that infiltrates through the surface soil layer is provided by an underlying high-capacity geocomposite drainage layer. The drainage layer is protected from clogging by the geotextile between the geonet and the overlying surface soil layer. The base of the drainage layer is a very low-permeability, flexible membrane liner sloped at a 3 percent grade toward the edge of the cover. Near the edge of the cover, the slope increases to 3H:1V, leading to a peripheral drainage ditch that forms the discharge zone for the geocomposite drainage layer. The drainage ditches will conduct water by gravity flow to one or more release points downslope from the LLBG.

The surface area of the trench 31 cover is estimated to be 1.6 hectares. The daily discharge of infiltrated water from the geocomposite drainage layer was determined using the HELP model. The peak daily discharge for the 10-year study period was about 3 cubic meters, or approximately 1 cubic centimeter per second. This discharge is small and readily can be accommodated by the peripheral drainage system.

The peak discharge of drainage water from the surface of the covers is expected to occur during winter periods of rain-induced rapid snowmelt. The 50-year, 24-hour storm (4.5 centimeters) of rain (PNL-4622), coupled with snowmelt was used to determine surface run-off over the surface area of the 1.6 hectare cover to provide a worst-case analysis. A snow depth of 22.9 centimeters was used in the analysis, representing the average cumulative snowfall recorded in Richland, Washington, during the months of December through February, for the period of 1951 through 1980 (NOAA 1985).

The HEC-1 computer model (USACE 1981) was used to determine the peak flow resulting from the forementioned combination of events. This model was selected because the model permits analysis of run-off from detailed hydrographs of individual, severe storms. The input data required for this model include the volume of precipitation, the soil type and vegetative cover, and the geometry of the covers. The results of this modeling indicate a peak surface discharge of about 0.35 cubic meter per second, which readily can be accommodated by a reasonable sized ditch. The design of drainage ditch will be performed during final design, using the approach outlined herein.

The surface run-off water discharged from the covers will be controlled by the surface drainage ditches of the run-off/run-on control systems. These drainage ditches will release cover run-off water to the 200 Areas surface water control systems. These systems consist of a network of unlined ditches,

generally parallel to roadways, which traverse the 200 Areas. Final designs of the run-of/run-on control systems will be developed as part of a comprehensive surface water control plan.

5.0 COVER RUN-ON

Perimeter ditches, located on the ground surface along the outboard margins of each cover and part of the previously mentioned run-off run-on control systems, will act as barriers to prevent run-on generated by precipitation from reaching the cover. The ditches will follow local topography and will drain by gravity flow into the 200 Areas surface water control system. The topography of the 200 Areas is relatively flat. The flow paths and travel times for run-on surface water typically are short, because the areas adjacent to the LLBG that contribute to run-on are limited by the many roads and structures, which are drained by the existing surface water control system.

The run-on control ditches will be located at the toe of the top surface of the cover, as shown on Figure 2. If necessary, these ditches will be lined with coarse sands and fine gravels to prevent erosion during high intensity, short-duration thunderstorms and large, rare precipitation events. The design flow will include run-on toward the cover as well as run-off from the surface of the cover, and will be based on the same rain-induced snowmelt scenario discussed previously. The ditches will be sized for a minimum of 9.1 centimeters of freeboard when carrying the peak design flow from a 50-year, 24-hour storm (4.5 centimeters) (PNL-4622), coupled with snowmelt.

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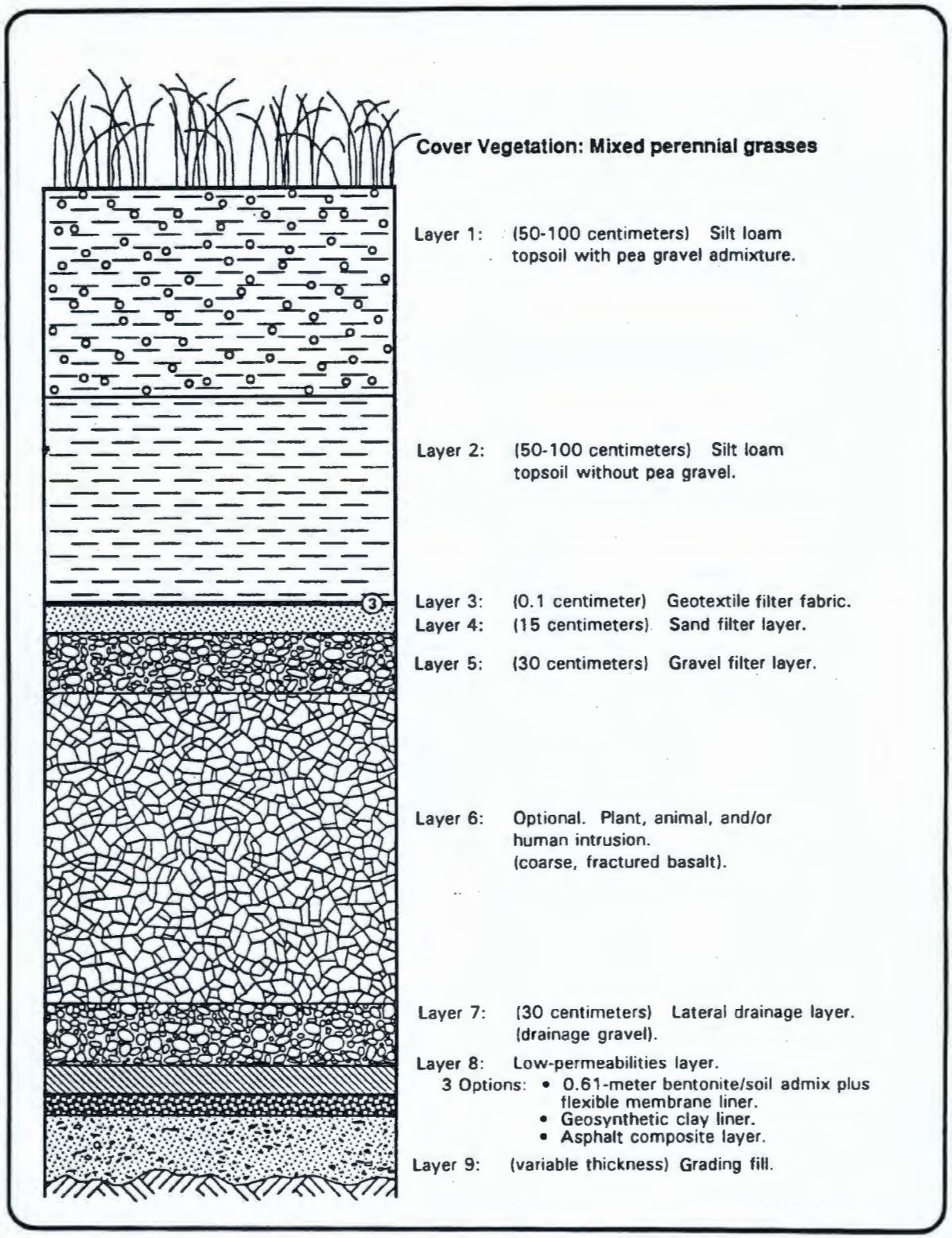

Figure 1. Cross-Section of Proposed Cover Design for Trench 31 and Trench 34.

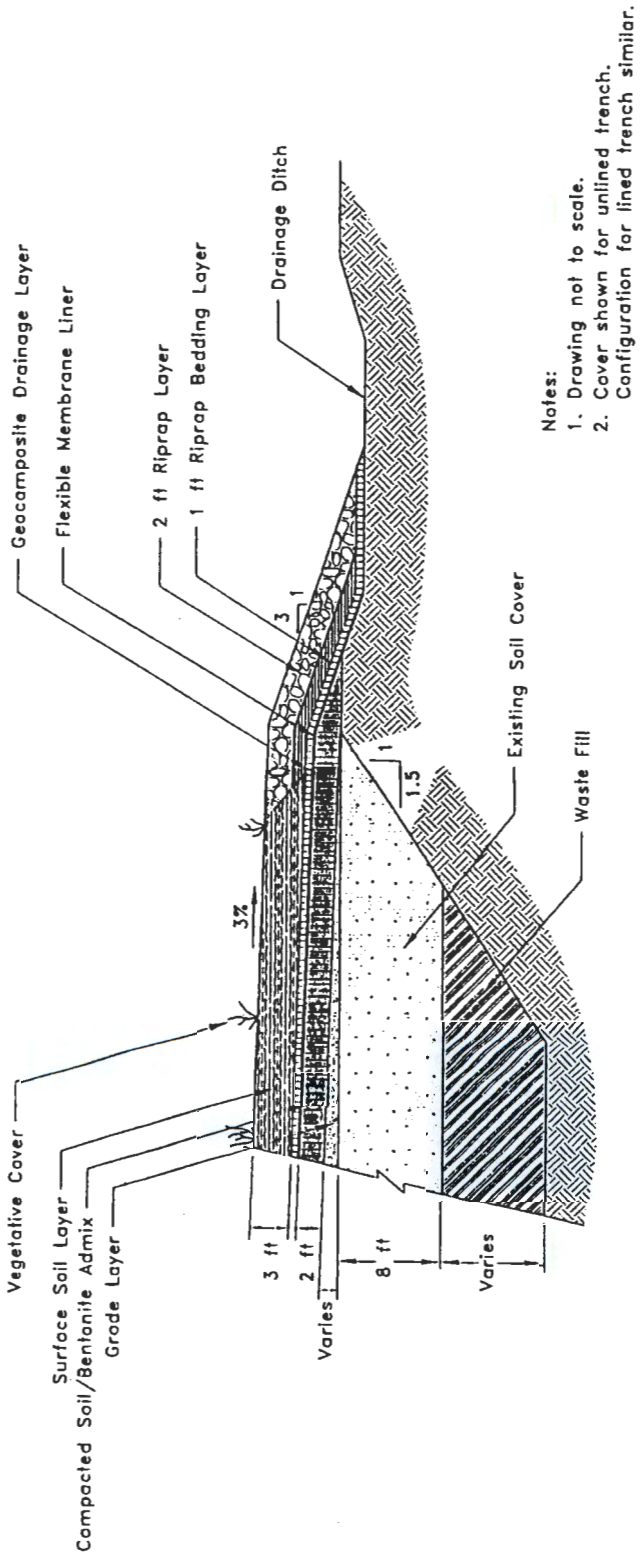

Figure 2. Cross-Section Showing Proposed Sideslope Treatment and Drainage Ditch.

APPENDIX C

COVER DESIGN INFORMATION

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FIGURE

1. Generalized Cross-Section of Landfill Cover . . . . . APP C F1

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APPENDIX C

COVER DESIGN INFORMATION

This appendix presents a single conceptual cover design that satisfies all requirements for dangerous waste disposal as defined in WAC 173-303. In addition, this design satisfies U.S. Department of Energy requirements as documented in Order 5820.2A and the U.S. Nuclear Regulatory Commission requirements codified in 10 CFR, Subpart D.

A discussion of the cover design and the basis for the design are provided in the following sections. Although this design incorporates the most advanced features of cover design at the present time, innovation will continue to bring about change and the cover design will be revised before construction of final cover(s) to include the latest innovation. A discussion of potential sideslope treatments also is included.

1.0 COVER COMPONENTS

The cover consists of several layers that will be constructed on top of native soil base. A generalized cross-section of an example cover is shown on Figure 1. The cover will be constructed on a soil grade layer (graded fill) shown as layer 9 in Figure 1. It is assumed that before construction of the final cover, the waste form will be appropriately stabilized. It is critical that the final cover be constructed on a solid foundation to avoid subsidence and or collapse of the structure.

1.1 GRADE LAYER

The surface of the TSD unit will be graded and/or shaped to match the slope of the desired low-permeability layer. It is assumed that the existing surface of the soil over the waste left in place will be essentially flat before shaping the grade layer. Additional soil will be placed over the TSD unit to achieve the required cover grade. This grade layer could taper from zero thickness near the edge of the outermost unit (the cover boundary) to perhaps several meters at the center of the cover; the thickness will depend on the lateral dimensions of the particular cover and the grade of the cover. As discussed, the grade layer also will provide a firm (nonsettling) foundation for the overlying layers.

The grade layer will consist of soils obtained near the construction. This material will be sufficiently well-graded to allow effective compaction. Field studies will be performed to identify suitable borrow sites. These studies will consist of evaluating existing geologic data pertaining to surficial deposits, surface mapping and sampling, test pits, laboratory testing, and possibly surface geophysics and/or limited drilling. This information is available for most cover material located on the Hanford Site. During construction of the prototype barrier at the 200-BP-1 operable unit (DOE/RL-94-76), design requirements specified that the subgrade fill be constructed from sandy soil (containing cobbles less than 75 millimeters at their greatest dimension with a constitution not more than 20 percent of the

fill), obtained from a local borrow site. The material was found within a kilometer of the construction location.

The grade layer generally will be placed in uniform horizontal lifts, or tapered for sloped or crowned covers, to meet grade specifications after compaction. The optimum lift thickness will depend on the soil and equipment characteristics and will be determined using laboratory test data. Field verification could be provided by constructing a test pad before cover construction. To minimize settlement, the grade layer will be compacted to 95 percent of maximum density as determined by ASTM D 1557 [modified proctor (ASTM 1993)] or other method. Compaction will be accomplished with a large, smooth, drum vibratory roller or similar piece of equipment, sized to prevent damage to underlying liner system components if present.

During construction of the cover, measurements on density of the placed grade layer will be taken periodically by bulk sampling and volume measurement techniques (e.g., ASTM D 4914). This testing will be used to determine the need for moisture conditioning, time constraints for placement, the optimum lift thickness, the required number of passes to achieve compaction, and similar information necessary to establish quality control specifications.

1.2 LOW-PERMEABILITY LAYER

The low-permeability layer will consist of either a 0.61 meter layer of soil mixed with bentonite, a geosynthetic clay liner (GCL), or a composite asphalt layer. The permeability of this layer will be greater than the permeability of the liner, if a liner is present. The selection of an appropriate material for this layer will be based on the hazard that is to be isolated. The low-permeability layer is the primary barrier in preventing soil and/or water from migrating into the waste zone.

The GCLs will be placed as panels on top of the grade layer. All GCLs are manufactured as panels approximately 4 to 5 meters in width and approximately 25 to 60 meters in length. The panels are placed on rolls at the factory and unrolled at the construction site. The weight of the roll varies but ranges from 600 to 2,000 kilograms. The panels typically are overlapped 75 to 300 millimeters and tend to be self-sealing. Slight differences in the recommended installation exists between the various manufactures.

A 60-centimeter thick layer of soil mixed with bentonite could be used as the low-permeability layer. The soil component will consist of well-graded silt or silty sand from a suitable borrow source or else screened from native soils. The maximum particle size generally will be 4.75 millimeters (No. 4 sieve) to exclude larger particles that might reduce the overall permeability of the mixture or puncture the overlying geomembrane. This soil will be mixed with enough bentonite to lower the hydraulic conductivity of the mixture to 1×10^{-7} centimeters per second per day or less at a readily achievable degree of compaction. The optimum percentage of bentonite will depend on the properties of both the soil and the bentonite itself and will be determined by laboratory testing of candidate mixtures. However, previous studies (Daniels 1988) indicate that approximately 10 percent bentonite should provide satisfactory performance.

The soil/bentonite material will be mixed (e.g., by disking or in a pugmill) at a location close to the cover and will be stockpiled to minimize moisture changes. If necessary, the surface of the grade layer will be moistened and proof rolled immediately before placing this admixture. To meet permeability specifications, the soil/bentonite layer will be placed in 15-centimeter thick lifts and compacted with a self-propelled sheepsfoot compactor. The first lift could be somewhat thicker depending on compactor and grade layer characteristics, to prevent the soil/bentonite from being driven into the underlying layer. In-place densities will be measured with a sand cone or other direct method or a nuclear density gage calibrated to the specific mixture used for the cover. Permeability will be measured on thin-walled tube samples in the laboratory. The sample holes in the cover will be carefully backfilled and compacted by hand. Material that does not have an in-place hydraulic conductivity of $1x10^{-7}$ centimeters per second or less will be recompacted or replaced as appropriate, and the permeability test repeated. The top surface of the soil/bentonite layer will be rolled with a smooth drum roller to provide a flat, even surface for the overlying geomembrane. The moisture content of the admix surface will be maintained by sprinkling, covering, or other means to prevent drying and desiccation. Potential concerns about desiccation also will be mitigated by installing the other layers of the cover as soon as possible after the admix layer has been placed.

Placement of the composite asphalt layer will follow the procedure used to construct the prototype barrier (DOE/RL-94-76). The layer will be placed using conventional paving practices. Material either will be batched in the 200 Areas or hauled from the nearest batch plant. A conventional paving machine will be used to place the asphalt. The asphalt will be placed in two lifts. Each lift will be approximately 7.5-centimeters thick. An overlap of approximately 1.5 meters is specified. A material specification that at least 6 percent of the material will be less than 0.074 millimeter was used during construction of the prototype. The asphalt will be covered with either a coat of polymer-modified asphalt or gilsonite, a naturally occurring derivative of tar sand. It is recommended that the protective coat be at least 250 millimeters in thickness.

It has been reported that GCLs are much better able to resist damage from freeze-thaw considerations, desiccation, and differential settlement than are compacted soil liners (Daniels 1994). The GCLs are thin blankets of bentonite clay attached to one or more geosynthetic materials (geotextile or geomembrane). These are commercially available and are particularly well suited for arid or dry conditions. The liners typically contain approximately 5 kilograms per square meter of bentonite that has an effective hydraulic conductivity of $1x10^{-9}$ centimeters per second.

It has been shown that desiccation-induced cracking can occur after several freeze-thaw cycles or dry-wetting cycles for the composite clay soil layers. Furthermore, the data published by Lagatta (1992) indicates that most compacted soil layers cannot withstand tensile strains greater than 0.1 to 1.0 percent. The GCLs can withstand tensile strains from 5 to 20 percent (Daniels 1994). Therefore, if freeze-thaw or wetting drying cycles are anticipated and/or differential settlement, which could result in significant distortion is anticipated, it is recommended that a GCL be used instead of compacted soil/bentonite layer. If biological intrusion, freeze-thaw or wetting-drying, and differential settlement are not anticipated, a

60-centimeter two component [flexible membrane liner (FML) and compacted soil/bentonite layer] might prove to be the most economical low-permeability layer.

It is recommended that GCLs and/or composite soil/bentonite layers be used to isolate dangerous and mixed waste where the radiological component of risk is very low. As opposed to the asphaltic concrete composite layer, the GCL will not provide a barrier to biological intrusion. Although the design life of the GCL is unknown, it is assumed to be several hundred years (Daniel 1994). By comparison, the design life of the composite asphalt layer is estimated to be several thousand years (Freeman and Romine 1994).

1.3 FLEXIBLE MEMBRANE LINER (OPTIONAL)

If the soil/bentonite layer is used, a low-permeability layer FML (or geomembrane) will be placed over the soil/bentonite layer. Using a FML is consistent with the two component EPA guidance for RCRA cover design (EPA-530-SW-89-047).

The geomembrane will consist of a 40-mil sheet of high-density polyethylene (HDPE), very-low-density polyethylene (VLDPE), or other suitable material. The 40-mil thickness is twice that recommended by the (EPA-530-SW-89-047), but is considered appropriate to reduce the risk of damage during construction and subsequently during the postclosure period from such potential hazards as settlement, roots, and burrowing animals. The composition of the geomembrane will be selected for high resistance to normal weathering and chemical deterioration, including any fertilizers and herbicides that might be used to establish the vegetative cover. Physical and mechanical properties of the geomembrane, such as thickness, strength, and density, will be verified by conformance testing (to ASTM and other standard tests as appropriate) on samples of material received at the site. A FML that does not meet manufacturer's or design specifications will be rejected.

The geomembrane will be placed on the prepared soil/bentonite surface with several centimeters of overlap between adjacent sheets. In most cases, the panels will be placed so that the seams run downgradient. Sheets will be joined by fusion or extrusion welding. Samples for destructive seam-strength tests will be taken every few hundred meters to ensure adequacy of the welding process, and the sample locations will be patched. Nondestructive tests such as vacuum box or pressure testing (the type of test will depend on the welding method) will be performed along the entire length of all seams to ensure total seam integrity. Any part of a seam that fails these tests will be repaired or removed and patched as appropriate. A FML installation will be performed by specialists experienced in this technology and will be conducted under detailed quality assurance/quality control procedures to be developed as part of the final cover design.

Depending on construction staging, sandbags will be placed on the FML at approximately regular intervals to prevent damage from wind uplift before the overlying layers are placed. Design methods, such as those described by Wayne and Koerner (1988), will be used to estimate more precisely the sandbag requirements. The sandbags will be removed before placing the drainage layer.

As stated, this is an optional layer that will only be used if the 60 centimeter thickness of soil mixed with bentonite is used as the low-permeability layer.

1.4 DRAINAGE LAYER

The drainage layer will conduct any water that percolates through the overlying layers laterally to the drainage ditch. Thus, the drainage layer will prevent hydraulic pressure from building up directly on the low-permeability liner, and thereby eliminate one set of forces that would drive moisture through the primary moisture control barrier.

The design criteria for the drainage layer will be that the layer convey water at a rate no less than $1x10^{-2}$ centimeters per second per day. The drainage layer will consist of a geonet or layers of sand and gravel. If asphalt is used as the primary low-permeability layer, a 15-centimeter layer of gravel will be placed directly on the asphalt. If either the GCL or two component FML composite soil and bentonite layer is selected for use, then either a geocomposite (geotextile combined with a geonet), if a capillary break is not included in the design, or a 30 centimeter layer of sand (15 centimeters) overlaid by gravel (15 centimeters) will be used. For this case, the drainage layer will be constructed by first placing the 15 centimeter thickness of sand on the FML and placing the 15-centimeter thickness of gravel on the layer of sand. If the surface grade of the FML is 3 percent or greater, a geosynthetic bedding material might need to be placed on the FML before placement of the sand to prevent the slippage of sand off the surface of the FML. This is a characteristic that will need further review before construction of the cover.

The gravel or sand followed by gravel layer will be placed using conventional construction practice. Placement of the material will be in two 15 centimeter lifts. Each lift will be consolidated using a vibratory roller. During the construction of the prototype barrier, two passes of the vibratory roller were found to be sufficient. If a FML or GCL is used, it is recommended that rounded (not crushed) material be used as the drainage medium to avoid damaging the FML. The maximum grain size should be no greater than 0.95 centimeter. If a composite asphalt layer is used, crushed material can be used. However, if crushed material is used, the material as applied (specifications) will need to satisfy the minimum drainage criteria of $1*10^{-2}$ centimeters per second.

1.5 PLANT, ANIMAL, AND HUMAN INTRUSION LAYER (OPTIONAL)

The performance objectives for the permanent isolation surface barrier are summarized as follows:

- Function in a semiarid to sub-humid environment
- Limit the recharge of water through the waste to near zero amounts [0.05 centimeter per year ($1.6*10^{-9}$ centimeters per second)]
- Be maintenance free

- Minimize the likelihood of plant, animal, and human intrusion
- Limit the exhalation of noxious gases
- Minimize erosion-related problems
- Meet or exceed RCRA Subtitle C cover performance requirements
- Isolate waste for 1,000 years.

To satisfy the intrusion performance objective, a layer of fractured basalt riprap 1.5-meter thick has been incorporated into the design of the prototype permanent isolation surface barrier. This is an optional layer that will only be included in the design of barriers that require the additional human and/or bio-intrusion protection to reduce either the environmental or human health risk.

1.6 GRADED FILTER LAYER

A graded filter consisting of crushed rock overlaid by sand is the next layer. This layer will be placed on either the plant, animal and human intrusion layer (Section 1.5) if incorporated into the design, directly over the drainage layer (Section 1.4) if the bio-barrier is not included in the design and a geosynthetic drainage layer (geonet) is used. The graded filter layer will function as a capillary break and will increase the effectiveness of the surface layer by imposing the use of the "Richards" principal. The graded filter serves to separate the surface soil layer from the drainage layer. A geotextile will be placed on the top of the graded filter to decrease the potential for fine material to enter the filter and drainage zone. The geotextile will be permeable to drainage and will not support a standing head of water.

The thickness of the graded filter will vary. For the prototype barrier, 30 centimeters of crushed rock was placed on the railroad or highway ballast. The crushed rock was placed in two lifts of 15 centimeters graded, and rolled to 95 percent maximum density using a steel drum vibratory roller. The crushed material was screened through a 16-millimeters mesh before being placed.

During the construction of the prototype barrier, a 15-centimeter layer of sand was placed directly over the crushed rock. The sand was obtained onsite and placed in accordance with WSDOT M41-10, 2-03.3(14) (WSDOT 1991). Standard dump trucks were used to haul the sand from Pit 30 located in the 200 Areas to the construction site. A grader was used to level and finish grade the sand layer. A geotextile was placed on top of the graded filter before construction of the surface soil layer.

It is important to note that the creation of the 'capillary break' allows the surface soil layer to both store and recycle water. This will reduce and might eliminate the need to build a surface slope into the final grade of the surface soil layer under semiarid conditions.

1.7 SURFACE SOIL LAYER

A surface soil will be placed over the geotextile to intercept, store and recycle water, and prevent damage to the underlying structure from natural and synthetic processes. Factors assimilated into the design of the surface soil layer include the following:

- Aspects of soil physics including the characterization and quantification of soil physical properties
- The collection, interpretation, and use of meteorological and long-term climatology data
- The collection and use of wind and water erosion
- The collection and use of information on vegetation, bio-intrusion, and human intrusion
- The use of physical models (lysimeters) and numerical models (computer codes) to simulate performance and help optimize design.

Analytical methods (simulation modeling) have been used to size the surface soil layer. Using field data collected from the Field Lysimeter Test Facility, both the UNSAT-H and HELP numerical models have been calibrated to simulate onsite conditions. For several years, these calibrated models have been used to compute the performance of barrier designs thereby, defining the appropriate surface soil thickness for the barrier. The two most important factors in engineering the surface soil thickness are the assignment of the water retention characteristics for soil and climate information.

The selection of soil to be used for the surface soil layer started in the mid-1980's. By the time the Hanford Defense Waste Environmental Impact Statement was issued (DOE/EIS-0119D), it had been decided that the Warden Silt Loam Soil available at several locations on the 200 Area Plateau was the desired material for constructing surface barriers that would recycle water. Most design studies have assumed the use of this material. The physical and hydraulic properties of this soil have been quantified.

The surface soil layer could consist of two layers. The top layer consists of the selected silt loam to which 15 percent (by weight) pea gravel is added. The addition of this pea gravel serves to armor this layer thereby reducing the rate of soil deflation to less than 5 percent of the nominal unprotected rate. The bottom layer consists of silt rich material. The silt rich material is found naturally occurring at several locations on the 200 Area Plateau and is characterized with more than 30 percent passing the No. 230 sieve. The silt layers are placed using conventional construction techniques in a single lift. Once the material is placed, it is groomed to a compaction of 88 percent maximum dry density.

As discussed in Section 1.7.6, the actual thickness of the two layers will vary depending on the desired water storage of the soil. The minimum thickness guideline recommended by EPA is 60 centimeters (EPA-530-SW-89-047).

1.7.1 Vegetative Cover

The vegetative cover performs three functions. First, the plants return water stored in the surface soil back to the atmosphere, significantly decreasing net infiltration and reducing the amount of moisture available to penetrate the cover. Second, the vegetation stabilizes the surface soil component of the cover against wind and water erosion. Finally, the vegetative cover restores the appearance of the land to a more natural condition.

The importance of vegetation on the recycling of water has been recognized and measured for years onsite and at other locations in the semiarid west. A number of lysimeters have been constructed onsite to measure recharge and the effectiveness of plants and grasses in reducing recharge. The most controlled studies on this phenomenon have been performed at the Field Lysimeter Test Facility. In these studies it has been observed that a 2.0-meter thickness of soil supporting no vegetation and isolated through the use of a capillary break has sufficient storage capacity to recycle twice the annual amount of seasonable precipitation on the Hanford Site. If vegetation is introduced, the storage capacity of the soil column is increased to three times the annual average (Gee et al. 1992).

A mixture of seeds will be used to establish vegetation. The selection of the seed mix will be based on past vegetation activities onsite and work performed in support of the engineered barrier (Link et al. 1994). The seed types will be selected based on resistance to drought, rooting density, and ability to extract water. In particular, attention will be given towards those factors that prevent deep root penetration into the buried waste. It has been observed that the best way to control root penetration is to construct a layer of rocks that creates a void space. Both the graded filter and the optional bio-barrier serve this purpose. During final design, suitable plant and grass species, such as wheatgrasses, will be identified.

1.7.2 Wind Erosion

The principal hazard associated with wind erosion is the thinning of the cover surface soil layer. This in turn potentially could lead to breaching of the moisture barriers, gradually allowing larger quantities of water to reach the waste. The engineering approaches to mitigating wind erosion of the cover are (1) designing the surface soil layer with an appropriate total thickness to compensate for future soil loss that might result from wind erosion, (2) establishing a vegetative cover on the surface to reduce wind erosion, and (3) include an appropriate coarse material (admix) in the upper layer of the surface soil to form an armor layer.

The use of coarse soil on the cover surface is expected to reduce wind erosion to negligible levels. The use of gravel admixtures for protecting silt-loam Hanford soils exposed to environmental conditions has been studied for several years by PNNL. The result of this work have been documented by Ligotke (1994). As a result of this work, a pea gravel admix of 15 percent has been added to the surface layer. Use of the pea gravel admix will serve as an armor layer thereby minimizing the rate of soil deflation.

Although soil deflation has been minimized (estimated to be less than 5 percent of an unarmored surface), some erosion of the native surface soils in the vicinity of the cover will certainly occur. The rate of deflation will be governed by wind speed and saltating sand. The result of wind erosion could effect the operation of the drainage ditches. Periodic maintenance of these ditches may be required.

1.7.3 Water Erosion

The potential hazard associated with water erosion is the same as that for wind erosion, namely the loss of soil from the top or surface layer. The effect of water erosion on cover designs on the Hanford Site has been studied for several years by PNNL. The results indicate that vegetation cover has the most dominant effect on reducing water erosion. The rock mulch or pea gravel admix also has a positive effect in reducing water erosion but is less effective than vegetation. The effects of potential water erosion have been measured and quantified in terms of the universal soil loss equation (Gilmore and Walters 1992). Results from this work were used to design the top layer and side slopes of the conceptual barrier design is discussed in Section 1.7.7.

Several engineering approaches have been adopted to minimize the potential for water erosion:

- Limiting the surface slopes
- Providing run-on control with the sideslope drainage ditches
- Compacting the surface soil in a way that promotes significant infiltration rather than excessive run-off
- Properly designing the sideslopes to prevent gullying
- Establishing a vegetative cover to slow surface run-off
- Incorporating coarse material (pea gravel admix) in the upper portion of the surface soil layer to help form an erosion-resistant armor
- Limiting flow path lengths through the use of vegetation and admix.

The cover design was evaluated for potential erosion damage from overall soil erodibility, sheet flow, and gullying. The results indicate that expected erosion under worst-case conditions is within acceptable limits (refer to Chapter 11.0, Section 11.1.5).

1.7.4 Deep-Rooted Plants

The potential hazard from deep-rooted plants roots penetrating the GCL and a compacted soil/bentonite layer. The asphalt layer is assumed to resist this hazard. Penetration of this layer will provide a pathway for surface water to infiltrate the waste. Dangerous materials could be absorbed by the roots and brought to the ground surface where it could be released into the

environment. Plants common to the 200 Areas are reported to have roots up to approximately 2.4-meters deep (PNL-5684), and might be sufficient to penetrate the thickness of the cover.

The following are design features that will minimize the potential for problems with deep-rooted plants.

- The surface soil (top two layers) will retain most of the precipitation, because the underlying drainage layer has significantly higher permeability and much less water retention capacity. Therefore, it is expected that vegetation preferentially will occupy the surface soil layer and not have an affinity for growing into the drier underlying layers.

- The thickness of the surface soils will be sized to promote the development of semiarid deep-rooted perennial grasses and to discourage the development of deep-rooting intrusive species.

The use of plants to recycle water has been studied for several years. This work was initiated at the Field Lysimeter Test Facility in the 200 Area and continues at the prototype barrier test site located on the 200 Area Plateau. Results of this work have been documented by Link (1994). Results from the ongoing work at the prototype barrier test site will be used during final design of the cover.

1.7.5 Burrowing Animals

Small animals indigenous to the Hanford Site have been reported to burrow to depths of more than approximately 2 meters (PNL-4241). This is sufficient to penetrate the thickness of the top two layers. The sand and gravel filter layers and the gravel drainage layer should prevent the animals from burrowing any deeper. Of primary concern is the effect of borrowing on either reducing the storage capacity of the cover or providing a burrow that would in effect short circuit the effectiveness of the soil layers to store water.

This possible condition has been studied by Landeen (1994). An animal intrusion lysimeter test facility consisting of six lysimeters (150 centimeters by 150 centimeters by 180 centimeters deep) was constructed. Small burrowing animals common to the Hanford Site (Great Basin pocket mice, Townsend ground squirrels, and pocket gophers) were introduced over a 3 to 4 month test period. The animals were allowed to habitat the lysimeters. The soil wetting and drainage were forced using a rainulator. Tests were performed from April 1988 through August 1990.

Information collected from five tests indicated that water was lost from all the lysimeters including the control lysimeter (no animals) during the summer months. During the winter months, all lysimeters gained water. The data collected from the lysimeters also indicated that there was little difference in the total water content between the control and animal held lysimeters during the test periods. This suggest that burrow systems will not significantly increase the amount of water at depth or in storage. In fact the burrowing activity may enhance the removal of water from the soil (Landeen 1994).

1.7.6 Meteorology and Climatology

Meteorological records have been collected for over 75 years in eastern Washington. Meteorological records have been collected for approximately 50 years as part of the onsite operations. On the Hanford Site, the 79-year average annual precipitation is 16.2 centimeters per year. This annual precipitation record has been extended to over 75,000 years using a pollen analog developed on the Hanford Site (Petersen 1994). Based on this record, the long-term range of annual precipitation has ranged from 50 percent below the present day mean annual precipitation to more than 25 percent greater than the present day mean annual precipitation.

Based on extreme-value analysis, the 100-year and 1,000-year storm events have been predicted for the Hanford Site. The 24-hour maximum accumulation for the 100-year return period is 5.05 centimeters and for the 1,000-year return is 6.81 centimeters. Using 35 years of extreme event precipitation records (1946-1980), there were two 24-hour precipitation events where the accumulated precipitation exceeded 5.0 centimeters (WHC-SD-EN-DP-086). The 100-year and 1,000-year recurrence events were based on this record.

About 38 percent of all precipitation is in the form of snow. This form of precipitation usually occurs during December through February. One out of every four winters is expected to produce an accumulation of snow that exceeds 16.2 centimeters (WHC-SD-EN-DP-086). The water content of the snow varies greatly.

1.7.7 Numerical Simulation Models

Both the HELP model and UNSAT-H numerical simulation models have been used to predict the performance of various cover designs for possible use onsite. The two models have been compared and have been found to provide consistent results. The HELP model usually overpredicts drainage.

Both models were used by Martian (1994) to compare the performance of three designs with a surface soil thickness ranging from 1 to 2 meters. The results from this analysis tends to bound the design considerations that are of interest for use onsite. The soil layering consisted of a Warden Silt layer containing the pea gravel admix overlaying a Warden silt layer. The thickness of the layers is provided in Table 1.

Water balance simulations were conducted for each design for three different precipitation treatments: (a) ambient conditions, (b) 2X ambient precipitation conditions, and (c) design storm condition. The ambient precipitation scenarios used daily precipitation information from the Hanford Meteorological Station for the 10-year period 1979 through 1988. The 2X ambient precipitation scenario was realized by simply doubling the daily precipitation. The design storm event varied for each design and was superimposed on the ambient and 2X precipitation condition when the soil was at its maximum moisture content following the maximum precipitation event. For all three designs, this event was simulated to occur on December 31, 1983. The results from these calculations, using both the UNSAT-H and HELP simulation models, are provided in Table 2.

The design storm events are summarized as follows; (a) a 1,000 year, 24-hour event for design 1, (b) a 500 year, 24-hour event for design 2, and (c) a 100 year, 24-hour event for design 3. Superimposing these events on the simulated precipitation treatments had no effect on the calculated drainage.

2.0 SIDESLOPE TREATMENTS

Sideslope treatments could vary. Two sideslope treatments are being tested in the prototype barrier. One is a relatively flat slope of naturally occurring soil (sand and gravel) placed at a 10H:1V slope. A second treatment, consisting of a basalt riprap, was placed as a steep embankment on a 2H:1V slope.

Sideslope treatments will be defined during final design. The design of the sideslope must take drainage (both run-on and run-off) into consideration. In addition, the sideslopes will be contoured to fit the surrounding terrain. As the slope is increased from 10H:1V to 2H:1V, cobbles and basalt riprap will be substituted for soil. For the 5H:1V sideslope proposed for use on the Nonradioactive Dangerous Waste Landfill closure, it is proposed that a 5.1-centimeter minus rock or 10.1-centimeter minus riprap layer be placed over the contoured soil surface to protect the surface from erosion (DOE/RL-90-17). A 3H:1V sideslope treatment was assumed for the drainage and erosion. The following placement is assumed.

2.1 RIPRAP BEDDING LAYER

On the 3H:1V sideslopes, a 0.3-meter thick bedding layer will be placed on the geotextile to serve as a foundation for the overlying riprap layer. The bedding layer also will serve to protect the geotextile from puncture by angular riprap, and consequently will help maintain the integrity of the drainage layer.

The riprap bedding layer will consist of native material ranging in size from coarse sand to fine gravel. The grading will be suitable to provide a firm foundation for the overlying riprap layer and to prevent the underlying soil from washing out. The grading will be determined during final cover design after the riprap material has been characterized. It is anticipated that the riprap bedding layer can be produced by screening material from gravel pits located near the 200 Areas.

The riprap bedding layer will be placed in a single 0.3-meter lift to minimize the possibility of damage to the underlying geocomposite. The material will be dumped and carefully spread in the upslope direction by small, low-ground- pressure bulldozers using placement techniques that will avoid dragging the material across the geocomposite. No specific degree of compaction is required for this material, and 'track walking' should be adequate to prepare the bedding layer for the overlying material.

2.2 RIPRAP LAYER

On the 3H:1V sideslopes, a 0.6-meter thick riprap layer will be placed over the riprap bedding layer to prevent erosion and gullying of these slopes from surface run-off. This layer also will prevent animals from burrowing laterally into these slopes.

The riprap layer will consist of native materials greater than 5.0 centimeters in dimension. This material should be readily available as a byproduct of preparing the bedding layer described previously. Because the cobble-sized material on the Hanford Site generally appears to be surrounded, it might need to be crushed to form a sufficiently stable slope. The need for crushing will be determined by characterizing the actual material and applying accepted design methodology. Precise grading requirements for the riprap material will be determined during the detailed design process. Adequacy of riprap design will be verified by constructing a simulated test slope and subjecting it to the maximum expected run-off.

The riprap layer will be placed in a single lift. The material will be dumped and carefully spread in the upslope direction by small, low-ground pressure-bulldozers using placement techniques that will avoid dragging the material along the bedding layer. 'Track walking' is expected to adequately compact the riprap layer.

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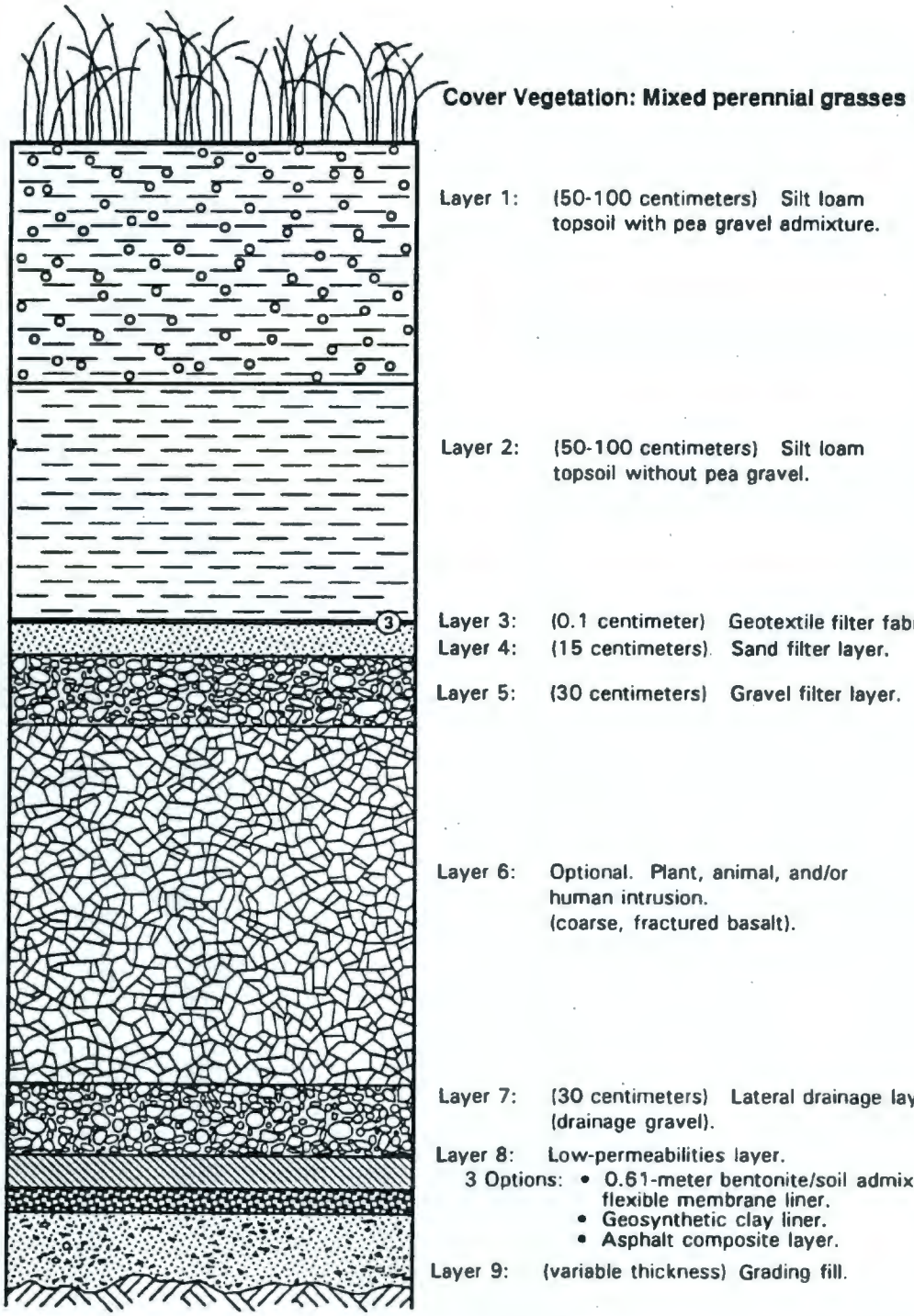

Figure 1. Generalized Cross-Section of Landfill Cover (Conceptual Design). (Note: This figure is an approximate facsimile, but has not been updated for this review.)

Table 1. Comparison of Three Surface Soil Geometries.

Design 1	Design 2	Design 3
Layer 1: 101.6 centimeters (Silt/15 % Pea Gravel by volume)	Layer 1: 50.8 centimeters (Silt/15 % Pea Gravel)	Layer 1: 20.32 centimeters (Silt/15 % Pea Gravel)
Layer 2: 101.6 centimeters (Silt)	Layer 2: 101.6 centimeters (Silt)	Layer 2: 71.12 centimeters (Silt)

Table 2. Comparison of Calculated Drainage for Three Surface Soil Geometries.

Numerical Model	Design	Treatment	Drainage (centimeters)
UNSAT-H	Design 1	Ambient	0.0
UNSAT-H	Design 1	2X	0.0
UNSAT-H	Design 2	Ambient	0.0
UNSAT-H	Design 2	2X	0.0
UNSAT-H	Design 3	Ambient	0.005
UNSAT-H	Design 3	2X	0.683
HELP	Design 1	Ambient	0.0001
HELP	Design 1	2X	0.0011
HELP	Design 2	Ambient	0.00025
HELP	Design 2	2X	0.299
HELP	Design 3	Ambient	0.0022
HELP	Design 3	2X	0.2872

APPENDIX D

SINGLE GROUNDWATER PROJECT FOR THE HANFORD SITE

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Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

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Contractors, Richland, Washington

Dr. W. J. Madia, Director
Pacific Northwest National Laboratory

✓Dr. A. L. Trego, President
Westinghouse Hanford Company

Addressees:

SINGLE "GROUNDWATER PROJECT" FOR THE HANFORD SITE

The U.S. Department of Energy (DOE), Richland Operations Office (RL), has moved to a single "Groundwater Project" for Hanford; RL has moved away from separate and distinct groundwater "programs" operated by three contractors. Under previous conditions costly redundancies and inefficiencies were identified. Under the rescoping initiative described herein, there will be unique roles and scope for Bechtel Hanford, Inc. (BHI), Pacific Northwest National Laboratory (PNNL), and the Project Hanford Management Contractor (PHMC). The objectives of scope assignments of this project are attached. This is the envelope in which further implementation decisions will be developed with the assistance of the three contractors.

Hanford must focus its attention on remediation of the groundwater and on the long term protection of groundwater resources. During the period of active remediation, BHI will provide the project control mechanisms and coordination necessary to build a single groundwater project. All contractors performing groundwater work scope will provide requisite data to BHI for project control, and identify appropriate points of contact to assist in these functions. RL directs PNNL to perform the monitoring function (scope) and the Hanford standard groundwater model for assessing cumulative impacts. In this capacity, PNNL will be provided sufficient technical autonomy to provide an internal independent Hanford groundwater monitoring assessment. BHI and PNNL are to coordinate activities in an essentially "seamless manner." Sampling and analytical services in support of groundwater monitoring will be included in the RL initiative to consolidate laboratory analytical services through the PHMC. The PHMC will also provide well maintenance and decommissioning as a site service to BHI.

To effect the rescoping initiative RL assigns the following workscope to BHI:

- Perform all groundwater remediation, including Remedial Investigation/Feasibility Study (Resource Conservation and Recovery Act [RCRA] Facility Investigation/Corrective Measures Study) activities.

- Provide project management functions for all well drilling and characterization. Well maintenance, well remediation, and well abandonment will be coordinated by BHI and performed by privatized services provided by RUST (characterization of contaminated soils within tank farms is within the scope of the Tank Waste Remediation System (TWRS) and is not part of this initiative).

- Perform necessary activities required to operate remedial systems and evaluate the performance of these systems (capture zone analyses, performance projections, performance samples, etc.).

- Maintain the project control system for the overall Groundwater Project.

- Develop and maintain the Hanford Groundwater Remediation Strategy.

- Provide input to the monitoring approach, modeling initiatives and the Groundwater Protection Management Plan (GPMP).

- Characterization, including RCRA assessments, Columbia River Comprehensive Impact Assessment follow-on actions, remedial action assessment data.

To effect the rescoping initiative RL assigns the following workscope to PNNL:

- With RL and contractor customers, regulatory, Tribal and stakeholder participation, develop and maintain a predictive Hanford standard groundwater model. This model will evaluate the cumulative effects of Hanford wastes and discharges to groundwater and evaluate long-term groundwater protection. There is the option for other projects (TWRS, Waste Management, etc.) to develop the vadose zone predictions that are inputs to this model. However, this will be the "site standard" groundwater model.

- Perform as a "clearinghouse" for Hanford groundwater and vadose zone models to assure sitewide consistency.

- Develop and maintain the groundwater monitoring scope. This scope will address the requirements of RCRA, DOE Orders, interim and final Records of Decision (ROD) under the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement).

  - Manage and coordinate the collection of groundwater samples.

- Perform scheduled monitoring required by existing Tri-Party Agreement documents.

- Perform post remedial action monitoring, including monitoring for "no action" RODs (as part of the post ROD review, BHI will be expected to assess effectiveness of remedial actions).

- Produce the annual groundwater monitoring report. BHI and PHMC will provide input to assigned portions and will provide overall review and concurrence.

- Maintain and enhance regulatory, Tribal and stakeholder electronic access to groundwater data and data analysis tools.

- Coordinate the production of the groundwater GPMP for RL. Sections will be assigned as appropriate to other RL programs and associated contractors.

- Provide site services for seismic monitoring.

To effect the rescoping initiative, RL assigns the following workscope to the PHMC:

- Maintain regulatory assessment capability to address compliance issues resulting from groundwater data and interpretations.

- Provide a point of contact to interface with the groundwater project.

- Consolidate analytical laboratory contracts. The Hanford Groundwater Project will participate in this initiative.

- Provide site services for: Vadose zone monitoring, monitoring well maintenance, remediation and abandonment, and monitoring well sampling.

BHI, PNNL, and PHMC are directed to continue discussions with RL to develop and submit a transition plan for RL approval to transfer pertinent activities, personnel, and equipment as described herein. The contractors are to make the appropriate adjustment to personnel head count (i.e., according to head count ceilings for the involved projects). The contractors shall develop in conjunction with RL's Contractor Workforce Programs and the Westinghouse Hanford Company (WHC), a letter of understanding on the conditions of appropriate staff transfers.

The realignment of responsibilities and personnel transfers are to be completed by October 1, 1996. Those employees that will remain with WHC are being included in the personnel mapping process that the PHMC is undertaking.

Multi-year work plans and the initial FY 1997 funding distributions will be managed to reflect this distribution of workscope. All involved parties shall immediately begin work in concert for a timely completion of this realignment.

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Please provide designated Point of Contacts to Mr. K. Michael Thompson of the Groundwater Project, by October 4, 1996. If you or your staff have questions, please contact me, or Mr. Thompson at 373-7050.

Sincerely,

John D. Wagoner

John D. Wagoner
Manager

GWP:KMT

Attachment

cc w/o attach:
H. J. Hatch, FDH
J. F. Nemec, BHI

APPENDIX E

INTERIM STATUS GROUNDWATER MONITORING

APPENDIX E

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APPENDIX E

INTERIM STATUS GROUNDWATER MONITORING

Eight burial grounds were included in the interim status groundwater monitoring program. These are the 218-E-10 and 218-E-12B Burial Grounds in the 200 East Area (refer to Chapter 1.0) and the 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, 218-W-5, and 218-W-6 Burial Grounds in the 200 West Area (refer to Chapter 1.0).

In accordance with an agreement signed by Ecology and the DOE-RL (Ecology 1986), an initial groundwater monitoring system consisting of 35 wells was installed around the LLBG. This system was designed in accordance with WAC 173-303-400 and 40 CFR 265, Subpart F requirements. Based on information from the initial 35 wells, 46 additional wells have been installed completing the monitoring network for the LLBG.

The following sections provide a summary of the groundwater monitoring data obtained from wells installed during the interim status period.

1.0 INTERIM STATUS GROUNDWATER MONITORING APPROACH

A specific investigative approach was taken to support the design of the LLBG groundwater monitoring system. This approach consisted of the following elements.

- Define specific waste management areas for the LLBG. These low-level waste management areas (LLWMAs) consisted of one or more regulated units treated as a single monitored unit with respect to groundwater monitoring. The size and extent of a LLWMA were determined principally by the size and location of regulated units.

- Establish an initial groundwater monitoring well network from which stratigraphic, hydrogeologic, and background water quality information can be obtained. The data were used to determine the need for additional groundwater monitoring wells.

- Provide preliminary hydrogeologic properties of the uppermost aquifer system beneath the LLBG using data collected from the monitoring well network and from previously collected or published data.

Within the scope of the 1986 agreement (Ecology 1986), the DOE-RL agreed to install an initial network of 35 groundwater monitoring wells of no more than 305 total meters drilled to supplement the interim status program. The groundwater monitoring plan for installation contained specific details for these 35 wells (PNL 1987). These wells were to provide information regarding the hydrogeologic properties of the uppermost aquifer beneath the LLBG and also were to be used in collecting background water quality data at quarterly intervals for at least 1 year from the time of installation. The initial network of 35 wells was installed as planned, and the goals of the network in

providing preliminary hydrogeologic information and background water quality data were met. Based on data from the initial well network, 46 additional groundwater monitoring wells were installed. The construction details for these wells are contained in the various borehole completion reports (WHC-MR-0204; WHC-MR-0205; WHC-SD-EN-DP-044, WHC-SD-EN-DP-049, and WHC-SD-EN-DP-086).

Preliminary hydrogeologic properties within the uppermost aquifer were documented by PNL-6820 based on information from the initial network of 35 wells. Within the scope of the characterization plan, the following four specific objectives were achieved:

- Development of a preliminary conceptual model of the hydrogeologic system within the uppermost aquifer
- Determination of horizontal and vertical hydraulic gradients within the uppermost aquifer
- Determination of the range and distribution of horizontal hydraulic conductivity values within the uppermost aquifer
- Determination of the storativity of the sediments within the uppermost aquifer.

The methods applied to achieve the objectives are described in Section 2.2. Hydrogeologic properties for the 46 additional groundwater monitoring wells were reported in WHC 1989; WHC-MR-205; and WHC-SD-EN-DP-044, WHC-SD-EN-DP-049, and WHC-SD-EN-DP-086.

Compliance boundaries were established for five LLWMA that incorporate portions of one or more burial grounds. These boundaries, shown in Figure 1 and Figure 2, were defined by a line that connects the monitoring wells spaced around the perimeter of each LLWMA. Because of uncertainties and potential future changes in the direction of groundwater flow described later in this text, the compliance boundaries are shown in the figures to extend around the entire LLWMA. However, at any specified time, the regulatory compliance boundary will be considered to be present only along the existing downgradient limit of the LLWMA, in compliance with WAC 173-303-645(6)(a). The individual monitoring wells were located in accordance with WAC 173-303-645(9)(b), as close as possible to the hydraulically downgradient limit of the LLWMA taking into account rights-of-way and other physical obstructions. The following are the designated burial grounds incorporated in the LLWMA:

- LLWMA-1--218-E-10 Burial Ground
- LLWMA-2--218-E-12B Burial Ground
- LLWMA-3--218-W-3A, 218-W-3AE, and 218-W-5 Burial Grounds
- LLWMA-4--218-W-4B and 218-W-4C Burial Grounds
- LLWMA-5--218-W-6 Burial Ground.

2.0 INVESTIGATIVE METHODS

This section summarizes the techniques and methods used to assess the hydrogeologic properties of the uppermost aquifer beneath the LLBG.

2.1 EXISTING SITE HYDROGEOLOGIC INFORMATION

Hydrogeologic information has been collected since activities began in the mid-1940s. Much of the information on subsurface geology in the 200 Areas has resulted from the analysis and interpretation of more than 1,400 boreholes and wells completed in and around the 200 Areas. Raw data have been compiled into the following databases:

- Hanford Groundwater Database
  - Summarized borehole geologic logs
  - Water level data
  - Groundwater quality data
  - Well elevation data

- ROCSAN Database System
  - Particle size distribution from borehole sediment samples
  - Calcium carbonate content from borehole sediment samples.

Borehole samples were archived in the Hanford Geotechnical Sample Library and have been catalogued (Additon 1977). Geophysical logs from the boreholes are maintained by Pacific Northwest National Laboratory's (PNNL) Earth and Environmental Sciences Center.

Interpretations of the raw data were published and a well-documented list of published studies was provided by PNL-6820. Many of the early reports, however, present relatively little detail because of the limited groundwater and subsurface geologic data available at the time.

2.2 GENERAL WELL DESIGN

As required by WAC 173-303-400(3)(a) and 40 CFR 265.91, the interim status groundwater monitoring system included monitoring wells completed to obtain representative groundwater samples from the uppermost saturated zone beneath each of the LLWMAs. This saturated zone is within the Ringold Formation and/or the Hanford formation, depending on the local geology (DOE/RL-91-28). The interim status groundwater monitoring wells were drilled and constructed consistent with Ecology and EPA guidance and with Ecology review, and are in compliance with WAC and RCRA regulations.

The initial interim status monitoring well network consisted of 35 wells located around four existing LLWMA. These wells were drilled and installed from July to October 1987, and are referred to hereafter as the '1987 wells'. Sixteen wells were installed in the 200 East Area and 19 wells were installed in the 200 West Area. Eleven of the wells in the 200 West Area and all 16 wells in the 200 East Area were drilled as single wells. The remaining

eight wells were in the 200 West Area and were drilled as four pairs with wells of a given pair located 7.6 to 15.2 meters apart. For each pair, one is a deep well penetrating the uppermost aquifer system to a lower semiconfining unit (a depth of approximately 61 to 76 meters below the water table) and is screened over the lower 6.1 meters of the aquifer, while the second is a shallow well penetrating only the upper 6.1 to 9.1 meters of the aquifer. Dimensions and locations for each of these wells are presented in Figures 1 and 2, and Tables 1 through 5.

A larger number of wells monitor the upper part of the uppermost aquifer than have been installed to monitor the lower part of that aquifer. This is because there is considered to be virtually no likelihood of dense, nonaqueous phase liquids (DNAPL) from the waste in the LLBG reaching the groundwater and sinking to the bottom of the aquifer. This conclusion is based on the lack of large volumes of liquid waste disposed in the LLBG, and the disposal of small liquid volumes in sorbing materials. Such waste could migrate to the groundwater only as low density aqueous phase solutions dissolved in infiltrating precipitation. However, despite the very low likelihood of generating DNAPLs from the LLBG, four wells were completed in the lower part of the uppermost aquifer for verification.

Ten additional wells, referred to hereafter as the '1989 wells', were drilled and installed from June to November 1989. Six more wells were installed from October 1989 to February 1990, and are referred to hereafter as the '1990 wells'. All 1989 and 1990 wells are shallow wells screened over the upper 6.1 to 9.1 meters of the aquifer. Seven of these wells are located in the 200 East Area and nine wells are located in the 200 West Area. In 1991, 18 wells were installed between March and December. Two of these wells were designed to monitor the lower portion of the unconfined aquifer at LLWMA-5. All remaining 1991 wells were designed to monitor the upper part of the aquifer. However, problems encountered during drilling one well at LLWMA-4 resulted in the well being completed in a localized perched water zone associated with a nearby liquid disposal unit. Ten wells were installed in 1992 and two in 1993. These 12 shallow wells monitor the upper 6.1 meters of the aquifer and completed the monitoring network for the LLBG. Dimensions and locations for each of these wells are presented in Figures 1 and 2, and Tables 1 through 5.

The following summarizes the general design used in the construction of wells. The procedures employed in drilling the 1987 wells followed guidelines specified in Kasper and Myers (1987) and presented in PNL-6820. Procedures for installation of the 1989 and 1990 interim status wells were provided in the revised groundwater monitoring plan (WHC-SD-EN-AL-015). Procedures for installation of the 1991, 1992, and 1993 wells were documented in drilling specifications (WHC-S-014) and in subsequent revisions.

Figure 3 presents a schematic diagram for both the shallow and the deep groundwater monitoring wells. The majority of the wells were drilled with cable-tool rigs using either drive-barrel or hard-tool methods; however, two of the 1992 and both of the 1993 wells were drilled using the air rotary method. During cable-tool drilling, the hard-tool method normally was used when gravels consisted of very large particles or when the sediments were

saturated. Using the drive-barrel method, a short length of heavy-walled pipe was driven into the sediments and withdrawn. The sediments removed from the barrel generally were representative of the formation. During hard-tool drilling, a solid metal bit was used to break up the sediments. Water was added to the sediments to form a mud that was bailed out of the borehole providing formation samples for geologic description.

Each well was drilled to its required depth using temporary carbon steel casing to support the walls of the borehole. The temporary casing was nested to facilitate its removal once the final stainless steel casing was in place. The temporary casings were removed from the borehole in 0.6-meter increments for every 0.6 meter of completion material emplaced (e.g., filter sand, bentonite grout). This prevented the completion materials from 'locking up' the casings and prevented sediments from collapsing into the borehole. For the 1987 wells, a 3.1-meter long, 20-centimeter outside diameter stainless steel screen (30-slot) was installed at the bottom of the temporary casing for aquifer testing. For the 1989 and 1990 wells, slug tests were performed after the monitoring well installation was completed.

Once the temporary outer casing was in place (and aquifer testing was completed in the 1987 wells), the permanent casing was set. Permanent casing consisted of factory-slotted, 4-inch Schedule-5 type 304 stainless steel screen, and threaded, flush-jointed Schedule-40 type 304 stainless steel casing. Screen lengths ranged from 3.1 to 9.1 meters. For all the 1987 wells and two of the 1989 wells (299-E34-7 and 299-E35-1), the screens were wire-wound with a slot size of 0.03 centimeter (10-slot) to 0.8 centimeter (30-slot). The remaining 1989 and all 1990 wells were completed using 10-slot screens. All subsequent wells were completed using screens. All well casings and screens were factory cleaned and wrapped in polyethylene for delivery to the site. Factory cleaning included a phosphoric acid bath, pressure washing using an alkaline degreaser/cleaner, a warm water rinse, and air drying. All casing and screen segments were inspected for integrity and cleanliness before installation.

Before setting the permanent casing, Colorado silica sand (20-40, 16-30, 10-20, 20-30, or 8-12 mesh) was used to backfill the hole to the desired depth. The bottom of the screen was set at approximately 15 centimeters above the base of the aquifer for the deep wells, while the top of the screen was placed no more than 0.9 meter above the water table for the shallow wells. Once the stainless steel permanent casing and screen were set in the hole, silica sand was used to fill the annulus between the outer and inner casing to 1.5 meters above the top of the screen. Above the sand pack, approximately 1.5 meters of bentonite pellets were emplaced. In 12 of the 1987 wells, grout was used to seal the well to the surface. The remaining wells were sealed to the surface with either bentonite granules or bentonite slurry. The type of seal used was determined by the drilling contractors.

After settlement of the bentonite seal, cement was used to permanently seal either the upper 0.9 to 1.5 meters of the annulus for the 1987 wells, or the upper 5.2 to 6.1 meters of the annulus for the 1989 and 1990 wells. A 1.2-meter by 1.2-meter concrete pad was placed around the well and marked by a

brass plate stamped with the well number. Protective guard posts were installed around each well.

2.3 WELL LOCATIONS AND CONSTRUCTION DETAILS

The locations of the 81 interim status monitoring wells for the 200 East and 200 West Areas are shown in Figure 1 and Figure 2, respectively. The wells also are shown on the topographic maps in Appendix 2A. The location coordinates, surface elevations, drilled depths, and screened interval depths are summarized in Tables 1 through 5. The 1987 wells represent 2,893 total meters drilled. The general construction of all wells is described in Section 2.2.2. Construction logs for the monitoring wells are presented in the following documents: WHC-EP-0225; WHC-MR-0204; WHC-MR-0205; and WHC-SD-EN-DP-049, WHC-SD-EN-DP-049, and WHC-SD-EN-DP-086.

Of the 33 wells installed around LLWMA-1 and LLWMA-2 in the 200 East Area, 23 wells were drilled through the relatively thin uppermost aquifer to the top of the Elephant Mountain Member of the Saddle Mountains Basalt. The remaining wells were drilled to a maximum of 5.2 meters into the unconfined aquifer. All wells were completed in the top of the unconfined aquifer with 3.1 to 6.1 meters of screen.

In the 200 West Area, 48 wells were constructed around LLWMA-3, LLWMA-4, and LLWMA-5, of which one well (299-W7-3) was completed to the top of the basalt. Five other wells (299-W6-3, 299-W6-6, 299-W10-14, 299-W15-17, and 299-W18-22) were drilled to the top of the lower mud unit of the Ringold Formation. Approximately 7.6 to 15.2 meters from each deep well, a second well was completed in the top 5.2 to 8.2 meters of the aquifer. One well at LLWMA-4 (299-W18-29) was completed in an area of localized perched water because attempts to seal the annulus in the perched zone casing failed. This well has a 4.9-meter screen. Thirty-three of the shallow wells in the 200 West Area were completed with 6.1-meter screens. Seven were completed with 9.1-meter screens to account for projected water level declines in response to the 1984 decommissioning of the 216-U-10 Pond (U Pond). One well at LLWMA-5 (299-W6-12) was completed with a 4.9-meter screen because of a suspected localized confining layer of silt at the water table.

2.4 DOWNGRADIENT AND UPGRADIENT INTERIM STATUS WELLS

Based on water table elevations at the time of well installation, and consistent with recent water table elevations, the following wells are considered downgradient and upgradient wells for each LLWMA. The wells have been identified with a superscript indicating the year of installation:

<u>Downgradient Shallow Wells</u>

LLWMA-1 299-E32-2^{87}, 299-E32-3^{87}, 299-E32-5^{89}, 299-E32-6^{91}, 299-E32-7^{91},
299-E32-8^{91}, 299-E32-9^{91}, 299-E32-10^{92}, 299-E33-30^{87}, 299-E33-34^{90}

LLWMA-2 299-E27-8[87], 299-E27-9[87], 299-E27-11[89], 299-E27-17[91], 299-E34-2[87], 299-E34-3[87], 299-E34-7[89], 299-E34-9[91], 299-E34-10[91], 299-E34-11[92], 299-E34-12[92]

LLWMA-3 299-W6-2[87], 299-W7-1[87], 299-W7-2[87], 299-W7-4[87], 299-W7-5[87], 299-W7-6[87], 299-W7-7[89], 299-W7-8[89], 299-W7-9[90], 299-W7-10[90], 299-W7-11[91], 299-W7-12[91], 299-W8-1[87]

LLWMA-4 299-W15-15[87], 299-W15-19[89], 299-W15-20[89], 299-W15-23[90], 299-W15-24[89], 299-W18-21[87], 299-W18-23[87], 299-W18-26[89], 299-W18-27[91], 299-W18-28[91], 299-W15-21 was drilled and abandoned in 1989 because of problems encountered in well completion.

LLWMA-5 299-W6-5[91], 299-W6-7[91], 299-W6-8[91], 299-W6-11[92], 299-W6-12[92]

<u>Upgradient Shallow Wells</u>

LLWMA-1 299-E28-26[87] 299-E28-27[87], 299-E28-28[90], 299-E32-4[87], 299-E33-28[87], 299-E33-29[87], 299-E33-35[90]

LLWMA-2 299-E27-10[87], 299-E34-4[87], 299-E34-5[87], 299-E34-6[87], 299-E35-1[89]

LLWMA-3 299-W9-1[87], 299-W10-13[87], 299-W10-19[92], 299-W10-20[93], 299-W10-21[93]

LLWMA-4 299-W15-16[87], 299-W15-18[87], 299-W18-24[87], 299-W18-32[92]

LLWMA-5 299-W6-2[87], 299-W6-4[91], 299-W6-9[92], 299-W6-10[92], 299-W7-10[90], 299-W11-31[92]

<u>Upgradient Perched Well</u>

LLWMA-4 299-W18-29[91]

<u>Downgradient Deep Wells</u>

LLWMA-3 299-W7-3[87]

LLWMA-4 299-W18-22[87]

LLWMA-5 299-W6-6[91]

<u>Upgradient Deep Wells</u>

LLWMA-3 299-W10-14[87]

LLWMA-4 299-W15-17[87].

LLWMA-5 299-W6-3[91]

The designation of monitoring wells as being upgradient or downgradient is complicated in certain instances because of low groundwater gradients and complex site geometries. Wells 299-E28-26 and 299-E32-4 at LLWMA-1 and wells

299-E34-4, 299-E34-5, and 299-E34-6 at LLWMA-2 were at one time considered to be downgradient wells, based on limited data from the immediately surrounding groundwater monitoring wells. However, a reevaluation of the water level data from an expanded network of wells and over a 6-year period from 1987 to 1993 indicates that these are upgradient wells. These data are presented in Section 2.3.2.1. Well 299-E34-3 at LLWMA-2 originally was listed as an upgradient well, but because of its location at an interior corner of the unit, it is more appropriately designated a downgradient well. Other wells are located in alcoves, corners, or between sections of burial grounds such that these are downgradient of one part of the burial ground and upgradient of another part. These wells include 299-E32-2 in LLWMA-1, 299-E34-2 in LLWMA-2, and 299-W7-4 in LLWMA-3. These wells have been tentatively designated as either downgradient or upgradient based on the presently filled portions of the burial grounds.

Well 299-E32-4 at LLWMA-2 was completed to the top of basalt without encountering the water table. In the years following installation of the well, the water level has declined as a result of diminishing liquid disposal activities in the 200 East Area. As a result, water sampling at three other wells at LLWMA-2 (299-E34-4, 299-E34-6, and 299-E35-1) has been discontinued because of the lack of water.

The upgradient wells were screened at approximately the same hydrostratigraphic horizon as the downgradient wells. The *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* (EPA 1986) recommends that the upgradient wells be located beyond the upgradient extent of potential contaminants from the regulated LLWMA. In addition, 40 CFR 265.91(a)(1)(i) and (ii) requires that upgradient wells provide background water quality data that are 'representative' of the uppermost aquifer near the unit and not affected by the unit. The upgradient wells, with the exception of 299-W18-24 in LLWMA-4, are located at the upgradient edge of the respective LLWMA.

2.5 GENERAL HYDROGEOLOGIC INVESTIGATIVE TECHNIQUES

Characterization of the geohydrologic properties of the LLBG was based on information gained from borehole sediment samples, geophysical logging, aquifer testing, and water level measurements.

Borehole sediment samples were collected using four different sampling methods: split-barrel continuous core, drive-barrel grab samples, hard-tool and bailer grab samples, and grab samples from the rotary drillings. Split-barrel sampling was conducted on five wells: 299-W15-21, 299-W7-8, 299-E32-5, 299-E35-1, and 299-W7-9. Well 299-W15-21 subsequently was abandoned when a casing broke and was replaced with well 299-W15-24; no soil sampling was performed in the replacement well. Soil samples were collected from the remainder of the wells using either drive-barrel or hard-tool and bailer. Although drive-barrel sampling was preferred over hard-tool and bailer sampling, the noncohesive, gravelly nature of the sediments (particularly in the 200 East area) precluded the use of the drive-barrel for much of the drilling. Samples were collected at 1.5-meter intervals. Additional samples were collected at lithologic contacts, in moist zones, and

in zones where organic substances were detected. The following testing was conducted on selected sediment samples:

- Field lithologic characterization
- Laboratory petrographic and mineralogic analyses (thin sections, x-ray diffraction, x-ray fluorescence)
- Grain size distribution
- Field moisture content
- Water retention capacity
- Calcium carbonate content
- Total and inorganic carbon analysis
- Cation exchange capacity
- Hydraulic conductivity.

Field moisture content, water retention capacity, and hydraulic conductivity analyses were not performed on bailed samples because of the high degree of physical disturbance.

The following types of geophysical borehole logging were conducted:

- Natural gamma (gross gamma ray)
- Porosity (neutron-epithermal neutron; 1987 wells only)
- Density (gamma-gamma; 1987 wells only).

Predevelopment groundwater sampling was conducted in the 1987 wells for volatile organics, gross alpha and beta radiation, gamma radiation, tritium, total strontium, plutonium, uranium, cyanide, and semivolatile organics (200 East Area only), and WAC 173-303-9905 constituents (three wells in 200 West Area, one well in 200 East Area). This sampling was conducted to determine the disposition of purgewater. No predevelopment groundwater sampling was conducted in the later wells because all purgewater was handled as if it were contaminated in 1989 and 1990. In 1990, a strategy for dealing with purgewater was developed [HF RCRA Permit, Attachment 5 (Ecology 1994)].

Constant discharge production and recovery aquifer testing was conducted in all 1987 wells except in 299-E28-26 (high uranium), 299-E34-4 (dry), and 299-E34-6 (low water). Slug tests were conducted in wells installed in later years and after 1991 drawdown and recovery data were collected during well development. Water level measurements were conducted before and after well installation and subsequently at least quarterly.

Detailed results for the 1987 wells are presented in PNL-6820. Results for the remaining wells are reported in WHC 1989; WHC-MR-0205; and WHC-SD-EN-DP-004, WHC-SD-EN-DP-049, and WHC-SD-EN-DP-086.

3.0 INTERIM STATUS DATA

This section summarizes groundwater monitoring activities during the interim status period. The sampling and analysis plan, water level measurements, and analytical chemistry results are presented.

3.1 SAMPLING AND ANALYSIS PLAN

This section summarizes aspects of the groundwater sampling and analysis plan (PNL-6820, Appendix B) that have been and currently are being used for the interim status program at the LLBG groundwater monitoring wells. Groundwater samples representative of the uppermost aquifer beneath the LLBG have been obtained and analyzed for detecting potential contaminant releases.

All interim status sampling activities at the LLBG currently are performed under contract by PNNL. The interim status groundwater sampling program at the LLBG was designed to provide initial water quality information on the uppermost aquifer beneath active and proposed regulated units within the LLWMA. Dedicated sampling equipment is provided for most of the wells, thus minimizing the potential for cross-contamination between the wells. The dedicated components of the system consist of a pump, well cap, and access for a water-level measurement device. In all wells, a dedicated pump was installed.

3.1.1 Static Water-Level Measurements

Before purging or sampling the monitoring well, the static water level is measured, recorded, and remeasured until reproducible results are obtained. These measurements are taken as depth-to-water from the top of the well casing and are subtracted from the surveyed elevation of the casing to obtain the elevation of the water level. Graduated steel measuring tapes are used for official measurements. Measurements are reported to the nearest 0.3 centimeter and are repeated until two readings agree to within plus or minus 0.6 centimeter. Between wells, the wetted section of tape is rinsed with de-ionized water and dried with a paper towel to minimize the risk of cross-contamination.

3.1.2 Well Purging

Interim status monitoring wells are purged before sample collection to obtain groundwater samples that are representative of the formation water rather than of the stagnant water from the well casing. Groundwater that has occupied the well undergoes chemical changes and becomes dissimilar from true formation water. Monitoring wells are purged until a minimum of three casing volumes of water have been removed.

3.1.3 Sample Withdrawal

After the interim status monitoring well has been purged, water samples are withdrawn from the well using the dedicated pump. The pumping rate during purging is approximately 11.4 to 18.9 liters per minute. If a monitoring well is not capable of sustaining this extraction rate, the pumping rate is reduced. The pumping rate is reduced to about 3.8 liters per minute for collection of groundwater samples.

During the sampling event, multiple groundwater samples are obtained for the specific laboratory analyses. Samples are collected and bottled in the following order:

- Bottles with septum caps (volatiles)
- Unfiltered samples (major-ions, cyanide, semivolatiles, metals)
- Filtered samples (metals).

3.1.4 Field Analyses

During interim status well purging and sample withdrawal, field determinations of temperature, pH, and specific conductivity are measured and recorded. Groundwater samples for laboratory analysis are not collected until each of these parameters has stabilized (PNL-6820).

3.1.5 Sample Preservation and Handling

Measurements of temperature, specific conductance, and pH are taken in the field on unpreserved samples. Samples submitted for dissolved metals analysis are filtered in the field using a 0.45-micrometer membrane filter and are acidified with nitric acid to a pH of less than 2.0. Samples analyzed for cyanide are not filtered and are preserved by adding sodium hydroxide to raise the pH to greater than 12.0. Samples for volatile and semivolatile organic compounds are unfiltered and unpreserved. Samples for total organic halogen (TOX) and total organic carbon (TOC) are acidified to a pH of less than 2.0 using sulfuric acid and phosphoric acid, respectively. Samples for radium, gross alpha, and gross beta radiation are acidified with nitric acid to a pH of less than 2.0.

Prelabeled sample bottles containing the appropriate preservative are used for each monitoring well. Bottles that contain samples to be analyzed for volatile compounds, TOX, and TOC are filled to slightly more than full to ensure that there is no free head space. Bottles containing samples for all remaining parameters are filled to approximately 95 percent of capacity. Recommended sample containers and sample volumes are presented in Table 6.

Immediately after collection, the sample bottles are placed in sealed, insulated coolers packed with ice to cool the bottles to approximately 4°C. The coolers are transported to the lead laboratory for analysis. Field parameter record forms are attached to the sealed containers. The temperatures of the samples are measured upon opening the cooler in the laboratory. If the temperature is approximately 4°C and some of the original unmelted ice is found to remain in the cooler, the samples are considered to have been maintained at the appropriate temperature during the time the samples were in the cooler.

3.1.6 Chain-of-Custody

Chain-of-custody procedures are followed in collecting interim status data to ensure the integrity of groundwater samples from the time of collection through laboratory analysis and data reporting. This program includes sample labels, sample seals, field record forms, chain-of-custody forms, sample analysis request forms, and laboratory acceptance procedures.

3.1.7 Quality Assurance and Quality Control Procedures

Quality assurance and quality control procedures are applied to both field and laboratory interim status data to ensure the reliability and validity of the data. One aspect of the quality assurance and quality control program is to monitor field and trip blanks and interlaboratory samples to evaluate the accuracy of results from the lead laboratory.

Interlaboratory comparisons are conducted to determine if the analytical results obtained from the lead laboratory are comparable to results from other laboratories. Comparisons are conducted for anions, volatile organics, and metals.

Spiked samples are submitted to the lead laboratory to estimate any bias in laboratory analytical procedures and to determine whether such bias exceeds control limits. Blind, spiked samples prepared by PNNL and spiked samples prepared under a multilaboratory comparison program are both used in this procedure. Field duplicates are obtained by retrieving a second sample from the same well using the same sampling equipment and sampling techniques. Field duplicates are taken on a frequency of one for every 20 wells.

Field and trip blanks are submitted to the lead laboratory to determine whether environmental conditions encountered during collection and transportation of samples have affected the results of sample analyses. Preparation of field blank samples consists of filling sample vials at the wellhead with Type 2-ASTM water (de-ionized, charcoal-filtered, and boiled). At least one field blank is submitted for each sample period per LLWMA, or at the rate of one blank for each 20 wells. Trip blanks, prepared in the laboratory by filling sample vials with Type 2-ASTM water, travel into the field with the empty field blank and sample containers. Both field and trip blank sample bottles are packed with ice and are transported to the laboratory for analysis along with the groundwater samples. Because wells are sampled using dedicated sampling pumps, no equipment blanks are obtained.

3.1.8 Disposal of Purgewater

Before May 1989, all purgewater generated from sampling of interim status wells was released to the ground surface in the vicinity of the well. Beginning in May 1989, purgewater has been contained initially in galvanized steel troughs located near the well head. Tanker trucks are used to collect and transport the purgewater from the troughs to a modular-tank area. The modular-tank area consists of multiple 3,785,400-liter storage tanks

constructed of double layers of HDPE with a geotextile leak detection and containment system. Collected purgewater is stored in the modular-tank area until transferred to the 200 Area Effluent Treatment Facility.

3.2 ANALYTICAL DATA

The following sections present analytical data on interim status water quality.

3.2.1 Groundwater Elevations

Groundwater elevation data have been obtained for the interim status wells since well installation. Water levels were measured weekly from December 1987 to mid-March 1988 and then at least quarterly to the present time. Table 7 presents representative water-level data for selected wells between the time of well installation and the present. Data collected is reported in the RCRA quarterly groundwater monitoring reports.

Groundwater elevations for June 1991, 1992, 1993 are shown in Figures 4 through 9. These figures are based on data from various Hanford Facility groundwater monitoring wells located near the 200 Areas. These figures have been published in annual reports (e.g., DOE/RL-93-88).

Groundwater elevations beneath both LLWMA-1 and LLWMA-2 have exhibited minor fluctuations since 1987, probably in response to variations in discharge rates to the nearby 216-B-3 Pond (B Pond) and to the decommissioning of Gable Mountain Pond. Water levels near these two LLWMAs rose an average of 23 centimeters between December 1987 to January 1989, and dropped approximately 31 centimeters per year since that time. The water table has dropped below the top of the basalt at wells 299-E34-6 and 299-E35-1 on the north and east sides of LLWMA-2. Both of these wells are completed to the top of basalt; therefore sampling is precluded at these wells.

From December 1987 to January 1989, water levels in groundwater monitoring wells near LLWMA-3 decreased an average of more than 15 centimeters, while monitoring wells located adjacent to LLWMA-4 decreased about 21 centimeters. Since 1991, water levels have decreased approximately 31 centimeters a year in monitoring wells near LLWMA-3 and LLWMA-4. Indications from the first year of measurements at LLWMA-5 are consistent with this rate of decline. These decreases probably result from the continuing dissipation of the U Pond mound.

Measured groundwater elevations reflect both present and past disposal of waste water to surface ponds and trenches. The significant groundwater mounding in the vicinity of the B Pond (east of the 200 East Area) has caused the normal regional eastward flow gradient to reverse and develop a westward flow component beneath LLWMA-1 and LLWMA-2. The water table map of June 1993 for LLWMA-1 and LLWMA-2 shows the westward flow to have a hydraulic gradient of approximately 0.00025 beneath the 200 East Area. The magnitudes and directions of the hydraulic gradients in the 200 East Area are somewhat

uncertain because of the relatively flat gradients in the area and the variable influence of the nearby disposal ponds.

Beneath the 200 West Area, the apex of the groundwater mound formed in response to disposal at the U Pond has moved to the northeast since use of the pond was discontinued in 1984 and has been reinforced by continued waste water disposal to the 216-U-14 Ditch. The continued existence of the mound (greater than 18.3 meters above pre-Hanford Site conditions) has forced the normal regional eastward groundwater flow to a more north-northeast direction beneath LLWMA-3 and LLWMA-5, and to a west-northwest direction beneath LLWMA-4. In June 1993, the hydraulic gradient was approximately 0.0015 beneath LLWMA-3 and LLWMA-5 and 0.0006 beneath LLWMA-4.

As the groundwater mound in the 200 West Area continues to decline, water levels in monitoring wells at LLWMA-3, LLWMA-4, and LLWMA-5 will continue to decline, and the regional groundwater flow direction will shift more toward the northeast and the east. Decreased disposal of waste water to the B Pond in the 200 East Area has lowered groundwater levels beneath the 200 East Area. Continued groundwater level decreases are expected in the 200 East Area following decommissioning of the B Pond in the 1990s.

3.2.2 Results of Water Quality Analyses--Predevelopment Samples

Predevelopment groundwater quality data were obtained for each of the 1987 wells at the completion of well construction and before aquifer testing. These samples were taken to determine if the groundwater geochemically was acceptable for discharge to the ground during aquifer testing and borehole development. Samples were analyzed for volatile organic compounds, gross alpha and beta radiation, gamma radiation, tritium, total strontium, plutonium, and uranium. Samples taken from wells in the 200 East Area also were analyzed for cyanide and semivolatile organics. Three wells in the 200 West Area (299-W7-3, 299-W15-17, and 299-W18-22) and one well in the 200 East Area (299-E34-2) were analyzed for the complete suite of WAC 173-303-9905 constituents. These analytical data are documented (PNL-6820).

The predevelopment water was considered acceptable for direct ground discharge if the contaminant levels were below 10 percent of the designated WAC 173-303 dangerous waste guidelines and below 1/25 of the derived concentration guides for radionuclides (DOE/RW-0164; PNL-6820). The derived concentration guides are being developed to be in compliance with 40 CFR 61 Subpart H standard of 25 millirems per year for radiological exposure. Results of the water quality analyses show that water from only one well (299-E28-26) exceeded these criteria. The water obtained from that well was shown to have a mean concentration of 21.8 picocuries per liter of uranium-234, which is greater than 1/25 of the derived concentration guideline of 500 picocuries per liter that the DOE is considering establishing for this constituent. For this reason, well 299-E28-26 was not pump tested.

No other constituents analyzed during the predevelopment sampling events were shown to be in concentrations that would limit the water discharge to the

ground. However, detectable concentrations of tritium, carbon tetrachloride, chloroform, total alpha radiation, total beta radiation, and methylene chloride were observed.

3.2.3 Results of Water Quality Analyses--Quarterly and Semi-annual Samples

The first sampling event for the interim status well network was completed in September/October 1988. Sampling was continued quarterly for the first six sampling rounds. As a result of elevated values of specific conductance and TOX at LLWMA-1 and LLWMA-3 respectively, groundwater quality assessment plans were prepared (WHC-SD-EN-AP-021 and WHC-SD-EN-AP-022). Sampling continued quarterly at LLWMA-1 and LLWMA-3 until January of 1994 when assessment reports (WHC-SD-EN-EV-025 and WHC-SD-EN-EV-026) concluded the groundwater contamination was not the result of disposal practices at the LLBG. Sampling is now conducted semi-annually at LLWMA-1 and LLWMA-3. Semi-annual sampling began at LLWMA-2 and LLWMA-4 in 1989 after initial background values for contamination indicator parameters were established. Quarterly sampling began at LLWMA-5 after the initial monitoring wells were installed in 1991. Semi-annual sampling began at LLWMA-5 in 1993. Statistical comparisons are made on the semi-annual sampling results to determine the impact, if any, of the LLBG.

Samples were analyzed for WAC 173-303-645(5) (Table 1) drinking water parameters and WAC 173-303-9905 chemical parameters, pH, specific conductivity, TOX, and TOC. These four latter parameters are the interim status contamination indicator parameters, and four replicates are obtained and analyzed from each well in each sampling round; other parameters are analyzed less frequently and no replicates are obtained. All groundwater quality data from the LLBG monitoring well network are entered into a PNNL database for permanent storage and are published in quarterly groundwater monitoring reports.

Table 8 identifies those chemical constituents that exceeded established drinking water standards (40 CFR 141) during the initial interim status groundwater sampling event (September/October 1988). At LLWMA-1, groundwater obtained from wells 299-E28-26, 299-E28-27, 299-E32-2, and 299-E32-3 exceeded established drinking water standards for tritium (20,000 picocuries per liter), and groundwater from well 299-E28-26 exceeded limits for nitrate and gross alpha radiation (45 milligrams per liter and 15 picocuries per liter, respectively). This well also was shown to have a high level of dissolved uranium (53.2 micrograms per liter). The concentration of dissolved chromium approached the drinking water standard in well 299-E33-29 (50 micrograms per liter), but the concentration might be reflective of well construction practices rather than true groundwater contamination (PNL-6789).

In wells installed around LLWMA-2, only the concentration of dissolved chromium approached the drinking water limits (wells 299-E34-2 and 299-E34-6). The source of the dissolved chromium might be from the well installation technique, because elevated concentrations of iron and manganese (unfiltered) also were observed. An investigation into the source of the chromium is

ongoing, and the chromium concentrations are being carefully monitored and evaluated

The concentration of dissolved chromium exceeded the drinking water standard in three wells (299-W6-2, 299-W7-6, and 299-W10-14) adjacent to LLWMA-3, while nitrate exceeded 45 milligrams per liter in two wells (299-W6-2 and 299-W7-4) and approached the standard in two additional wells (299-W7-1 and 299-W7-5). Carbon tetrachloride was detected in five samples and exceeded the established drinking water standard (5 micrograms per liter) in four of the samples (299-W6-2, 299-W7-4, 299-W7-5, and 299-W10-13).

Samples obtained from wells at LLWMA-4 were shown to be above detection limit in gross alpha radiation (299-W18-21), chromium (299-W15-15, 299-W15-16, 299-W15-18, 299-W18-21, and 299-W18-23), nitrate (299-W15-16, and 299-W15-18), carbon tetrachloride (299-W15-15, 299-W15-16, 299-W15-18, 299-W18-21, 299-W18-23, and 299-W18-24), and trichloroethylene (299-W15-16). The high concentrations of carbon tetrachloride (0.13 to 8.1 milligrams per liter) observed in the samples might be reflective of constituents derived from past waste water disposal practices at the 216-Z cribs. The highest concentrations of carbon tetrachloride were observed in samples upgradient of LLWMA-4 and immediately downgradient of the waste water disposal areas and the Plutonium Finishing Plant in the 200 West Area.

3.2.4 Statistical Results

Background data were collected during the first year of sampling, from September 1988 to July 1989, and included four sampling events. These data have been published in quarterly groundwater monitoring reports (e.g., PNL-6789). Statistical analysis of the September/October 1989 sampling results for contamination indicator parameters (pH, specific conductivity, TOC, and TOX) were calculated. Results of the statistical analysis indicated that LLWMA-1 and LLWMA-3 statistically had significant increased levels of contamination indicator parameters in a downgradient well compared to background values determined from upgradient wells. Assessment plans were delivered to Ecology for both LLWMAs (WHC-SD-EN-AP-021; WHC-SD-EN-AP-022). Details of the statistical analyses are presented in the assessment plans and summarized in the following.

Interim status data from the fall 1989 sampling round were analyzed using the Average Replicate Test (EPA 1986). This methodology compares the average replicate mean for each indicator parameter at every downgradient well to a critical mean. The critical mean is a function of the mean and standard deviation of the background data, the confidence interval (0.99 in this case), the degrees of freedom in the background data, and the number of comparisons in each sampling event. The number of comparisons in each sampling event is the product of the number of indicator parameters (four in this case) and the number of downgradient wells in the LLWMA.

The assessment plan for LLWMA-1 was triggered by a statistically significant higher specific conductance in well 299-E28-26. The critical mean for specific conductance at LLWMA-1 was 492.9 micromhos per centimeter, while

the average value in 299-E28-26 was 511 micromhos per centimeter. The primary objective of the assessment plan was to determine if the elevated value was due to disposal activities at LLWMA-1, or to activities at another location, such as the 216-B-62 Crib.

An assessment report (WHC-SD-EN-EV-025) determined that well 299-E28-26 is upgradient rather than downgradient of LLWMA-1. The most likely source of the high specific conductance was elevated nitrate associated with past disposal practices at the 216-B-55 and 216-B-62 cribs located to the south of LLWMA-1. The observed contamination therefore appears to have originated at another location. Updated critical means for the contamination indicator parameters have been calculated and LLWMA-1 has returned to detection level monitoring.

The assessment plan for LLWMA-3 was triggered by a statistically significant higher TOX in well 299-W7-4. The critical mean for TOX at LLWMA-3 was 95.5 parts per billion, and the average concentration in 299-W7-4 was 171 parts per billion. The primary purpose of the assessment plan was to determine if the elevated value was due to disposal activities at LLWMA-3, or to activities at an upgradient location, such as the 216-Z-18 Crib.

Additional upgradient groundwater monitoring wells have been installed at LLWMA-3 and analysis of the groundwater chemistry data indicates that the original upgradient wells did not adequately characterize the groundwater beneath LLWMA-3. The assessment report (WHC-SD-EN-EV-025) issued concluded that the elevated TOX in well 299-W7-4 was a result of the extensive carbon tetrachloride contamination beneath the 200 West Area. The source of this contamination is to the south of LLWMA-3. Background levels of the contamination indicator parameters are being re-established for LLWMA-3. Quarterly samples for the contamination indicator parameters were collected from the shallow upgradient monitoring wells for four quarters and upgradient/downgradient comparison values were reestablished in May 1995. Sampling for contamination indicator parameters, interim primary drinking water parameters, water quality parameters, and site-specific parameters currently is semi-annually.

Analysis of the data from LLWMA-2, LLWMA-4, and LLWMA-5 does not indicate statistically significant increases of contamination indicator parameters in downgradient wells.

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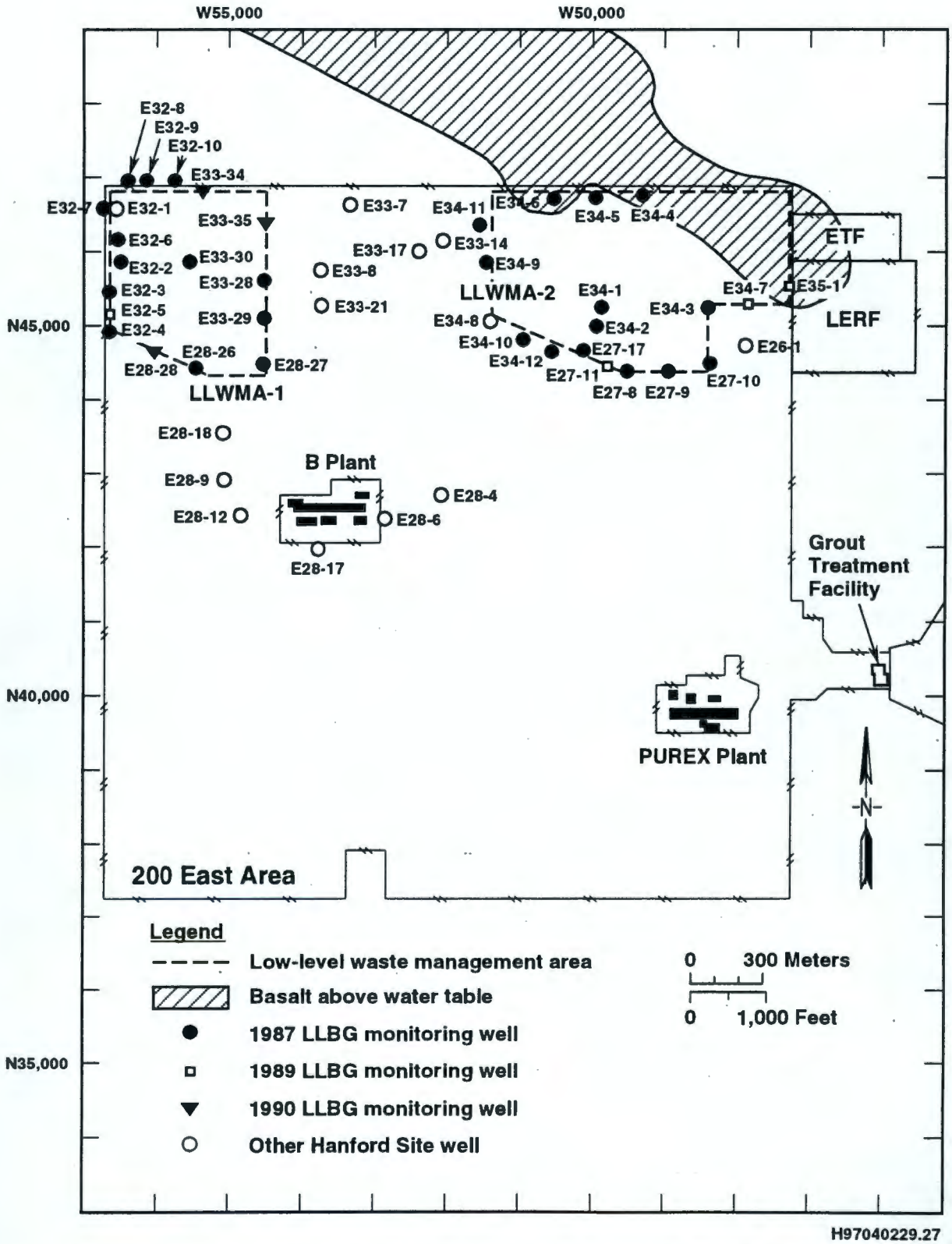

Figure 1. Locations of Interim Status Monitoring Wells in the 200 East Area.

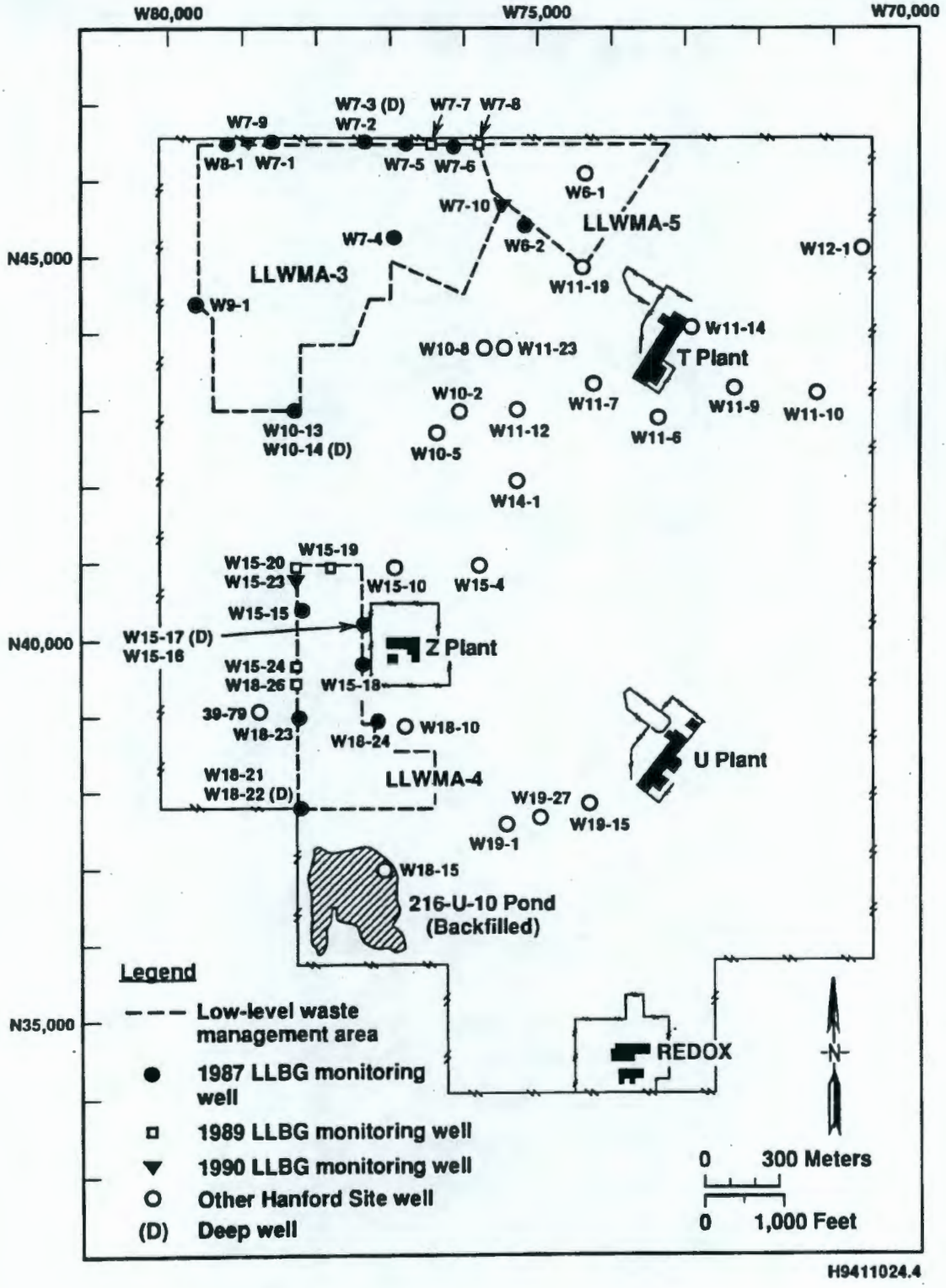

Figure 2. Locations of Interim Status Monitoring Wells in the 200 West Area.

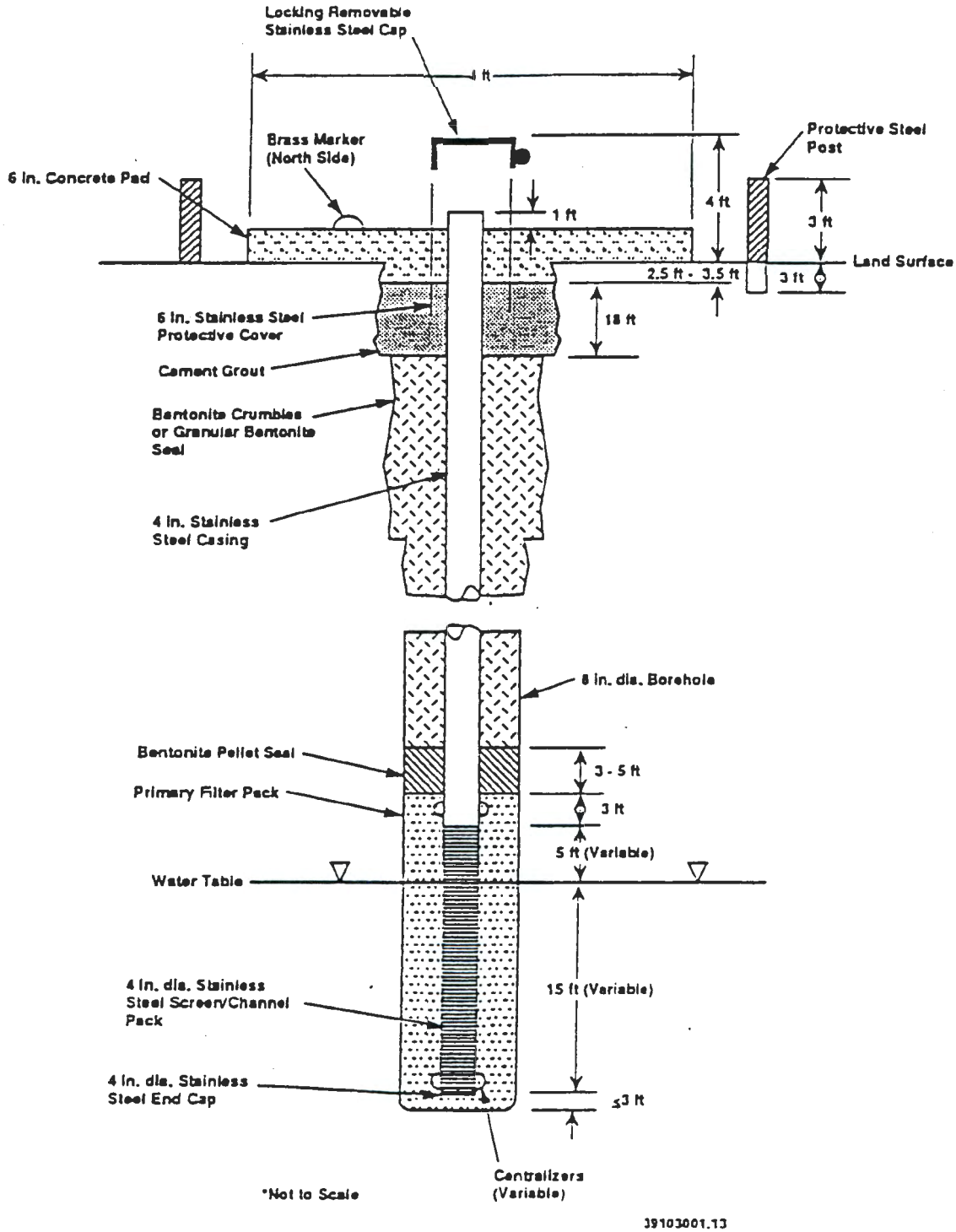

Figure 3. Schematic Design Used for Monitoring Wells Around the Low-Level Burial Grounds (stratigraphy representative of the 200 West Area) (After PNL-6820).

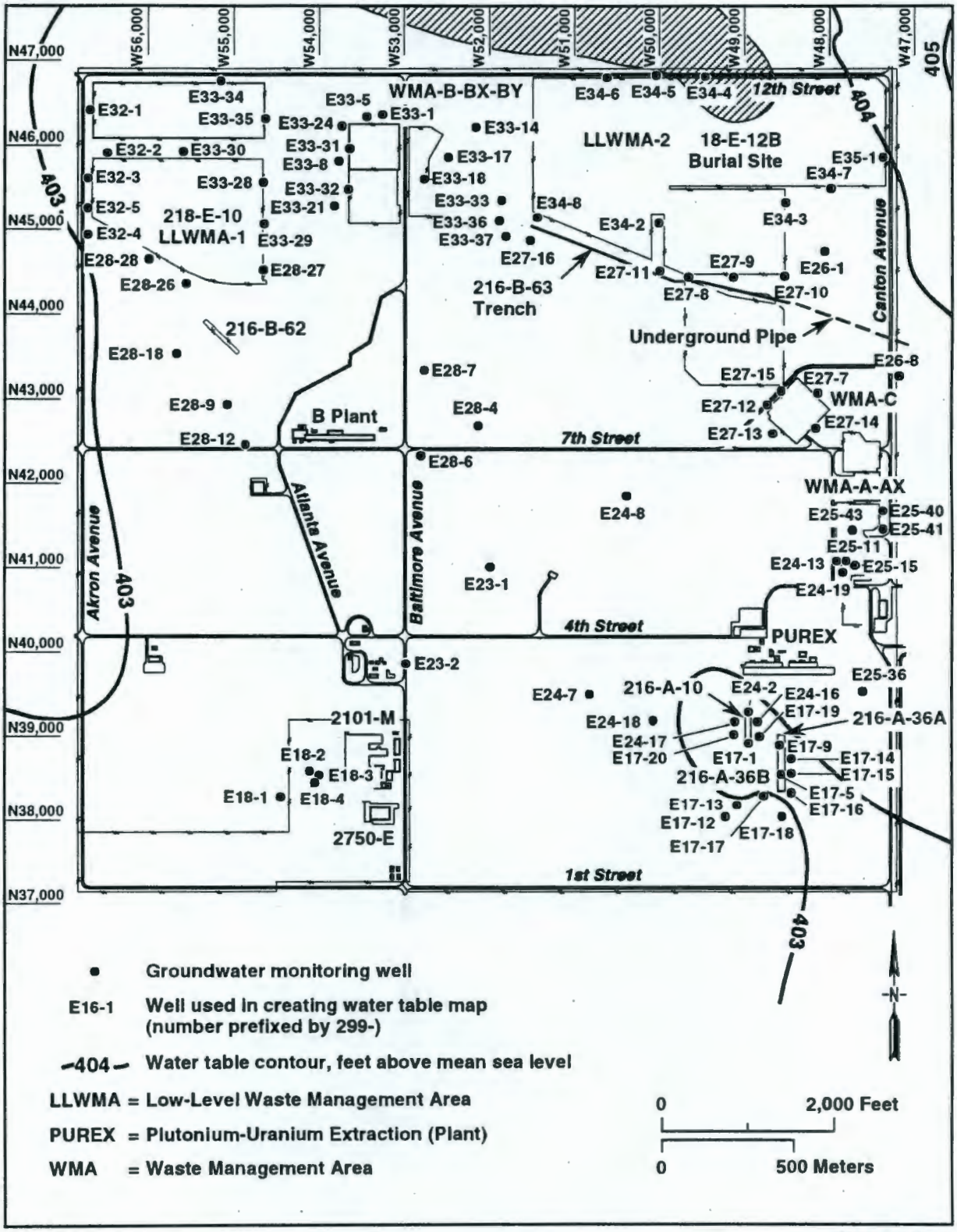

Figure 4. Water Table Beneath Low-Level Waste Management Areas 1 and 2 in the 200 East Area, June 1991.

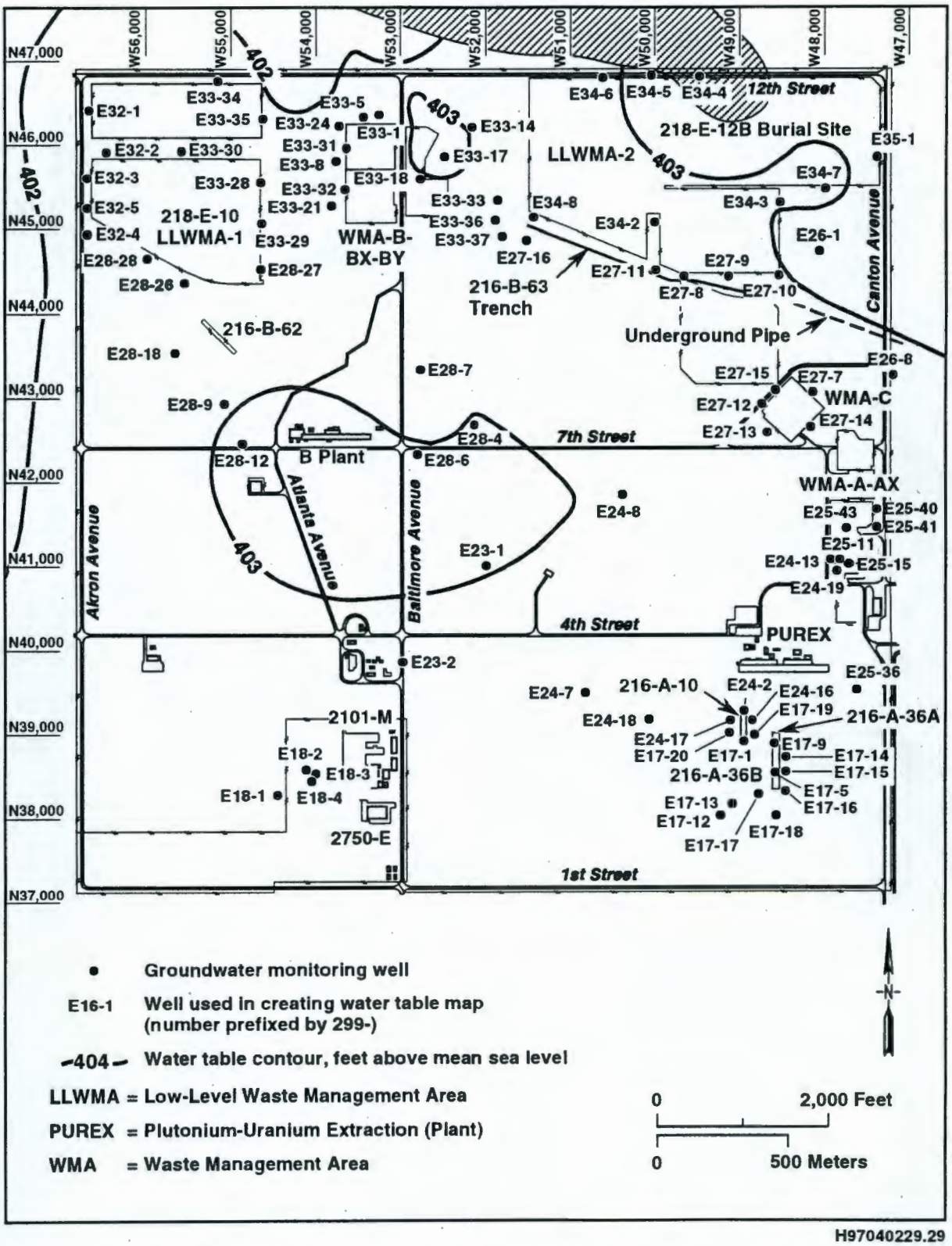

Figure 5. Water Table Beneath Low-Level Waste Management Areas 1 and 2 in the 200 East Area, June 1992.

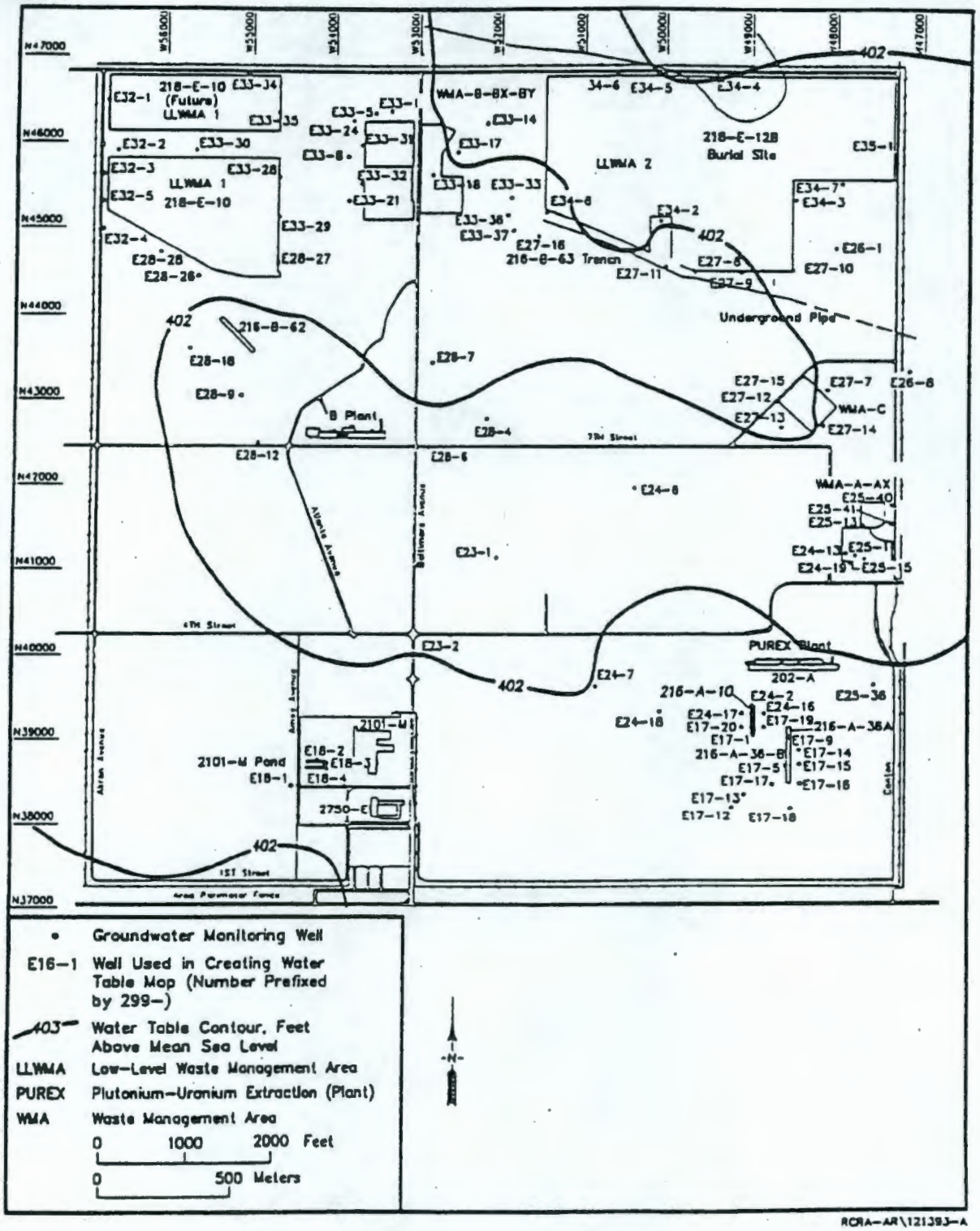

Figure 6. Water Table Beneath Low-Level Waste Management Areas 1 and 2 in the 200 East Area, June 1993.

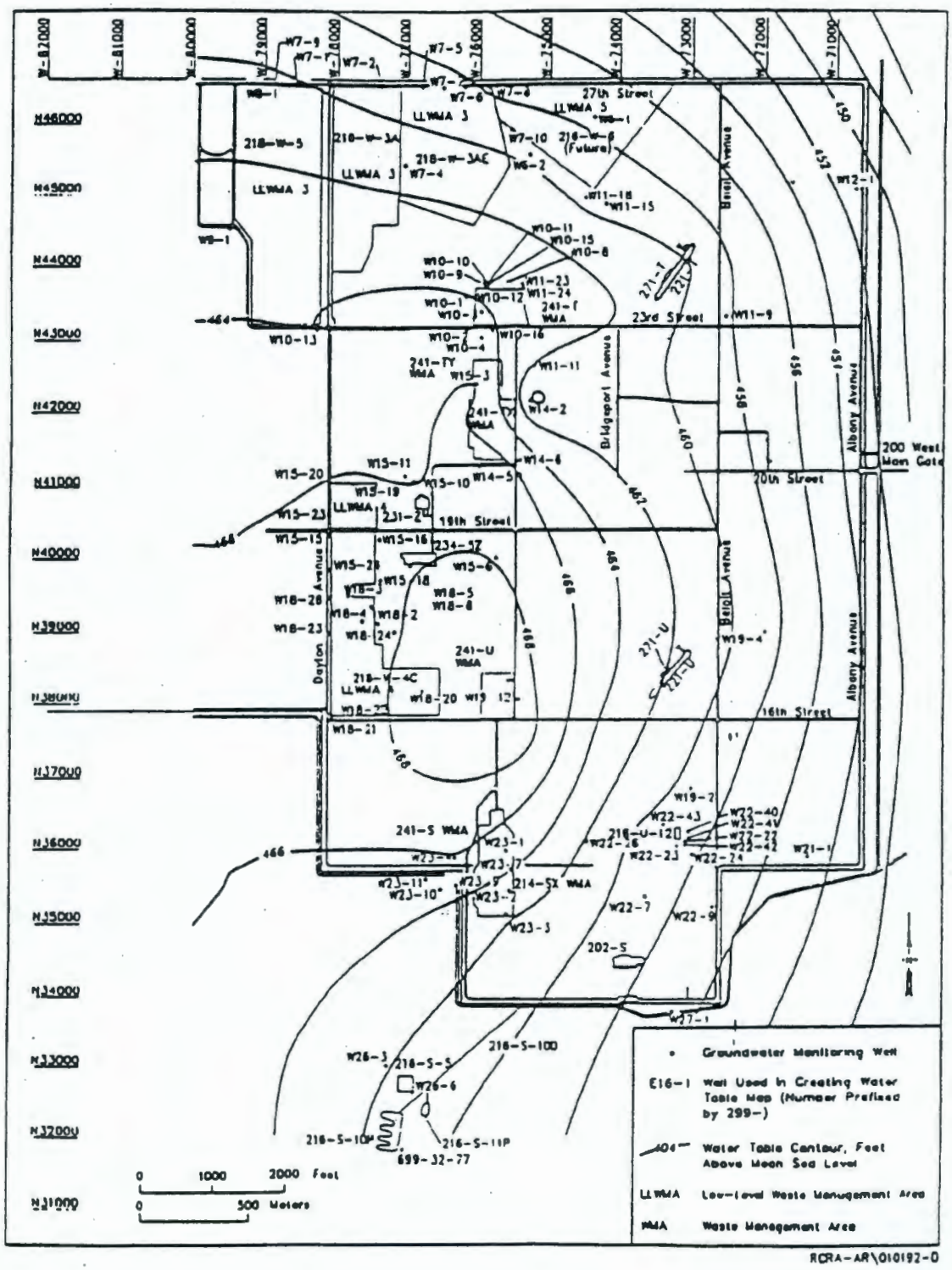

Figure 7. Water Table Beneath Low-Level Waste Management Areas 3, 4 and 5 in the 200 West Area, June 1991.

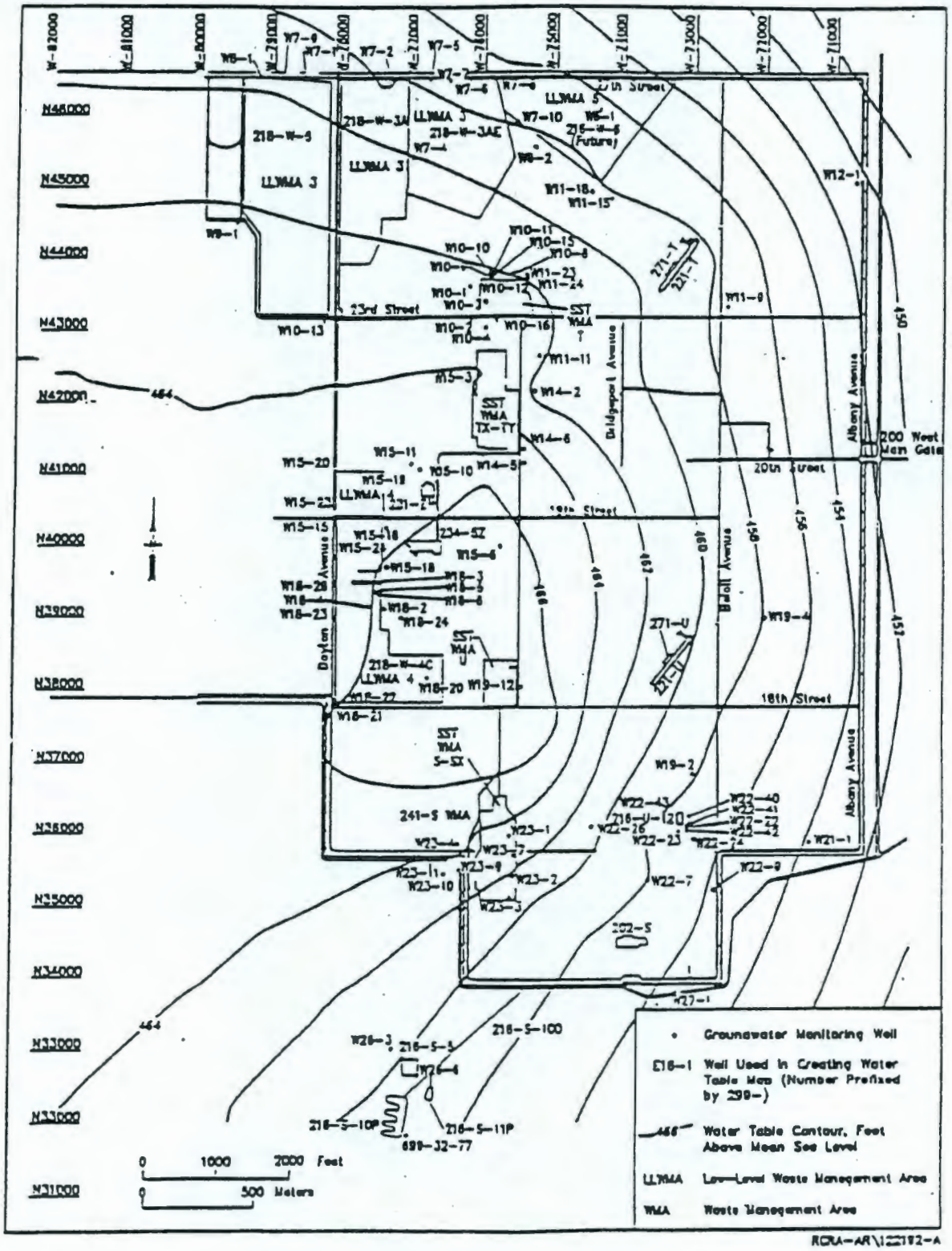

Figure 8. Water Table Beneath Low-Level Waste Management Areas 3, 4 and 5 in the 200 West Area, June 1992.

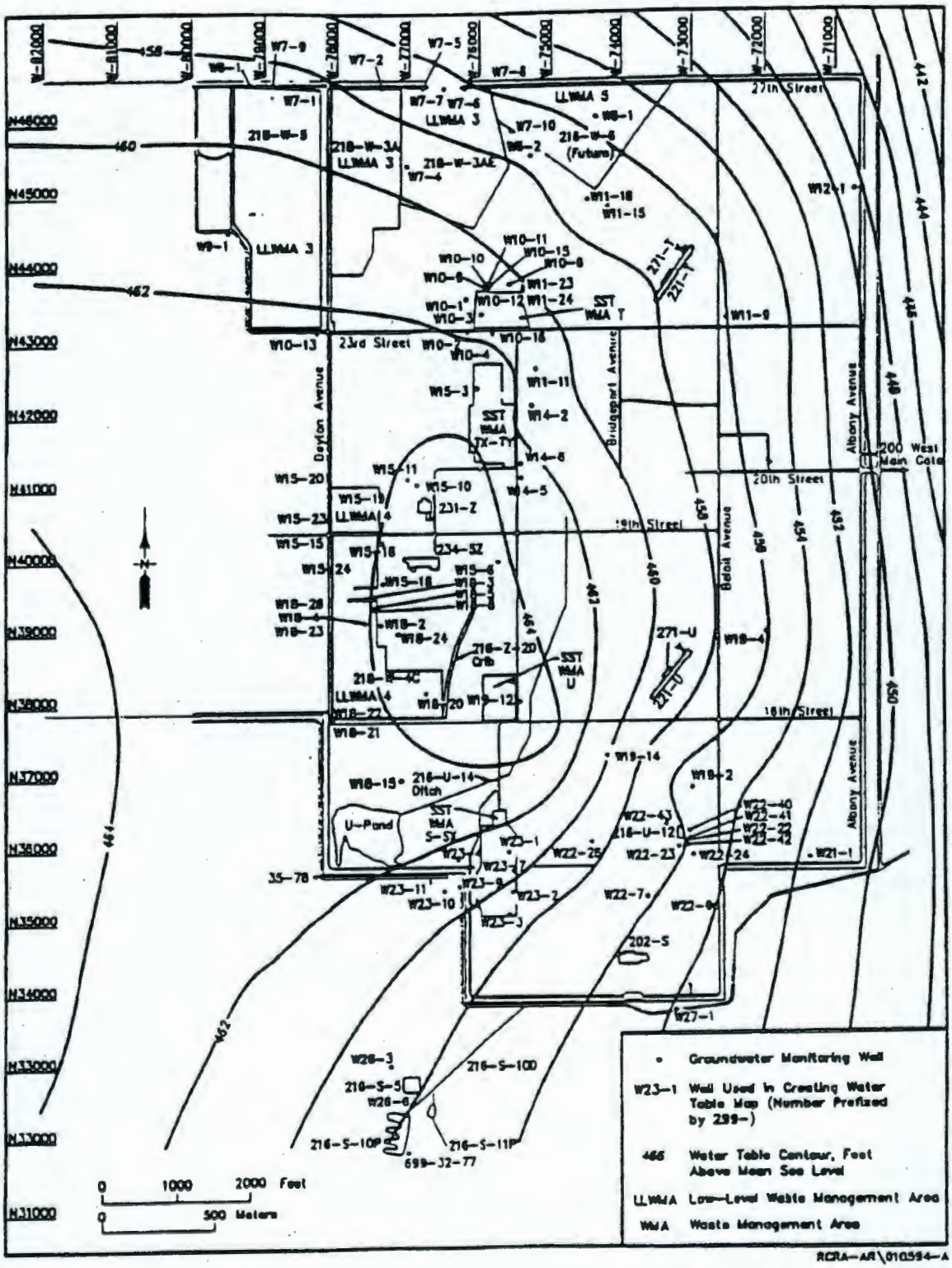

Figure 9. Water Table Beneath Low-Level Waste Management Areas 3, 4, and 5 in the 200 West Area, June 1993.

Table 1. Construction Details for Detection-Level Monitoring Wells; Low-Level Waste Management Area-1. (sheet 1 of 2)

Well	Coordinates	Top of casing elevation (meters)	Drilled depth (meters)	Screened interval (meters)
299-E28-26	N 44,446 W 55,606	209.48	100	85-91
299-E28-27	N 44,595 W 54,670	207.38	92	82-88
299-E28-28	N 44,724 W 56,056	209.32	90	84-90
299-E32-2	N 45,904 W 56,565	204.23	88	79-85
299-E32-3	N 45,631 W 56,721	206.21	93	81-87
299-E32-4	N 44,985 W 56,713	209.06	95	85-91
299-E32-5	N 45,306 W 56,725	207.92	90	83-89
299-E32-6	N 46,060 W 56,722	203.44	85	78-84
299-E32-7	N 46,493 W 56,720	200.69	83	75-81
299-E32-8	N 46,802 W 56,513	196.77	78	72-78
299-E32-9	N 46,802 W 56,081	196.09	78	70-76
299-E32-10	N 46,800 W 55,569	194.44	75	68-74
299-E33-28	N 45,596 W 54,668	202.46	85	78-84
299-E33-29	N 45,124 W 54,665	205.36	88	80-86

Table 1. Construction Details for Detection-Level Monitoring Wells; Low-Level Waste Management Area-1. (sheet 2 of 2)

Well	Coordinates	Top of casing elevation (meters)	Drilled depth (meters)	Screened interval (meters)
299-E33-30	N 45,903 W 55,660	202.29	85	78-84
299-E33-34	N 46,796 W 55,065	193.04	73	67-73
299-E33-35	N 46,351 W 54,685	195.99	76	69-76

Table 2. Construction Details for Detection-Level Monitoring Wells; Low-Level Waste Management Area-2. (sheet 1 of 2)

Well	Coordinates	Top of casing elevation (meters)	Drilled depth (meters)	Screened interval (meters)
299-E27-8	N 44,496 W 49,642	194.41	78	69-75
299-E27-9	N 44,484 W 49,122	191.78	74	67-73
299-E27-10	N 44,520 W 48,522	190.34	73	65-71
299-E27-11	N 44,558 W 49,990	196.07	81	70-76
299-E27-17	N 44,752 W 50,337	193.46	75	68-74
299-E34-2	N 45,076 W 50,048	192.27	74	67-73
299-E34-3	N 45,337 W 48,488	186.39	65	59-65
299-E34-4	N 46,791 W 49,419	179.09	54	48-54
299-E34-5	N 46,791 W 50,014	180.07	58	52-58
299-E34-6	N 46,784 W 50,609	182.22	59	53-59
299-E34-7	N 45,520 W 47,949	184.17	63	59-62
299-E34-9	N 45,765 W 51,520	191.62	71	65-71
299-E34-10	N 45,091 W 51,199	195.00	76	69-75
299-E34-11	N 46,264 W 51,551	188.35	67	63-66

Table 2. Construction Details for Detection-Level Monitoring Wells; Low-Level Waste Management Area-2. (sheet 2 of 2)

Well	Coordinates	Top of casing elevation (meters)	Drilled depth (meters)	Screened interval (meters)
299-E34-12	N 44,907 W 50,783	194.71	76	68-75
299-E35-1	N 45,870 W 47,339	182.36	59	55-58

Table 3. Construction Details for Detection-Level Monitoring Wells; Low-Level Waste Management Area-3.
(sheet 1 of 2)

Well	Coordinates	Top of casing elevation (meters)	Drilled depth (meters)	Screened interval (meters)
299-W6-2	N 45,571 W 75,302	211.06	76	68-75
299-W7-1	N 46,551 W 78,601	210.53	75	68-75
299-W7-2	N 46,519 W 77,385	205.92	72	62-68
299-W7-3	N 46,520 W 77,420	206.09	145	137-143
299-W7-4	N 45,435 W 77,040	204.73	72	62-71
299-W7-5	N 46,509 W 76,816	205.14	70	63-69
299-W7-6	N 46,509 W 76,219	206.85	74	64-70
299-W7-7	N 46,509 W 76,519	205.72	70	63-69
299-W7-8	N 46,510 W 75,880	209.50	75	67-73
299-W7-9	N 46,549 W 78,889	210.95	77	67-73
299-W7-10	N 45,921 W 75,564	210.21	74	67-73
299-W7-11	N 46,512 W 77,769	207.70	72	65-71
299-W7-12	N 46,514 W 78,246	209.68	75	67-73
299-W8-1	N 46,551 W 79,200	213.76	83	72-78
299-W9-1	N 44,508 W 79,507	224.86	90	81-87

Table 3. Construction Details for Detection-Level Monitoring Wells; Low-Level Waste Management Area-3.
(sheet 2 of 2)

Well	Coordinates	Top of casing elevation (meters)	Drilled depth (meters)	Screened interval (meters)
299-W10-13	N 43,137 W 78,297	213.07	76	69-75
299-W10-14	N 43,143 W 78,330	213.19	141	130-136
299-W10-19	N 44,545 W 77,249	208.17	72	65-72
299-W10-20	N 43,987 W 77,565	209.56	74	68-74
299-W10-21	N 44,930 W 76,466	205.45	72	64-70

Table 4. Construction Details for Detection-Level Monitoring Wells; Low-Level Waste Management Area-4.
(sheet 1 of 2)

Well	Coordinates	Top of casing elevation (meters)	Drilled depth (meters)	Screened interval (meters)
299-W15-15	N 40,330 W 78,103	212.74	78	68-77
299-W15-16	N 40,269 W 77,387	208.75	74	63-72
299-W15-17	N 40,221 W 77,387	208.68	137	129-132
299-W15-18	N 39,705 W 77,383	117.56	74	63-72
299-W15-19	N 41,041 W 77,772	210.80	75	65-72
299-W15-20	N 41,028 W 78,120	212.86	74	67-73
299-W15-23	N 40,680 W 78,119	213.20	74	67-73
299-W15-24	N 39,851 W 78,096	213.17	74	67-73
299-W18-21	N 37,794 W 78,080	203.80	69	60-69
299-W18-22	N 37,831 W 78,109	203.76	139	127-137
299-W18-23	N 38,987 W 78,120	212.39	78	67-76
299-W18-24	N 38,998 W 77,180	208.59	73	63-72
299-W18-26	N 39,477 W 78,097	213.07	76	68-74
299-W18-27	N 38,607 W 78,103	210.39	73	66-72
299-W18-28	N 38,214 W 78,096	207.26	70	63-70

Table 4. Construction Details for Detection-Level Monitoring Wells; Low-Level Waste Management Area-4.
(sheet 2 of 2)

Well	Coordinates	Top of casing elevation (meters)	Drilled depth (meters)	Screened interval (meters)
299-W18-29	N 37,952 W 76,560	205.48	46	36-41
299-W18-32	N 37,780 W 76,709	206.24	69	62-68

Table 5. Construction Details for Detection-Level Monitoring Wells; Low-Level Waste Management Area-5.

Well	Coordinates	Top of casing elevation (meters)	Drilled depth (meters)	Screened interval (meters)
299-W6-2	N 45,571 W 75,302	211.06	76	68-75
299-W6-3	N 45,399 W 74,713	213.31	134	125-128
299-W6-4	N 45,370 W 74,667	213.74	79	72-78
299-W6-5	N 46,510 W 73,477	217.64	87	80-87
299-W6-6	N 46,511 W 74,053	216.40	144	128-131
299-W6-7	N 46,512 W 74,077	216.49	84	75-81
299-W6-8	N 46,514 W 75,004	211.45	77	70-76
299-W6-9	N 45,609 W 74,997	212.78	77	70-77
299-W6-10	N 45,901 W 73,744	217.16	85	77-83
299-W6-11	N 46,500 W 74,564	214.23	85	83-85
299-W6-12	N 46,504 W 75,374	211.08	78	73-78
299-W7-10	N 45,921 W 75,564	210.21	74	67-73
299-W11-31	N 45,188 W 74,375	215.45	81	73-79

Table 6. Sample Volume and Container Type for Interim Status Groundwater Sampling Parameters.

Parameter	Recommended container[a]	Sample volume (milliliters)
pH	P, CG	25
Specific conductivity	P, CG	100
<u>Organic compounds</u>		
Volatile organic compounds	AG - Teflon[b] lined septum in cap	2-40 vials
Semi-volatile organic compounds	AG	2,000
Total organic halogen (TOX)	AG	250
Total organic carbon (TOC)	AG	250
<u>Metals</u>		
Beryllium	P	1,000
Chromium	P	1,000
Copper	P	1,000
Cadmium	P	1,000
Silver	P	1,000
Sodium	P	1,000
Mercury	G	1,000
Lead	P	1,000
<u>Inorganic anions</u>		
Chloride	P	1,000
Fluoride	P	1,000
Sulfate	P	1,000
Nitrate	P	1,000
<u>Nonmetals</u>		
Radium	P	500
Gross alpha	P	500
Gross beta	P	500
Cyanide	P	500

[a]Container types: P - plastic (PE), AG - amber glass, CG - clear glass.
[b]Teflon is a trademark of E.I. duPont de Nemours and Company, Incorporated.

Table 7. Water Level Information for Selected Low-Level Burial Grounds Groundwater Monitoring Wells.

	Well	December measurements (meters above mean sea level) 1987	1989	1991	1993
LLWMA-1					
	299-E28-26	123.40	123.28	122.86	122.31
	299-E32-2	123.32	123.21	122.79	122.29
	299-E33-28	123.40	123.28	122.84	122.36
LLWMA-2					
	299-E27-10	123.64	123.48	123.03	122.52
	299-E34-2	123.49*	123.39	122.86	122.42
	299-E34-5	123.78	123.63	123.20	122.77
LLWMA-3					
	299-W6-2	140.81	140.66	140.05	139.31
	299-W7-2	140.55	140.32	139.88	139.19
	299-W7-4	141.23	140.95	140.43	139.74
	299-W7-3d	140.17	139.90	139.55	138.87
	299-W10-14d	142.20	141.88	141.36	140.53
LLWMA-4					
	299-W15-15	143.15	142.86	142.14	141.23
	299-W15-16	143.37	143.12	142.28	141.36
	299-W18-21	143.28	142.91	142.22	141.22
	299-W15-17d	143.23	142.96	142.17	141.33
	299-W18-22d	143.05	142.63	142.00	141.09
LLWMA-5					
	299-W6-2	140.81	140.66	140.05	139.31
	299-W6-4	----	----	----	139.45
	299-W6-7	----	----	----	138.38
	299-W6-3d	----	----	----	139.27
	299-W6-6d	----	----	----	138.37

* - Measured 1/8/88.
d - Monitors bottom of unconfined aquifer.

Table 8. Chemical Constituents Exceeding Drinking Water Standards During Initial Interim Status Sampling Event (September/October 1988).

Constituent	Number of wells			
	LLWMA-1	LLWMA-2	LLWMA-3	LLWMA-4
Gross alpha (15 picocuries per liter)[a]	1	0	0	1
Carbon tetrachloride (5 parts per billion)[a]	0	0	4	6
Coliform bacteria (1 MPN)[a]	0	0	0	1
Chromium (50 parts per billion)[a]	0	0	3	5
Nitrate (45 milligrams per liter)[a]	1	0	2	2
Trichloroethylene (5 parts per billion)[a]	0	0	0	1
Tritium (20,000 picocuries per liter)[a]	5	0	0	0

[a]40 CFR 141; MPN = most probable number.

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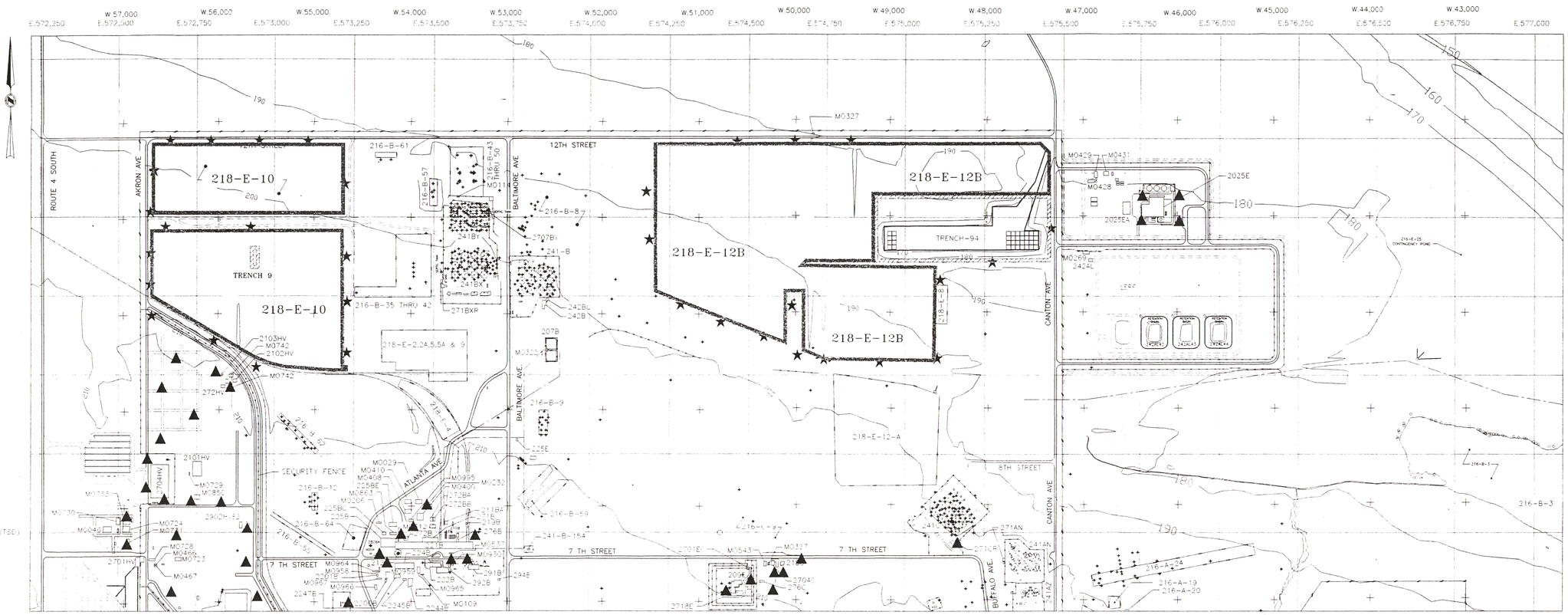
- PERIMETER FENCES
- WELL
- TANKS
- PROCESS SEWER
- SANITARY SEWER
- 216-A-42 — CRIB
- 218-E-10 — BURIAL GROUND
- SOLID WASTE MANAGEMENT UNIT (SWMU), TREATMENT, STORAGE, AND/OR DISPOSAL (TSD) UNIT BOUNDARY SEE NOTE 4
- POST-AUGUST 19, 1987 TSD UNIT BOUNDARY SEE NOTE 4
- WITHDRAWAL WELL
- INJECTION WELL
- RCRA MONITORING WELLS FOR LLBG
- FIRE HYDRANTS



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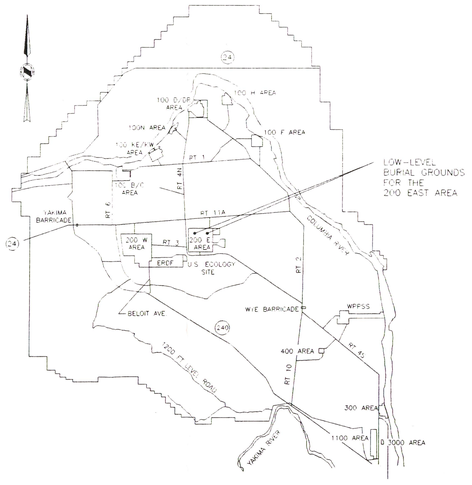
   HORIZONTAL DATUM: NAD-83 LAMBERT PROJECTION. WASHINGTON STATE PLANE COORDINATES ARE SHOWN IN METERS.

   CONTOUR INTERVAL: 2.5 METERS.

3. HANFORD PLANT GRID: A LOCAL GRID SYSTEM WITH ITS INITIAL POINT NORTHEAST OF THE 400 AREA. IT COVERS 200 EAST AND 200 WEST AREA AS WELL AS GENERAL SITE WORK SUCH AS WELLS AND BURIAL GROUNDS. HANFORD COORDINATES ARE SHOWN IN FEET.

4. THE SWMU AND THE POST-AUGUST 19,1987 (TSD) UNIT BOUNDARY COMPRISE THE TSD UNIT BOUNDARY AS IDENTIFIED IN THE HANFORD FACILITY DANGEROUS WASTE PERMIT APPLICATION, LOW LEVEL BURIAL GROUNDS (DOE/RL-88-20).



KEY PLAN

SCALE: NONE

SITE PLAN

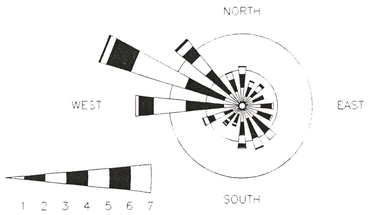
SCALE: 1:6000

0 60 120 240 360 480

1 cm = 60 meters

WIND ROSE FOR: 200E AREA
% CALM WINDS = .7
STATION NO.6

PERIOD COVERED
1/1/93 - 12/31/93



PADDLES INDICATE DIRECTION WIND IS COMING FROM.
RADIAL GRIDS REPRESENT 5.0% AND 10.0% OCCURRENCE.

WIND CLASS	MILES/HOUR
1-------	>1.0 - 3.0
2-------	4.0 - 7.0
3-------	8.0 - 12.0
4-------	13.0 - 18.0
5-------	19.0 - 24.0
6-------	25.0 - 31.0
7-------	32.0 +

WIND ROSE

MAY 20 1997
DATE
BY 37 RECEIVED

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DRAWN RAFAEL TORRES	DATE 4-30-97
CHECKED	4/30/97
DFTG APVD	4/30/97
COG ENGR	5/12/97
APVD	5/12/97
APVD	5/13/97
APVD	5/13/97
APVD	
APVD	
APVD	

U.S. DEPARTMENT OF ENERGY
Richland Operations Office
Fluor Daniel North West

200 EAST AREA LOW-LEVEL BURIAL GROUND TOPOGRAPHIC MAP

SIZE	BLDG NO.	INDEX NO.	DWG NO.	REV.
F	200E	0103	H-13-000259	0

SCALE SHOWN | EDT 614848 | SHEET 1 OF 2

DWG NO	TITLE
H-13-000205 THRU H-13-000207	200 AREA TOPOGRAPHIC MAP
H-13-000213 THRU H-13-000216	200 AREA TOPOGRAPHIC MAP
H-13-000221 THRU H-13-000224	200 AREA TOPOGRAPHIC MAP
H-13-000228 THRU H-13-000231	200 AREA TOPOGRAPHIC MAP

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REF NUMBER: | TITLE
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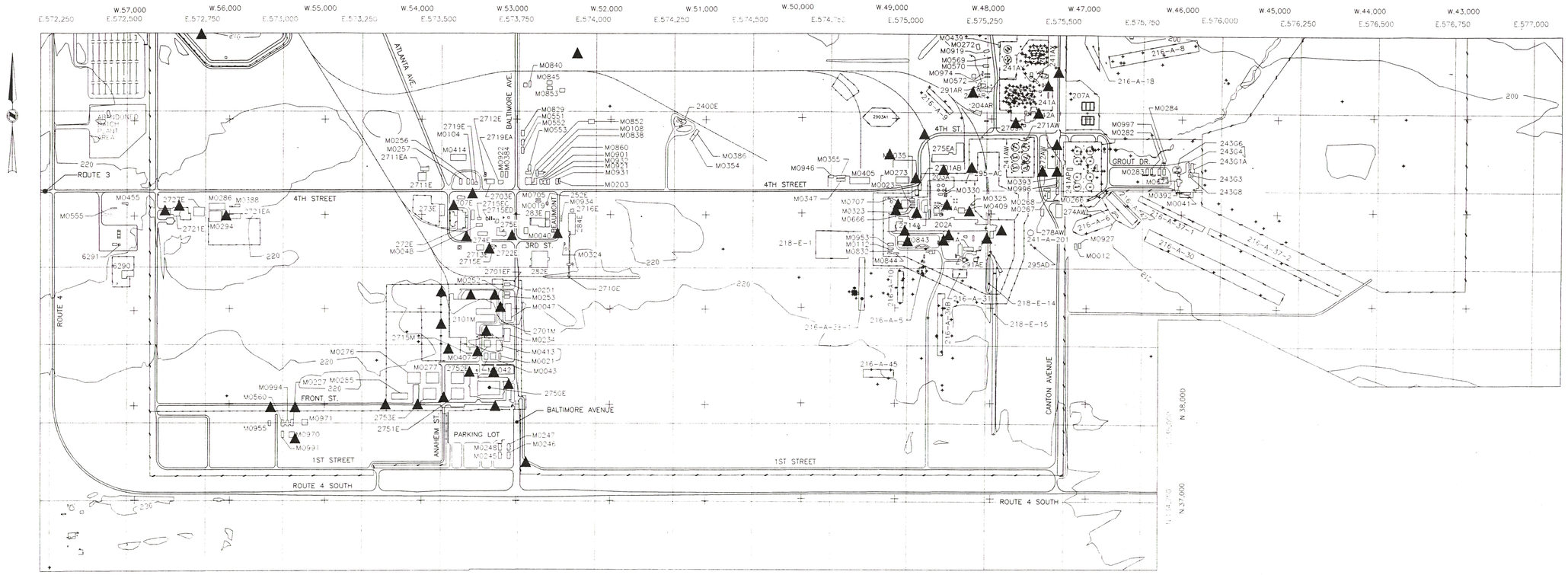
MFD REV NO	DESCRIPTION	REV BY DATE	CHK BY DATE	DFTG APVD DATE	COG ENGR	OTHER	OTHER
REV REL	REVISIONS				APPROVALS : BY/DATE		

CADFILE N000259A | CADCODE DOS:6.0:ACD2:12.0:SS

CHK PRINT DATE | COMMENT PRINT DATE

54-6000-027(5/89)

DWG NO H-13-000259 | SH 1 of 2 | REV 0



SITE PLAN

SCALE: 1:6000

0 60 120 240 360 480

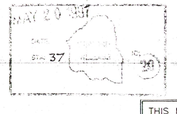
1 cm = 60 meters

WIND ROSE

1. FOR WIND ROSE SEE SHEET 1.

GENERAL NOTES

1. FOR GENERAL NOTES AND LEGEND SEE SHEET 1.



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		DATE
DRAWN	RAFAEL TORRES	4-30-97
CHECKED		4/30/97
DFTG APVD		4/30/97
COG ENGR		5/12/97
APVD		5/12/97
APVD		5/13/97
APVD		5/13/97
APVD		
APVD		
APVD		

U.S. DEPARTMENT OF ENERGY
Richland Operations Office
Fluor Daniel North West

200 EAST AREA
LOW-LEVEL BURIAL GROUND
TOPOGRAPHIC MAP

SIZE	BLDG NO	INDEX NO	DWG NO	REV
F	200E	0103	H-13-000259	0

SCALE SHOWN FDT 614848 SHEET 2 OF 2

CHK PRINT DATE COMMENT PRINT DATE

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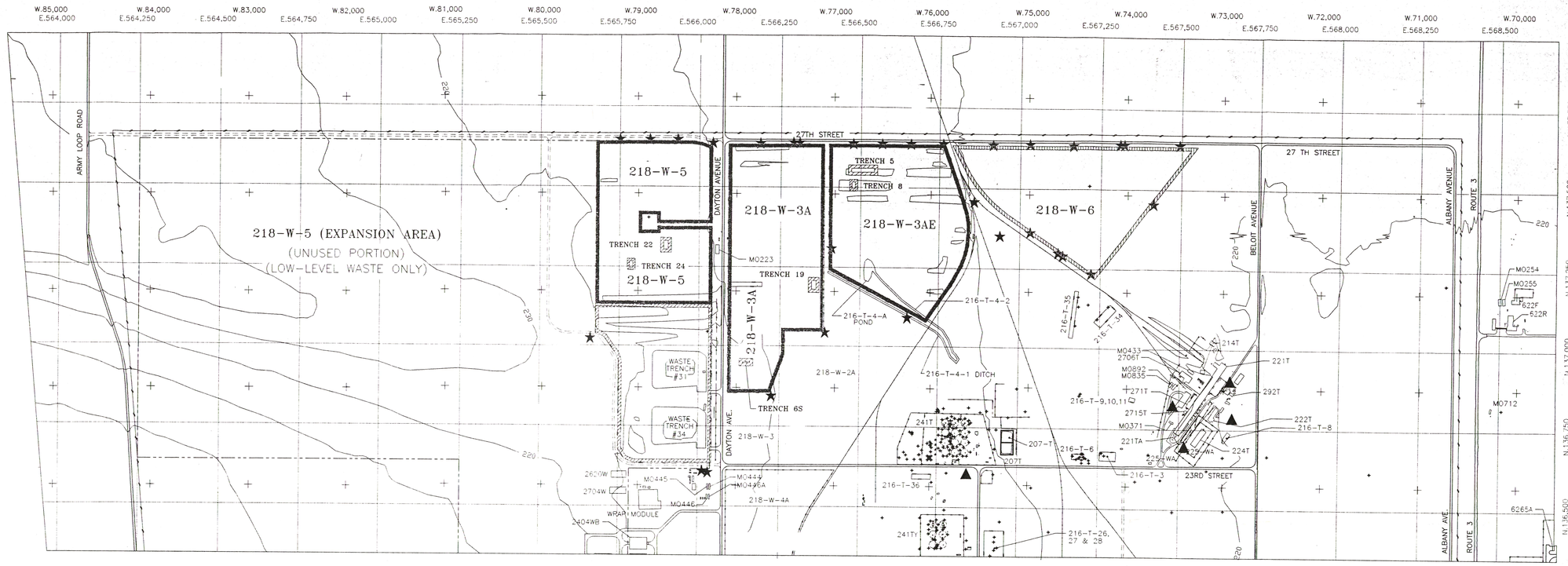

SITE PLAN

SCALE: 1:6000

0 60 120 240 360 480

1 cm = 60 meters

LEGEND

- W.47,000 N.43,000 — HANFORD PLANT COORDINATES (FEET)
- E.576,250 N.136,000 — WASHINGTON STATE COORDINATES (METERS)
- 2150 — INDEX CONTOUR (METERS)
- INDEX CONTOUR (METERS)
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- UNIMPROVED ROAD
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- SIDEWALKS\PARKING LOTS
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- INJECTION WELL
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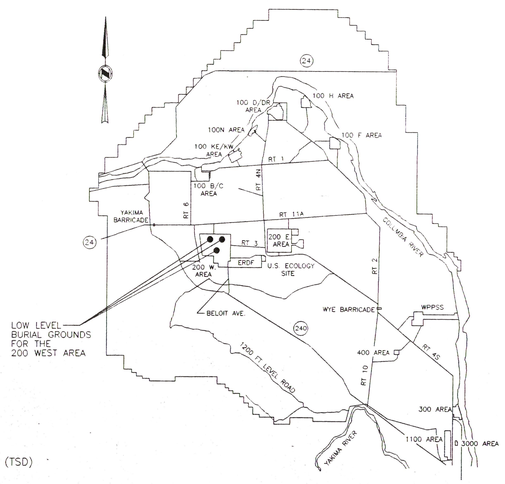

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SCALE: NONE

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   HORIZONTAL DATUM: NAD-83 LAMBERT PROJECTION. WASHINGTON STATE PLANE COORDINATES ARE SHOWN IN METERS.

   CONTOUR INTERVAL: 2.5 METERS.

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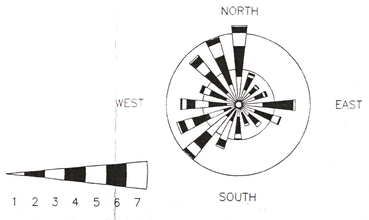
WIND ROSE FOR: HANFORD MET STATION
% CALM WINDS = .5
STATION NO. 21

PERIOD COVERED
1/1/93 - 12/31/93



PADDLES INDICATE DIRECTION WIND IS COMING FROM.
RADIAL GRIDS REPRESENT 5.0% AND 10.0% OCCURRENCE.

WIND CLASS	MILES/HOUR
1-------	>1.0 - 3.0
2-------	4.0 - 7.0
3-------	8.0 - 12.0
4-------	13.0 - 18.0
5-------	19.0 - 24.0
6-------	25.0 - 31.0
7-------	32.0 +

WIND ROSE

MAY 20 1997
DATE
STA. 37
29

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REF NUMBER	TITLE
H-13-000201 THRU H-13-000203	200 AREA TOPOGRAPHIC MAP
H-13-000209 THRU H-13-000211	200 AREA TOPOGRAPHIC MAP
H-13-000217 THRU H-13-000219	200 AREA TOPOGRAPHIC MAP
H-13-000225 THRU H-13-000227	200 AREA TOPOGRAPHIC MAP
H-13-000233 H-13-000234	200 AREA TOPOGRAPHIC MAP

REFERENCES

DWG NO	TITLE

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					APPROVALS BY/DATE			

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CADFILE N000260A CADCODE DOS:6.0:ADD2:12.0:SS

		DATE
DRAWN	RAFAEL TORRES	4-30-97
CHECKED		4/24/97
DFTG APVD		4/24/97
COG ENGR		5/12/97
APVD		5/14/97
APVD		5/14/97
APVD		5/14/97
APVD		
APVD		

U.S. DEPARTMENT OF ENERGY
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200 WEST AREA LOW-LEVEL BURIAL GROUND TOPOGRAPHICAL MAP

SIZE	BLDG NO	INDEX NO	DWG NO	REV
F	200W	0103	H-13-000260	0

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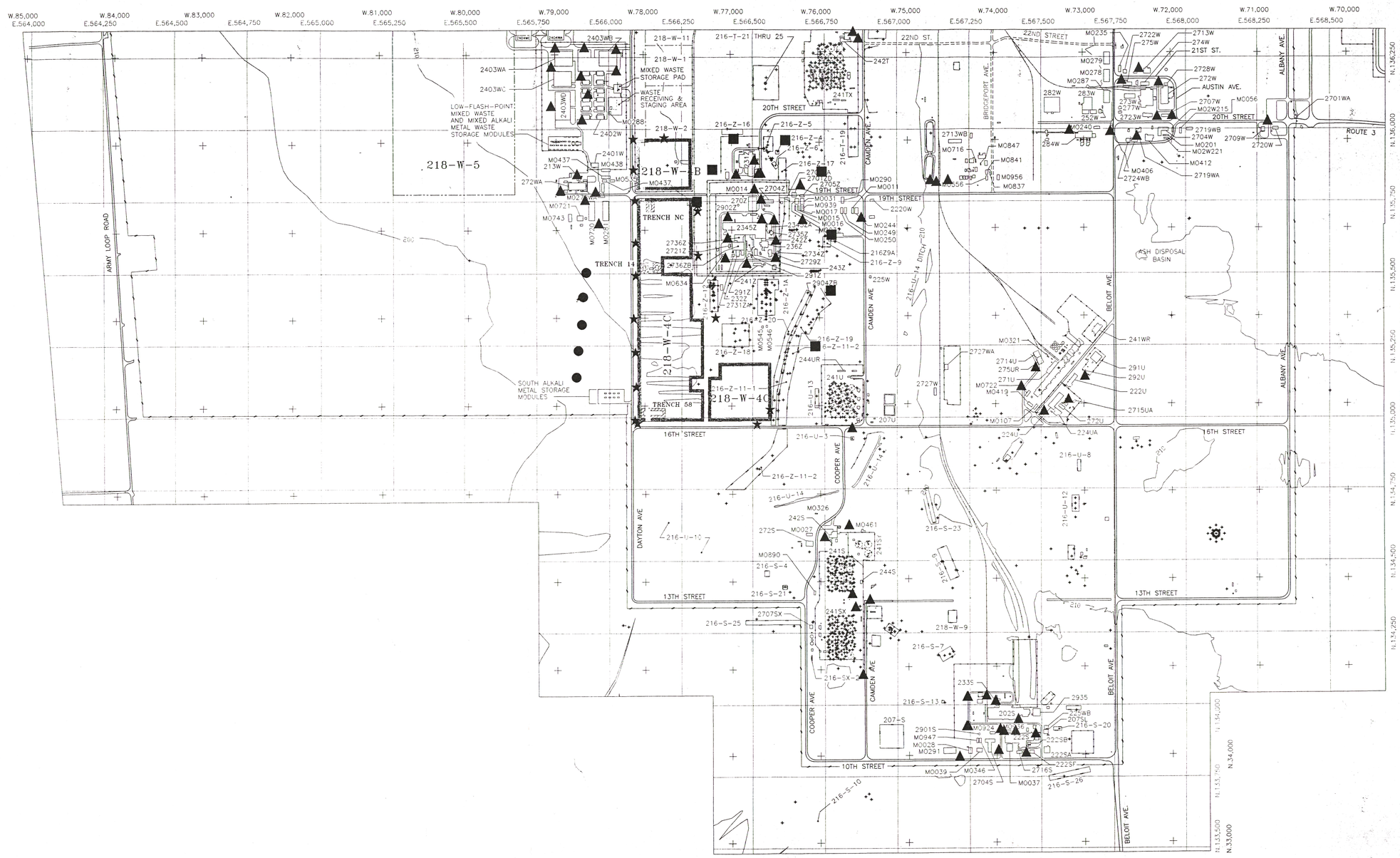
CHK PRINT DATE COMMENT PRINT DATE

54-6000-027(5/89)

DWG NO H-13-000260 SH 1 OF 2 REV 0



SITE PLAN

SCALE: 1:6000

0 60 120 240 360 480

1 cm = 60 meters

GENERAL NOTES

1. FOR GENERAL NOTES SEE SHEET 1.

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		DATE
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COG ENGR		5/13/97
APVD		5/13/97
APVD		5/13/97
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APVD		
APVD		
APVD		

U.S. DEPARTMENT OF ENERGY
Richland Operations Office
Fluor Daniel Northwest

200 WEST AREA
LOW-LEVEL BURIAL GROUND
TOPOGRAPHICAL MAP

SIZE	BLDG NO	INDEX NO	DWG NO	REV
F	200W	0103	H-13-000260	0
SCALE	SHOWN	TDF	614849	SHEET 2 of 2

REV NO	DESCRIPTION	REV BY DATE	CHK BY DATE	DFTG APVD DATE	COG ENGR	OTHER	OTHER
A	1						

REVISIONS

APPROVALS BY/DATE

CADFILE N000260B

CADCODE DOS:6.0/ACD2:12.0-SS

REF NUMBER	TITLE

REFERENCES

DWG NO	TITLE

DRAWING TRACEABILITY LIST

NEXT USED ON H-13-000200

84-6000-027(5/89)

DWG NO H-13-000260 SH 2 of 2 REV 0