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Nevada Nuclear Waste Storage Investigations Project

Site Characterization Plan Conceptual Design Report

Volume 2 Chapters 4-9

Compiled by Hugh R. MacDougall, Leo W. Scully, Joe R. Tillerson

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
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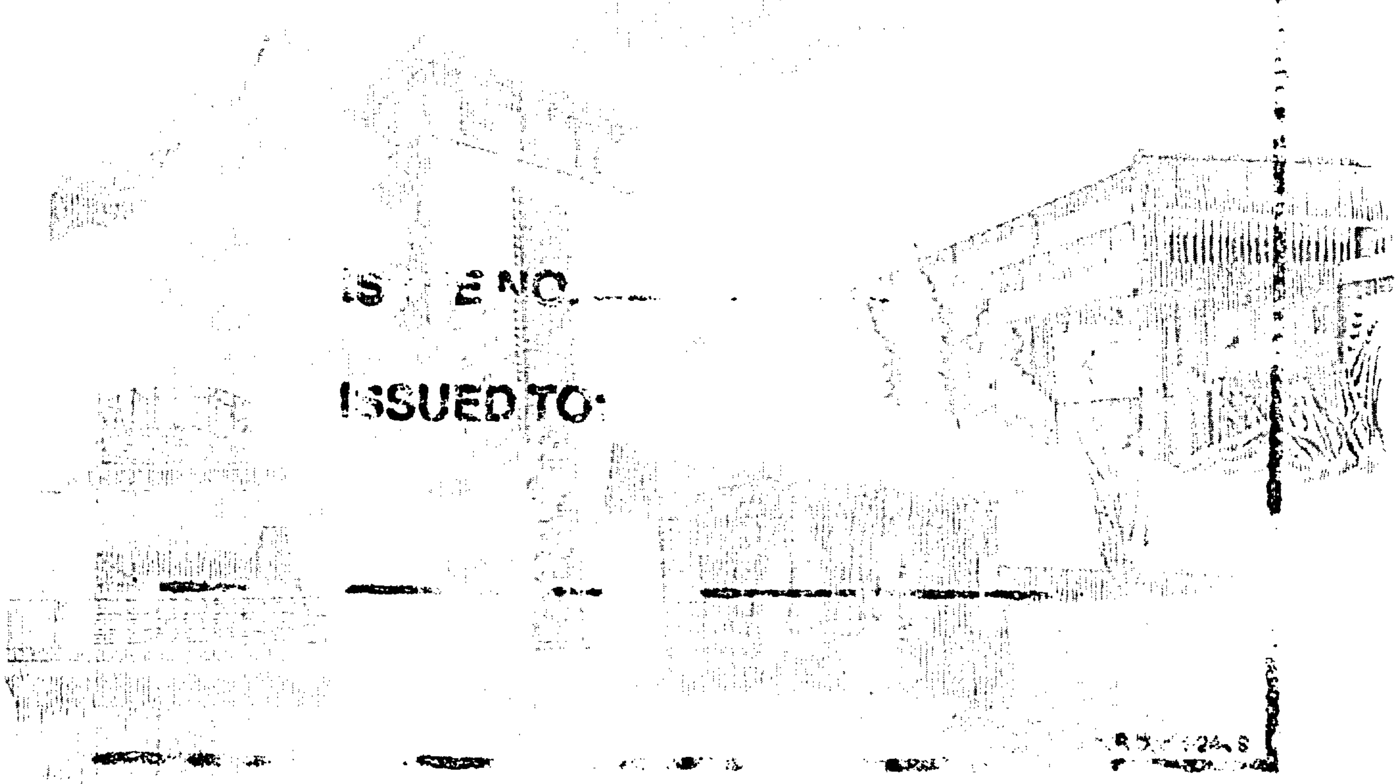

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SITE CHARACTERIZATION PLAN CONCEPTUAL DESIGN REPORT
Volume 2

Compiled by

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San Francisco, California 94109

ABSTRACT

This document presents a description of a prospective geologic repository for high-level radioactive waste to support the development of the Site Characterization Plan for the Yucca Mountain site. This conceptual design has been developed for the Department of Energy's Nevada Nuclear Waste Storage Investigations Project by Sandia National Laboratories and its supporting contractors.

The site for the prospective repository is located at Yucca Mountain in southwestern Nevada, and the waste emplacement area will be constructed in the underlying volcanic tuffs. The target horizon for waste emplacement is a sloping bed of densely welded tuff more than 650 ft below the surface and typically more than 600 ft above the water table. The conceptual design described in this report is unique among repository designs in that (1) it uses ramps in addition to shafts to gain access to the underground facility, (2) the emplacement horizon is located above the water table, and (3) it is possible that 300- to 400-ft-long horizontal waste emplacement boreholes will be used.

In addition to describing the design and operations, this report summarizes the design bases (site and properties of the waste package), design and performance criteria, and the design analyses performed. The current status of meeting the preclosure performance objectives for licensing and of resolving the repository design and preclosure issues is presented. The repository design presented in this report will be expanded and refined during the advanced conceptual design, the license application design, and the final procurement and construction design phases.

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4.0 DESIGN DESCRIPTION

4.1 The Site and Its Environs

4.1.1 Location and Climate

The prospective repository site is located at Yucca Mountain in Nye County, Nevada, approximately 85 airline miles northwest of Las Vegas (Figure 4-1). The site is located on federal land controlled by the Department of Energy (DOE), the Air Force, and the Bureau of Land Management. The land controlled by the DOE is currently part of the Nevada Test Site (NTS). Yucca Mountain lies in a broad range of mountains characterized by sparse vegetation, low precipitation, few population centers, and varied geologic conditions. The geohydrologic system includes both open and closed ground-water basins and a thick unsaturated zone that is thought to have little water movement. More detailed descriptions appear in Sections 2.2 and 2.3.

The terrain at the site is characterized by prominent north-trending fault-block ridges and eastward-tilted volcanic rocks. Slopes are locally steep (15 to 30°) on the west side of Yucca Mountain and along some of the valleys that cut into the more gently sloping (5 to 10°) east side of the mountain (Section 2.2.2).

Fortymile Wash, a major drainage channel trending from north to south in the western portion of the NTS, is a primary feature of the terrain near the proposed repository site. Drainage washes on the east face of Yucca Mountain trend primarily from northwest to southeast and are tributary to Fortymile Wash. The valley floors are covered by alluvium. Sandy fans extend down from the lower slopes of the ridges (Section 2.2.6).

The arid climate of this region exhibits a wide variation in daily and seasonal temperatures. Summer maximum and winter minimum temperatures are 42°C and -7°C, respectively. Precipitation, which normally occurs as rainfall, averages less than 8 in./yr. Annual snowfall amounts to less than 9 in. (Section 2.3.2).

Surface runoff from rainfall and snowmelt flows to Fortymile Wash, approximately 2 mi east of the repository site, and to Crater Flat to the west. No lakes or rivers are located in this site area. Normal runoff evaporates or filters into the ground; heavy runoff flows to the Amargosa River, 30 mi to the south.

In the vicinity of the repository site, the static water table is 600 to 1,300 ft below the horizon of the proposed repository. Ground water beneath Yucca Mountain is part of the Death Valley ground-water system. The water table is recharged from direct precipitation and infiltration of surface runoff (Section 2.2.4.2).

Because of the mountainous terrain, diurnal wind reversals occur in this area from southerly (upslope) daytime directions to northerly (downslope) nighttime directions. Wind direction also changes according to the season, from a predominantly southerly direction in the summer to a northerly direction in the winter. Although tornadoes are rare in Nevada, dust

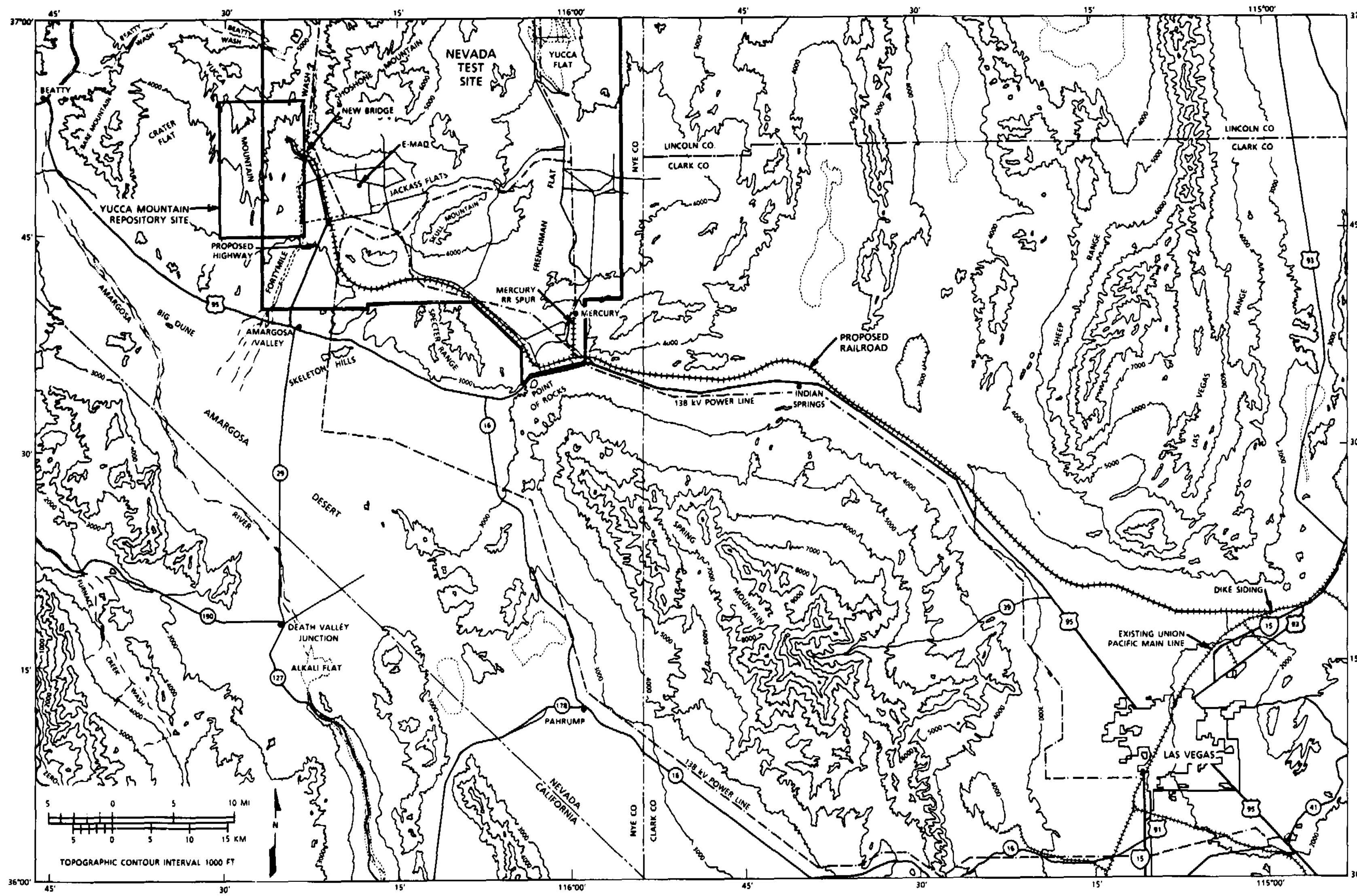


Figure 4-1. Location and Access Plan (Modified from Bechtel Drawing SK-13-C-002-B)

devils--local, extreme wind currents of a circular nature--are common during summer months. Generally, these phenomena are small, short-lived storms; there are instances, however, when some reach tornado proportions (Section 2.3.2.2.1).

4.1.2 Population and Economy

Although predominantly rural, Nye County is a growing area. In 1984, the estimated population was 17,750 people, most of whom live in the southern portion of the county (Ryan, 1984). Mining, service industries, and government employment provide jobs for 89% of the labor force (State of Nevada, 1984a). Nine percent of the Nye County work force was employed by the government in 1983. The primary activities of the federal government in Nye County are located at the NTS and the Nellis Air Force Range. More than 500 county and state government employees in Nye County provide education, police and fire protection, and other services (McBrien and Jones, 1984).

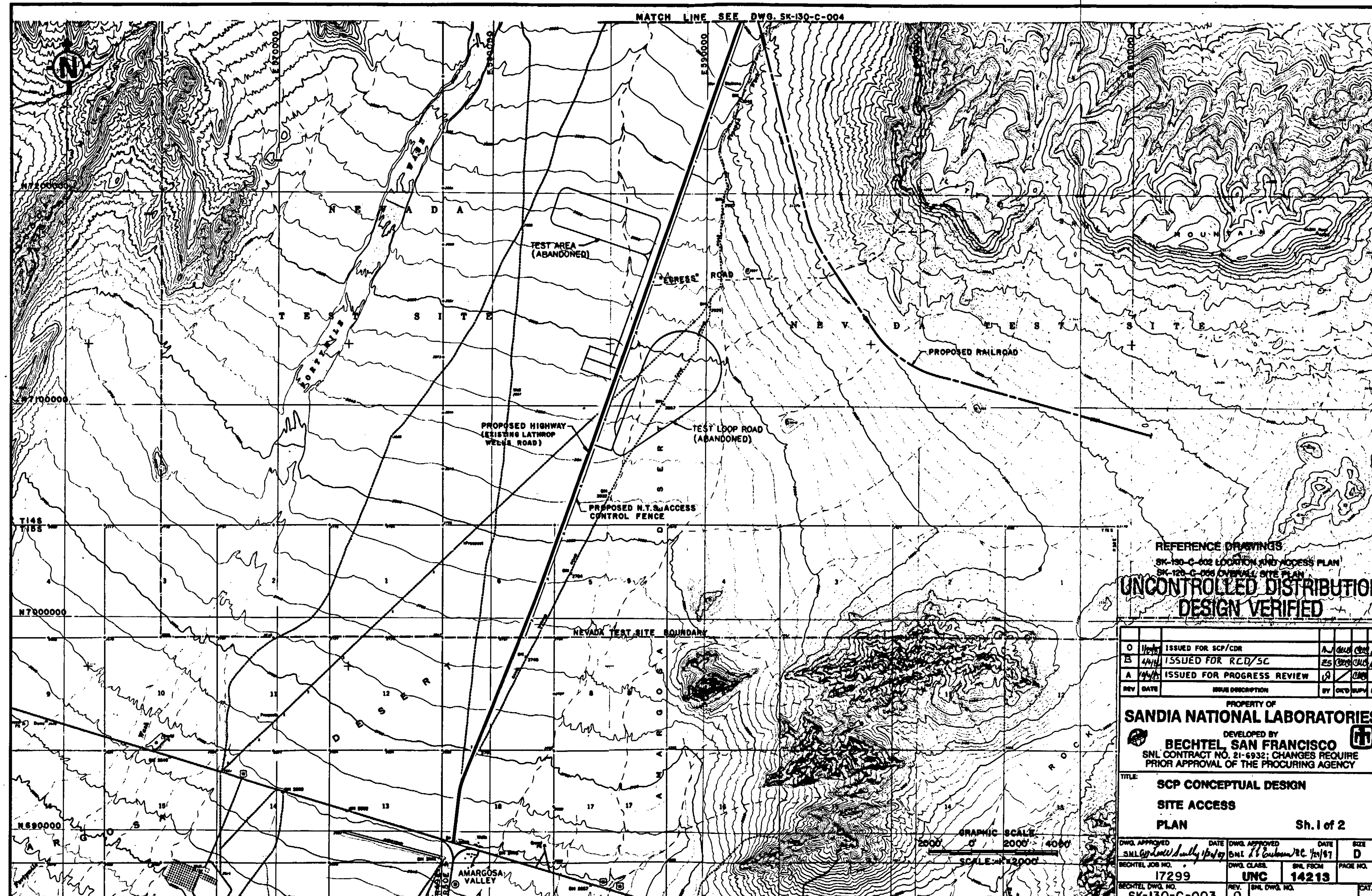
It is assumed that most of the repository employees, like employees of the NTS, will be drawn from neighboring Clark County. Currently, 87% of the NTS work force (DOE and contractor employees) lives in Clark County in or near Las Vegas, and the remainder lives in Nye County. More than half of the 1980 Nevada work force was employed in Clark County (State of Nevada, 1984a). By 1983, the service industry (hotels, gaming, and recreation) employed more than 130,000 individuals (48%). Other major employers in Clark County were the trade industries (20%), government (12%), transportation and public utilities (6%), and construction (5%). The retail trade industry depends heavily on the hotel and gaming industries to bring customers into the region. The mining industry employed 300 workers from Clark County in 1983 (State of Nevada, 1984b).

4.1.3 Infrastructure

Existing U.S. Highway 95 connects Las Vegas to Amargosa Valley. The prospective repository site is not visible from the highway. The existing Lathrop Wells Road provides access from Amargosa Valley to the NTS and connects with Drill Hole Wash Road, which runs through the proposed repository site (Figures 4-2 and 4-3). Three railroads have existing main or branch lines within 200 mi of the site. Union Pacific's main line is the line closest to the repository. Dike Siding, located on the Union Pacific main line 11 mi northeast of Las Vegas, is the primary candidate for the spur line tie-in. A study of alternate rail routes is provided in Appendix H-7.

Two independent electrical utilities now serve the NTS. Valley Electrical Association connects to the existing Jackass Flats substation, and Nevada Power Company ties in at a switchyard in Mercury. An existing 69-kV radial feeder, which extends from the Canyon Substation on the NTS distribution loop, will provide services for the exploratory shaft facility (ESF) and the repository.

Existing Well J-13 now serves the Nevada Research and Development Area (NRDA) and will serve the ESF. The water requirements of the repository will be provided by new wells drilled into the aquifer that


MATCH LINE SEE DWG. SK-130-C-004
NEVADA TEST SITE
TEST AREA (ABANDONED)
EGRESS ROAD
PROPOSED RAILROAD
PROPOSED HIGHWAY (EXISTING LATHROP WELLS ROAD)
TEST LOOP ROAD (ABANDONED)
PROPOSED N.T.S. ACCESS CONTROL FENCE
NEVADA TEST SITE BOUNDARY
AMARGOSA DESERT
AMARGOSA VALLEY
N720000
N710000
N700000
N690000
T14S
T15S
REFERENCE DRAWINGS
SK-130-C-002 LOCATION AND ACCESS PLAN
SK-120-C-006 OVERALL SITE PLAN
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2000 0 2000 4000
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B ISSUED FOR RCD/SC
A ISSUED FOR PROGRESS REVIEW
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DEVELOPED BY
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 21-6932; CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
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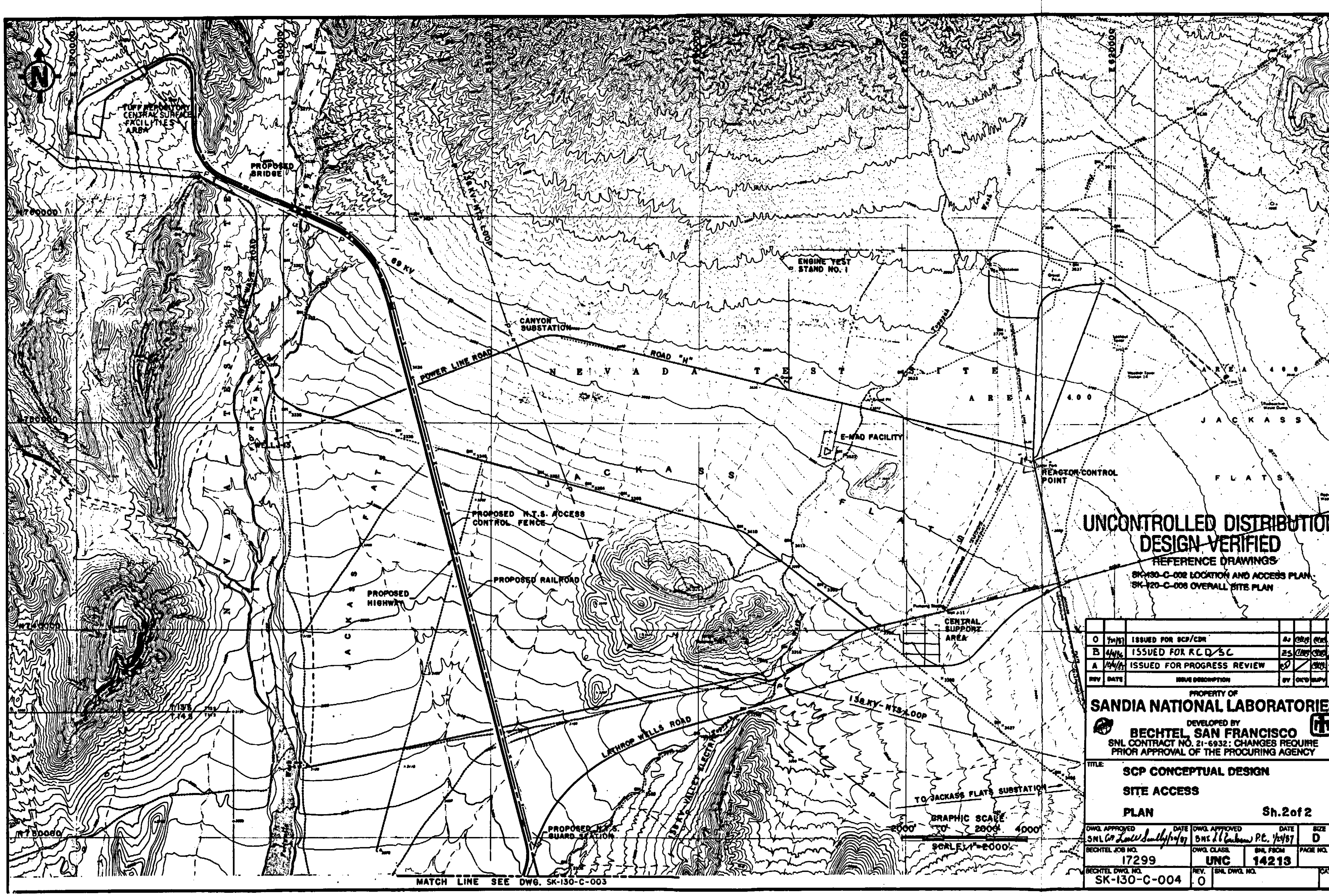
Figure 4-2.



N
TUFF REPOSITORY CENTRAL SURFACE FACILITIES AREA
PROPOSED BRIDGE
N760000
N755000
N745000
N750000
E560000
E580000
E570000
E600000
E620000
69 KV
138 KV NTS LOOP
CANYON SUBSTATION
POWER LINE ROAD
ROAD "H"
N E V A D A T E S T S I T E
A R E A 4 0 0
ENGINE TEST STAND NO. 1
E-MAD FACILITY
REACTOR CONTROL POINT
J A C K A S S F L A T S
WELL J-13
PROPOSED N.T.S. ACCESS CONTROL FENCE
PROPOSED RAILROAD
PROPOSED HIGHWAY
CENTRAL SUPPORT AREA
LATHROP WELLS ROAD
TO JACKASS FLATS SUBSTATION
PROPOSED N.T.S. GUARD STATION
GRAPHIC SCALE
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SCALE: 1"=2000'
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UNCONTROLLED DISTRIBUTION
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CAT.

Figure 4-3.

supplies Well J-13. The total amount of water used during siting, construction, operations, closure, and decommissioning is under investigation; however, water used by the repository is expected to cause only a very localized drawdown of the regional water supply.

The only existing facility nearby is the NRDA, which includes the engine maintenance, assembly, and disassembly facility. The NRDA, which has been set aside for the research and development activities of non-weapons programs, is located approximately 10 mi east of the repository site. The locations of existing facilities and utilities are shown on Figure 4-3.

4.2 Surface Facilities

4.2.1 Site Access

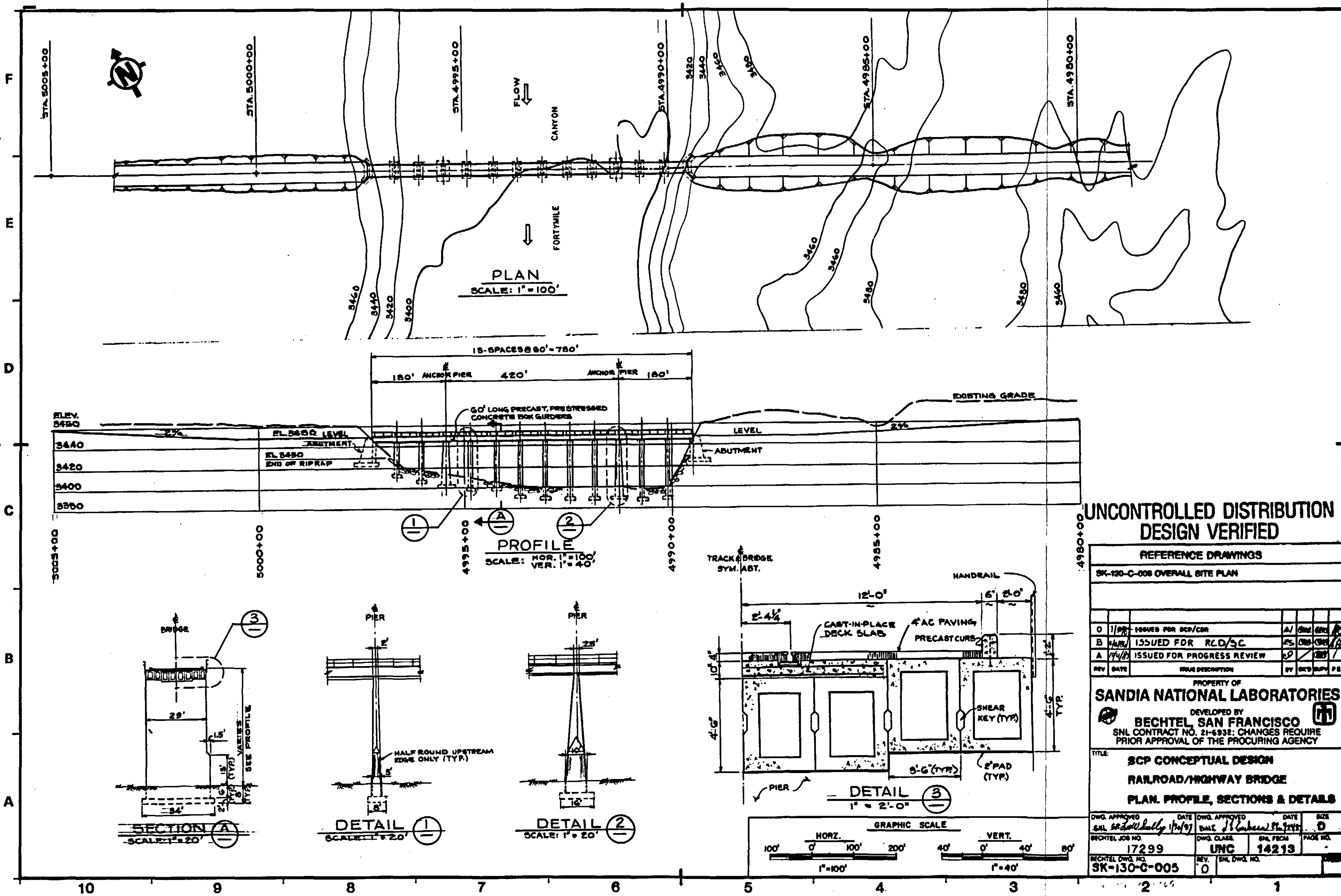
Rail, highway, and helicopter access serve the site for transport of radioactive waste and personnel. Radioactive waste is shipped to the site by either public rail or truck. Proposed highway and rail access routes to the site are shown in Figure 4-1. The new highway originates at U.S. Highway 95, approximately 0.5 mi west of the town of Amargosa Valley, and extends about 16 mi north to the site. A new railroad will originate at Dike Siding on the Union Pacific railway, about 11 mi northeast of Las Vegas, and will extend about 98 mi to the site. A rail spur is included to provide general rail service to Mercury, Nevada.

4.2.1.1 Railroad

The proposed railroad, which is routed entirely on federal land, follows the natural topography at a maximum grade of 2% and a maximum curvature of 2°. The railroad is a single-track line along which siding tracks are provided at intervals of approximately 50 mi for emergency and maintenance use. Drainage of upland surface runoff and potential flooding are considered in the design of the railroad. Along the route, ditches and culverts control drainage. Water is diverted into local arroyos and ultimately to Fortymile Wash. Bridges built of structural steel or concrete are used at crossings of existing drainage channels. A new bridge across Fortymile Wash is necessary for highway and rail access to the site.

The railroad spur line and highway cross Fortymile Wash approximately 2 mi before reaching the repository site. Alternate routes were considered; however, the other possible routes would still cross several washes directly downstream of Fortymile Wash and would require longer travel distances.

The bridge that crosses Fortymile Wash is designed for alternating use by railroad and highway traffic. The bridge (Figure 4-4) is 780 ft long, has a maximum height of 50 ft, and is constructed of precast, prestressed concrete box girders and reinforced-concrete piers. The bridge's design takes into account flood levels and debris flow during flooding. The roadbed has walkways and 12-ft-wide lanes on each side, for a total width of 29 ft. The railway is routed along the bridge centerline, and track is embedded in the bridge roadway to provide a smooth surface for vehicles. Vehicles will be held up when trains are on the bridge.


PLAN
SCALE: 1" = 100'
PROFILE
SCALE: HOR. 1" = 100' VER. 1" = 40'
15-SPACES @ 60' = 780'
60' LONG PRECAST, PRESTRESSED CONCRETE BOX GIRDERS
EXISTING GRADE
ABUTMENT
SECTION A
SCALE: 1" = 20'
DETAIL 1
SCALE: 1" = 20'
DETAIL 2
SCALE: 1" = 20'
DETAIL 3
1" = 2'-0"
CAST-IN-PLACE DECK SLAB
4" AC PAVING
PRECAST CURB
HANDRAIL
SHEAR KEY (TYP)
2" PAD (TYP)
HALF ROUND UPSTREAM EDGE ONLY (TYP.)
UNCONTROLLED DISTRIBUTION
DESIGN VERIFIED
REFERENCE DRAWINGS
SK-130-C-005 OVERALL SITE PLAN
ISSUED FOR RCD/SC
ISSUED FOR PROGRESS REVIEW
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SCP CONCEPTUAL DESIGN
RAILROAD/HIGHWAY BRIDGE
PLAN, PROFILE, SECTIONS & DETAILS
17299
UNC
14213
SK-130-C-005
GRAPHIC SCALE

Figure 4-4.

4.2.1.2 Highway

The access highway connects with U.S. Highway 95 near Amargosa Valley and continues north for approximately 8 mi on the upgraded Lathrop Wells Road into the NTS (Figure 4-2). Here, the new highway runs parallel to the railroad for the final 8 mi to the site area, crossing Fortymile Wash on the railroad and highway bridge (Figure 4-3).

A new guard station and security fencing along Lathrop Wells Road and the new highway control access to the NTS. The guard station is located where the new highway and Lathrop Wells Road meet.

4.2.1.3 Helipad

A helipad is located near the parking area south of the surface facilities (Figure 4-5). The helipad permits access and emergency medical service for the repository.

4.2.2 Overall Site Arrangement

The site plan at Yucca Mountain, based on current concepts, is shown in Figure 4-5. In this section, the rationale for the current site arrangement is discussed.

4.2.2.1 Location of the Underground Facility

The location and boundary of the underground facility are shown in Figure 4-6. This area was selected after consideration of desirable rock properties, required overburden thicknesses, depth to the water table, and constraints imposed by underground development and operations. A discussion of the procedures used to locate the underground facility is located in Section 6.4.2.

The underground facility lies entirely within the primary area targeted for waste emplacement. Based on exploratory drilling, it appears that additional area is available for waste emplacement to the north or southwest of the primary area.

As part of the site characterization program, efforts will be made to determine the distribution, properties, and variability of the emplacement horizon at the ESF. At present, characterization of the emplacement horizon has been based solely on exploratory borings.

4.2.2.2 Location of the Surface Facilities and Waste Ramp

The ridges overlying the underground facility range in elevation from 4,800 to 4,900 ft. Major surface facilities cannot be located directly over the underground facility for two primary reasons: (1) the difficulty of access for waste shipments (particularly by rail) and (2) the unreasonable costs associated with construction on bedrock in the steep terrain overlying the underground facility. Therefore, the major surface facilities associated with waste handling are located on the gently sloping terrain at the eastern base of Yucca Mountain at an approximate elevation of 3,665 ft. This location allows transport of the waste to

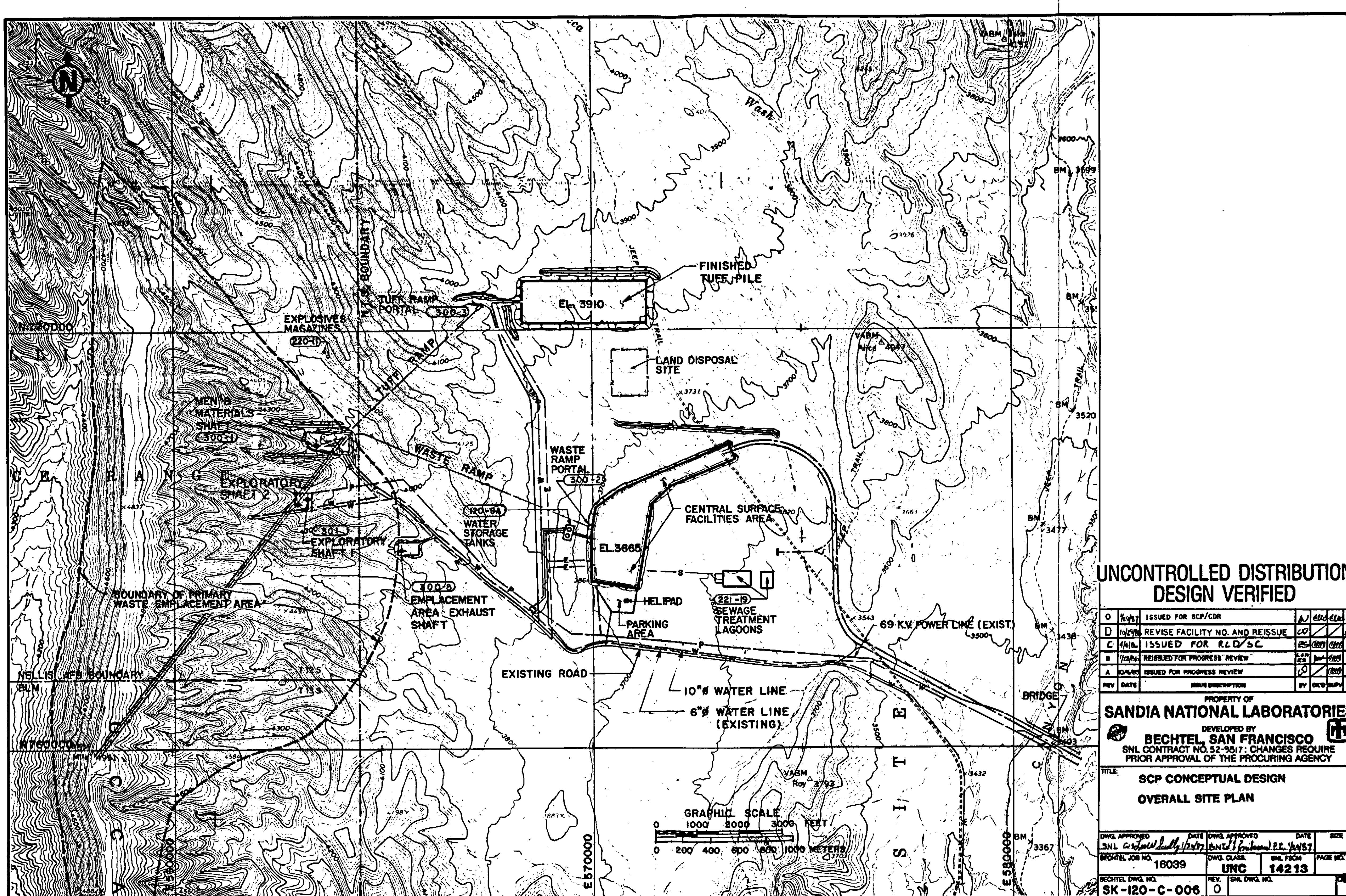
FINISHED TUFF PILE
EL. 3910
TUFF RAMP PORTAL
300-3
EXPLOSIVES MAGAZINES
220-11
LAND DISPOSAL SITE
TUFF RAMP
MEN & MATERIALS SHAFT
300-1
WASTE RAMP
WASTE RAMP PORTAL
300-2
EXPLORATORY SHAFT 2
CENTRAL SURFACE FACILITIES AREA
120-9A
WATER STORAGE TANKS
301
EXPLORATORY SHAFT 1
EL.3665
300-5
EMPLACEMENT AREA EXHAUST SHAFT
221-19
HELIPAD
SEWAGE TREATMENT LAGOONS
PARKING AREA
BOUNDARY OF PRIMARY WASTE EMPLACEMENT AREA
69 K.V. POWER LINE (EXIST.)
EXISTING ROAD
NELLIS AFB BOUNDARY
BLM
10"Ø WATER LINE
6"Ø WATER LINE (EXISTING)
BRIDGE
N.T.S. BOUNDARY
N760000
N765000
E570000
E580000
E565000
GRAPHIC SCALE
0 1000 2000 3000 FEET
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Figure 4-5.

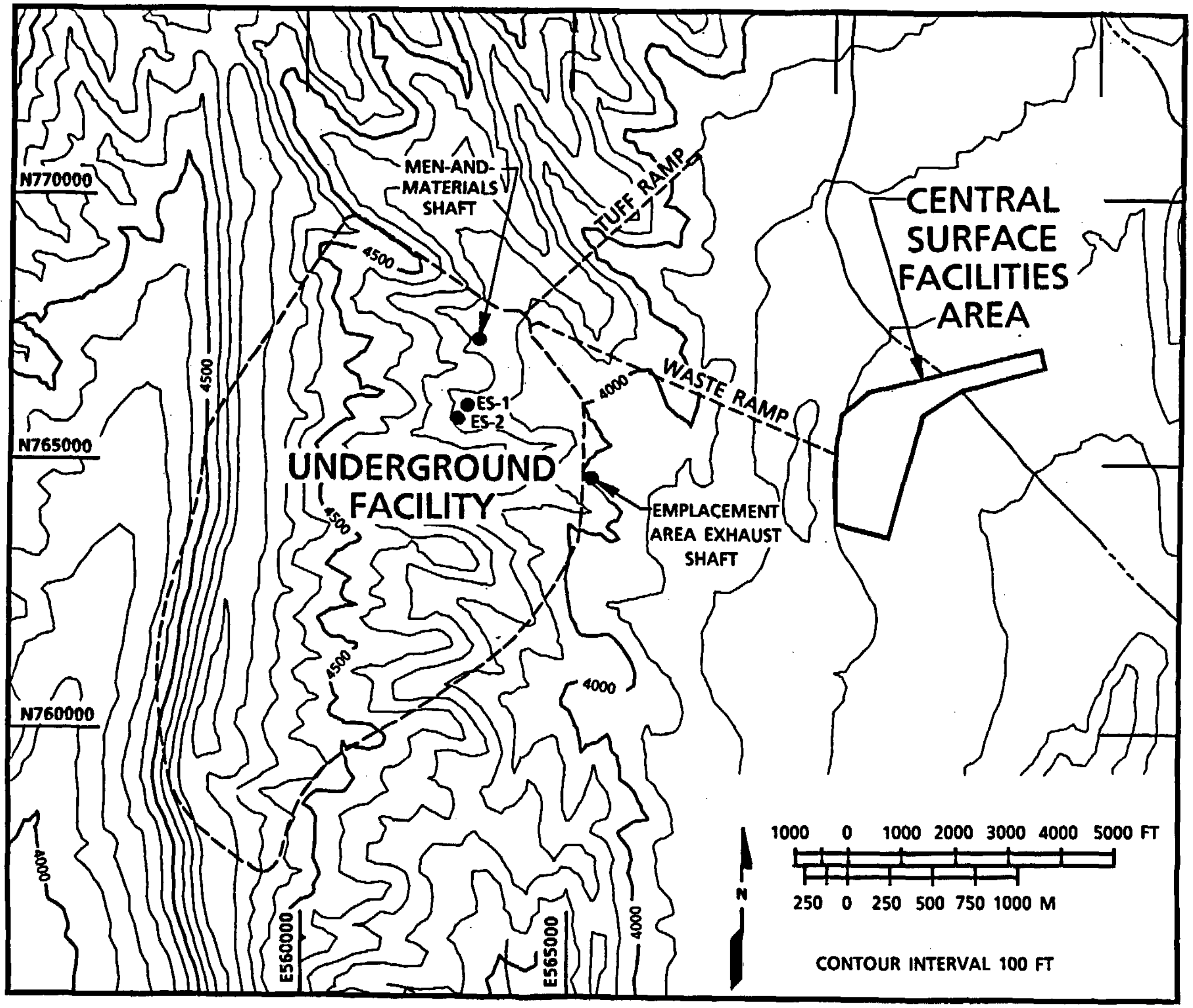


Figure 4-6. Location of the Underground Facility (SNL, CAD-IGIS Data Base, CAL0120 and CAL0202.)

the underground facility via a ramp inclined at an 8.9% grade and 6,603 ft long. The selection of a ramp rather than a shaft is explained by Dennis and Dravo (1985).

A study has been conducted to select a reference location for the major surface facilities for the purpose of developing the conceptual design (Neal, 1985). After an initial screening, areas located on the alluvial fans along the eastern base of Yucca Mountain (Figure 4-7) were selected for evaluation. The siting factors used to compare the six areas are those given in preclosure system guidelines (preclosure radiological safety; environmental quality; and ease and cost of construction, operation, and closure). The siting factors include air transport and diffusion of ventilation exhaust, flash flooding, ramp inclination, tectonic and fault displacement, protection of botanical and faunal species, archaeologic and cultural stability, average slope, area availability and contiguity, structural complexity of faults, ground motion, portal access, ramp length, and proximity to the northern area.

Numerical weighting and ranking methods were used to select the preferred site, an area east of Exile Hill (Figure 4-7). The primary advantages of this site are gentle slopes (necessary for railroad construction), protection from flash flooding, and an unbroken area of sufficient size to accommodate the central surface facilities. The site is located adjacent to a rock outcrop, which provides a suitable foundation for constructing the portal of the waste ramp. This location also permits the ramp to be constructed at a grade of less than 10% and provides flexibility for possible expansion of the emplacement area to the north, if that becomes necessary.

Data obtained thus far indicate that there are no conditions that would disqualify the area for location of the waste-handling facilities. However, the evaluation was based only on preliminary information, and detailed site characterization studies may lead to different conclusions (Neal, 1985).

4.2.2.3 Location of the Tuff Ramp and Tuff Pile

A ramp, rather than a combination of a shaft and overland transport, has been selected as the passageway for transporting excavated tuff from the subsurface facilities to the surface. The location of the intersection of the tuff ramp with the underground facility was selected based on the underground layout and the proximity of this intersection to the northern area. Preliminary locations for the portal of the tuff ramp and the tuff pile were selected based on field observations of rock outcrops, which provide stable foundations for portal construction, and on the terrain in the vicinity of the portal. The location of the tuff pile results in a tuff ramp that is 4,627 ft long and has a grade of 17.9%.

During the construction and waste emplacement phases, approximately 15 million tons of tuff will be excavated and piled on the surface, assuming that the vertical emplacement configuration is used and that the underground facility is not backfilled before closure. The gently sloping alluvial fans on the eastern base of Yucca Mountain were selected as a site that would provide sufficient space for the tuff pile and protection from flash flooding.

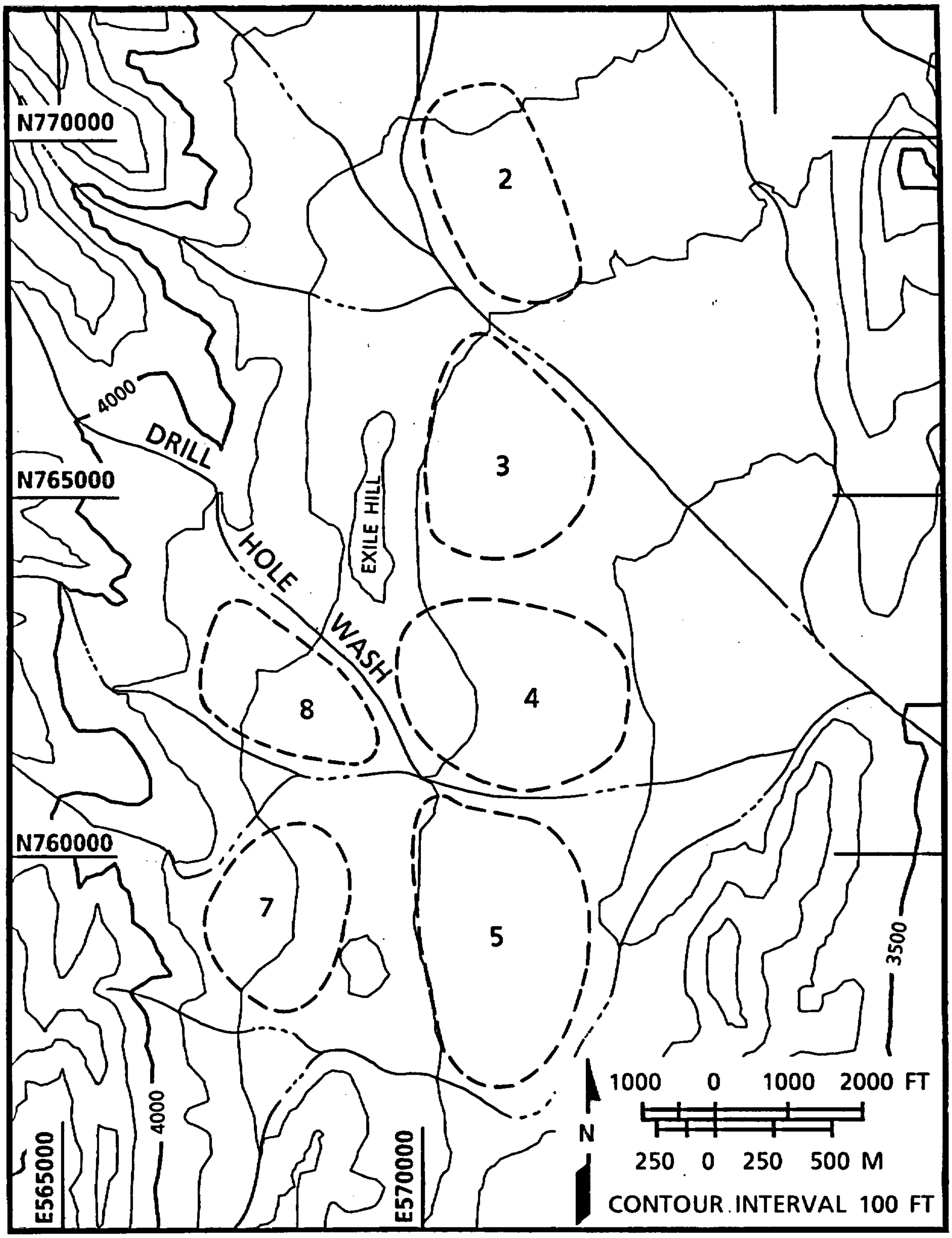


Figure 4-7. Locations of the Six Candidate Areas for the Surface Facilities (Modified from Neal, 1985.)

4.2.2.4 Location of Other Entries to the Underground Facility

For purposes of worker safety, it was decided to separate the access to the underground facility for personnel and materials from the access for the waste. Because of construction and operating costs, a preliminary decision was made to use a shaft rather than a ramp. However, access for men and materials will be studied in more detail during later stages of design. The number and location of other accesses to the underground facility, including the emplacement area exhaust shaft, are dictated by ventilation requirements (Section 3.4).

4.2.3 Layout of Surface Facilities

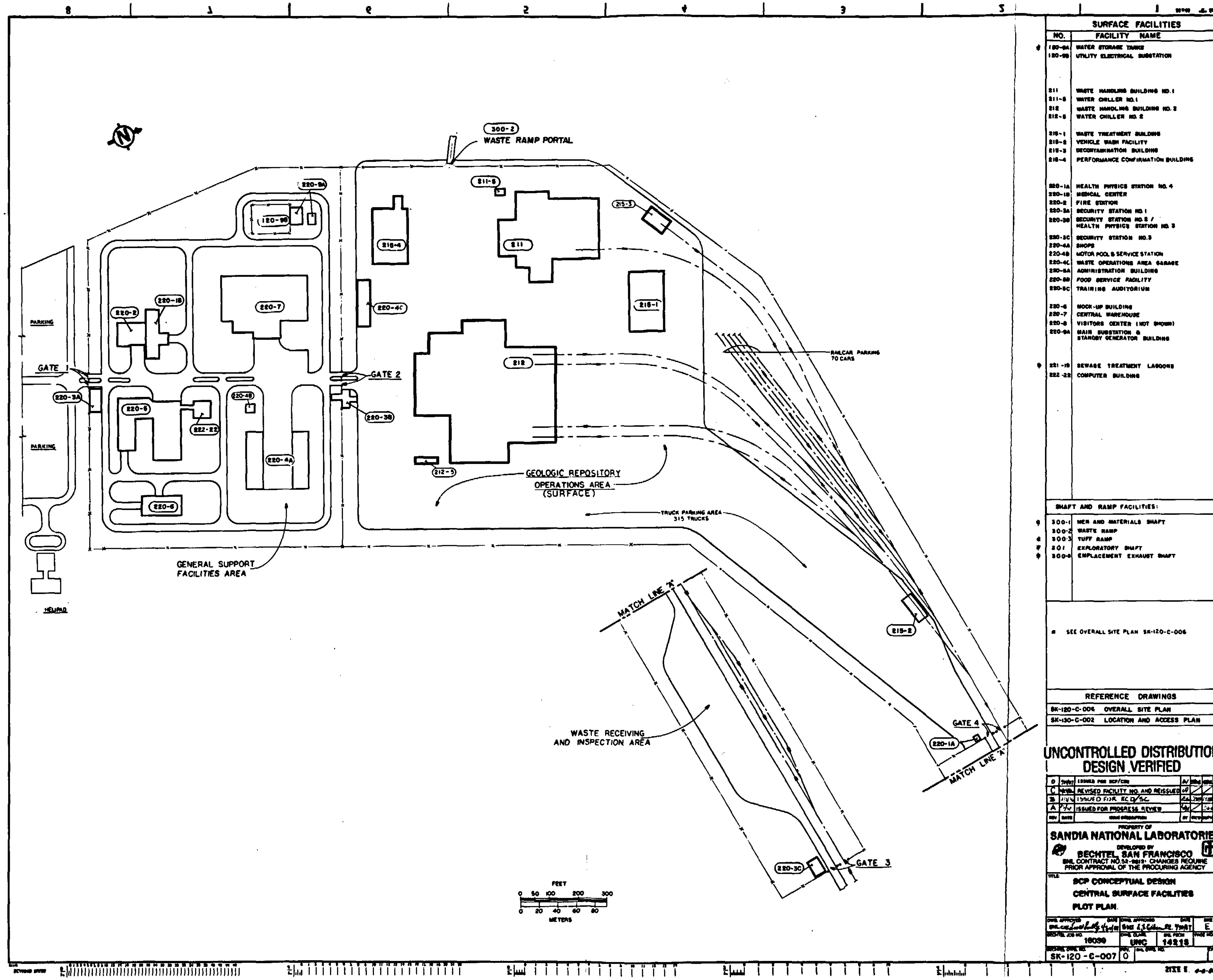
The layout and configuration of the surface facility areas are described in this section. Individual surface facilities are described in Section 4.2.4.

4.2.3.1 Central Surface Facilities Area

The central surface facilities area (Figure 4-5), which contains the major waste-handling facilities and contiguous support facilities, is located on a leveled bench at an approximate elevation of 3,665 ft. The fenced area (Figure 4-8), which includes the general support facilities area, the waste operations area (surface), and the waste-receiving and inspection area, is approximately 91 acres. For the purposes of this report, the regulatory requirements placed on the geologic repository operations area are generally applicable to the surface and subsurface portions of the waste operations area. The total central surface facilities area, including the parking area to the south, is approximately 100 acres. Certain operating considerations influenced the design, including (1) the provision of short distances between the waste-handling buildings and the waste ramp over which the waste transporter must travel, (2) the capability of isolating Stage 2 construction activities from Stage 1 operations, (3) the provision of adequate room for expansion to the east, if necessary, and (4) the provision of level areas for truck and railcar parking. The major surface facilities are founded on alluvial soils of varying depths; therefore, buildings can be constructed on either mat foundations or spread footings.

Radioactive waste delivered by truck or by rail enters the site from Gate 3 (Figure 4-8). Personnel and materials enter the site from Gate 1. Access to Gate 1 is from an improved existing road (Drill Hole Wash Road) oriented in an east/west direction and connecting to the new highway approximately 1 mi west of the bridge at Fortymile Wash. Drill Hole Wash Road also provides access to the ESF, the men-and-materials shaft, and the emplacement area exhaust shaft facilities. Drainage control and flood protection for the access road will be discussed in detail in the advanced conceptual design (ACD).

The central surface facilities area is divided into three distinct functional areas--the waste-receiving and inspection area, the waste operations area, and the general support facilities area (Figure 4-8). Each area is bounded by security fencing and has sufficient room for security patrols at its perimeter.



WASTE RAMP PORTAL
300-2
120-9B
220-9A
211-5
215-3
215-4
211
220-1B
220-2
220-7
220-4C
215-1
RAILCAR PARKING 70 CARS
PARKING
GATE 1
GATE 2
212
220-3A
220-9
220-4B
220-3B
222-22
220-4A
212-5
GEOLOGIC REPOSITORY OPERATIONS AREA (SURFACE)
PARKING
220-6
TRUCK PARKING AREA 315 TRUCKS
GENERAL SUPPORT FACILITIES AREA
HELIPAD
MATCH LINE "A"
215-2
WASTE RECEIVING AND INSPECTION AREA
GATE 4
220-1A
MATCH LINE "A"
FEET
0 50 100 200 300
0 20 40 60 80
METERS
220-3C
GATE 3
SURFACE FACILITIES
NO. | FACILITY NAME
120-9A WATER STORAGE TANKS
120-9B UTILITY ELECTRICAL SUBSTATION
211 WASTE HANDLING BUILDING NO. 1
211-5 WATER CHILLER NO. 1
212 WASTE HANDLING BUILDING NO. 2
212-5 WATER CHILLER NO. 2
215-1 WASTE TREATMENT BUILDING
215-2 VEHICLE WASH FACILITY
215-3 DECONTAMINATION BUILDING
215-4 PERFORMANCE CONFIRMATION BUILDING
220-1A HEALTH PHYSICS STATION NO. 4
220-1B MEDICAL CENTER
220-2 FIRE STATION
220-3A SECURITY STATION NO. 1
220-3B SECURITY STATION NO. 2 / HEALTH PHYSICS STATION NO. 3
220-3C SECURITY STATION NO. 3
220-4A SHOPS
220-4B MOTOR POOL & SERVICE STATION
220-4C WASTE OPERATIONS AREA GARAGE
220-5A ADMINISTRATION BUILDING
220-5B FOOD SERVICE FACILITY
220-5C TRAINING AUDITORIUM
220-6 MOCK-UP BUILDING
220-7 CENTRAL WAREHOUSE
220-8 VISITORS CENTER (NOT SHOWN)
220-9A MAIN SUBSTATION & STANDBY GENERATOR BUILDING
221-19 SEWAGE TREATMENT LAGOONS
222-22 COMPUTER BUILDING
SHAFT AND RAMP FACILITIES:
300-1 MEN AND MATERIALS SHAFT
300-2 WASTE RAMP
300-3 TUFF RAMP
301 EXPLORATORY SHAFT
300-8 EMPLACEMENT EXHAUST SHAFT
SEE OVERALL SITE PLAN SK-120-C-006
REFERENCE DRAWINGS
SK-120-C-006 OVERALL SITE PLAN
SK-130-C-002 LOCATION AND ACCESS PLAN
UNCONTROLLED DISTRIBUTION
DESIGN VERIFIED
C REVISED FACILITY NO. AND REISSUED
B ISSUED FOR RCD/SC
A ISSUED FOR PROGRESS REVIEW
PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
BECHTEL SAN FRANCISCO
PRIOR APPROVAL OF THE PROCURING AGENCY
TITLE:
SCP CONCEPTUAL DESIGN
CENTRAL SURFACE FACILITIES
PLOT PLAN.
16036
UNC
14218
SK-120-C-007

Figure 4-8.

The waste-receiving and inspection area, which begins at Gate 3, is oriented parallel to the incoming railroad and highway. Railcar sidings and a truck parking area are provided to accommodate delays in incoming waste shipments and to provide temporary storage of empty casks awaiting offsite transport.

The surface portions of the waste operations area include all surface facilities in which radioactive materials are handled or stored. Most of the area is paved to accommodate trucks and to provide easy access between the waste-handling facilities. An unpaved railyard includes switches between alternate tracks entering the waste-handling buildings and sidings for storage of railcars. Parking space for 315 trucks and 70 railcars provides storage for up to 6 wk of waste throughput. Health physics and security stations are located at Gate 4, which borders the waste-receiving and inspection area, and at a central entrance (Gate 2), which permits access to and from the general support facilities area.

The general support facilities area includes the facilities in the central surface facilities area that do not handle or treat radioactive materials. Gate 1 is the primary access to the repository for personnel, visitors, and nonwaste deliveries. Roads and walkways between buildings provide sufficient room for personnel and materials traffic. An unsecured parking area for 525 cars is located parallel to the south access road just south of Gate 1.

Outside the fenced area are a land disposal site for nonradioactive waste, sewage treatment lagoons, water storage tanks, and other structures associated with utility systems.

Drainage channels, berms, and swales sized for the expected amount of precipitation are provided around all areas to divert runoff and to prevent erosion of embankments. Culverts are used to route drainage under railbeds and roads. Preliminary locations of these flood diversion structures are shown in Figure 4-9.

The current conceptual design, as described in Sections 2.2.6, 4.1.1, 4.2.3.1, and 4.2.3.2, provides general provisions for the control of surface runoff. The ACD will ensure that Environmental Protection Agency (EPA) and State of Nevada environmental regulations are met.

4.2.3.2 Shaft and Ramp Areas

The two exploratory shafts (ES-1 and ES-2), the men-and-materials shaft, the emplacement area exhaust shaft, and their related facilities are located 1 to 1.5 mi west of the central surface facilities area in the rugged terrain of Yucca Mountain. Access to these shafts is provided by a road located in Drill Hole Wash. The road will be rerouted to provide access to the explosives magazines, which are located approximately 0.5 mi north of the men-and-materials shaft at an elevation of 4,240 ft. All shaft sites are located on leveled benches and are bounded by security fencing. Surface facilities located at the shafts are founded on soil or rock.

The men-and-materials shaft (Figure 4-10) is located near the junction of two washes that discharge into Drill Hole Wash. Based on

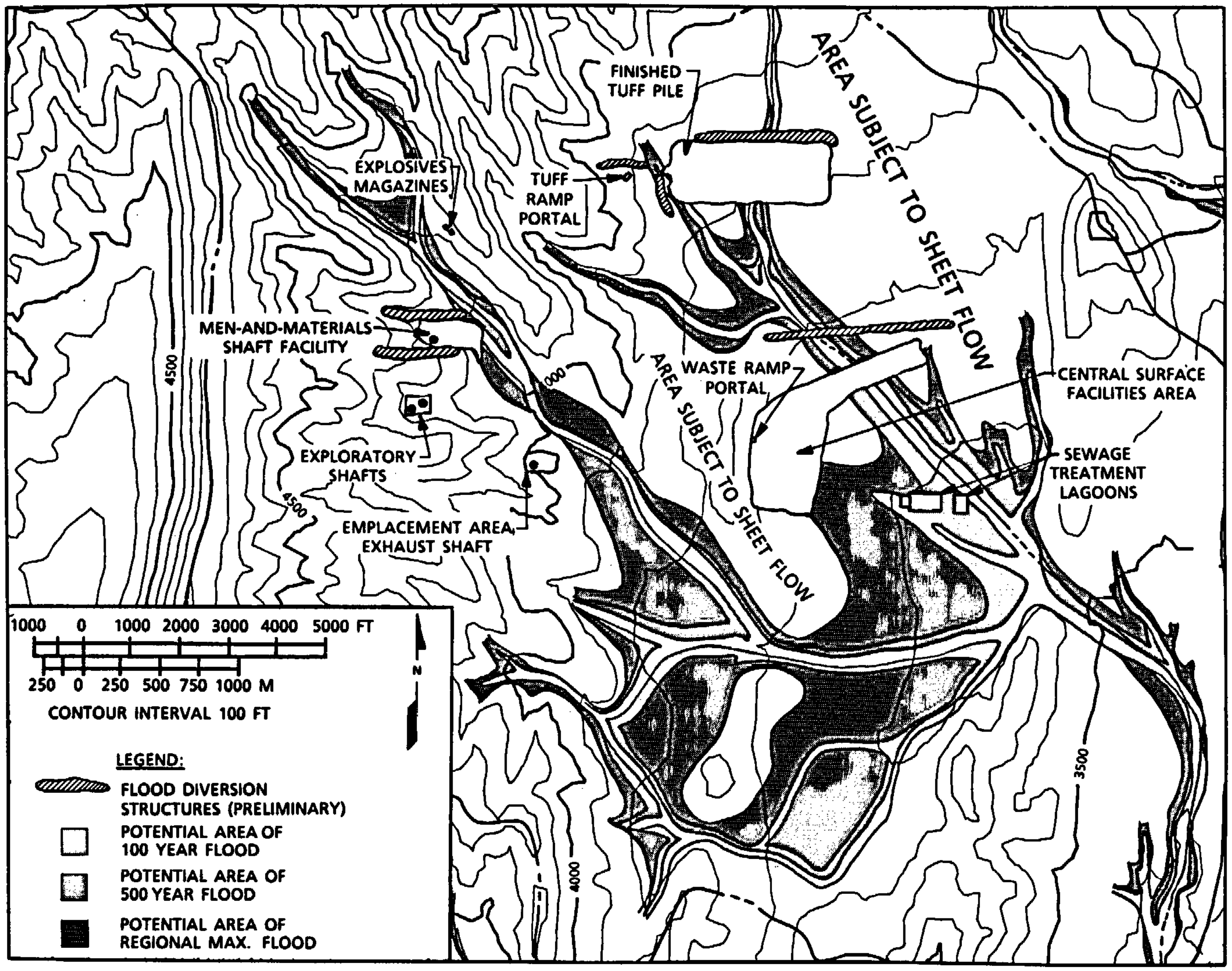


Figure 4-9. Flood Diversion Structures (Modified from Squires and Young, 1984, and Figure 4-5.)

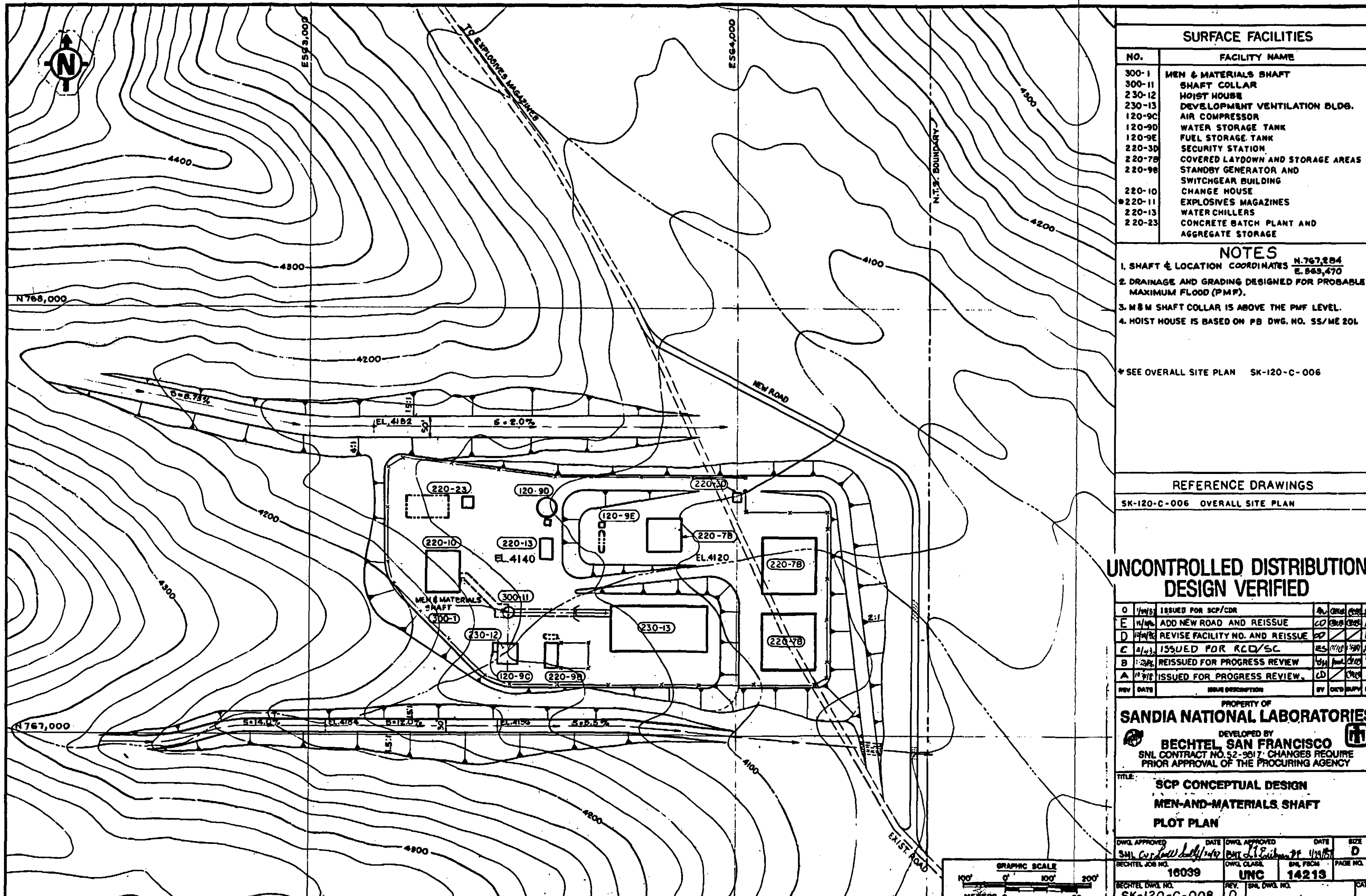

SURFACE FACILITIES
NO. FACILITY NAME
300-1 MEN & MATERIALS SHAFT
300-11 SHAFT COLLAR
230-12 HOIST HOUSE
230-13 DEVELOPMENT VENTILATION BLDG.
120-9C AIR COMPRESSOR
120-9D WATER STORAGE TANK
120-9E FUEL STORAGE TANK
220-3D SECURITY STATION
220-7B COVERED LAYDOWN AND STORAGE AREAS
220-9B STANDBY GENERATOR AND SWITCHGEAR BUILDING
220-10 CHANGE HOUSE
*220-11 EXPLOSIVES MAGAZINES
220-13 WATER CHILLERS
220-23 CONCRETE BATCH PLANT AND AGGREGATE STORAGE
NOTES
1. SHAFT ℄ LOCATION COORDINATES N.767,284 / E.563,470
2. DRAINAGE AND GRADING DESIGNED FOR PROBABLE MAXIMUM FLOOD (PMF).
3. M&M SHAFT COLLAR IS ABOVE THE PMF LEVEL.
4. HOIST HOUSE IS BASED ON PB DWG. NO. SS/ME 20L
*SEE OVERALL SITE PLAN SK-120-C-006
REFERENCE DRAWINGS
SK-120-C-006 OVERALL SITE PLAN
UNCONTROLLED DISTRIBUTION
DESIGN VERIFIED
0 ISSUED FOR SCP/CDR
E ADD NEW ROAD AND REISSUE
D REVISE FACILITY NO. AND REISSUE
C ISSUED FOR RCD/SC
B REISSUED FOR PROGRESS REVIEW
A ISSUED FOR PROGRESS REVIEW
PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 52-9817. CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
SCP CONCEPTUAL DESIGN
MEN-AND-MATERIALS SHAFT
PLOT PLAN
16039
UNC
14213
D
SK-120-C-008
0
GRAPHIC SCALE
METERS
TO EXPLOSIVES MAGAZINES
NEW ROAD
EXIST. ROAD
N.T.S. BOUNDARY
E563,000
E564,000
N768,000
N767,000
MEN & MATERIALS SHAFT
EL.4140
EL.4120
EL.4182
EL.4184
S=8.75%
S=2.0%
S=14.0%
S=12.0%
4400
4300
4200
4100
2:1
4:1
1.5:1

Figure 4-10.

preliminary data, the shaft collar, which is located on a leveled bench at an elevation of 4,140 ft, is above the probable maximum flood (PMF) level. The remaining facilities are located on a lower bench at an elevation of 4,120 ft. Drainage channels sized for the PMF divert runoff around the area (Figure 4-9).

The collar of the emplacement area exhaust shaft, the emplacement area exhaust building, and stack are on a leveled bench at an elevation of 3,960 ft (Figure 4-11). Dikes and drainage channels divert surface runoff around the benched areas. The design has not yet been analyzed for the PMF.

ES-1 and ES-2 are located at an elevation of 4,160 ft on a level embankment that is large enough to support subsurface investigations during the site characterization phase. During emplacement operations, the exploratory shafts are used as fresh air intakes for the emplacement area. The grading and drainage design for conversion from the ESF to the permanent arrangement for the emplacement area ventilation intake will be developed at a later stage of design.

The tuff pile and tuff-handling equipment are located 1 mi north of the central surface facilities complex near the tuff ramp portal. The portal area is reached by a road routed west of Exile Hill. The tuff pile will expand eastward over a 25-yr period to a maximum size of 3,000 by 1,000 by 120 ft. Drainage dikes north of the tuff pile and near the ramp portal provide flood protection by diverting surface runoff around embankments.

The current conceptual design does not include details for the removal, storage, or reuse of topsoil and cut-and-fill earthwork for the site. The ACD will develop surface-grading designs to balance cut-and-fill earthwork quantities and handling of topsoil to ensure compliance with EPA and State of Nevada environmental regulations.

4.2.4 Description of Facilities

The facilities are designed to withstand the effect of natural forces (earthquakes, wind, tornadoes, and floods) and human-induced phenomena, such as underground nuclear explosions on the NTS. The design criteria for each phenomenon are given in Chapter 2. Appendix H contains analyses of the effects of wind, tornadoes, earthquakes, and PMF on the surface element design.

In general, the buildings are low in profile and are finished with either concrete or ribbed metal siding in tones that blend with the natural surroundings. The buildings are arranged to allow for future expansion, if necessary, without restricting movement through the site. Tables 4-1 and 4-2 provide summaries of building descriptions.

The following discussion describes the surface facilities with emphasis on the structures in the area where waste handling occurs (Figure 4-8). This discussion addresses the waste-handling buildings, the support facilities for repository operations, general support facilities, and support facilities at shafts and ramps.

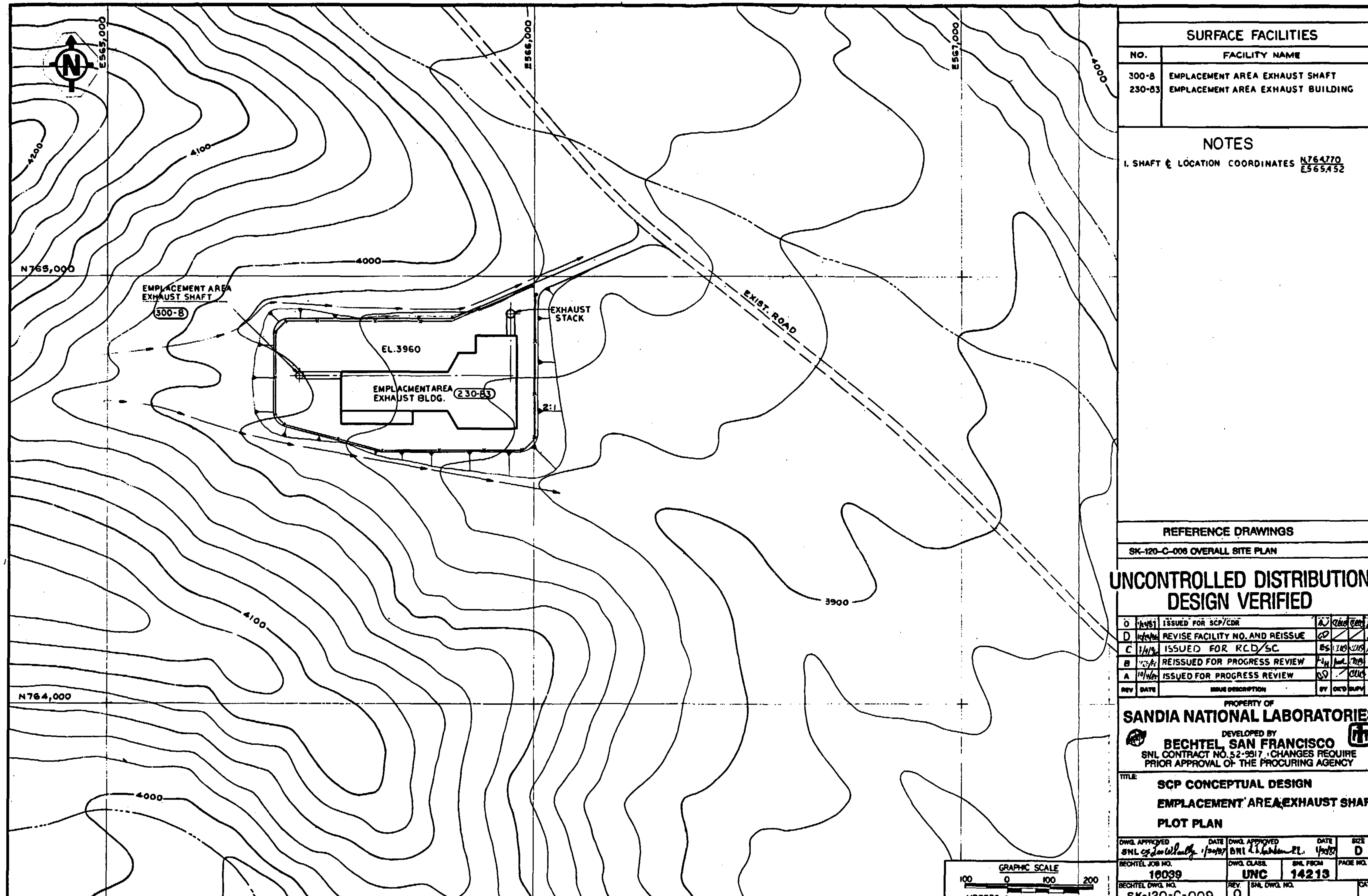

N
E565,000
E566,000
E567,000
N765,000
N764,000
4200
4100
4000
3900
EMPLACEMENT AREA EXHAUST SHAFT
300-8
EL.3960
EMPLACMENT AREA EXHAUST BLDG.
230-83
EXHAUST STACK
2:1
EXIST. ROAD
GRAPHIC SCALE
100 0 100 200
METERS 0 50
SURFACE FACILITIES
NO. FACILITY NAME
300-8 EMPLACEMENT AREA EXHAUST SHAFT
230-83 EMPLACEMENT AREA EXHAUST BUILDING
NOTES
1. SHAFT ℄ LOCATION COORDINATES N764770 E565452
REFERENCE DRAWINGS
SK-120-C-006 OVERALL SITE PLAN
UNCONTROLLED DISTRIBUTION
DESIGN VERIFIED
0 ISSUED FOR SCP/CDR
D REVISE FACILITY NO. AND REISSUE
C ISSUED FOR RCD/SC
B REISSUED FOR PROGRESS REVIEW
A ISSUED FOR PROGRESS REVIEW
REV DATE ISSUE DESCRIPTION BY CK'D SUPV PE
PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 52-9817 CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
TITLE: SCP CONCEPTUAL DESIGN
EMPLACEMENT AREA EXHAUST SHAFT
PLOT PLAN
DWG. APPROVED SNL DATE 1/30/87
DWG. APPROVED BNI DATE 1/30/87
SIZE D
BECHTEL JOB NO. 16039
DWG. CLASS. UNC
SNL FSCM 14213
PAGE NO.
BECHTEL DWG. NO. SK-120-C-009
REV. 0
SNL DWG. NO.
CAT.

Figure 4-11.

TABLE 4-1

DESCRIPTIONS OF BUILDINGS IN THE WASTE OPERATIONS AREA

Facility Number	Building	Functional Areas		Type of Construction	Principal Dimensions (ft)	Total Floor Area (ft^2)	Building Volume (1,000 ft^3)
211	WHB-1	Cask-receiving and shipping bays Unloading and waste-packaging hot cell Operating gallery Remote maintenance cell Decontamination area Surface storage vault	Personnel annex • Control room • Change room • Laboratories • Health physics • Offices	High-bay, structural-steel-frame receiving and shipping area; multilevel, reinforced-concrete hot cell; a steel-frame, insulated-siding personnel annex	315 x 360	124,000	3,863
212	WHB-2	Cask-receiving and shipping bays Cask preparation area Cask-unloading hot cell Consolidation hot cells Waste-packaging hot cells Operating gallery Remote maintenance cell Decontamination area	Surface storage vault Personnel annex • Control room • Change room • Laboratories • Health physics • Offices	High-bay, structural-steel-frame receiving and shipping area; multilevel reinforced-concrete hot cells; a steel-frame, insulated-siding personnel annex	492 x 484	300,000	10,477
215-1	Waste treatment building	Liquid radioactive waste treatment area Waste solidification area Solid radioactive waste treatment area	Loading and unloading area Office and laundry area Health physics	Two-story reinforced-concrete construction with a high bay; structural-steel frame for loading and unloading	128 x 208	30,850	770
215-4	Performance confirmation building	Unloading bay Hot cell Machining chamber Mechanical/electrical room	Operating gallery Laboratory Change room Offices	Structural-steel frame with insulated metal siding; a multilevel, interior, reinforced-concrete hot cell	125 x 190	24,500	1,020
215-3	Decontamination building	Vehicle and cask decontamination bay Small component and tool decontamination room	Health physics Mechanical/ electrical room Offices	High-bay, structural-steel-frame with insulated metal siding	60 x 90	6,600	324
215-2	Vehicle wash facility	Drive-through vehicle-wash area	Mechanical room	Single-story, metal-frame and concrete-block-wall structure	40 x 100	4,000	80
220-4c	Waste transporter garage	Transporter storage Parts storage	Change room Offices	Single-story, structural-steel frame with insulated metal siding	50 x 150	7,500	135

TABLE 4-2

DESCRIPTIONS OF BUILDINGS IN THE SUPPORT AREA

Facility Number	Building	Functional Areas		Type of Construction	Principal Dimensions (ft)	Total Floor Area (ft^2)	Building Volume (1,000 ft^3)
220-3A	Security Station 1	Waiting room Offices Badge distribution Communications center	Records storage Security administration Lockers and showers	Two-story, structural-steel frame with insulated metal siding	50 x 80	8,000	110
220-3B	Security Station 2	Security check station Health physics Offices		Single-story, structural-steel frame with insulated metal siding	65 x 80	3,000	41
220-3C	Security Station 3	Health physics Offices		Single-story, structural-steel frame with insulated metal siding	40 x 60	2,400	34
220-5A	Administration building	Offices Laboratories	Data analysis Operations monitoring	Two-story, structural-steel frame with insulated metal siding	100 x 220	44,000	561
220-5B	Food service facility	Kitchen Storage	Serving Lunchroom	Single-story, structural-steel frame with insulated metal siding	60 x 180	11,000	181
220-5C	Training auditorium			Single-story, steel frame with insulated metal siding; 50-seat capacity	25 x 40	1,000	18
222-22	Computer center	Computer room Offices	Mechanical room	Single-story, reinforced-concrete structure	60 x 65	4,000	65
220-2	Fire station	Apparatus room Communications room Firemen's quarters	Offices Equipment storage Lockers and showers Lunchroom	Single-story, structural-steel frame with insulated metal siding	85 x 100	7,600	105
220-1A	Health physics building	Storage for contamination detection equipment		Single-story, structural-steel frame with insulated metal siding	20 x 20	400	5
220-1B	Medical building	Examination rooms X-ray Medical labs	Offices Waiting room Ambulance garage	Single-story, structural-steel frame with insulated metal siding	40 x 175	8,200	90
220-7	Central warehouse	Storage space Receiving and shipping dock	Offices	Single-story (clear height 23 ft) steel frame with insulated metal siding	200 x 285	57,000	1,602

TABLE 4-2

DESCRIPTIONS OF BUILDINGS IN THE SUPPORT AREA
(concluded)

Facility Number	Building	Functional Areas		Type of Construction	Principal Dimensions (ft)	Total Floor Area (ft^2)	Building Volume (1,000 ft^3)
220-4A	Shops	Shop areas for each craft area Mechanical/electrical Offices Lunchroom First aid Lockers	Central covered work area (not included in floor area)	Single-story, structural-steel frame with insulated metal siding	120 x 120	24,000	384
220-4B	Motor pool and facility service station	Dispatch office Carwash area	Fuel storage Paved parking	Single-story, structural-steel frame with insulated metal siding	30 x 40	1,200	19
220-6	Mockup building	High-bay mockup room Classrooms	Offices	Single-story, structural-steel frame with insulated metal siding	72 x 120	9,840	432
220-9A	Main substation and standby generator building	Electrical switchgear Standby generators		Single-story, structural-steel frame with insulated metal siding	40 x 90	3,600	50
220-8	Visitors' center	Display room Auditorium	Meeting rooms	Single-story, structural-steel frame with insulated metal siding	50 x 80	4,000	60
220-9B	Standby generator at men-and-materials shaft	Electrical switchgear Standby generators		Single-story, structural-steel frame with insulated metal siding	30 x 60	1,800	22
221-10	Change house	Shower and change rooms First aid and mine rescue	Training area Offices	Single-story, structural-steel frame with insulated metal siding	80 x 100	8,000	148
230-12	Men-and-materials shaft hoist house	Hoist control center		Single-story, structural-steel frame with insulated metal siding	50 x 50	2,760	71
230-83	Emplacement area exhaust building	HEPA filters Ventilation fans Offices		Single-story, structural-steel frame with insulated metal siding Reinforced-concrete plenum	219 x 410	60,130	1,870
230-13	Development area ventilation building	Ventilation fans		Single-story, strucutral-steel frame with insulated metal siding	105 x 226	23,700	617

4.2.4.1 Waste-Handling Buildings

A two-stage approach to repository construction involves two waste-handling buildings in the surface portion of the geologic repository waste-handling operations area. During the first 3 yr of operations, only Waste-Handling Building 1 (WHB-1) will operate while construction of a full-capacity waste-handling building (WHB-2) is completed. A temporary fence will separate operations in WHB-1 from construction activities at WHB-2 during this period.

4.2.4.1.1 Waste-Handling Building 1

WHB-1 is designed to receive and prepare for subsurface disposal the equivalent of 400 metric tons of uranium per year (MTU/yr) of spent fuel, defense high-level waste (DHLW), and West Valley high-level waste (WVHLW) (Figure 4-12). The building is scheduled to receive waste by January 31, 1998, and is designed to process only intact spent fuel assemblies through 2002. Beginning in 2003, 2 yr after the start of Stage 2, WHB-1 will handle only DHLW and WVHLW. No major modifications are required to accommodate Stage 2 operations.

The overall dimensions of WHB-1 are 330 by 360 ft. The cask-receiving and shipping area of the building is a high-bay, structural-steel-frame building provided with a 125-ton-capacity bridge crane for lifting the cask and a 25-ton auxiliary hoist for lifting the personnel barrier, impact limiters, and outer cover of the cask. An airlock is provided at each bay for carriers entering or leaving the building.

A cask preparation area is provided adjacent to the receiving and shipping bays. This area is located on the lower level of the waste-handling building, 25 ft below grade. Inside the cask preparation area are four cask transfer carts, which receive casks transferred by the bridge crane from a truck or railcar. Equipment is provided in the cask preparation area to remove the bolts that hold down the cask's outer cover, to perform gas-sampling and contamination surveys, and to prepare the cask for removal of the fuel assemblies. The motorized cask transfer cart then positions the cask under the cask-unloading hot cell, where the top of the shipping cask interfaces with the floor port in the cask-unloading hot cell. The conceptual design of the cask-unloading facilities is described by Townes et al. (1987b).

A station adjacent to the cask preparation area is equipped with a spray system to decontaminate casks, if necessary, and to prepare them for shipment. At the cask decontamination station, an adjustable-height work platform provides access around the cask. Equipment interfaces and couplings are provided to flush the interior of all empty casks coming back from the cask-unloading hot cell. A jib crane is provided to replace the cask's outer lid and to prepare the cask for outgoing shipment. Equipment to support cask decontamination, including a 5,000-gal flush-water tank, flush-water pump, and filter system, is located in an adjacent room.

In the cask-unloading hot cell, one cask-unloading port is provided for each of the four cask transfer carts. A 20-ton-capacity, bridge-mounted crane transfers fuel assemblies from the shipping casks through

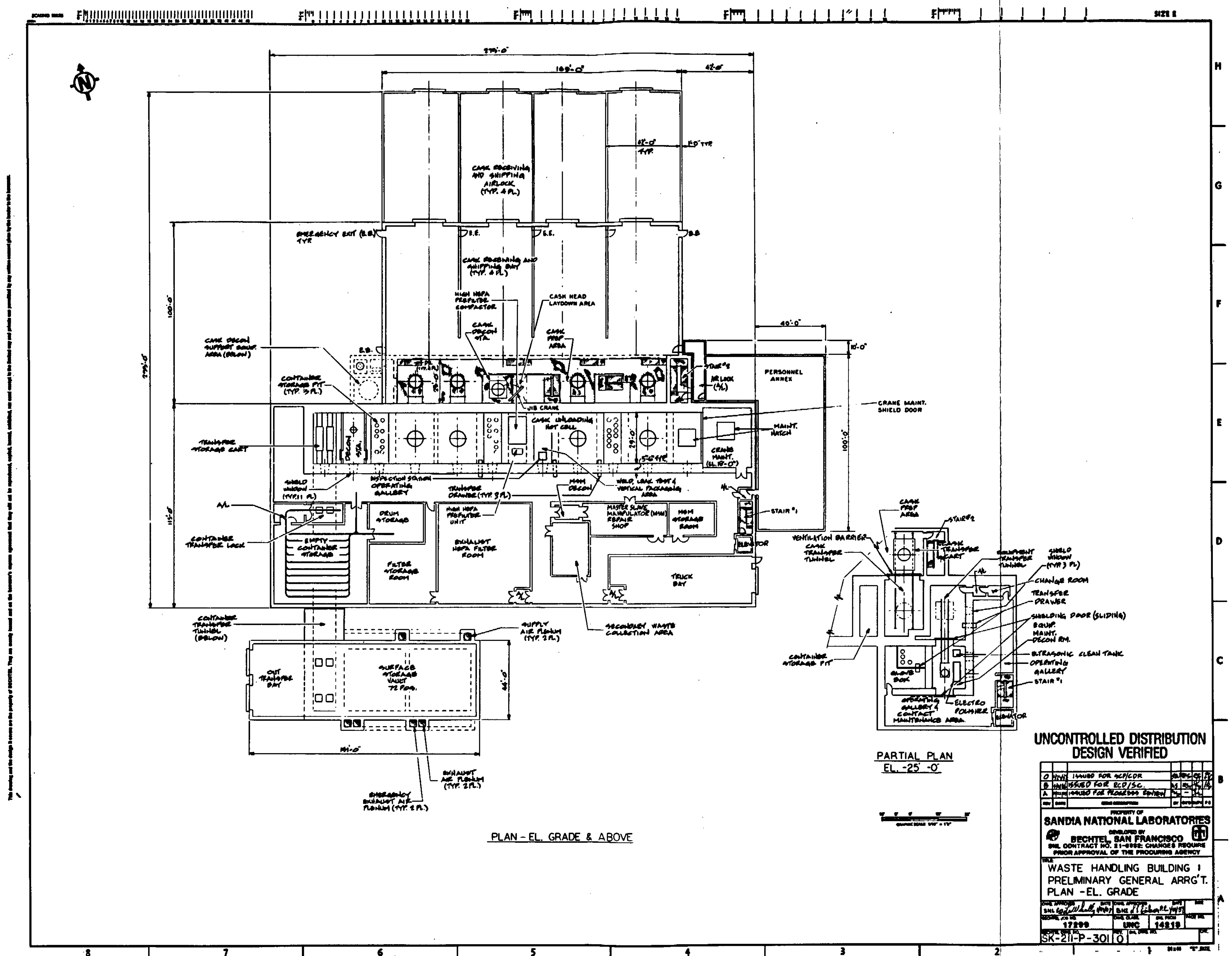

PLAN - EL. GRADE & ABOVE
PARTIAL PLAN
EL. -25' -0"
UNCONTROLLED DISTRIBUTION
DESIGN VERIFIED
SANDIA NATIONAL LABORATORIES
BECHTEL, SAN FRANCISCO
WASTE HANDLING BUILDING I
PRELIMINARY GENERAL ARRG'T.
PLAN -EL. GRADE
SK-211-P-301

Figure 4-12.

the unloading port into the hot cell and places them directly in disposal containers or storage racks. Container-welding and testing stations are provided in the cask-unloading hot cell. Transfer/storage carts are used to transport containers to the surface storage vault adjacent to the cask-unloading hot cell. The vault has a lag storage capacity of 50 MTU, which corresponds to approximately 6 wk of throughput during Stage 2 operations. Containers can also be transferred directly to the out-transfer bay, where they are lifted from the transfer/storage cart to the waste transporter for conveyance to the underground emplacement area.

The surface storage vault is ventilated by forced air convection to ensure that container temperatures are within the required limits at all times. Instruments are provided to monitor exhaust air continuously. If an off-normal event in the vault results in the release of contaminants, the vault's exhaust air is automatically diverted through high-efficency particulate air (HEPA) filters.

The surface storage vault is equipped with a container transfer machine (CTM) to move the containers from the storage cells to the out-transfer bay. The CTM is equipped with a shielding cask into which containers are lifted during transfer operations. At the loading port of the out-transfer bay, containers are placed on a transfer/storage cart to await transfer to the waste transporter. The conceptual design of the container-loading ports is based on the vertical emplacement configuration. The design will be changed if horizontal emplacement is selected.

An operating gallery, in which off-normal operations and maintenance of hot cell equipment are performed, is provided at the perimeter of the cask-unloading hot cell. Viewing ports and remote manipulators are provided in the cask-unloading hot cell to facilitate these functions.

A remote maintenance cell is located below the cask-unloading hot cell (25 ft below grade) for the maintenance of facility equipment. This cell has a 10-ton crane and crane-mounted manipulators, all remotely operated. Shielded viewing windows and master/slave manipulators are provided in the remote maintenance cell. Equipment in the cask-unloading hot cell is modular in design, with features that facilitate decontamination and removal of the equipment for replacement, maintenance, or repair by remote handling. A hatch in the floor of the cask-unloading hot cell provides direct access to the remote maintenance cell below.

An equipment decontamination room is adjacent to the remote maintenance cell. A rail-mounted shuttle cart transfers equipment into the decontamination room, where equipment is decontaminated before it is transferred to an area for contact-handled maintenance. A maintenance area is located at the perimeter of the remote maintenance cell. A repair shop and storage room for master/slave manipulators are also provided on this lower level.

A room for maintaining and decontaminating cranes is located at one end of the cask-unloading hot cell. A shield door on the cask-unloading hot cell allows the crane to be moved into this room for hands-on maintenance.

In addition to the waste-handling areas of WHB-1, an annex is provided on the east side of the building for a control room, mechanical and electrical equipment room, offices, laboratory, health physics room, and change room.

A protective coating is needed in some areas of WHB-1 to facilitate decontamination. More protective coating must be applied to areas with a greater potential for contamination. In areas in which fuel assemblies are handled during Stage 1 (including the cask-unloading hot cell and the cask transfer tunnels below the unloading cell), the floors and walls are lined with stainless steel up to the level of the crane rails. In these areas, a protective epoxy coating is applied to the walls above the crane rails and to the ceilings. In the remote maintenance cell, a stainless steel pan is provided for the floor, and a protective epoxy coating is applied to the walls and ceiling. The decontamination rooms, including the walls and ceilings, are treated with a protective epoxy coating. All other operations areas in WHB-1, including truck bays, operating galleries, the cask preparation area, contact maintenance areas, and container transfer tunnels, have a protective epoxy coating on the floors and wainscot only.

4.2.4.1.2 Waste-Handling Building 2

WHB-2 is scheduled to begin operations in 2001 and is designed to receive, consolidate, and prepare a maximum of 3,000 MTU/yr of spent fuel for subsurface disposal. In addition, the building is designed to package fuel assembly hardware, which results from the consolidation process. The overall dimensions of WHB-2 are 492 by 485 ft (Figures 4-13 and 4-14).

The cask-receiving and shipping area is similar to, although much larger than, that in WHB-1 and contains eight receiving and shipping bays. An adjacent truck bay is provided for transfer of site-generated waste to the waste treatment building. The cask preparation area has eight cask transfer carts. The 125-ton bridge crane in this area can transfer a cask from any of the receiving and shipping bays to any available cask transfer cart. There are two cask decontamination stations in the cask preparation area, with decontamination support equipment, similar to that described for WHB-1.

The cask-unloading hot cell has eight cask-unloading ports, one for each cask transfer cart. Two 20-ton-capacity bridge-mounted cranes, each equipped with a bridge-mounted manipulator, transfer fuel assemblies from the shipping casks through the unloading port into the hot cell and place the assemblies in transfer/storage carts. Approximately 2 wk of throughput storage capacity (125 MTU) is provided on the transfer/storage carts in the cask-unloading hot cell.

Off-normal assemblies are packaged in the cask-unloading hot cell, bypassing consolidation operations. Two waste-packaging, weld-testing, leak-testing, and waste container decontamination stations are provided in the cask-unloading hot cell. A contamination barrier separates the decontamination station from the remainder of the cask-unloading hot cell. Two transfer/storage carts transfer spent fuel, which has been

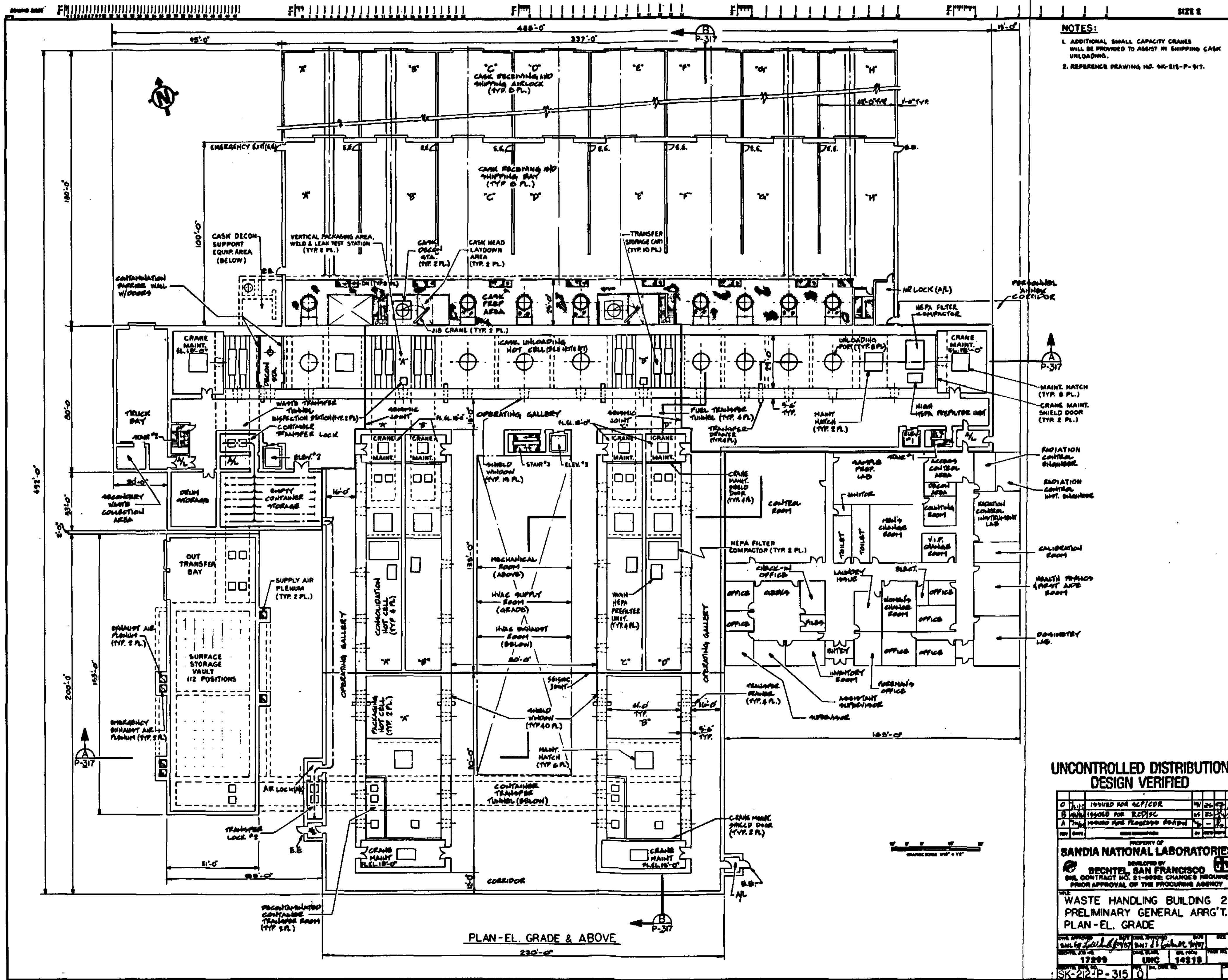
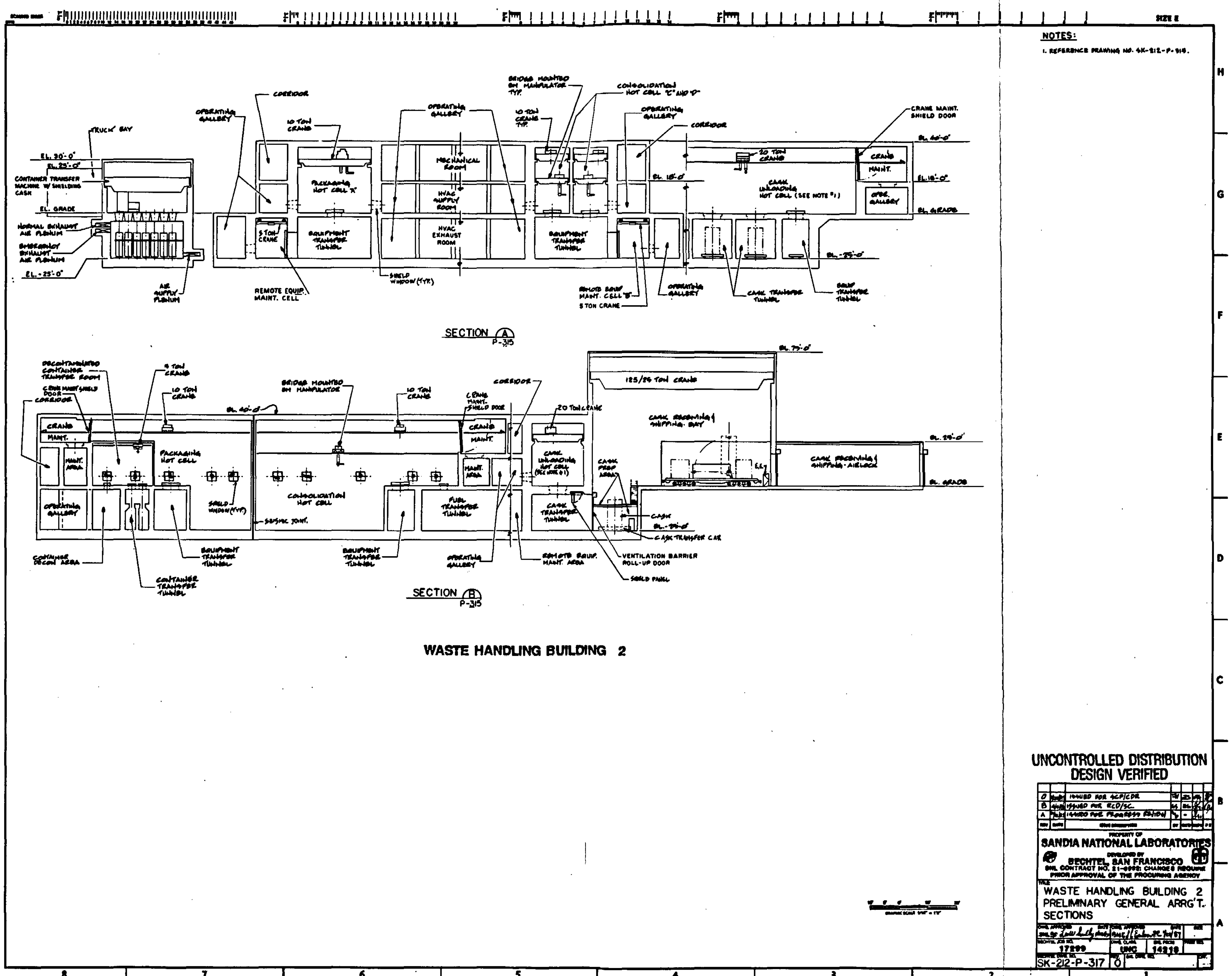

NOTES:
1. ADDITIONAL SMALL CAPACITY CRANES WILL BE PROVIDED TO ASSIST IN SHIPPING CASK UNLOADING.
2. REFERENCE DRAWING NO. SK-212-P-317.
CASK RECEIVING AND SHIPPING AIRLOCK (TYP. 8 PL.)
CASK RECEIVING AND SHIPPING BAY (TYP 8 PL.)
CASK UNLOADING HOT CELL
OPERATING GALLERY
CONSOLIDATION HOT CELL (TYP. 4 PL.)
PACKAGING HOT CELL
MECHANICAL ROOM (ABOVE)
HVAC SUPPLY ROOM (GRADE)
HVAC EXHAUST ROOM (BELOW)
CONTAINER TRANSFER TUNNEL (BELOW)
SURFACE STORAGE VAULT 112 POSITIONS
OUT TRANSFER BAY
TRUCK BAY
DRUM STORAGE
EMPTY CONTAINER STORAGE
CONTROL ROOM
CORRIDOR
PLAN-EL. GRADE & ABOVE
UNCONTROLLED DISTRIBUTION
DESIGN VERIFIED
SANDIA NATIONAL LABORATORIES
BECHTEL, SAN FRANCISCO
WASTE HANDLING BUILDING 2
PRELIMINARY GENERAL ARRG'T.
PLAN-EL. GRADE
SK-212-P-315

Figure 4-13.


NOTES:
SECTION A P-315
SECTION B P-315
WASTE HANDLING BUILDING 2
OPERATING GALLERY
CORRIDOR
10 TON CRANE
MECHANICAL ROOM
HVAC SUPPLY ROOM
HVAC EXHAUST ROOM
CONSOLIDATION HOT CELL
EQUIPMENT TRANSFER TUNNEL
REMOTE EQUIP. MAINT. CELL
5 TON CRANE
20 TON CRANE
CASK TRANSFER TUNNEL
FUEL TRANSFER TUNNEL
CONTAINER TRANSFER TUNNEL
125/25 TON CRANE
VENTILATION BARRIER ROLL-UP DOOR
CASK TRANSFER CAR
UNCONTROLLED DISTRIBUTION
DESIGN VERIFIED
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BECHTEL, SAN FRANCISCO
WASTE HANDLING BUILDING 2
PRELIMINARY GENERAL ARRG'T.
SECTIONS
17299
UNC
SK-212-P-317
0

Figure 4-14.

packaged in the cask-unloading hot cell, through the waste transfer tunnel (25 ft below grade) to the surface storage vault or the out-transfer bay.

Four fuel transfer tunnels connect the cask-unloading hot cell to the four consolidation hot cells. In each tunnel, 2 rail-mounted transfer/storage carts with 6 spent fuel assembly baskets on each cart, provide about 2 wk of waste throughput storage capacity. A 10-ton bridge crane in each consolidation hot cell removes the fuel assemblies from the racks in the transfer/storage carts. In addition, each consolidation hot cell has a 6-ton-capacity bridge crane and a bridge-mounted manipulator below the 10-ton crane. A frame assembly in each consolidation hot cell removes end fittings, extracts and collects fuel rods from the assemblies, and then loads them into a device for collecting the rods in separate sectors for insertion in the waste container (Section 2.1). When fully loaded, the disposal container is rotated to a horizontal position and placed at a transfer port in the wall that separates the consolidation hot cell and the waste-packaging hot cell (Figure 3-8).

One waste-packaging hot cell serves two consolidation hot cells. Two sets of waste-packaging, welding, and testing equipment are provided in each waste-packaging hot cell, one set serving each consolidation hot cell.

Two transfer/storage carts carry packaged waste from the waste-packaging hot cells to the surface storage vault or to the out-transfer bay, adjacent to the storage vault, for transport to the underground facility. Each cart can hold four containers. A container transfer tunnel (25 ft below grade) connects the waste-packaging cells with the surface storage vault. Lag time for storing containers in the reinforced-concrete, multicelled vault equals approximately 4 wk of throughput capacity [250 MTU (space for 100 containers)]. A 15-ton-capacity CTM, similar to that described for WHB-1, is provided in the surface storage vault. Two ports for loading the waste transporter are provided in the out-transfer bay. The container is placed on a transfer/storage cart by the CTM. The cart holds the container in position until it is transferred to the waste transporter.

Operating galleries surround each processing cell. Shielded windows for viewing remote manipulators permit remote handling in each cell and maintenance when the cells are not in use. Remote maintenance cells are also located below the consolidation hot cells. Maintenance hatches in the floors of the cask-unloading hot cell, the consolidation hot cells, and the waste-packaging hot cells, allow removal of the modular equipment. Transfer tunnels with rail-mounted shuttle carts provide access to the remote maintenance cells.

Other than the processing cells, which are made of reinforced concrete, WHB-2 is constructed of steel framing with insulated metal siding. A personnel annex, located on the east side of WHB-2, houses offices, a control room, change rooms, health physics, and laboratories.

Some areas in WHB-2 require a protective coating to facilitate decontamination. The areas with a greater potential for contamination need more protective coating. In areas in which bare fuel is handled (including the cask-unloading hot cell, the cask transfer tunnels below the cask-unloading hot cell, the fuel transfer tunnels, and the consolidation hot cell), the floors and walls are lined with stainless steel up to the level of the crane rails. In these areas, a protective epoxy coating is applied to the walls above the rails and to the ceilings. In the remote maintenance cell and equipment transfer tunnel, a stainless-steel pan is provided for the floor, and a protective epoxy coating is applied to the walls and ceiling. The floors, walls, and ceilings of the waste-packaging hot cell and decontamination rooms are treated with a protective epoxy coating. All other operations areas in the WHB-2, including truck bays, operating galleries, cask preparation area, contact maintenance areas, and container transfer tunnels, have a protective epoxy coating on the floors and wainscot only.

4.2.4.1.3 Heating, Ventilating, and Air-Conditioning Systems for Waste-Handling Buildings

The heating, ventilating, and air-conditioning (HVAC) systems provide controlled atmospheric conditions during operations. These systems ensure the safety and comfort of personnel, maintain the integrity and operability of equipment and components, and restrict the spread of airborne radioactivity in the buildings and the release of airborne radioactivity from the buildings. The chillers for the HVAC system are described in Section 4.2.5.2.

To control the spread of airborne contamination and to reduce the amount of radioactivity released to the environment, HEPA filters are provided in the ventilation systems of all potentially contaminated areas. Areas that could contain radioactive contamination are maintained at pressures lower than ambient pressure to prevent contamination from spreading. Differential pressures are maintained between areas with different potentials for contamination so that air flows from areas with less potential for radioactive contamination to areas of progressively greater potential for contamination. In potentially contaminated areas, ambient air is circulated by once-through systems. Ventilation exhaust filter assemblies and associated fans have sufficient redundancy to allow continuous ventilation during filter replacement or in the event of failure or shutdown necessitated by maintenance of one component. In areas with no potential for contamination, systems recirculate air to reduce heating and cooling requirements.

Table 4-3 and Figures 4-15 and 4-16 identify preliminary pressurization zones in major areas of the waste-handling buildings. Conceptual flow diagrams of the HVAC systems for the cask-unloading hot cells, waste-packaging hot cells, consolidation hot cells, and surface storage vault in WHB-2 are provided in Figures 4-17 through 4-19.

Ventilation exhaust from hot cells in which bare spent fuel is handled (cask-unloading hot cells and consolidation hot cells) is directed through a high-effecency filter bank and three HEPA filter banks before discharge to the atmosphere. The high-efficiency filter bank and the first bank of HEPA filters are housed in filter units located in the hot cells to permit removal and replacement of filters by remote handling.

TABLE 4-3

HEATING, VENTILATING AND AIR-CONDITIONING PRESSURE ZONES

Zone	Contamination Level	Gage Pressure Ranges (in. w.g.*)
I	Expected	-0.5 to -1.5
II	High potential	-0.1 to -0.5
III	Low potential	-0.05 to -0.1
IV	Not expected	0 to -0.05

*Inches water gage.

The two remaining banks of HEPA filters are housed in filter units located in a separate filter gallery and are designed for replacement by contact handling.

Ventilation exhaust from other potentially contaminated areas (such as the waste-packaging hot cells, remote maintenance cells, and operating galleries) is directed through at least two banks of HEPA filters before release. In each building, all ventilation exhaust from contaminated and potentially contaminated areas is combined into one common exhaust air stream, and the air is monitored for radioactivity before being discharged to the atmosphere.

These features of the ventilation exhaust systems ensure that airborne effluents do not exceed the limits specified in 10 CFR 20 (NRC, 1986a) and DOE Order 5480.1B (DOE, 1986a) for airborne radioactivity concentrations in restricted and unrestricted areas. In addition, the ventilation exhaust systems sufficiently reduce radioactive releases so that the radiation dose limits specified in Section 2.5 are met.

In WHB-1, ventilation supply and exhaust equipment is located on the lower level between the cask-unloading hot cell and the surface storage vault. In WHB-2, ventilation supply and exhaust equipment, including HEPA filters, is located on the lower level between the consolidation hot cells. In both buildings, the ventilation air is exhausted at the roof. Tornado dampers are provided on ventilation intake and exhaust ducts for the operations area and storage vault.

4.2.4.1.4 Fire Protection

Based on the requirements of DOE Order 6430.1, Chapter X (DOE, 1983), each waste-handling building includes fire protection systems consisting of a combination of the following features:

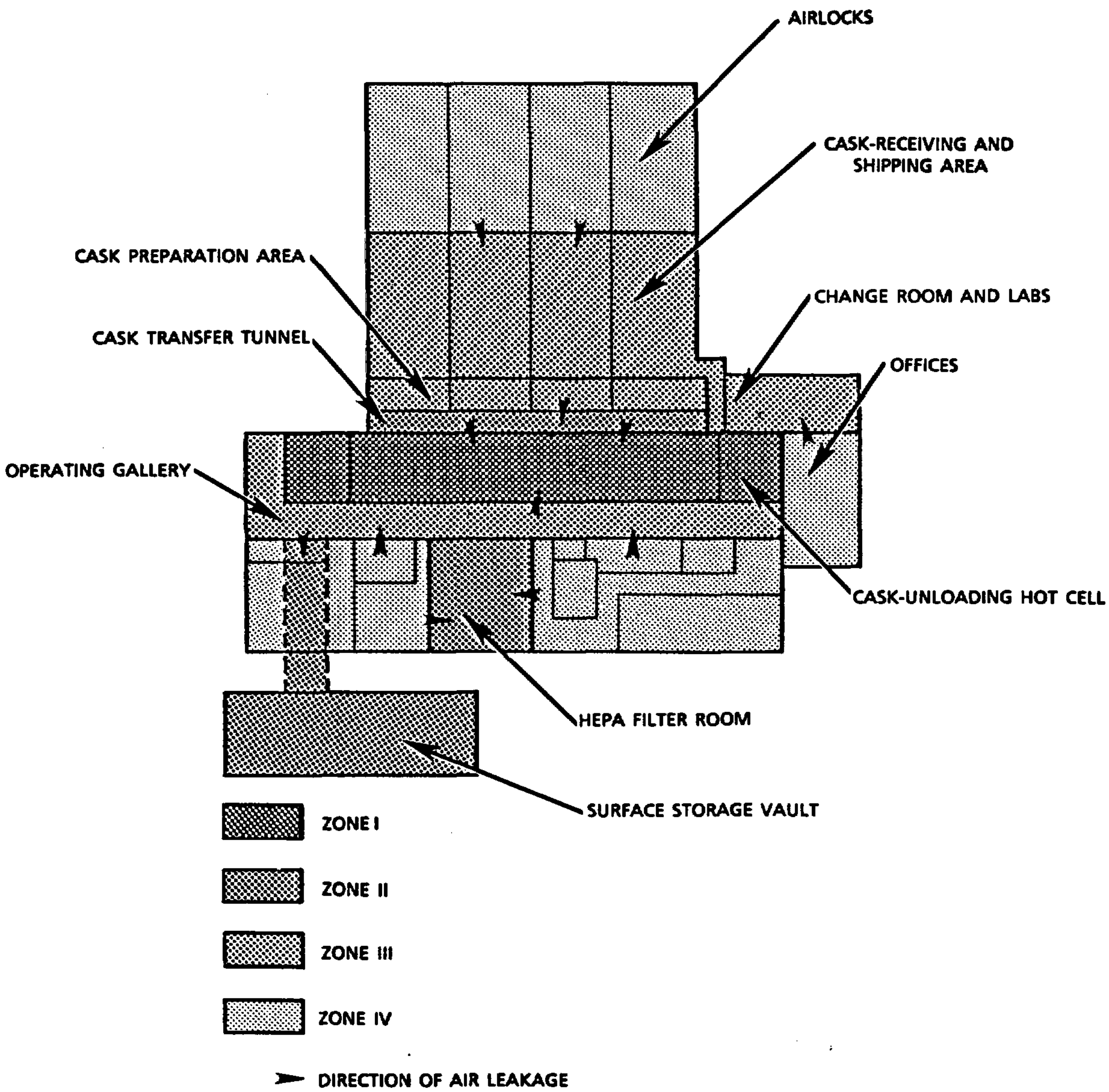


Figure 4-15. Heating, Ventilating, and Air-Conditioning Pressure Zones in Waste-Handling Building 1 (Figure prepared for the SCP-CDR.)

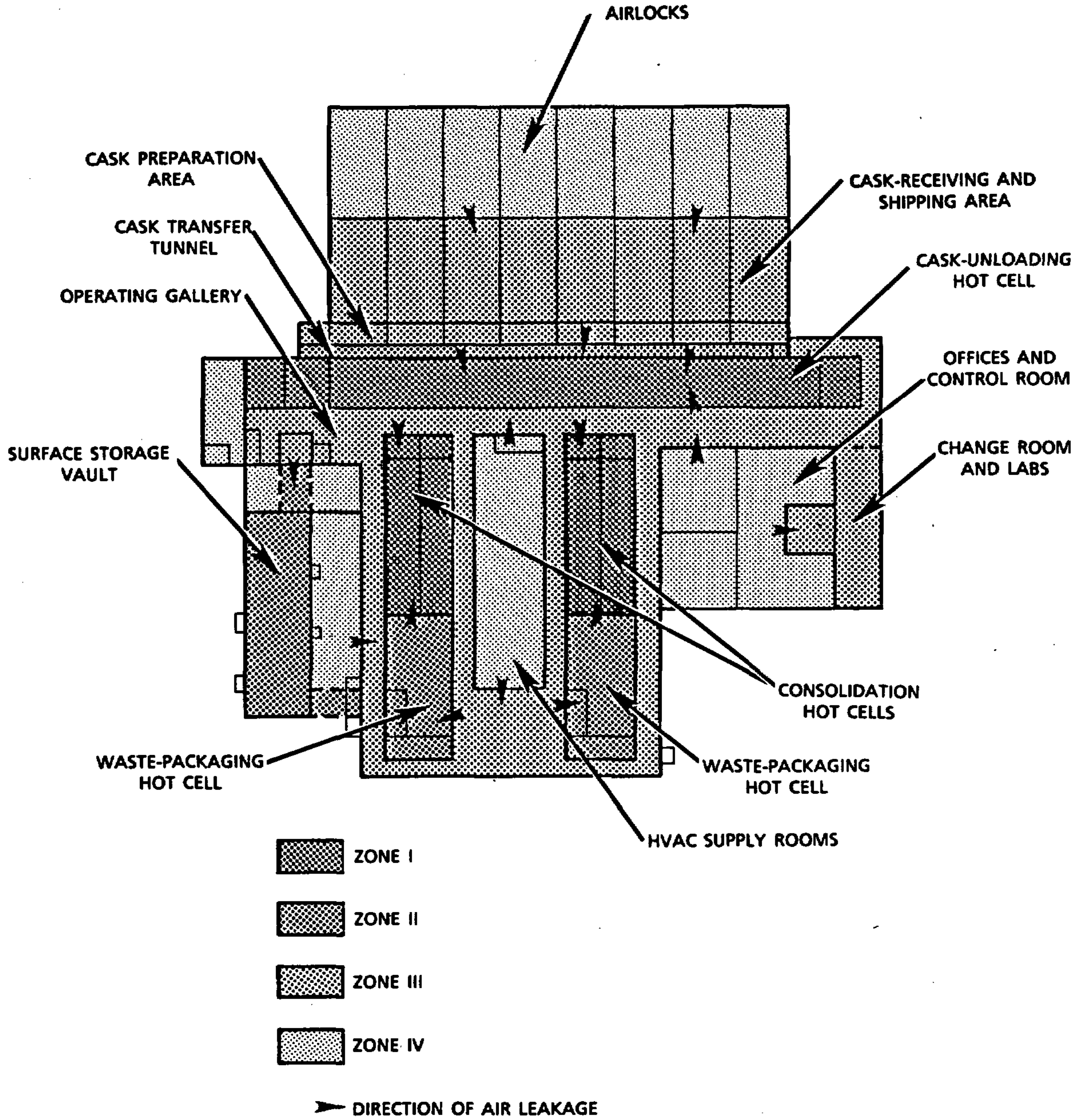
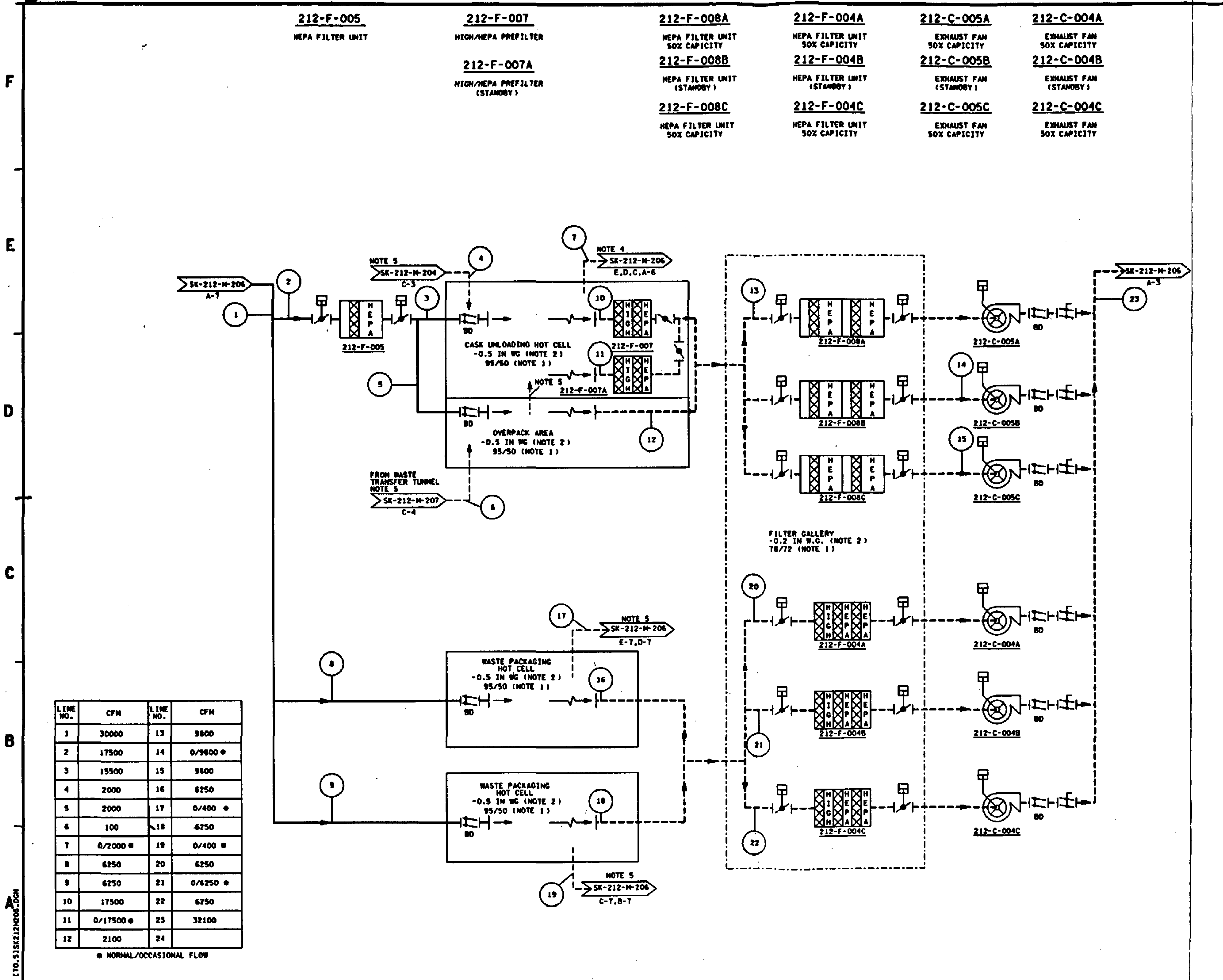


Figure 4-16. Heating, Ventilating, and Air-Conditioning Pressure Zones in Waste-Handling Building 2 (Figure prepared for the SCP-CDR.)



LINE NO.	CFM	LINE NO.	CFM
1	30000	13	9800
2	17500	14	0/9800 *
3	15500	15	9800
4	2000	16	6250
5	2000	17	0/400 *
6	100	18	6250
7	0/2000 *	19	0/400 *
8	6250	20	6250
9	6250	21	0/6250 *
10	17500	22	6250
11	0/17500 *	23	32100
12	2100	24	

* NORMAL/OCCASIONAL FLOW

[70.5]SK212M205.DGN

NOTES

1. THE TWO TEMPERATURES SHOWN INDICATE SUMMER MAXIMUM/WINTER MINIMUM ROOM DESIGN TEMPERATURES RESPECTIVELY.
2. PRESSURES INDICATED IN THE ROOMS ARE WITH REFERENCE ATMOSPHERIC PRESSURE OUTSIDE THE ROOM.
3. FOR THE SYMBOLS AND LEGEND, SEE DRAWING SK-212-M-206.
4. INTERMITTENT FLOW WHEN TRANSFERRING THE FUEL TO CONSOLIDATION HOT CELL.
5. INTERMITTENT FLOW.
6. 212-X-XXX DENOTES EQUIPMENT NUMBER.

SYMBOLS AND LEGEND

EQUIPMENT

CENTRIFUGAL FAN WITH INLET VANES AND ACTUATOR

SILENCER

FLEXIBLE DUCT

INFRA-RED HUMIDIFIER

LOUVER

COILS AND FILTERS

C = COOLING COIL
H = HEATING COIL (SHOWN)
E = ELECTRIC (SHOWN)
CH = CHILLED WATER
DX = DIRECT EXPANSION

EVAPORATIVE COOLER

LOW = LOW EFFICIENCY ROUGHING FILTER (SHOWN)
MOD = MODERATE EFFICIENCY FILTER
HIGH = HIGH EFFICIENCY FILTER
HEPA = HIGH EFFICIENCY PARTICULATE AIR FILTER

REFERENCE DRAWINGS

SK-212-M-206 WASTE HANDLING BUILDING 2 CONSOLIDATION HOT CELLS HVAC FLOW DIAGRAM

SK-212-M-207 WASTE HANDLING BUILDING 2 SURFACE STORAGE VAULT HVAC FLOW DIAGRAM

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SNL CONTRACT NO. 52-9817: CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY

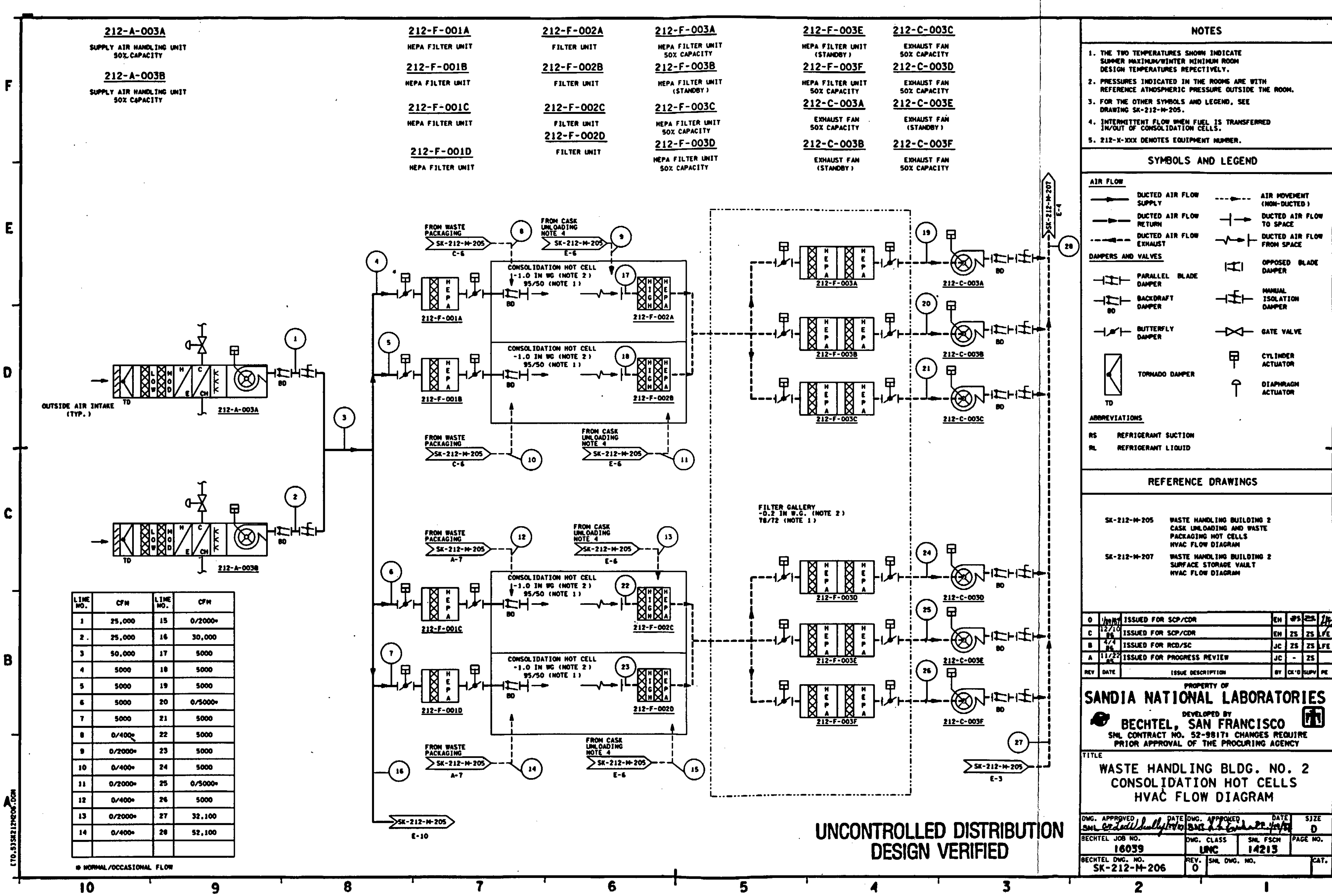
TITLE
WASTE HANDLING BLDG. NO. 2
CASK UNLOADING AND
WASTE PACKAGING HOT CELLS
HVAC FLOW DIAGRAM

DWG. APPROVED SNL [signature] DATE 1/23/87 | DWG. APPROVED BNI [signature] PE DATE [illegible]/87 | SIZE D

BECHTEL JOB NO. 16039 | DWG. CLASS UNC | SNL FSCM 14213 | PAGE NO.

BECHTEL DWG. NO. SK-212-M-205 | REV. 0 | SNL DWG. NO. | CAT.

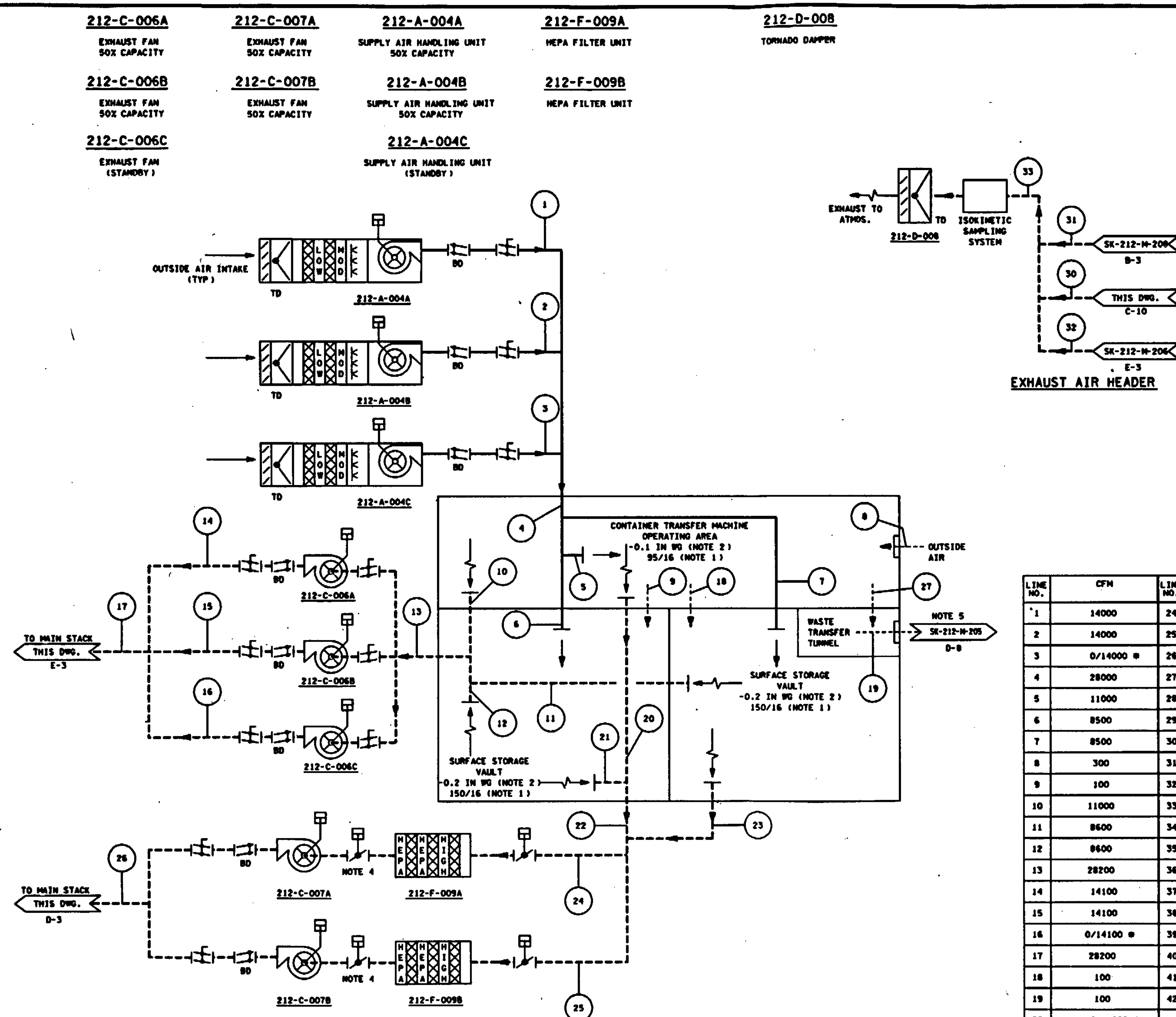
Figure 4-17.



LINE NO.	CFM	LINE NO.	CFM
1	25,000	15	0/2000*
2.	25,000	16	30,000
3	50,000	17	5000
4	5000	18	5000
5	5000	19	5000
6	5000	20	0/5000*
7	5000	21	5000
8	0/400*	22	5000
9	0/2000*	23	5000
10	0/400*	24	5000
11	0/2000*	25	0/5000*
12	0/400*	26	5000
13	0/2000*	27	32,100
14	0/400*	28	52,100

* NORMAL/OCCASIONAL FLOW

Figure 4-18.



LINE NO.	CFM	LINE NO.	CFM
1	14000	24	0/14100 *
2	14000	25	0/14150 *
3	0/14000 *	26	0/28200 *
4	28000	27	100
5	11000	28	—
6	8500	29	—
7	8500	30	28200
8	300	31	42300
9	100	32	52100
10	11000	33	122600
11	8600	34	—
12	8600	35	
13	28200	36	
14	14100	37	
15	14100	38	
16	0/14100 *	39	
17	28200	40	
18	100	41	
19	100	42	
20	0/11000 *		
21	0/8600 *		
22	0/19600 *		
23	0/8600 *		

* NORMAL/FILTRATION MODE FLOW

NOTES

1. THE TWO TEMPERATURES SHOWN INDICATE SUMMER MAXIMUM/WINTER MINIMUM ROOM DESIGN TEMPERATURES RESPECTIVELY.
2. PRESSURES INDICATED IN THE ROOMS ARE WITH REFERENCE TO ATMOSPHERIC PRESSURE OUTSIDE THE ROOM.
3. FOR SYMBOLS AND LEGEND, SEE DRAWINGS SK-212-M-205 AND SK-212-M-206.
4. HEPA FILTER/EXHAUST FANS UNITS SHALL OPERATE ONLY WHEN ACTUATED BY HIGH LEVEL ALARM FROM SURFACE STORAGE VAULT AIRBORNE RADIOACTIVITY MONITORS.
5. INTERMITTENT FLOW WHEN CONTAINERS ARE TRANSFERRED IN/OUT OF THE STORAGE AREA.
6. 212-X-XXX DENOTES EQUIPMENT NUMBER.

REFERENCE DRAWINGS

SK-212-M-205 WASTE HANDLING BUILDING 2 CASK UNLOADING AND WASTE PACKAGING HOT CELLS HVAC FLOW DIAGRAM

SK-212-M-206 WASTE HANDLING BUILDING 2 CONSOLIDATION HOT CELLS HVAC FLOW DIAGRAM

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D	1/29/87	ISSUED FOR SCP/CDR	EN	ZS	ZS	
C	12/10/86	ISSUED FOR SCP/CDR	EN	ZS	ZS	LFE
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A	11/22/85	ISSUED FOR PROGRESS REVIEW	JC	-	ZS	

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TITLE
WASTE HANDLING BLDG. NO. 2
SURFACE STORAGE VAULT
HVAC FLOW DIAGRAM

DWG. APPROVED SNL [signature] DATE · DWG. APPROVED BNI [signature] P.E. DATE · SIZE D
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Figure 4-19.

- portable fire extinguishers,
- standpipe hose system,
- fixed automatic sprinkler system,
- fire water supply and distribution system,
- fire-extinguishing system for special hazards (using Halon),
- fire detection and alarm system, and
- fire barriers and doors.

Areas in which spent fuel assemblies are handled are provided with special fire-extinguishing equipment that uses Halon 1301 so that water is not introduced in the event of a fire. Fixed automatic sprinkler systems are provided in other portions of the buildings.

4.2.4.1.5 Equipment

Major pieces of waste-handling equipment are listed in Tables 3-3 and 3-4, which also identify the equipment that needs development. A detailed equipment list for the surface facilities has been developed and is included in Appendix D of this report. In addition to waste-handling equipment, this equipment list includes HVAC equipment, tornado dampers, shield valves, port plugs and maintenance hatches, cell windows, shield doors, decontamination equipment, glove boxes, a radiation-monitoring system, and other items.

Equipment for consolidating spent fuel is in the initial stages of development (Townes et al., 1987a). This equipment must be reliable, maintainable, and cost-effective, and must meet requirements for radiological safety. Further design, development, and testing are needed to prove the basic design concept, which may result in significant changes in the current concept and may necessitate changes in facility design.

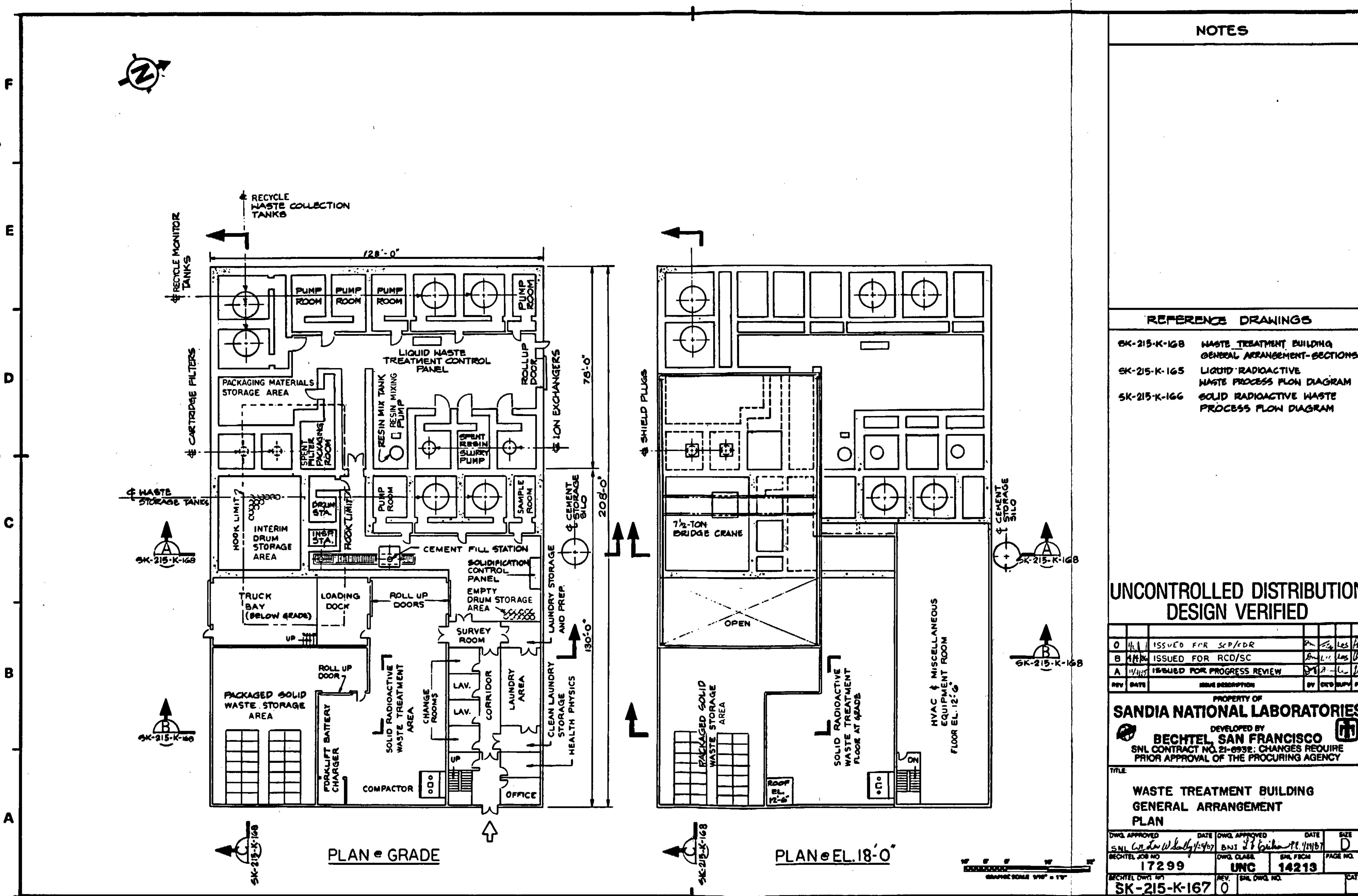
4.2.4.2 Support Facilities for Repository Operations

Support facilities located in the surface portion of the waste operations area include security stations, health physics station, vehicle wash facility, decontamination building, waste treatment building, waste transporter garage, and performance confirmation building. A summary of building descriptions is given in Table 4-1.

4.2.4.2.1 Waste Treatment Building

The waste treatment building receives site-generated radioactive wastes, both liquid and solid, and processes these wastes in preparation for shipment offsite. The waste treatment building is located in the surface portion of the waste operations area near the waste-handling buildings. The building is a reinforced-concrete structure, approximately 30,850 ft^2 in area. Figures 4-20 and 4-21 show the general arrangement of the waste treatment building.

The building is divided into six functional areas: (1) liquid radioactive waste treatment area, (2) waste solidification area, (3) solid radioactive waste treatment area, (4) loading and unloading area (including truck bay), (5) office and laundry area, and (6) mechanical and



NOTES
REFERENCE DRAWINGS
SK-215-K-168 WASTE TREATMENT BUILDING GENERAL ARRANGEMENT-SECTIONS
SK-215-K-165 LIQUID RADIOACTIVE WASTE PROCESS FLOW DIAGRAM
SK-215-K-166 SOLID RADIOACTIVE WASTE PROCESS FLOW DIAGRAM
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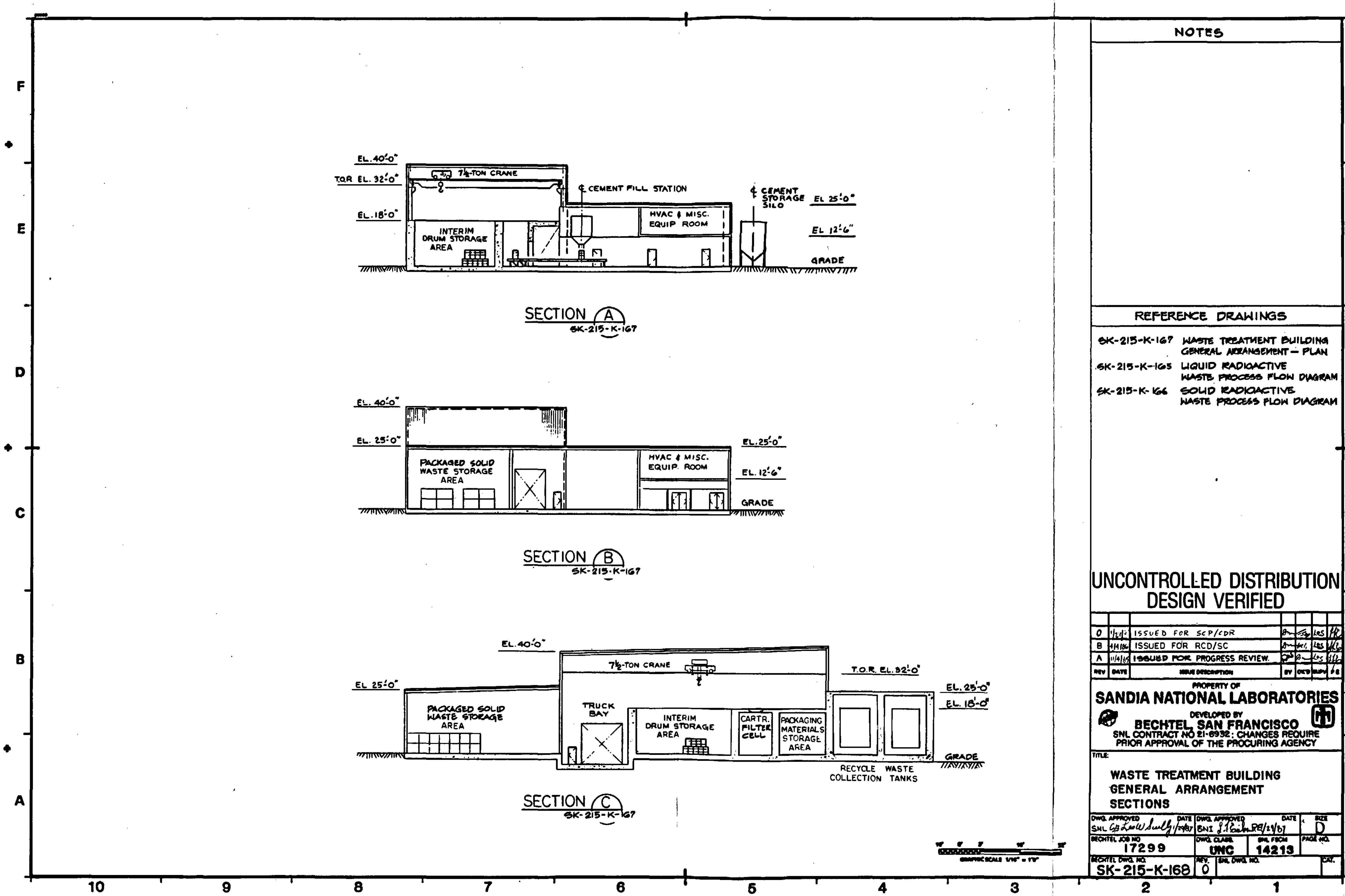
WASTE TREATMENT BUILDING
GENERAL ARRANGEMENT
PLAN
17299
UNC
14213
SK-215-K-167
PLAN @ GRADE
PLAN @ EL. 18'-0"
RECYCLE WASTE COLLECTION TANKS
RECYCLE MONITOR TANKS
CARTRIDGE FILTERS
WASTE STORAGE TANKS
PUMP ROOM
LIQUID WASTE TREATMENT CONTROL PANEL
PACKAGING MATERIALS STORAGE AREA
RESIN MIX TANK
RESIN MIXING PUMP
SPENT RESIN SLURRY PUMP
ION EXCHANGERS
ROLL UP DOOR
SPENT FILTER PACKAGING ROOM
INTERIM DRUM STORAGE AREA
HOOK LIMIT
DRUM STA.
INSP. STA.
SAMPLE ROOM
CEMENT FILL STATION
CEMENT STORAGE SILO
SOLIDIFICATION CONTROL PANEL
EMPTY DRUM STORAGE AREA
LAUNDRY STORAGE AND PREP.
TRUCK BAY (BELOW GRADE)
LOADING DOCK
ROLL UP DOORS
SURVEY ROOM
PACKAGED SOLID WASTE STORAGE AREA
FORKLIFT BATTERY CHARGER
SOLID RADIOACTIVE WASTE TREATMENT AREA
CHANGE ROOMS
LAV.
CORRIDOR
LAUNDRY AREA
CLEAN LAUNDRY STORAGE
HEALTH PHYSICS
COMPACTOR
OFFICE
128'-0"
78'-0"
208'-0"
130'-0"
SHIELD PLUGS
7 1/2-TON BRIDGE CRANE
OPEN
SOLID RADIOACTIVE WASTE TREATMENT FLOOR AT GRADE
HVAC & MISCELLANEOUS EQUIPMENT ROOM FLOOR EL. 12'-6"
ROOF EL. 12'-6"
SK-215-K-168

Figure 4-20.


EL. 40'-0"
T.O.R. EL. 32'-0"
EL. 18'-0"
7½-TON CRANE
℄ CEMENT FILL STATION
℄ CEMENT STORAGE SILO
EL. 25'-0"
EL. 12'-6"
GRADE
INTERIM DRUM STORAGE AREA
HVAC & MISC. EQUIP. ROOM
SECTION A SK-215-K-167
EL. 40'-0"
EL. 25'-0"
PACKAGED SOLID WASTE STORAGE AREA
HVAC & MISC. EQUIP. ROOM
EL. 25'-0"
EL. 12'-6"
GRADE
SECTION B SK-215-K-167
EL. 40'-0"
EL. 25'-0"
7½-TON CRANE
T.O.R. EL. 32'-0"
EL. 25'-0"
EL. 18'-0"
PACKAGED SOLID WASTE STORAGE AREA
TRUCK BAY
INTERIM DRUM STORAGE AREA
CARTR. FILTER CELL
PACKAGING MATERIALS STORAGE AREA
GRADE
RECYCLE WASTE COLLECTION TANKS
SECTION C SK-215-K-167
NOTES
REFERENCE DRAWINGS
SK-215-K-167 WASTE TREATMENT BUILDING GENERAL ARRANGEMENT – PLAN
SK-215-K-165 LIQUID RADIOACTIVE WASTE PROCESS FLOW DIAGRAM
SK-215-K-166 SOLID RADIOACTIVE WASTE PROCESS FLOW DIAGRAM
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WASTE TREATMENT BUILDING
GENERAL ARRANGEMENT
SECTIONS
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DWG. APPROVED BNI DATE
SIZE D
BECHTEL JOB NO 17299
DWG. CLASS. UNC
SNL FSCM 14213
PAGE NO.
BECHTEL DWG. NO. SK-215-K-168
REV. 0
SNL DWG. NO.
CAT.

Figure 4-21.

and electrical equipment area. The office and laundry area also includes facilities for health physics activities.

Liquid Radioactive Waste Treatment Area

Liquid radioactive wastes are generated in the waste-handling buildings, in the decontamination building, and possibly in the vehicle wash facility under off-normal conditions. Wastes that do not contain detergents, decontamination solutions, or other chemicals are segregated from those that do. A separate system of drains, sumps, piping, and tanks segregates and transfers these latter wastes to the waste treatment building. The wastes are collected and treated so that the water can be recycled. Cartridge filters, ion exchangers, and monitoring tanks for sampling treated waste are located in the liquid radioactive waste treatment area.

The wastes that contain detergents, chemicals, and spent resins from the waste treatment system are solidified in a system that includes waste storage tanks, recirculation and feed pumps, chemical treatment equipment, cement storage tanks, cement transfer devices, a waste and cement mixer, drum-capping and handling equipment, and an inspection station. A remotely operated 7.5-ton overhead bridge crane moves the drums and filter transfer casks. An area is provided for interim storage of the 55-gal drums of waste solidified in cement until they can be shipped offsite.

Solid Radioactive Waste Treatment Area

Solid radioactive wastes generated at the repository are bagged locally and brought by truck to the waste treatment building. Forklifts at the unloading dock transfer bagged waste. A sorting table is provided in a ventilated room so that compactible and noncompactible wastes can be separated manually, although this operation may not be necessary if a box compactor is used. The compactor places and compacts the solid wastes in 100-ft^3 boxes. An area is provided for interim storage of the boxes pending shipment offsite. A charging station is also provided in the solid waste treatment area for recharging forklift batteries.

Laundry

The laundry includes space for collecting and sorting contaminated laundry, dry cleaning equipment, respirator-cleaning equipment, and space to store clean laundry. Washing machines and dryers are also included for laundry not easily cleaned with dry cleaning equipment.

4.2.4.2.2 Performance Confirmation Building

It is assumed that selected disposal containers of spent fuel and DHLW will be removed from the emplacement area as part of the repository performance confirmation program. The performance confirmation building (24,500 ft^2) is located in the surface portion of the waste operations area near the portal of the waste ramp. The building has a shielded hot cell constructed of reinforced concrete and equipped with remote-handling equipment. An operating gallery surrounds the hot cell. A laboratory for preparation and analysis of container samples, a health physics area with change room, a mechanical and electrical room, and an office area are also provided. The facility receives and reopens the removed containers, and samples, tests, and repackages the waste for emplacement. The general arrangement of the performance confirmation building is shown in Figures 4-22 and 4-23.

Major equipment in the hot cell includes an overhead bridge crane, several bridge-mounted electromechanical manipulators, several master/slave manipulators and shielded viewing windows, a container transfer cart, container upender, container-cutting machine, container-welding station, and closed-circuit television viewing system. The walls of the hot cell are provided with a coating to facilitate decontamination.

Other major equipment in the performance confirmation building includes a control panel for remote-handling equipment, glove boxes, and other equipment used in sample preparation and analyses. HEPA filters clean exhaust air from the hot cell and other potentially contaminated areas.

4.2.4.2.3 Decontamination Building

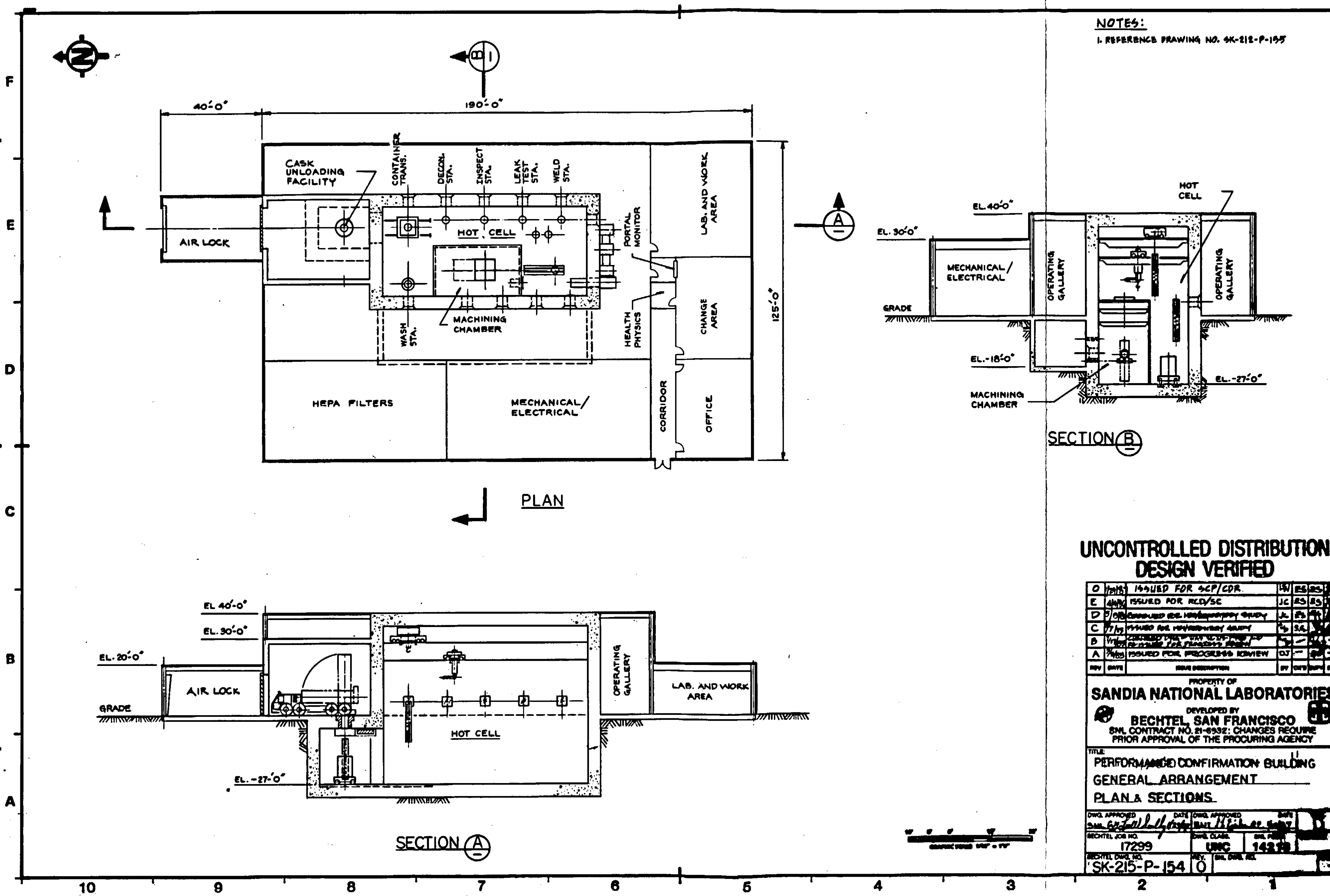
The decontamination building has the capability of receiving, disassembling, decontaminating, and returning to service any contaminated components or larger equipment, including the waste transporters (in the unusual event that they become contaminated). This high-bay building has approximately 4,200 ft^2 of work area and is equipped with a bridge crane. The work area includes a bay for vehicle and cask decontamination and a room for disassembling, decontaminating, and reassembling tools and other small components. Two additional stories, each with 1,200 ft^2, house offices, health physics facilities, change room, and mechanical equipment.

Decontamination equipment includes ultrasonic baths, electropolishers, chemical baths, and/or spray booths. All solid and liquid site-generated wastes are collected before transfer to the waste treatment building for treatment and eventual disposal offsite. A collection tank and pump are used to collect liquid wastes from decontamination processes and to pipe these wastes to the waste treatment building.

4.2.4.2.4 Security Stations

Security stations are provided at the two entrances to the surface portion of the waste operations area. Personnel and vehicle traffic into and out of the area is controlled at Security Station 2. Foot traffic passes through detection devices in the security station. Vehicles are monitored through controlled security gates adjacent to the building. Approximately 3,000 ft^2 of space is provided in Security Station 2.

Security Station 3 provides control of waste shipments entering and carrier traffic leaving the repository. A 2,400-ft^2 building houses


NOTES:
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40'-0"
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125'-0"
CASK UNLOADING FACILITY
CONTAINER TRANS.
DECON. STA.
INSPECT STA.
LEAK TEST STA.
WELD STA.
AIR LOCK
HOT CELL
MACHINING CHAMBER
WASH STA.
PORTAL MONITOR
HEALTH PHYSICS
LAB. AND WORK AREA
CHANGE AREA
CORRIDOR
OFFICE
HEPA FILTERS
MECHANICAL/ ELECTRICAL
PLAN
EL. 40'-0"
EL. 30'-0"
EL. 20'-0"
GRADE
EL. -18'-0"
EL. -27'-0"
OPERATING GALLERY
SECTION B
SECTION A
UNCONTROLLED DISTRIBUTION
DESIGN VERIFIED
O ISSUED FOR SCP/CDR
E ISSUED FOR RCD/SC
PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 21-6932: CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
PERFORMANCE CONFIRMATION BUILDING
GENERAL ARRANGEMENT
PLAN & SECTIONS
17299
UNC
SK-215-P-154
0

Figure 4-22.

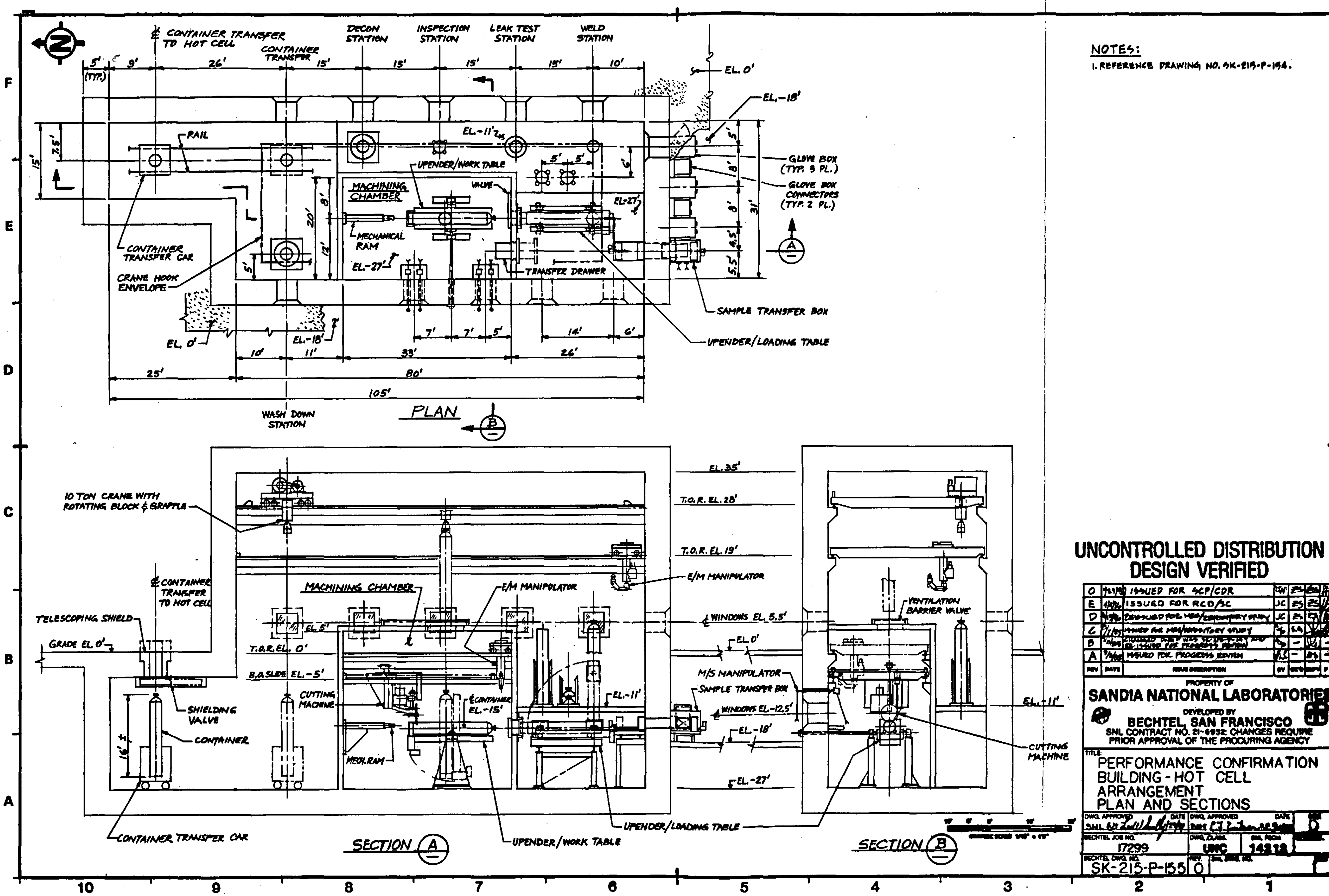
NOTES:
1. REFERENCE DRAWING NO. SK-215-P-154.
PLAN
SECTION A
SECTION B
DECON STATION
INSPECTION STATION
LEAK TEST STATION
WELD STATION
CONTAINER TRANSFER TO HOT CELL
CONTAINER TRANSFER
MACHINING CHAMBER
MECHANICAL RAM
UPENDER/WORK TABLE
TRANSFER DRAWER
SAMPLE TRANSFER BOX
UPENDER/LOADING TABLE
GLOVE BOX (TYP. 3 PL.)
GLOVE BOX CONNECTORS (TYP. 2 PL.)
CONTAINER TRANSFER CAR
CRANE HOOK ENVELOPE
RAIL
WASH DOWN STATION
10 TON CRANE WITH ROTATING BLOCK & GRAPPLE
E/M MANIPULATOR
M/S MANIPULATOR
TELESCOPING SHIELD
SHIELDING VALVE
CONTAINER
CUTTING MACHINE
VENTILATION BARRIER VALVE
GRADE EL. 0'
EL. 35'
T.O.R. EL. 28'
T.O.R. EL. 19'
WINDOWS EL. 5.5'
WINDOWS EL. -12.5'
EL. -27'
UNCONTROLLED DISTRIBUTION
DESIGN VERIFIED
ISSUED FOR SCP/CDR
ISSUED FOR RCD/SC
ISSUED FOR PROGRESS REVIEW
SANDIA NATIONAL LABORATORIES
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 21-6932: CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
PERFORMANCE CONFIRMATION BUILDING - HOT CELL ARRANGEMENT PLAN AND SECTIONS
17299
UNC
SK-215-P-155
0

Figure 4-23.

offices, toilet facilities, and a health physics laboratory. Security gates adjacent to the security building control the passage of roadway and railroad traffic.

4.2.4.2.5 Health Physics Station

A small, 400-ft^2 building houses the health physics station located at Gate 4. Space is provided for the equipment and personnel needed to monitor incoming shipments of waste.

4.2.4.2.6 Vehicle Wash Facility

A vehicle wash facility for waste carriers is provided just inside Gate 4. This drive-through structure accommodates both trucks and railcars. Automatic washing equipment, similar to a carwash, is housed inside this facility, which has an overall plan of about 4,000 ft^2.

4.2.4.2.7 Waste Transporter Garage

Waste transporters are stored in a garage south of the waste-handling buildings. The waste transporter garage (7,500 ft^2) has five bays for parking waste transporters, as well as space for offices, storage of tools and parts, and change rooms.

4.2.4.3 General Support Facilities

Buildings located in the general support facilities area include Security Station 1, the administration building, food service and computer buildings, the fire and medical facilities, warehouse, shops, and the mockup building. A summary of the buildings described below is given in Table 4-2.

In general, the service and support facilities have structural-steel frames and insulated metal siding and roofing. Columns are supported on reinforced-concrete spread footings. The ground floor is typically a concrete slab on grade. Floors are elevated metal deck with concrete topping supported by steel beams and girders. Rooms are partitioned by metal studs with gypsum board on each side, and the ceilings are suspended acoustical panels. As the design develops, consideration will be given to alternate building systems, such as precast-concrete fascia panels, precast-concrete tilt-up construction, or blockwall construction. Each method of construction will be evaluated, considering cost effectiveness, economy, energy efficiency, and constructibility.

4.2.4.3.1 Security Station 1

Security Station 1 is located at Gate 1, the personnel entrance to the repository. It is a two-story building with 4,000 ft^2 of floor space at each level. On the ground level, space is provided for a waiting room and toilet facilities. On the second level, space is provided for supervisors' offices, records storage, security administration and communications centers, and locker and shower facilities.

4.2.4.3.2 Administration Building

The administration building is a two-story structure with approximately 22,000 ft^2 of floor area at each level. A penthouse (3,500 ft^2) for mechanical equipment is located on the roof. On the ground floor, there is open office space (9,000 ft^2) in the center of the building; the perimeter of the building is dedicated to individual offices. In addition, a 1,000-ft^2 training auditorium provides seating for approximately 50 people on the ground level. On the second level, there is additional open office space (4,800 ft^2), with individual offices along most of the perimeter. Laboratories and training rooms (4,800 ft^2) are provided, with additional space (1,800 ft^2) for data analysis and operations monitoring. There are two elevators, one at each end of the building.

4.2.4.3.3 Food Service Facility

The food service facility, which adjoins the administration building to the south, provides approximately 11,000 ft^2 of space for kitchen, storage, serving, and dining facilities.

4.2.4.3.4 Computer Center

The computer center, connected to the administration building by an enclosed corridor to the north, is a single-story, reinforced-concrete building that provides approximately 4,000 ft^2 of floor space for computer hardware, tape storage, terminals, and office. A penthouse mechanical room houses the HVAC equipment. The building is designed to withstand seismic and tornado loading.

4.2.4.3.5 Fire and Medical Facilities

The fire and medical facilities are located east of the administration building. The fire station is a single-story building with space for the firemen's quarters, locker and shower facilities, and lunch room. Space is also provided for a communications room, offices, and equipment storage. A high-bay area houses the fire-fighting apparatus. The total area of the fire station is approximately 7,600 ft^2. Adjacent to the fire station is the medical building. A total area of approximately 8,200 ft^2 houses examination rooms, X-ray equipment, a medical laboratory, offices, and a waiting area. An enclosed garage, with space for two ambulances, is attached to this building.

4.2.4.3.6 Central Warehouse and Shops

The central warehouse and shops are located north of the administration building. The warehouse has approximately 48,000 ft^2 of storage space with a clear height of about 23 ft. Covered shipping and receiving docks are provided, as well as office space, lunch room, and locker rooms for warehouse personnel (9,000 ft^2 of building floor area). The central shop has approximately 24,000 ft^2 of work area, with a minimum clear height of about 23 ft. Individual shop areas are provided for each craft, including electrical, mechanical, instrumentation, plumbing, welding, automotive, and machine shop. The shops provide maintenance facilities for noncontaminated vehicles and equipment used in the surface facilities. Potentially contaminated equipment, including the waste transporter, will be serviced in a separate facility in the surface portion of the waste operations area. The remaining equipment used underground will be serviced underground. Space for offices, lunch room, first aid, and locker rooms is included. An overhead crane (or monorail and hydraulic lifts) for maintenance of vehicles is provided in the automotive shop area.

4.2.4.3.7 Mockup Building

The mockup building, in which personnel are trained to use equipment and waste-handling operations are simulated, is located east of the administration building. The building consists of an 8,640-ft^2, high-bay, mockup room equipped with a traveling bridge crane and a 1,200-ft^2 low-bay area for offices and classrooms.

4.2.4.3.8 Electrical Substation

The main electrical substation is located west of the fire and medical buildings. The transformers, which provide 13.8 kV of power for site distribution, are enclosed by a security fence. A 2,400-ft^2 building at this substation houses electrical switchgear, and a 1,200-ft^2 structure accommodates two diesel-driven generators, which provide standby power if offsite power is lost.

4.2.4.3.9 Motor Pool and Service Station

The motor pool and service station are located west of the shops. Carwash, vehicle parking, and refueling areas are provided. An enclosed garage provides space for minor maintenance, parts storage, and dispatcher's office. The station has 1,200 ft^2 of floor area.

4.2.4.3.10 Visitors' Center

A visitors' center (4,000 ft^2) provides information pertaining to the function and operation of the repository. Display rooms, auditorium, and meeting rooms are provided.

4.2.4.4 Support Facilities at Shafts and Ramps

Facilities located outside the central surface facilities area are described in this section. In general, these facilities are located at the shafts and ramps to the underground facility. Building descriptions are summarized in Table 4-2.

4.2.4.4.1 Support Facilities for the Men-and-Materials Shaft

Facilities that provide direct support for underground activities are located at the men-and-materials shaft, 1.5 mi west of the central surface facilities area. (The plot plan for the men-and-materials shaft and related support facilities is shown in Figure 4-10.) The major buildings located at this site are the change house for underground personnel, the ventilation building for the development area, and the standby generator and switchgear building. Other facilities that support underground operations at this site include a concrete batch plant, covered storage areas, security station, cooling tower for cooled water, and water and fuel storage tanks. The headframe and hoist house are described in Section 4.3.3.2.

The change house provides personnel who work underground with an area in which to prepare for their work shift and a staging area for arriving and departing workers. Men's and women's change rooms have locker baskets, showers, and toilet facilities. The change house also has a combination first aid, mine rescue, and training room, as well as office space for shift bosses, clerks, surveyors, and mine superintendents. Approximately 8,000 ft^2 of floor area is provided.

The ventilation building for the development area (23,700 ft^2) houses five motors to drive five fans that have a total maximum capacity of 411,800 ft^3/min of fresh air at a pressure of 9.0 in.* of water (gage pressure). This amount of air is delivered to the development area in the vertical emplacement configuration. Normally, four of the fans operate and one fan is on standby. The necessary volume of air is 281,300 ft^3/min at a pressure of 4.5 in.* of water in the horizontal emplacement configuration. The general arrangement of the ventilation building for the development area is shown in Figure 4-24.

4.2.4.4.2 Ventilation Shafts for the Waste Emplacement Area

ES-1 and ES-2 (Section 4.2.3.2) will be used during emplacement operations to supply ventilation air to the emplacement area, including the shops and decontamination facility. Modifications will be made at the shaft collars to provide the air plenum structures needed for air supply. The shaft site will be graded, as necessary, to ensure that the shaft openings are protected from the PMF (Appendix H).

4.2.4.4.3 Emplacement Area Exhaust Building

The exhaust building for the emplacement area (60,130 ft^2) is located at the emplacement area exhaust shaft, southeast of the men-and-materials shaft (Figure 4-11). The motors and fans adjacent to the building can pull a maximum of 837,200 ft^3/min of air at a pressure of 13.8 in.* of water from the emplacement area in the vertical emplacement configuration. For horizontal emplacement, the required volume of air is reduced to 517,200 ft^3/min at a pressure of 5.0 in.* of water. An exhaust stack and effluent-monitoring equipment (isokinetic sampler) are located nearby. In case of a radioactive release underground, exhaust air is filtered through HEPA filters housed in this building before it is released to the atmosphere. The general arrangement of the emplacement area exhaust building is shown in Figure 3-30.

4.2.4.4.4 Tuff Pile

Conveyors, a radial stacker, and mobile equipment transport the excavated tuff from the tuff ramp portal to the tuff pile for disposal.

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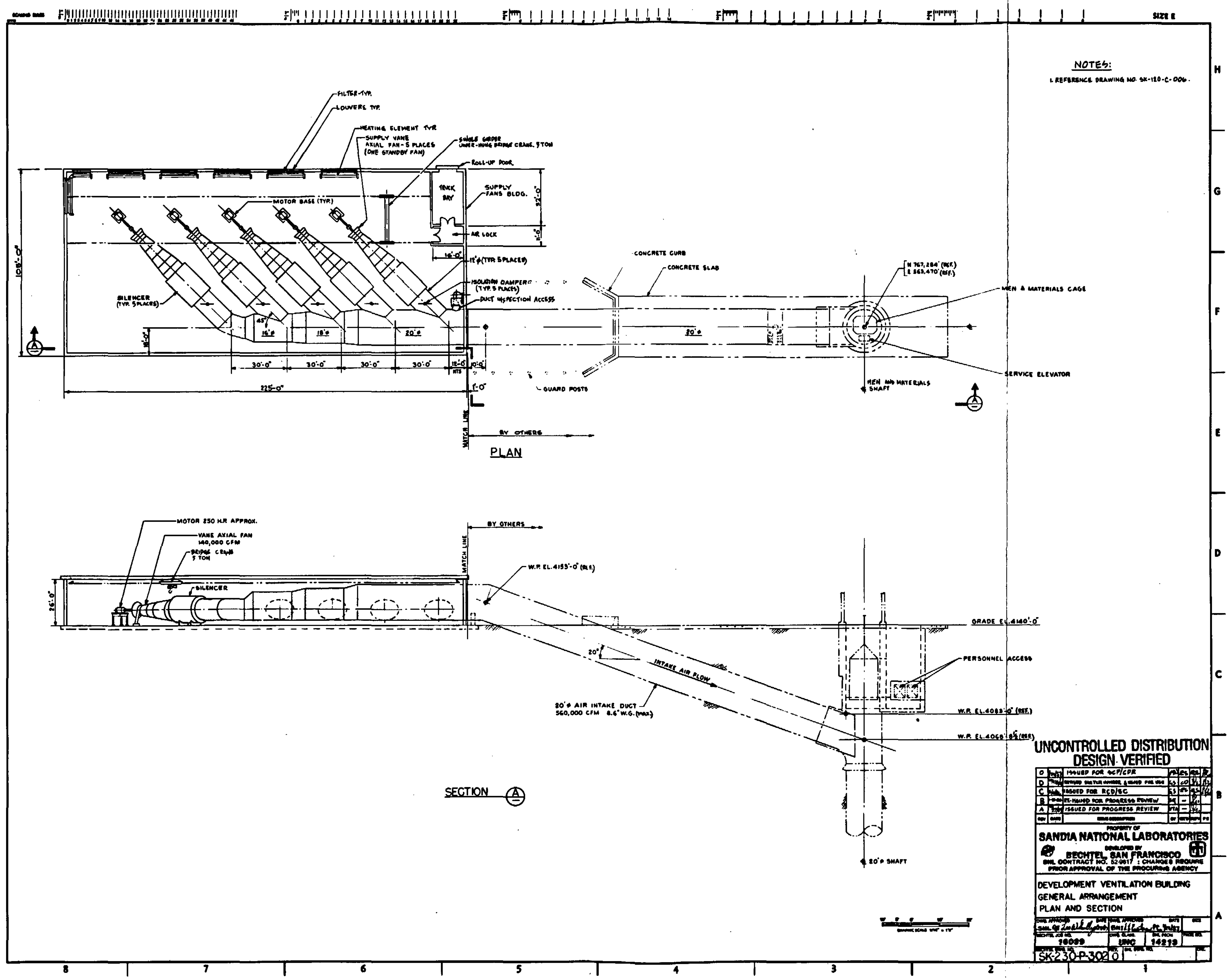
*The reference point for pressures is the shaft collar.



NOTES:
1. REFERENCE DRAWING NO. SK-120-C-006.
PLAN
SECTION A
UNCONTROLLED DISTRIBUTION
DESIGN VERIFIED
SANDIA NATIONAL LABORATORIES
BECHTEL SAN FRANCISCO
DEVELOPMENT VENTILATION BUILDING
GENERAL ARRANGEMENT
PLAN AND SECTION
SK-230-P-3020

Figure 4-24.

In the conceptual design, the conveyors are 42 in. wide to provide adequate capacity and the capability to handle surges in volume. Properties of the excavated tuff, given in Table 4-4, are used to select the tuff-handling equipment and the design of the tuff pile (Figure 3-24). Approximately 3,600 linear feet of surface conveyor are needed during the later stages of repository construction.

TABLE 4-4

PROPERTIES OF EXCAVATED TUFF USED FOR DESIGN[a]

Property	Value
In Situ Density	145 lb/ft^3
Specific Gravity	2.35
Excavated Density	96.7 lb/ft^3[b]
Angle of Repose	35°

a. See Appendix Q.
b. Density is based on a swell ratio of 1:1.50.

The ramp that provides access to the top of the tuff pile is approximately 240 ft long by 30 ft wide and has a gradient of 10%. The 42-in.-wide conveyor on this ramp (constructed in increments of 200 linear feet) carries the tuff to an extensible conveyor installed on the centerline of the tuff pile. At the end of the extensible conveyor, a stacker is installed to keep the stockpiling operation independent of the conveyor. The stacker is portable to be compatible with the extensible conveyor and with the construction of the tuff pile.

The tuff deposited by the conveyor is moved by a rubber-tired front-end loader from the stacker to the end of the tuff pile, where the tuff is dumped. The tuff pile has stable embankments and side slopes not steeper than approximately 1.5 to 1 (horizontal to vertical distance). During construction, drainage is provided to prevent water from collecting and to reduce erosion of the embankments.

4.2.4.4.5 Explosives Magazine

A secured facility for the storage of explosives used in the development of the underground facility is located in the hills at least 2,000 ft north of the men-and-materials shaft. Two concrete-block, bullet-resistant buildings are provided, one exclusively for the storage of explosives and the other for detonators.

4.2.5 Utilities

The following sections describe those utilities needed for the surface and subsurface facilities. Descriptions are included for power, chilled-water systems, communications, fuel, water, sewage, and sanitary landfill needs.

4.2.5.1 Power

Electrical power for the repository originates at the existing 138-kV distribution loop for the NTS, which is serviced by two independent electrical utility companies (Section 4.1.3). The incoming feed terminates at the utility electrical substation. Initial voltage is stepped down at the main substation. The main electrical substation is located west of the central warehouse. A fence surrounds the transformers, which provide 13.8 kV power for site distribution. Two enclosed buildings are located at this substation: one, which has approximately 2,400 ft^2 of floor space, houses electrical switchgear; the other building, which has approximately 1,200 ft^2 of floor space, houses two diesel-driven generators that provide standby power.

Power cables are routed in major utility corridors to the various facilities located in the central surface facilities area and along the site access roads. Local transformers at the individual facilities step voltages down to working levels. Electricity is distributed to the underground facility over two independent routes: one through the tuff ramp and the second through the men-and-materials shaft. Each system is adequate to supply the entire demand of the underground facility.

Three diesel-driven generators, which provide standby power for the underground operations support if offsite power is lost, are housed in the standby generator and switchgear building at the men-and-materials shaft.

Uninterruptible power supplies (UPS) for communications, security, computer, and radiation-monitoring systems are located near the systems they serve.

4.2.5.2 Chilled-Water System

Individual chilled-water systems for HVAC are provided in the waste-handling facilities, the support buildings, and the development area ventilation system. Chilled-water systems comprise an evaporator, compressor, condenser, cooling towers, and circulation pumps. Redundant systems for each installation ensure continued operation during breakdown or maintenance periods. In the surface portion of the waste operations area, independent chilled-water systems are provided for WHB-1 and WHB-2. In the men-and-materials shaft area, a cooling tower and water storage tank provide for cooling requirements underground.

4.2.5.3 Communications

A communications network, centered in the administration building, includes systems for telephone, radio, public address and paging, and alarm. The telephone system provides direct communication among the NTS network, the offsite commercial system, and the system that connects all parts of the repository. Radio communication is provided solely for the use of fire, medical, security, and offsite emergency service agencies. The radio system, before being used, must be carefully evaluated to ensure its compatibility with the use of explosives. The public address and paging system provides voice paging throughout the repository and serves as an alarm system.

4.2.5.4 Fuel

Diesel fuel for vehicles and emergency generators is procured from local suppliers and stored in underground fuel storage tanks located near the areas they serve.

4.2.5.5 Water

New wells, two 400,000-gal storage tanks on Exile Hill that serve the surface facilities, a 150,000-gal tank near the ESF, a 270,000-gal tank at the men-and-materials shaft, and a booster pump station provide an adequate and reliable water supply system for the site. The new wells will supply the repository with its potable, fire, and process water. Existing wells may be used as a supplemental source of water. The storage capacity of the tanks on Exile Hill is equal to the total daily domestic demand, plus fire demand for a 4-hr period. Total water use during repository siting, construction, operation, and decommissioning is expected to cause only very localized drawdown of the regional water table (Section 2.2.4).

The potable and fire protection water supplies are distributed by gravity from the storage tanks on Exile Hill. Two separate piping networks are used. One network supplies the domestic water needs in the buildings, and the other supplies the fire hydrants and sprinkler systems. To provide maximum reliability, both networks are looped around the central surface facilities area. Sectional valves, used throughout the networks, isolate portions of the system when repair or maintenance is needed without shutting off the entire system. Water is also needed to operate sprinklers, inside hose streams, and fire hydrants. This water demand is independent of the total daily demand and will only be used for fire protection. Water reserved for fire protection is stored and will not be used for any other purpose.

4.2.5.6 Sewage

In this conceptual design, lagoons are used for treatment of sanitary sewage. These lagoons are located 0.4 mi due east of the central surface facilities and provide treatment for all nonradioactive waste water and sewage generated at the repository. The lagoons, which are lined with a Hypalon liner, are aerobic/anaerobic ponds, which provide complete stabilization of organic material and removal of solids. After an adequate detention period in the lagoons, the effluent is discharged into an unlined evaporative pond sized to handle peak waste-water flow at the repository. A sewage collection system is provided at the central surface facilities area. The sewer lines for the system are routed in the main utility corridors. Waste water from the underground operations area is collected in tanks, hoisted to the surface through the men-and-materials shaft, and deposited in the sewage collection system (which also serves the change house). From the men-and-materials shaft area, a sewer line is routed in the utility corridor along the access road to the sewage treatment lagoons. Local septic tanks and leach fields are provided for treatment and disposal of sewage from remote areas not served by the collection system leading to the sewage treatment lagoons.

4.2.5.7 Sanitary Landfill

Refuse collected from personnel activities at the repository is disposed of at a land disposal site in the vicinity of the tuff pile. This site is within convenient hauling distance of the contributing facilities. Initially, an area of approximately 22 acres will be reserved for this use; however, there is sufficient land adjacent to the disposal site to permit expansion, if necessary. Sanitary landfill activities involve daily compaction of refuse and daily placement of an earth cover over the solid waste. Ditches divert storm drainage around the landfill site during and after filling (Figure 4-9).

4.3 Shafts and Ramps

The following description of shafts and ramps presents the current conceptual design. Evaluation of the advantages and disadvantages of the current design for each access is ongoing and may lead to modifications in the design before license application.

4.3.1 Access Functions

Access between the surface facilities and the underground facility is provided by shafts and ramps. A tradeoff study to evaluate the design of the means of access for high-level waste, personnel, and materials is documented by Dennis and Dravo (1985) and in Appendix R. The major functions of both shafts and ramps are to

- transfer mining equipment to the underground facility and remove mined tuff,
- transfer bulk construction and backfill materials to the underground facility,
- transfer general supplies,
- transfer explosives,
- transfer waste to the emplacement area (and possibly to retrieve the waste),
- transfer personnel,
- intake and exhaust ventilation air for the development and waste emplacement areas, and
- provide a route for underground utilities.

In determining the number, type, and location of the access points needed at the Yucca Mountain repository, the following factors were considered:

- personnel and operating safety;
- efficiency and effectiveness of operations, including transportation and ventilation functions;

- capital and operating costs;
- schedule;
- security;
- interaction with other structures, both surface and subsurface; and
- structural considerations for entry points.

4.3.2 Description of Accesses

In both the vertical and horizontal emplacement concepts, access to the underground facility is provided by two ramps and four shafts. All access is designed to permit sealing and backfilling to the extent necessary for closure of the subsurface facilities. The accesses to the underground facility are shown in Figure 4-5. Additional discussion of the surface characteristics and requirements is included in Section 4.2.2.2.

These accesses are also routes for either intake or exhaust of air. The ventilation system is designed to use the shafts and ramps in a way that ensures that the ventilation system for the waste emplacement area is entirely separate from the system for the development area (Section 3.4). The mining and construction of accesses (shafts and ramps) are discussed in Section 3.3.1.1. Construction methods and sequences are closely related and interdependent; hence, mining methods and sequences for the accesses and drifts are discussed in Sections 3.3.1.1.1 through 3.3.1.1.5.

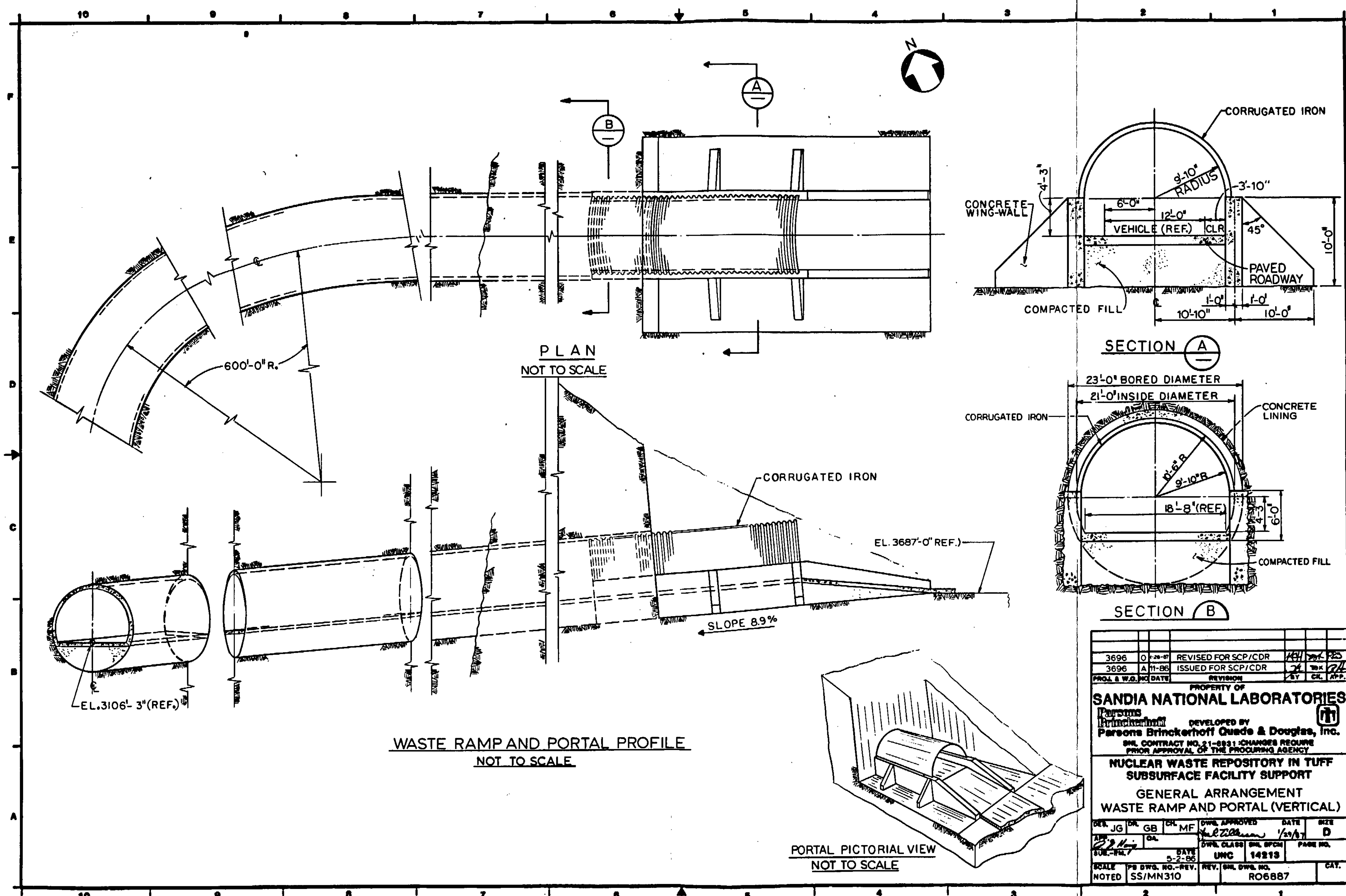
4.3.2.1 Waste Ramp

The waste ramp (Figures 4-25 and 4-31) permits transport of the waste from the waste-handling buildings to the emplacement area and includes a paved roadway suitable for the safe operation of the waste transporter. In all sections of the waste ramp that are longer than 400 ft, the slope is less than 10%. Current design criteria allow grades of up to 15% in segments of less than 400 ft. The location of the waste ramp is determined by these grade limitations, by the desired location of the surface and underground entry points, and by the location of the surface facilities. The portal of the waste ramp (Figure 4-25) is located in solid rock inside the boundary of the central surface facilities area. To permit flexibility in siting, the portal is physically separate from the waste-handling buildings (Section 4.2.2).

The dimensions and grade of the waste ramp are shown in Table 4-5. The ramp is ventilated by an approximate maximum of 300,000 cfm of fresh air in the vertical emplacement configuration and 185,000 cfm in the horizontal configuration. This amount is adequate to dilute diesel fumes generated by the transporters operating on the ramp and to provide a part of the intake air for the waste emplacement area. A large turning radius is provided at the base of the ramp to facilitate entry into the underground facility.

4.3.2.2 Tuff Ramp

The tuff ramp (Figures 4-26 and 4-31) is used for removing excavated tuff and ventilation exhaust from the development area. An approximate


PLAN
NOT TO SCALE
600'-0" R.
CORRUGATED IRON
CONCRETE WING-WALL
4'-3"
6'-0"
9'-10" RADIUS
3'-10"
12'-0"
VEHICLE (REF.)
CLR
45°
10'-0"
PAVED ROADWAY
COMPACTED FILL
1'-0"
10'-10"
10'-0"
SECTION A
23'-0" BORED DIAMETER
21'-0" INSIDE DIAMETER
CONCRETE LINING
10'-6" R
9'-10" R
18'-8" (REF.)
4'-3"
6'-0"
SECTION B
CORRUGATED IRON
EL. 3687'-0" REF.)
SLOPE 8.9%
EL. 3106'-3" (REF.)
WASTE RAMP AND PORTAL PROFILE
NOT TO SCALE
PORTAL PICTORIAL VIEW
NOT TO SCALE
3696 | 0 | 1-29-87 | REVISED FOR SCP/CDR
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Parsons Brinckerhoff Quade & Douglas, Inc.
SNL CONTRACT NO. 21-6831 :CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY SUPPORT
GENERAL ARRANGEMENT
WASTE RAMP AND PORTAL (VERTICAL)
DES. JG
DR. GB
CH. MF
DWG. APPROVED
DATE 1/29/87
SIZE D
DATE 5-2-86
DWG. CLASS UNC
SNL SFCM 14213
PAGE NO.
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Figure 4-25.

TABLE 4-5

DATA FOR RAMPS AND SHAFTS

Opening	Elevation at Portal or Collar (ft)	Length or Depth (ft)	Slope	Diameter[a] Vertical Method (ft)	Diameter[a] Horizontal Method (ft)
Waste Ramp	3,687	6,603[b]	8.9%	23[c]	21
Tuff Ramp	3,914	4,627[b]	17.9%	25[c]	21
Men-and-Materials Shaft	4,140[d]	1,090	e	20[f]	20[f]
Emplacement Area Exhaust Shaft	3,960[d]	1,030	e	20[f]	20[f]
ES-1	4,160[d]	1,480	e	12	12
ES-2	4,160[d]	1,020	e	6	6

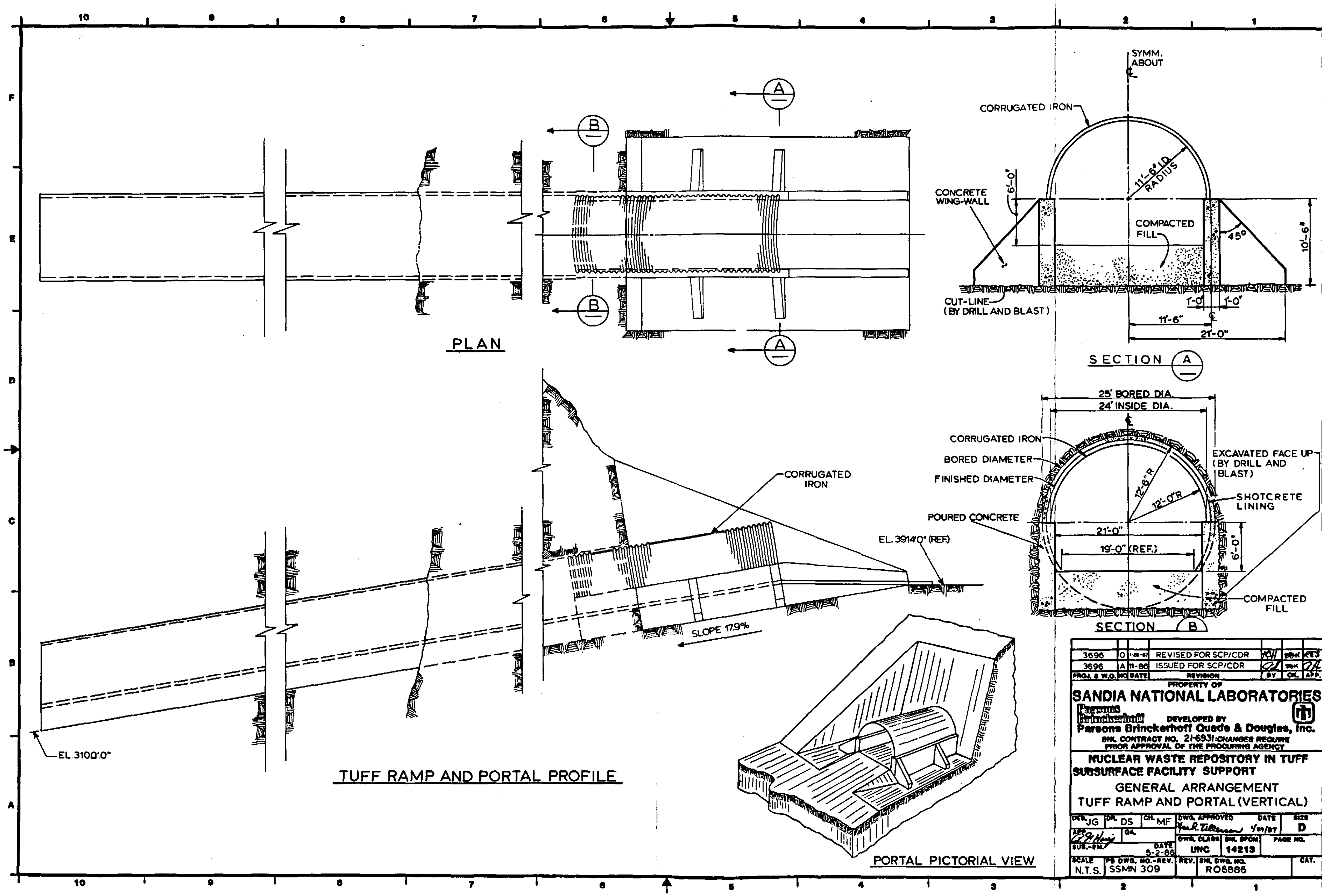
a. The dimensions of the ramps are excavated dimensions; those of the shafts are inside finished dimensions.
b. Includes the length of the portal.
c. The diameter of the ramps is larger in the vertical configuration because the ventilation airflow needed is greater than that in the horizontal configuration.
d. Final construction grade elevation.
e. All shafts are vertical.
f. The diameters of the shafts are controlled by operating requirements rather than ventilation airflows.

maximum of 350,000 cfm of return air in the vertical emplacement configuration and 240,000 cfm of return air in the horizontal configuration will travel up the ramp. The location of the tuff ramp (Figure 4-5) is determined by the desired entry point to the subsurface facilities, by the location of the waste emplacement area, including its proximity to the northern area, and by the location of the tuff pile. As currently located, the ramp portal is in solid rock within easy access of the tuff pile.

The dimensions and grade of the tuff ramp are shown in Table 4-5. The ramp is large enough in cross section to permit installation of a 42-in.-wide conveyor belt for tuff removal, to provide limited access for large machinery from the surface to the underground facility during construction and operation of the underground facility, and to serve as an exhaust route from the development area.

4.3.2.3 Exploratory Shafts

At Yucca Mountain, the ESF includes a main 12-ft-diameter exploratory shaft (ES-1) and a second, 6-ft-diameter shaft (ES-2). Figure 4-5 shows the locations of these shafts.



PLAN
TUFF RAMP AND PORTAL PROFILE
PORTAL PICTORIAL VIEW
SECTION A
SECTION B
SYMM. ABOUT ℄
CORRUGATED IRON
CONCRETE WING-WALL
11'-6" I.D. RADIUS
COMPACTED FILL
CUT-LINE (BY DRILL AND BLAST)
6'-0"
10'-6"
45°
1'-0"
11'-6"
21'-0"
25' BORED DIA.
24' INSIDE DIA.
BORED DIAMETER
FINISHED DIAMETER
POURED CONCRETE
EXCAVATED FACE UP (BY DRILL AND BLAST)
SHOTCRETE LINING
12'-6" R
12'-0" R
19'-0" (REF.)
EL. 3914'0" (REF.)
SLOPE 17.9%
EL. 3100'0"
3696 | O | 1-28-87 | REVISED FOR SCP/CDR
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Parsons Brinckerhoff
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Parsons Brinckerhoff Quade & Douglas, Inc.
SNL CONTRACT NO. 21-6931 :CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY SUPPORT
GENERAL ARRANGEMENT
TUFF RAMP AND PORTAL (VERTICAL)
DES. JG
DR. DS
CH. MF
DWG. APPROVED
DATE
SIZE D
SUB.-PM.
DATE 5-2-86
DWG. CLASS UNC
SNL SPCM 14213
PAGE NO.
SCALE N.T.S.
PB DWG. NO.-REV. SSMN 309
REV.
SNL DWG. NO. RO6886
CAT.

Figure 4-26.

The two exploratory shafts will be used as air intakes for the waste emplacement area during the emplacement phase. The shafts will bring an approximate maximum of 480,000 cfm of air in the vertical configuration and 300,000 cfm of air in the horizontal configuration into the waste emplacement area, the shops in the emplacement area, and the underground decontamination facility. Figure 4-27 illustrates the general arrangement and cross sections of each shaft. Additional data pertaining to the shafts in the ESF are presented in Table 4-5.

Before waste emplacement begins, the exploratory shafts will be converted for use as ventilation shafts. The conversion will include removal of the hoisting equipment and fixtures from ES-1 and construction of a surface ventilation structure.

4.3.2.4 Men-and-Materials Shaft

The men-and-materials shaft (Figure 4-28) provides access for men and materials and serves as an air intake for the development area. An approximate maximum of 410,000 cfm of air in the vertical case and 280,000 cfm of air in the horizontal case will enter the underground facility through this shaft. The location of the shaft (Figure 4-34) provides convenient access to the shops in the development area as well as to the remainder of the underground facility. This shaft is equipped with a large men-and-materials cage, a small service elevator (for four to six people), and an access for utilities. Additional data pertaining to the men-and-materials shaft are presented in Table 4-5.

4.3.2.5 Emplacement Area Exhaust Shaft

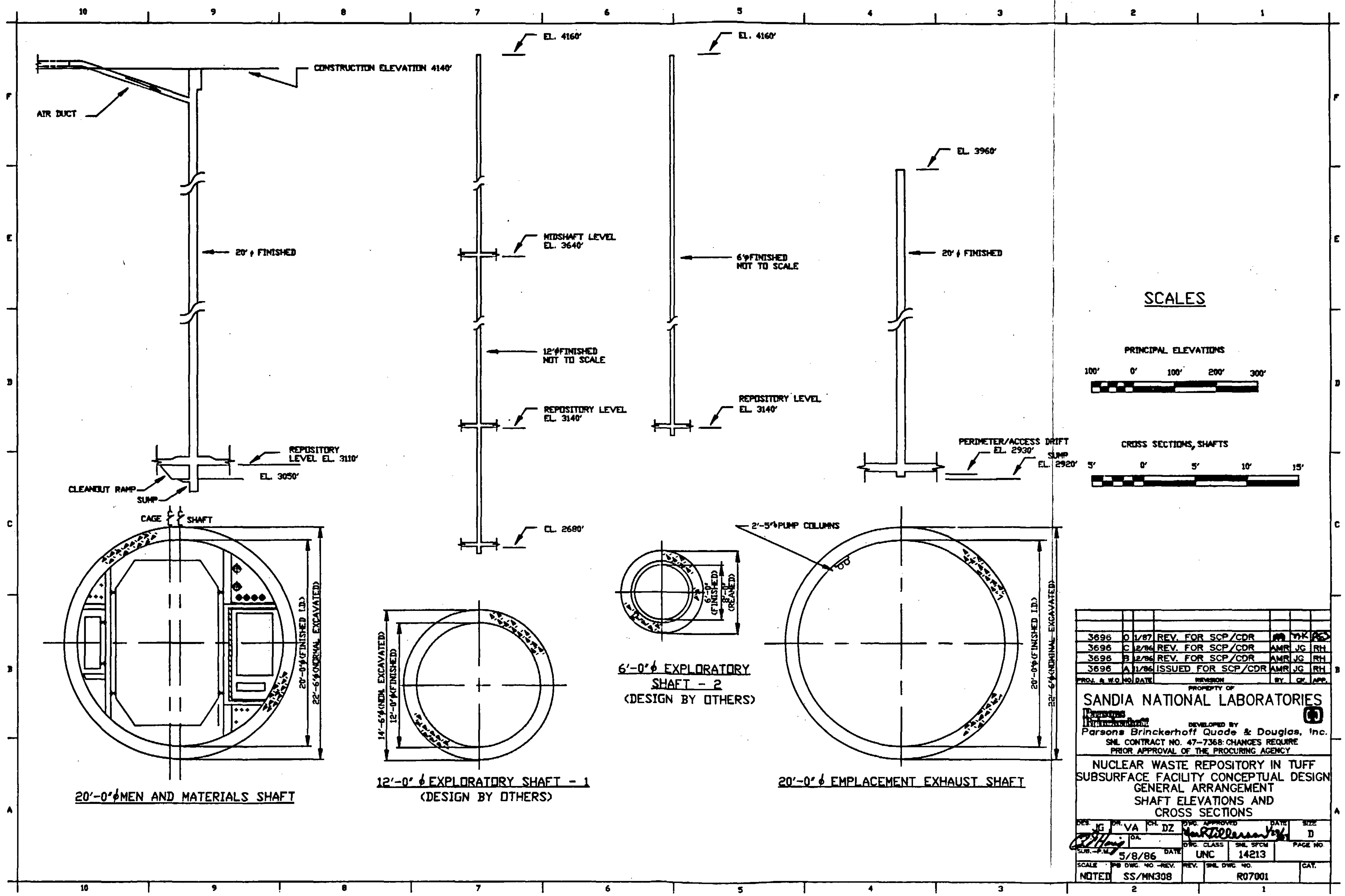
The exhaust shaft for the waste emplacement area is located near the first panels just east of the perimeter drift (Figure 4-34), which optimizes its use as an exhaust pathway. The maximum flow of air through this shaft is 840,000 cfm in the vertical case and 510,000 cfm in the horizontal case. The surface location (Figure 4-5) is suitable for the exhaust filtration facilities (Section 4.2.2.4). Data pertaining to the emplacement area exhaust shaft are presented in Table 4-5.

4.3.2.6 Seals and Linings

The water table at the Yucca Mountain site lies below the elevation proposed for the underground facility (Section 2.2.4.2); therefore, it is expected that seals will not be required to prevent ground water from entering the underground facility through the shafts and ramps during repository operations.

Shaft collars and ramp portals are constructed in a manner that prevents surface runoff from entering the shaft. Surface grading and drainage design also direct surface water away from the shafts. The collars and portals extend below the alluvial zone and are founded on bedrock. If necessary, a retaining ring will be built in the bedrock to prevent water from flowing between the shaft lining and the rock.

Final sealing of the emplacement area, which occurs just before closure of the repository, is described in Section 5.2.


CONSTRUCTION ELEVATION 4140'
AIR DUCT
20' ϕ FINISHED
REPOSITORY LEVEL EL. 3110'
EL. 3050'
CLEANOUT RAMP
SUMP
CAGE
SHAFT
EL. 4160'
MIDSHAFT LEVEL EL. 3640'
12'ϕFINISHED NOT TO SCALE
REPOSITORY LEVEL EL. 3140'
EL. 2680'
EL. 4160'
6'ϕFINISHED NOT TO SCALE
REPOSITORY LEVEL EL. 3140'
EL. 3960'
20' ϕ FINISHED
PERIMETER/ACCESS DRIFT EL. 2930'
SUMP EL. 2920'
SCALES
PRINCIPAL ELEVATIONS
100' 0' 100' 200' 300'
CROSS SECTIONS, SHAFTS
5' 0' 5' 10' 15'
20'-0"ϕ(FINISHED I.D.)
22'-6"ϕ(NORMAL EXCAVATED)
20'-0"ϕMEN AND MATERIALS SHAFT
14'-6"ϕ(NOM. EXCAVATED)
12'-0"ϕ(FINISHED)
12'-0" ϕ EXPLORATORY SHAFT - 1
(DESIGN BY OTHERS)
6'-0" (FINISHED)
8'-0" (REAMED)
6'-0"ϕ EXPLORATORY SHAFT - 2
(DESIGN BY OTHERS)
2'-5"ϕPUMP COLUMNS
20'-0"ϕ(FINISHED I.D.)
22'-6"ϕ(NOMINAL EXCAVATED)
20'-0" ϕ EMPLACEMENT EXHAUST SHAFT
3696 D 1/87 REV. FOR SCP/CDR
3696 C 12/86 REV. FOR SCP/CDR AMR JG RH
3696 B 12/86 REV. FOR SCP/CDR AMR JG RH
3696 A 11/86 ISSUED FOR SCP/CDR AMR JG RH
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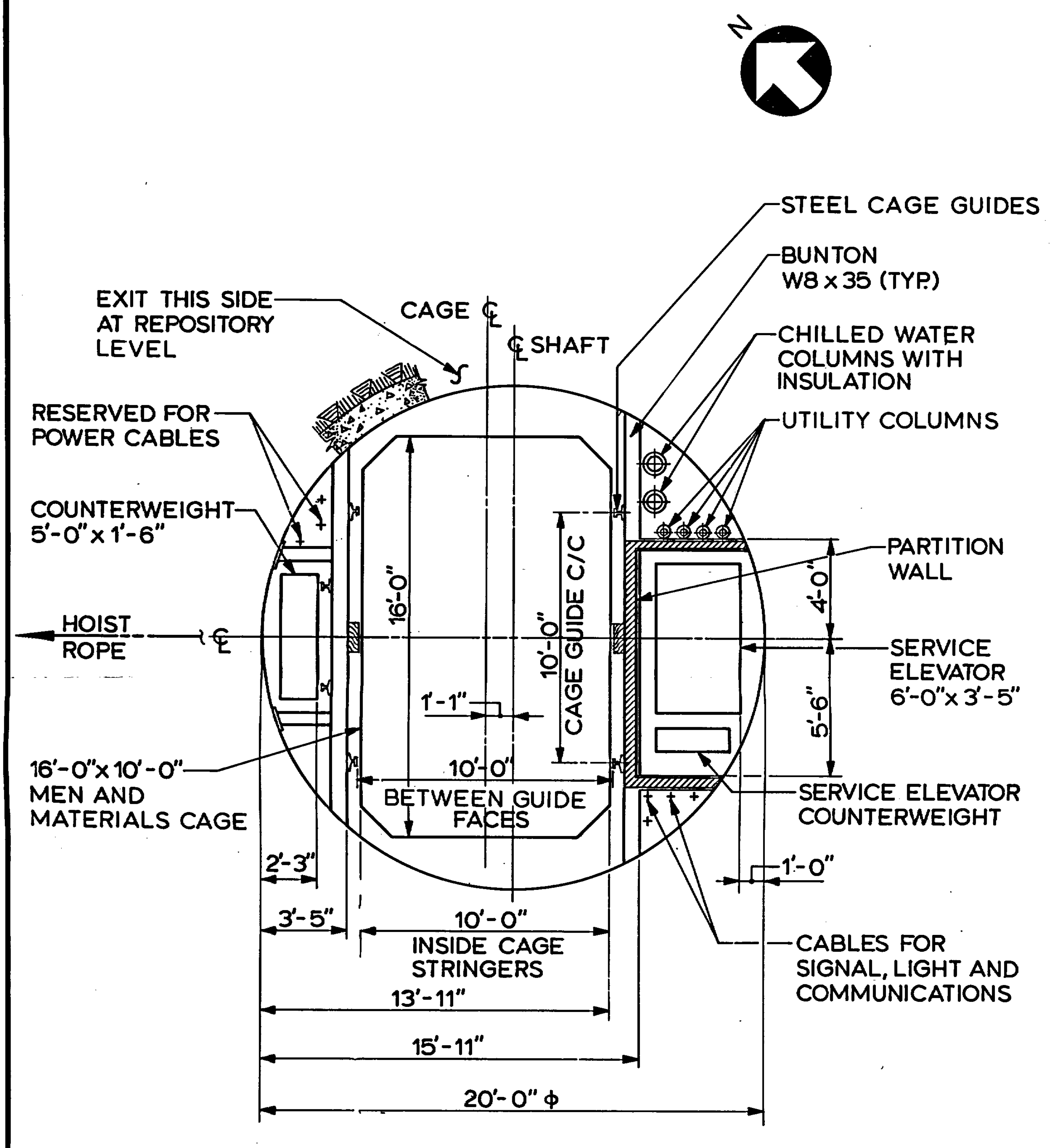
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
GENERAL ARRANGEMENT
SHAFT ELEVATIONS AND
CROSS SECTIONS
DES. JG DR. VA CH. DZ
SIZE D
5/8/86
UNC 14213
SCALE NOTED SS/MN308 R07001

Figure 4-27.

Figure 4-28.



GRAPHIC SCALE

5' 0 5'

SCALE: 1/4"=1'-0"

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3696	A	11-86	ISS. FOR SCP/CDR	[illegible]	[illegible]	[illegible]

GENERAL ARRANGEMENT
MEN AND MATERIALS SHAFT
CROSS SECTION

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DWG. APPROVED [illegible] DATE [illegible]
[illegible] 1/29/87
RO6892

NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY SUPPORT

PB SK. NO. SS/SMN320 DATE 8/14/85

The lining for both ramps is similar to the lining for the underground drifts (Section 3.3.1.3). Ground support, consisting of rock bolts, wire mesh, or shotcrete, is installed, depending on the ground conditions in each segment of ramp. Figure 3-25 shows the general concepts for the lining system. As a minimum, rock bolts and wire mesh are installed, and varying amounts of shotcrete and additional reinforcement up to 6 in. thick are applied as required. A 12-in.-thick, nonreinforced concrete liner has been included in the reference design of the waste ramp, and a 15-in.-thick, nonreinforced concrete liner has been included for the men-and-materials and emplacement area exhaust shafts.

4.3.3 Hoisting Arrangements

4.3.3.1 Exploratory Shafts

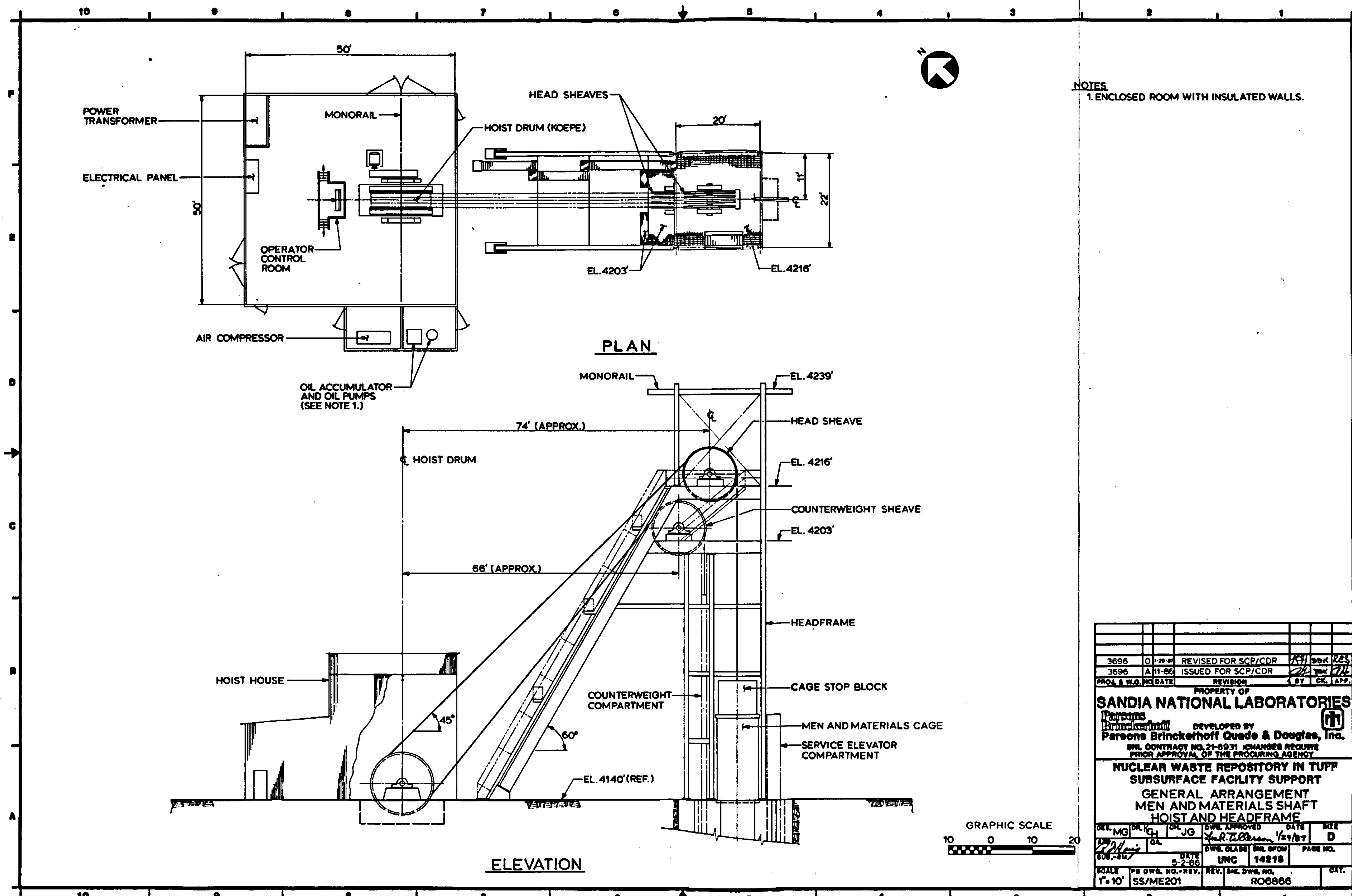
During site characterization, ES-1 permits removal of excavated tuff, hoisting of men and materials, and ventilation. ES-2 provides emergency egress and ventilation. When repository operations begin, all the equipment and fittings will be removed from ES-1 to permit unrestricted intake of fresh air. Shaft inspection capability, required by 10 CFR 60 (NRC, 1986b), will be maintained in both shafts. As a safety measure, a heavy wire-mesh grid will be placed over the openings of the shafts.

4.3.3.2 Men-and-Materials Shaft

The conceptual design of the men-and-materials hoist and headframe (Figure 4-29) is determined by the estimated number of personnel to be transported, the volume of materials and supplies transported during development, and the space available within the 20-ft-diameter cross section. Assumptions incorporated in the current design of the hoisting system are described below.

The conveyance (cage) is 16 by 10 by 22 ft high and has a payload of 16 tons. Overhead winches are incorporated in the cage to handle heavy materials. In the conceptual design, a friction hoist, mounted on the ground rather than on the headframe, is installed in the men-and-materials shaft. A counterweight balances the cage. All of the characteristics of this hoist meet the requirements of 30 CFR 57 (DOL, 1985). Hoist selection studies are continuing.

The service elevator, which the user controls by pushbutton, is separated from the main conveyance. The service elevator operates between the surface and the emplacement level. Any structures for the elevator drive and head rope suspension will be located adjacent to, but independent of, the main headframe. These structures will not be supported by the main structure, nor will they extend more than 20 ft above the surface. Independent of the operation of the main conveyance, the service elevator provides access to and from the underground facility at any time and an emergency access to the main cage, if necessary.



50'
POWER TRANSFORMER
ELECTRICAL PANEL
MONORAIL
HOIST DRUM (KOEPE)
HEAD SHEAVES
20'
11'
22'
50'
OPERATOR CONTROL ROOM
EL. 4203'
EL. 4216'
AIR COMPRESSOR
OIL ACCUMULATOR AND OIL PUMPS (SEE NOTE 1.)
PLAN
NOTES
1. ENCLOSED ROOM WITH INSULATED WALLS.
MONORAIL
EL. 4239'
HEAD SHEAVE
74' (APPROX.)
℄ HOIST DRUM
EL. 4216'
COUNTERWEIGHT SHEAVE
EL. 4203'
66' (APPROX.)
HEADFRAME
HOIST HOUSE
CAGE STOP BLOCK
COUNTERWEIGHT COMPARTMENT
45°
60°
MEN AND MATERIALS CAGE
SERVICE ELEVATOR COMPARTMENT
EL. 4140' (REF.)
GRAPHIC SCALE
10 0 10 20
ELEVATION
3696 O 1-26-87 REVISED FOR SCP/CDR
3696 A 11-86 ISSUED FOR SCP/CDR
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NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY SUPPORT
GENERAL ARRANGEMENT
MEN AND MATERIALS SHAFT
HOIST AND HEADFRAME
DES. MG DR. KCH CH. JG
DWG. APPROVED DATE 1/29/87 SIZE D
DATE 5-2-86
DWG. CLASS UNC SNL SPCM 14218 PAGE NO.
SCALE 1" = 10' PB DWG. NO.-REV. SS/ME201 REV. SNL DWG. NO. RO6866 CAT.

Figure 4-29.

4.3.3.3 Emplacement Area Exhaust Shaft

The emplacement area exhaust shaft will not be used to hoist either personnel or materials on a regular basis; therefore, this shaft is not subject to the requirements of Title 8.4.17 of the California Administrative Code (1981) or of the Safety and Health Standards for Mines (30 CFR 57), which require routine or intermittent inspection of shafts that serve as escape routes or as hoisting shafts for emergency evacuation. Neither regulation requires inspection for hazardous conditions.

However, 10 CFR 60 requires that access for inspection, testing, and maintenance be provided to allow the Nuclear Regulatory Commission (NRC) to inspect the premises of the underground portion of the geologic repository operations area (10 CFR 60.75) and to permit periodic inspection of structures important to safety [10 CFR 60.131(b)6]. Therefore, a conveyance has been included in the design of the emplacement area exhaust shaft to permit inspection. A small, cage-type conveyance will be provided to meet this requirement. The hoist will be supplied as a unit that consists of a drum hoist with safety devices, a sheave on a boom crane, a wire rope, and a cage. The boom crane can be rotated 180° to move it away from the shaft centerline when not in use. The cage holds approximately five people.

4.4 Underground Facilities

The underground facility includes all subsurface excavations except the shafts, ramps, exploratory boreholes, and their seals. This section describes the general layout of the facilities and provides a brief rationale for various elements of the underground design. More detailed discussions of the underground layout as it pertains to waste isolation objectives appear in Section 6.4.2.

4.4.1 Design Methodology

All underground openings, for both the vertical and horizontal configurations, have been designed taking the following considerations into account:

- dimensions of the mining equipment,
- dimensions of the drilling equipment used for the emplacement boreholes,
- dimensions of the waste transporter and emplacement equipment,
- dimensions of the waste retrieval equipment,
- ventilation requirements,
- other utility and support functions to be accommodated, and
- stability requirements.

The design of a series of drifts (i.e., panels) takes into account

- division of the usable area into approximately equal areas to facilitate staging of construction and waste-handling operations;
- drift orientation to minimize the average drift grade;
- frequency and direction of rock-mass fractures;
- in situ stress, magnitude, and direction;

- heat transfer and temperature constraints;
- thermal stress and opening stability;
- ventilation operations;
- ground-water control; and
- locations of the accesses from the surface.

The design of the openings and panels is an iterative process in which successive refinements are made until all the considerations discussed above and the functional requirements discussed in Sections 2.4, 2.5, and 2.6 have been met. The following sections describe the current design, which has resulted from this process.

4.4.2 Description of Underground Design

The conceptual designs for the underground layout in both the vertical and horizontal waste emplacement configurations are described in this section. The primary goal of both layouts is to provide a facility that is both functional and efficient and that meets the postclosure design criteria set forth in 10 CFR 60.133. Compliance with 10 CFR 60.133 is specifically addressed in Section 8.2.1.

The overall underground facility layouts for the vertical and horizontal emplacement configurations are shown in Figures 3-20 and 4-30, respectively. The overall layout of the two emplacement configurations is the same, although there are some differences in the emplacement panels.

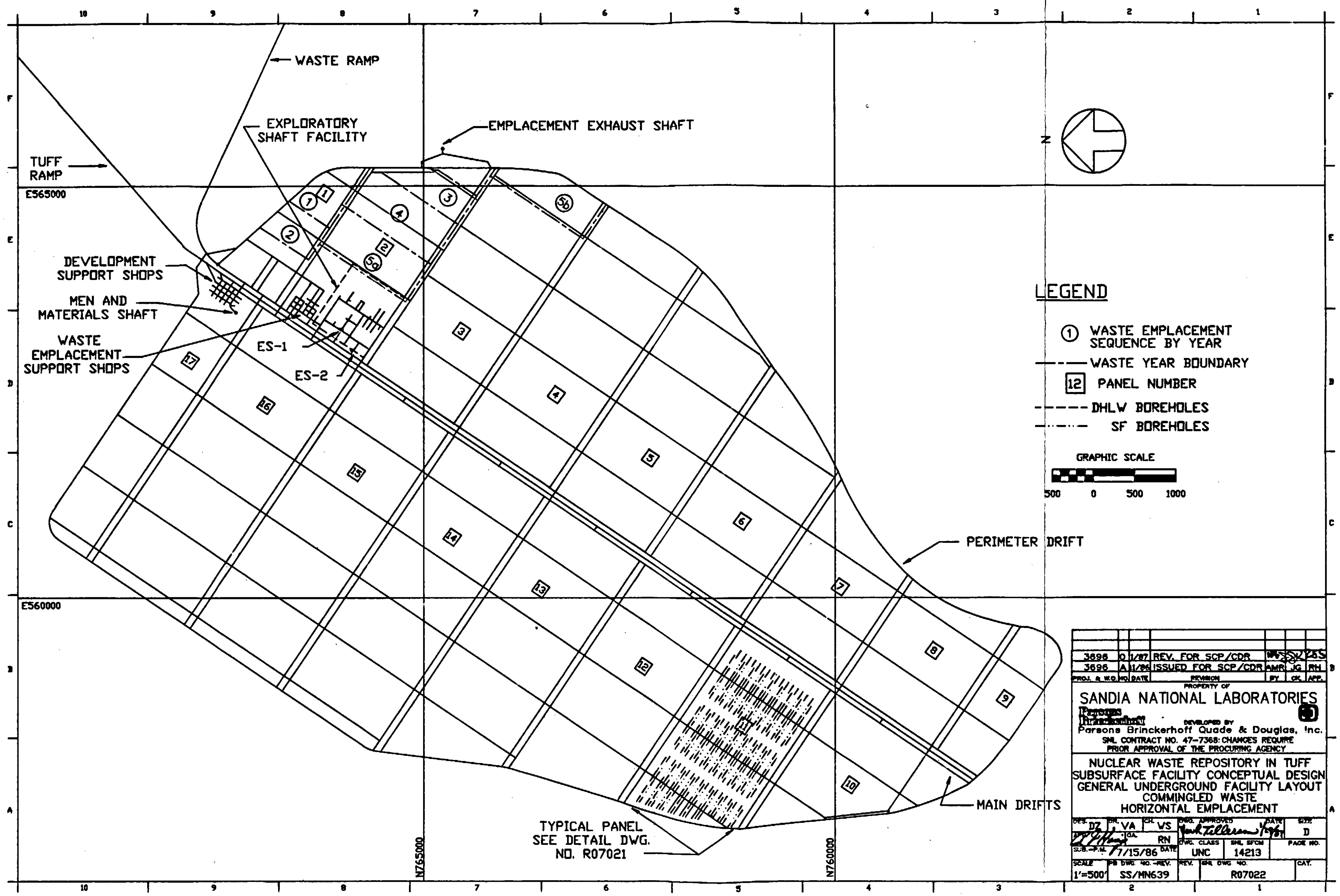
The orientation and rather irregular shape of the emplacement area are determined primarily by the geologic characteristics of the emplacement horizon. All facilities are located in the usable area of the Topopah Springs Member (Mansure and Ortiz, 1984).

The slopes of all drifts are designed to maintain the emplacement panels between the interpolated surfaces that bound the low-lithophysal zone of the target horizon (TSw2) (Figure 2-6 and Section 2.2.3.3). The maximum grade of all drift slopes is less than the design goal of 10%.

The cross sections of the major drifts are a combination of bored and drill-and-blast openings. The design and size of the major openings are shown in Figures 4-31 and 4-32 for vertical and horizontal emplacement, respectively.

It is not expected that ground water will infiltrate into the emplacement area in significant quantities; however, the drifts are designed so that any water, whether from ground water or from operations in the underground facilities, is diverted away from active waste emplacement areas during the operating period. Figure 4-33 illustrates the drainage plan for the fully developed facility. Additional information pertaining to the water-handling system is included in Section 4.4.3.4.

After excavation has been completed, all areas will drain in the direction of a sump located near the bottom of the emplacement area exhaust shaft, which is the lowest point in the underground facility. Any water collected will be pumped up the exhaust shaft for disposal.


WASTE RAMP
EXPLORATORY SHAFT FACILITY
EMPLACEMENT EXHAUST SHAFT
TUFF RAMP
E565000
DEVELOPMENT SUPPORT SHOPS
MEN AND MATERIALS SHAFT
WASTE EMPLACEMENT SUPPORT SHOPS
ES-1
ES-2
E560000
TYPICAL PANEL SEE DETAIL DWG. NO. R07021
N765000
N760000
MAIN DRIFTS
PERIMETER DRIFT
LEGEND
WASTE EMPLACEMENT SEQUENCE BY YEAR
WASTE YEAR BOUNDARY
PANEL NUMBER
DHLW BOREHOLES
SF BOREHOLES
GRAPHIC SCALE
500 0 500 1000
3696 0 1/87 REV. FOR SCP/CDR
3696 A 11/86 ISSUED FOR SCP/CDR AMR JG RH
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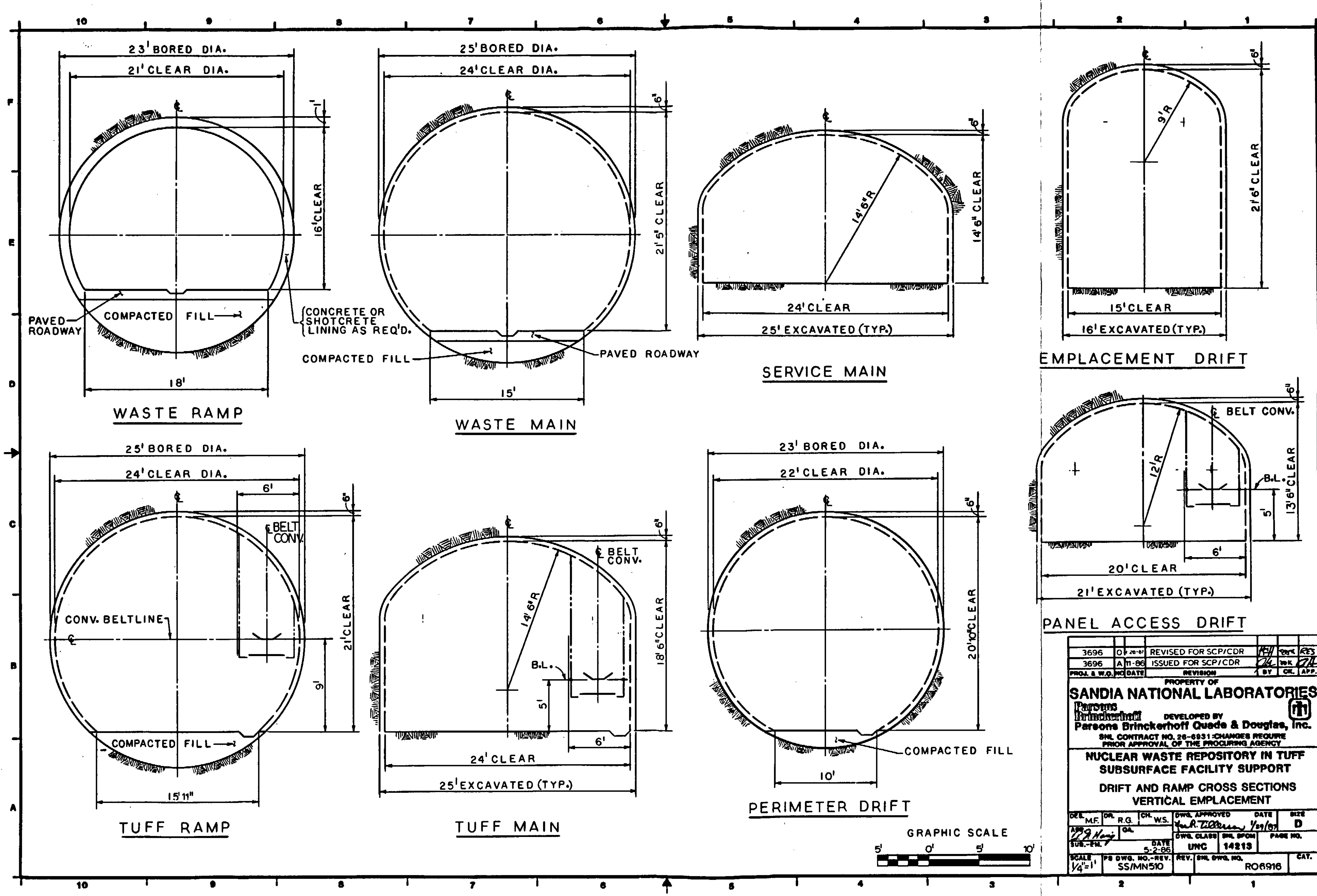
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
GENERAL UNDERGROUND FACILITY LAYOUT
COMMINGLED WASTE
HORIZONTAL EMPLACEMENT
DES. DZ DR. VA CH. VS
QA. RN
SUB.-P.M. 7/15/86 DATE
DWG. APPROVED DATE SIZE D
DWG. CLASS UNC SNL SFCM 14213 PAGE NO.
SCALE 1'=500' PB DWG. NO.-REV. SS/MN639 REV. SNL DWG. NO. R07022 CAT.

Figure 4-30.



WASTE RAMP
23' BORED DIA.
21' CLEAR DIA.
16' CLEAR
PAVED ROADWAY
COMPACTED FILL
CONCRETE OR SHOTCRETE LINING AS REQ'D.
18'
WASTE MAIN
25' BORED DIA.
24' CLEAR DIA.
21'5" CLEAR
COMPACTED FILL
PAVED ROADWAY
15'
SERVICE MAIN
14'6"R
14'6" CLEAR
24' CLEAR
25' EXCAVATED (TYP.)
EMPLACEMENT DRIFT
9'R
21'6" CLEAR
15' CLEAR
16' EXCAVATED (TYP.)
PANEL ACCESS DRIFT
BELT CONV.
12'R
B.L.
13'6" CLEAR
5'
6'
20' CLEAR
21' EXCAVATED (TYP.)
TUFF RAMP
25' BORED DIA.
24' CLEAR DIA.
6'
BELT CONV.
CONV. BELTLINE
21' CLEAR
9'
COMPACTED FILL
15'11"
TUFF MAIN
BELT CONV.
14'6"R
18'6" CLEAR
B.L.
5'
6'
24' CLEAR
25' EXCAVATED (TYP.)
PERIMETER DRIFT
23' BORED DIA.
22' CLEAR DIA.
20'0" CLEAR
COMPACTED FILL
10'
GRAPHIC SCALE
5' 0' 5' 10'
3696 | 0 | 20-87 | REVISED FOR SCP/CDR
3696 | A | 11-86 | ISSUED FOR SCP/CDR
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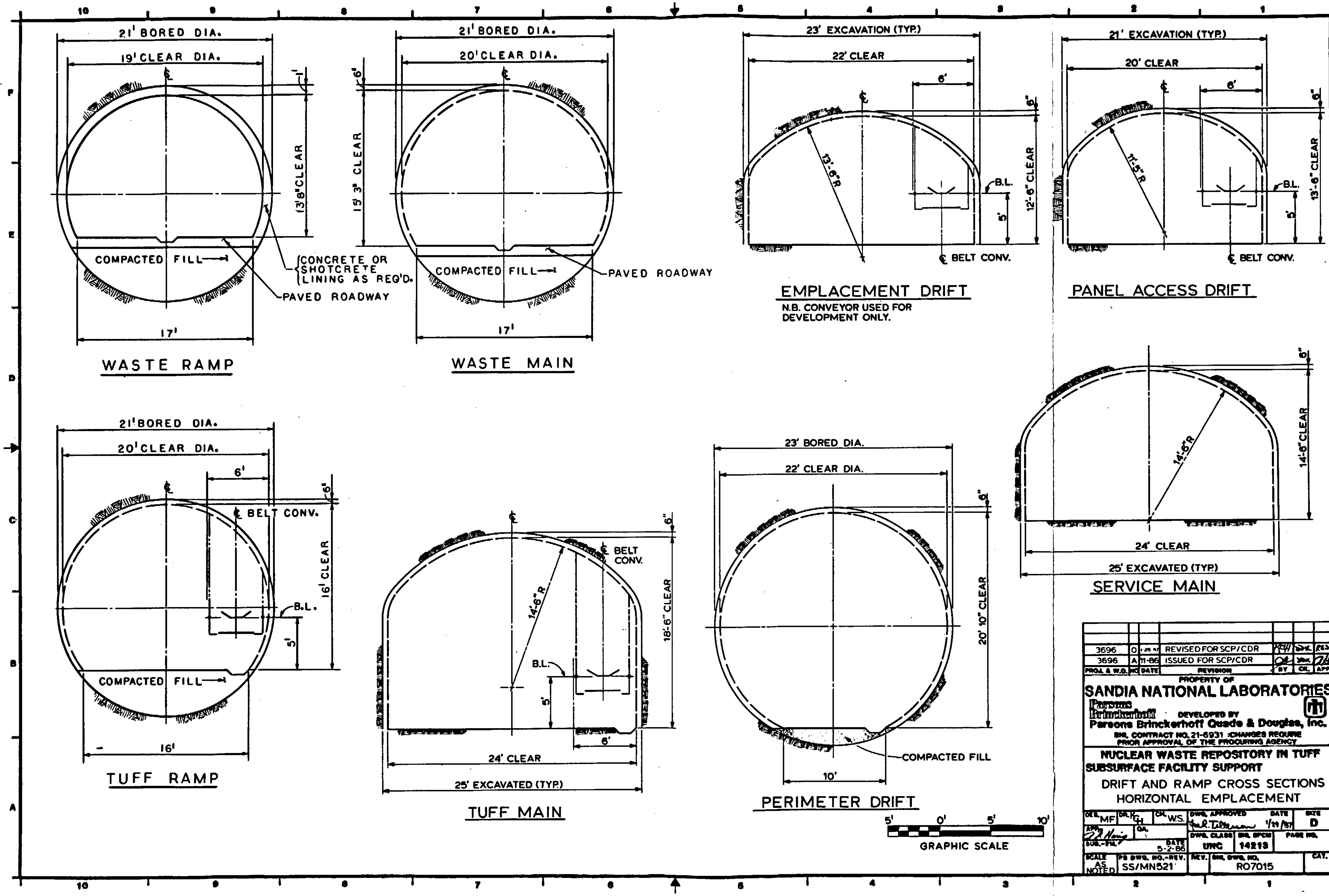
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY SUPPORT
DRIFT AND RAMP CROSS SECTIONS
VERTICAL EMPLACEMENT
DES. M.F. | DR. R.G. | CH. W.S. | DWG. APPROVED | DATE 1/29/87 | SIZE D
DWG. CLASS UNC | SNL SFCM 14213 | PAGE NO.
DATE 5-2-86
SCALE 1/4"=1' | PB DWG. NO.-REV. SS/MN510 | REV. | SNL DWG. NO. RO6916 | CAT.

Figure 4-31.



21' BORED DIA.
19' CLEAR DIA.
13'8" CLEAR
COMPACTED FILL
CONCRETE OR SHOTCRETE LINING AS REQ'D.
PAVED ROADWAY
17'
WASTE RAMP
21' BORED DIA.
20' CLEAR DIA.
15' 3" CLEAR
COMPACTED FILL
PAVED ROADWAY
17'
WASTE MAIN
23' EXCAVATION (TYP.)
22' CLEAR
12'-6" CLEAR
B.L.
BELT CONV.
EMPLACEMENT DRIFT
N.B. CONVEYOR USED FOR DEVELOPMENT ONLY.
21' EXCAVATION (TYP.)
20' CLEAR
13'-6" CLEAR
BELT CONV.
PANEL ACCESS DRIFT
21' BORED DIA.
20' CLEAR DIA.
BELT CONV.
16' CLEAR
B.L.
COMPACTED FILL
16'
TUFF RAMP
BELT CONV.
14'-8" R
18'-6" CLEAR
B.L.
24' CLEAR
25' EXCAVATED (TYP.)
TUFF MAIN
23' BORED DIA.
22' CLEAR DIA.
20' 10" CLEAR
COMPACTED FILL
10'
PERIMETER DRIFT
14'-8" R
14'-6" CLEAR
24' CLEAR
25' EXCAVATED (TYP.)
SERVICE MAIN
GRAPHIC SCALE
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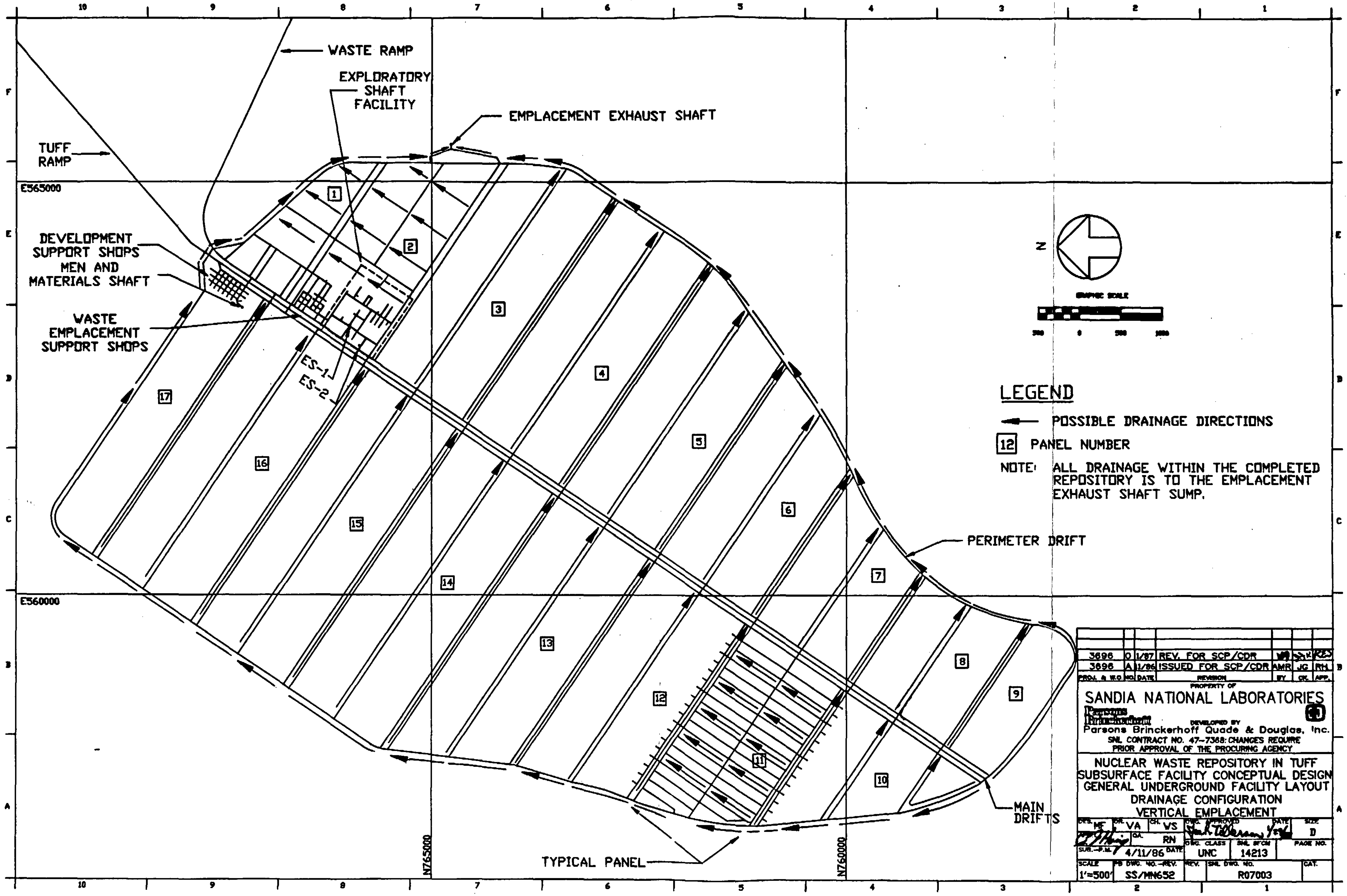
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY SUPPORT
DRIFT AND RAMP CROSS SECTIONS
HORIZONTAL EMPLACEMENT
SS/MN521
R07015

Figure 4-32.


WASTE RAMP
EXPLORATORY SHAFT FACILITY
EMPLACEMENT EXHAUST SHAFT
TUFF RAMP
E565000
DEVELOPMENT SUPPORT SHOPS
MEN AND MATERIALS SHAFT
WASTE EMPLACEMENT SUPPORT SHOPS
ES-1
ES-2
E560000
N765000
N760000
TYPICAL PANEL
MAIN DRIFTS
PERIMETER DRIFT
N
GRAPHIC SCALE
LEGEND
POSSIBLE DRAINAGE DIRECTIONS
12 PANEL NUMBER
NOTE: ALL DRAINAGE WITHIN THE COMPLETED REPOSITORY IS TO THE EMPLACEMENT EXHAUST SHAFT SUMP.
3696 0 1/87 REV. FOR SCP/CDR
3696 A 11/86 ISSUED FOR SCP/CDR AMR JG RH
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NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
GENERAL UNDERGROUND FACILITY LAYOUT
DRAINAGE CONFIGURATION
VERTICAL EMPLACEMENT
4/11/86
UNC
14213
1"=500'
SS/MN652
R07003

Figure 4-33.

4.4.2.1 Description of Common Features

The arrangement of the main drifts, maintenance shops, offices, warehouses, and radiological facilities for the vertical configuration is shown in Figure 4-34. The layout for the horizontal configuration is similar. The area indicated roughly approximates the extent of drifting required as part of the initial construction phase before the first waste is emplaced. Two special areas are set aside at the base of the waste ramp--one for performance confirmation testing and another for training of equipment operators. Figure 4-34 also shows the location of the ESF with respect to initial underground development. Details for these two special areas and the ESF will be developed for the ACD.

4.4.2.1.1 Main and Perimeter Drifts

The principal underground access is formed by three parallel main drifts extending from the base of the ramps to the southwest end of the emplacement area. Use of three main drifts allows complete separation of the ventilation air for the development area from the ventilation air for the waste emplacement area. The mains will remain operational throughout the construction, emplacement, and caretaker phases. Table 3-11 lists the functions of the main and perimeter drifts.

The cross sections of the major drifts and ramps are presented in Figures 4-31 for vertical emplacement and 4-32 for horizontal emplacement.

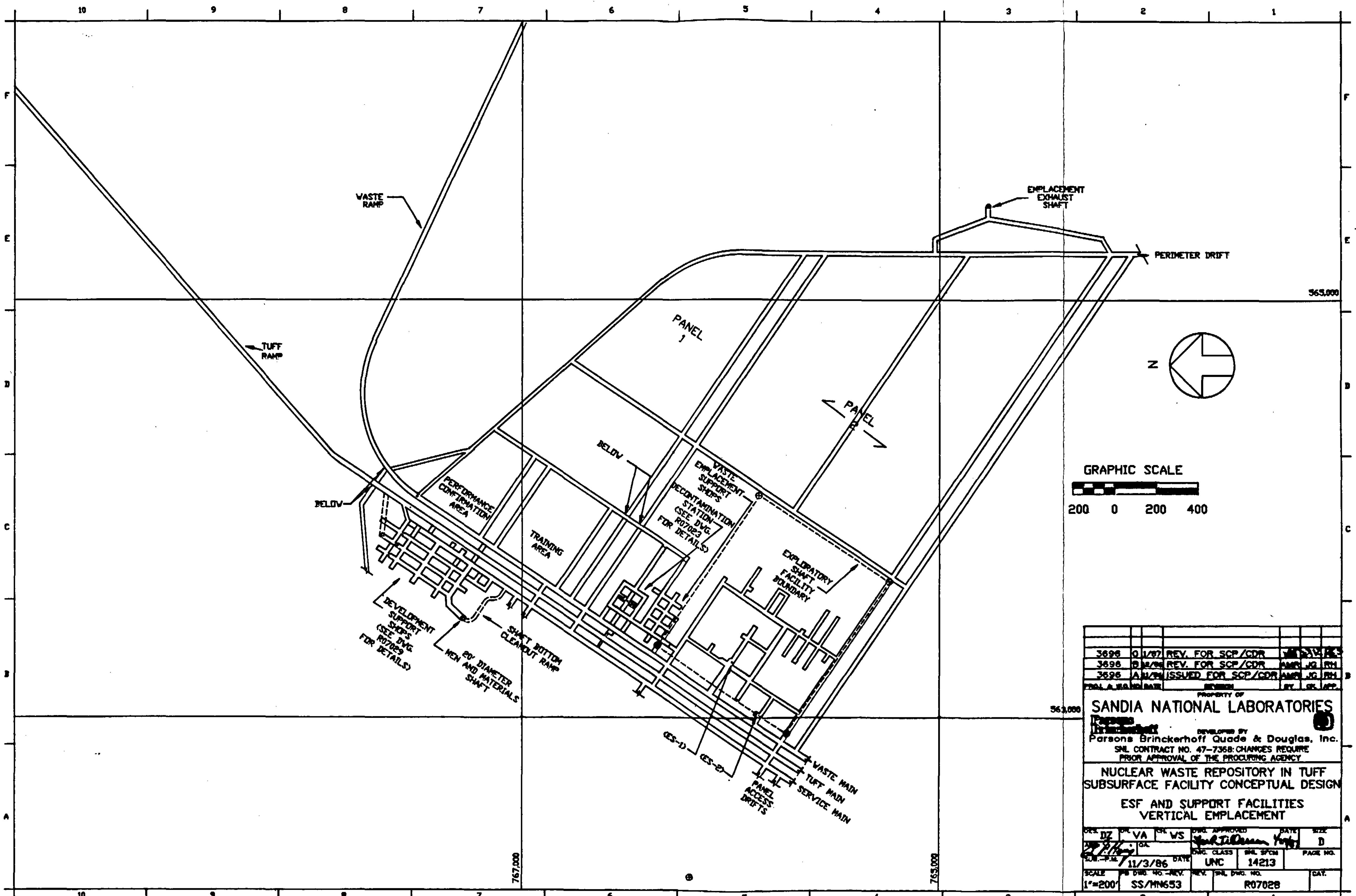
The dimensions of the main drifts are governed by ventilation air requirements. Rock mechanics analyses of the cross sections of the resulting drifts are described in Section 7.1.3.1.

The perimeter drift forms the outer boundary of the underground layout. The currently defined boundaries of the area usable for waste emplacement are described in Section 6.4.2. The perimeter drift functions as the exhaust airway for all air passing through the emplacement panels and is sized to accommodate maximum ventilation requirements.

4.4.2.1.2 Shops and Support Facilities

Maintenance shops in the development and emplacement areas are located near the base of the men-and-materials shaft and the two ramps. The underground service facilities are fully equipped with tools and replacement parts so that all maintenance and most repair functions can be performed underground. Major rebuilding and overhauling are performed in the maintenance facility on the surface. When such repair is necessary, equipment is brought to the surface either through the men-and-materials shaft or the tuff ramp.

The locations of the shops were chosen to (1) allow easy access for personnel and supplies to and from the men-and-materials shaft, (2) ensure a relatively fresh air supply from the shafts without elaborate ducting, (3) minimize space requirements, and (4) allow immediate exhausting of ventilation air from the shops.



WASTE RAMP
TUFF RAMP
EMPLACEMENT EXHAUST SHAFT
PERIMETER DRIFT
PANEL 1
PANEL 2
BELOW
PERFORMANCE CONFIRMATION AREA
TRAINING AREA
WASTE EMPLACEMENT SUPPORT SHOPS
DECONTAMINATION STATION (SEE DWG. R07029 FOR DETAILS)
EXPLORATORY SHAFT FACILITY BOUNDARY
DEVELOPMENT SUPPORT SHOPS (SEE DWG. R07029 FOR DETAILS)
SHAFT BOTTOM CLEANOUT RAMP
20' DIAMETER MEN AND MATERIALS SHAFT
ES-1
ES-2
PANEL ACCESS DRIFTS
WASTE MAIN
TUFF MAIN
SERVICE MAIN
N
GRAPHIC SCALE
200 0 200 400
565,000
563,000
767,000
765,000
3696 0 1/87 REV. FOR SCP/CDR
3696 B REV. FOR SCP/CDR AMR JG RH
3696 A ISSUED FOR SCP/CDR AMR JG RH
PROPERTY OF
SANDIA NATIONAL LABORATORIES
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Parsons Brinckerhoff Quade & Douglas, Inc.
SNL CONTRACT NO. 47-7368: CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
ESF AND SUPPORT FACILITIES
VERTICAL EMPLACEMENT
DZ
VA
WS
D
11/3/86
UNC
14213
1"=200'
SS/MN653
R07028

Figure 4-34.

Several office and support areas are located in the underground facility. A support area that contains a control room for the ventilation, conveyor, water, electrical, ground-control-monitoring, and underground communications systems is located near the men-and-materials shaft. This control room is the subsurface center for all underground monitoring and control systems; the main monitoring console for these systems is located in the central surface facility.

Other facilities in the underground development service area include a maintenance shop, a parking area for equipment, a storage area for bulk materials, a warehouse for service parts, main electrical substations, training area, and office space for administrative functions (Figure 4-35). The waste emplacement area provides maintenance, warehouse, and administrative facilities (smaller than those in the service area on the development side) and an area for emergency radiation decontamination and control of waste throughput (Figure 4-36). The service area on the waste emplacement side is ventilated by air from the exploratory shafts.

Explosives are stored on the surface at a remote location. Shortly before use, explosives are moved underground and are stored in magazines near the areas where they are to be used. Underground storage and transportation of explosives will follow the procedures described in 30 CFR 57.

4.4.2.1.3 Exploratory Shaft Facilities

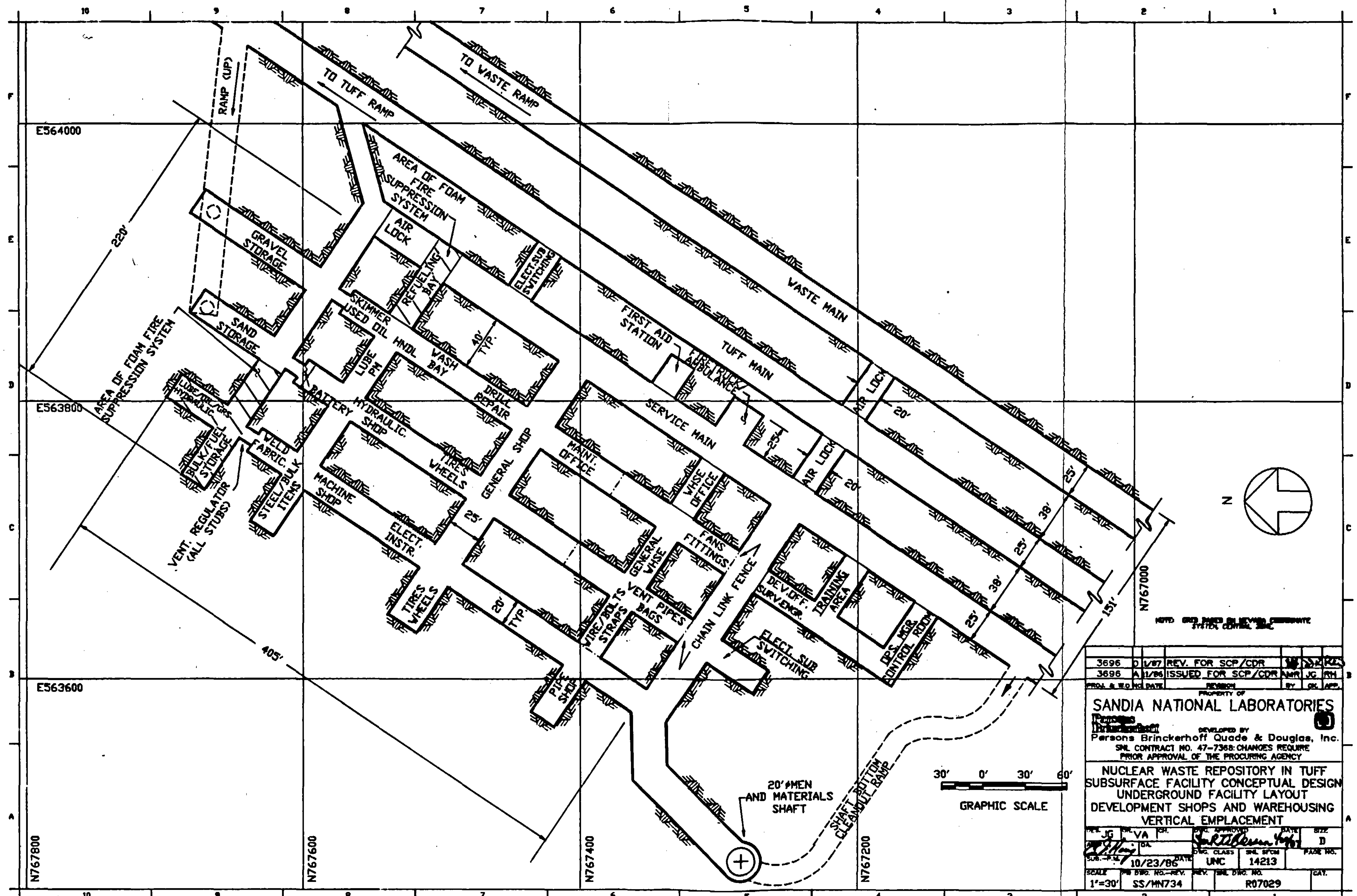
The layout currently proposed for the ESF is indicated in Figure 4-34 by a dashed line. The elevation of the shaft station at the main ESF level is 3,140 ft, which places it at the same elevation as that of the future emplacement area. It is assumed in the current design that both exploratory shafts are available for conversion to ventilation shafts before waste emplacement begins. The remainder of the ESF is not needed for other repository purposes; however, it is assumed that the ESF will remain accessible and functional until closure and decommissioning of the repository.

4.4.2.2 Description of Emplacement Panels

This section describes the waste emplacement panel designs for both the vertical and horizontal emplacement configurations. Typical panels for the vertical and horizontal configurations are shown in Figures 4-37 and 4-38. The panels in these two drawings have the following characteristics in common.

- The size and areas of the panels are identical. A panel width of 1,400 ft was selected, based on reasonable haulage distances for tuff removal. Also, this panel width is compatible with development and emplacement schedules. Optimum panel widths for the two different configurations may vary slightly in future designs.

- Each configuration has dual sets of panel access drifts that extend the length of the panel to intersect the perimeter drift. Two panel access drifts are needed to maintain separate ventilation systems between development and emplacement operations.



TO TUFF RAMP
TO WASTE RAMP
RAMP (UP)
WASTE MAIN
TUFF MAIN
SERVICE MAIN
GENERAL SHOP
AREA OF FOAM FIRE SUPPRESSION SYSTEM
AIR LOCK
REFUELING BAY
ELECT. SUB SWITCHING
GRAVEL STORAGE
SAND STORAGE
SKIMMER USED OIL HNDL
LUBE PM
WASH BAY
DRILL REPAIR
FIRST AID STATION
FIRE TRUCK/ AMBULANCE
BATTERY
HYDRAULIC SHOP
TIRES WHEELS
WELD FABRIC.
STEEL/BULK ITEMS
BULK/FUEL STORAGE
MACHINE SHOP
ELECT. INSTR.
VENT. REGULATOR (ALL STUBS)
MAINT. OFFICE
WHSE OFFICE
FANS FITTINGS
GENERAL WHSE
VENT PIPES BAGS
WIRE/BOLTS STRAPS
CHAIN LINK FENCE
DEV/OFF. SURV/ENGR.
TRAINING AREA
OPS. MGR. CONTROL ROOM
ELECT. SUB SWITCHING
PIPE SHOP
20'∅MEN AND MATERIALS SHAFT
SHAFT BOTTOM CLEANOUT RAMP
220'
405'
151'
25'
38'
20'
40' TYP.
20' TYP.
E564000
E563800
E563600
N767800
N767600
N767400
N767200
N767000
N
30' 0' 30' 60'
GRAPHIC SCALE
3696 D 1/87 REV. FOR SCP/CDR
3696 A 11/86 ISSUED FOR SCP/CDR
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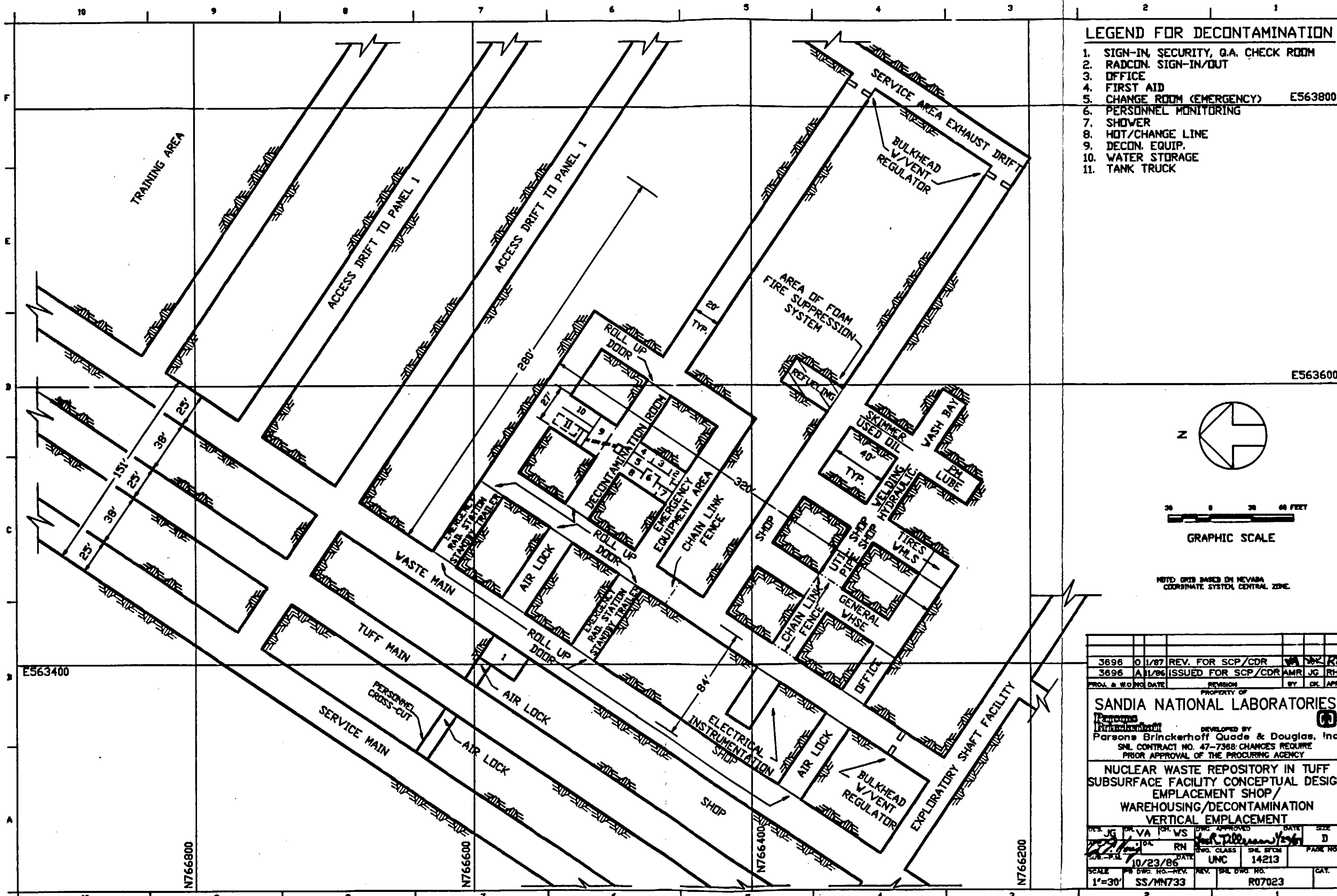
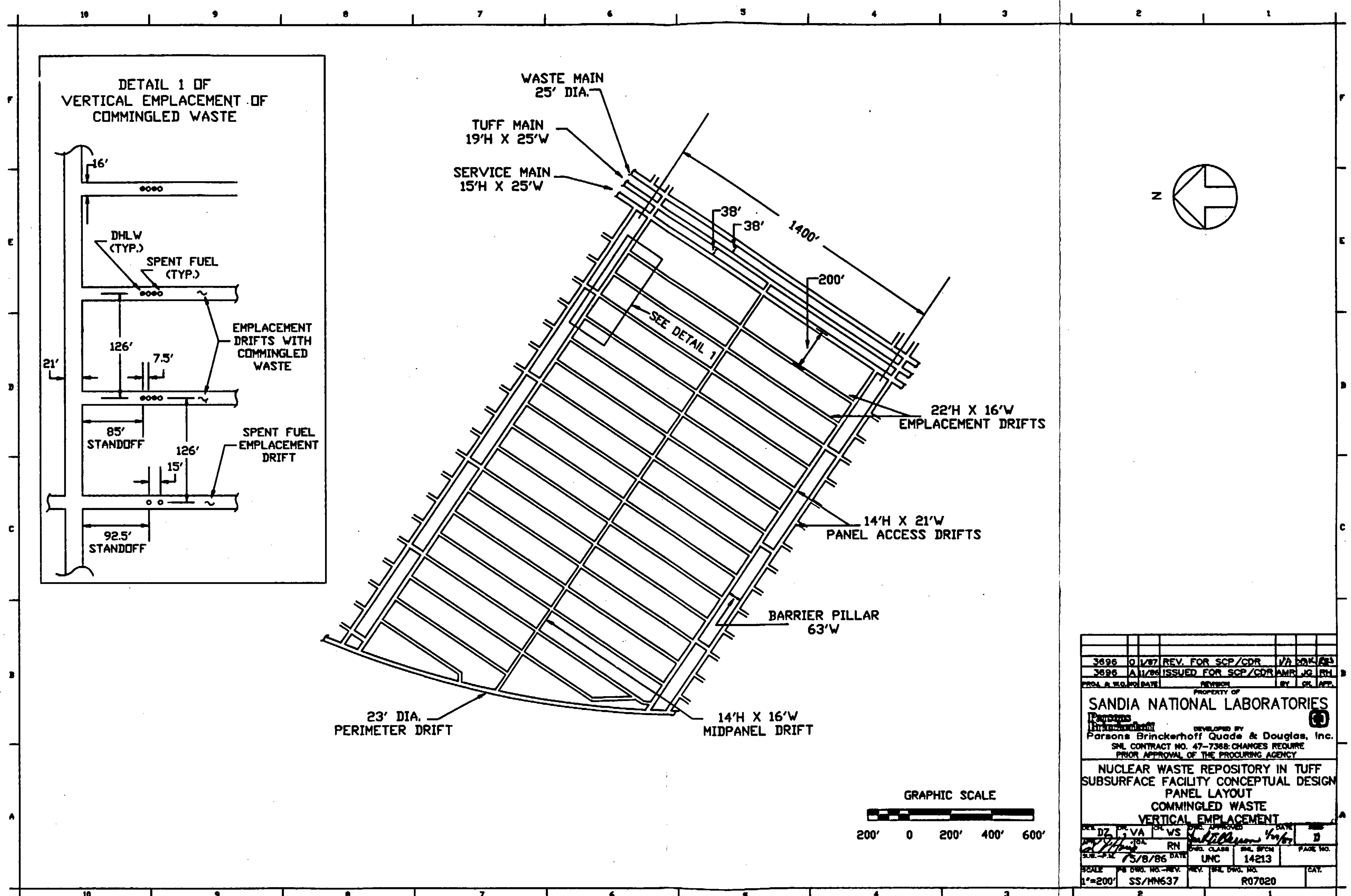
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
UNDERGROUND FACILITY LAYOUT
DEVELOPMENT SHOPS AND WAREHOUSING
VERTICAL EMPLACEMENT
JG
VA
10/23/86
UNC
14213
D
1"=30'
SS/MN734
R07029

Figure 4-35.



LEGEND FOR DECONTAMINATION
1. SIGN-IN, SECURITY, Q.A. CHECK ROOM
2. RADCON. SIGN-IN/OUT
3. OFFICE
4. FIRST AID
5. CHANGE ROOM (EMERGENCY)
6. PERSONNEL MONITORING
7. SHOWER
8. HOT/CHANGE LINE
9. DECON. EQUIP.
10. WATER STORAGE
11. TANK TRUCK
E563800
E563600
E563400
N766800
N766600
N766400
N766200
TRAINING AREA
ACCESS DRIFT TO PANEL 1
ACCESS DRIFT TO PANEL 1
SERVICE AREA EXHAUST DRIFT
BULKHEAD W/VENT REGULATOR
AREA OF FOAM FIRE SUPPRESSION SYSTEM
ROLL UP DOOR
DECONTAMINATION ROOM
EMERGENCY EQUIPMENT AREA
CHAIN LINK FENCE
REFUELING
SKIMMER USED OIL
WASH BAY
LUBE
WELDING HYDRAULIC
SHOP
UTIL. PIPE SHOP
TIRES VHLS
GENERAL WHSE
OFFICE
AIR LOCK
EMERGENCY RAD STATION STANDBY TRAILER
WASTE MAIN
TUFF MAIN
SERVICE MAIN
PERSONNEL CROSS-CUT
ELECTRICAL INSTRUMENTATION SHOP
EXPLORATORY SHAFT FACILITY
280'
320'
84'
151'
GRAPHIC SCALE
N
3696 0 1/87 REV. FOR SCP/CDR
3696 A 11/86 ISSUED FOR SCP/CDR AMR JG RH
SANDIA NATIONAL LABORATORIES
Parsons Brinckerhoff Quade & Douglas, Inc.
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
EMPLACEMENT SHOP/
WAREHOUSING/DECONTAMINATION
VERTICAL EMPLACEMENT
JG VA WS RN
10/23/86
UNC 14213
1"=30' SS/MN733 R07023

Figure 4-36.



DETAIL 1 OF
VERTICAL EMPLACEMENT OF
COMMINGLED WASTE
16'
DHLW
(TYP.)
SPENT FUEL
(TYP.)
EMPLACEMENT
DRIFTS WITH
COMMINGLED
WASTE
126'
7.5'
21'
85'
STANDOFF
126'
15'
SPENT FUEL
EMPLACEMENT
DRIFT
92.5'
STANDOFF
WASTE MAIN
25' DIA.
TUFF MAIN
19'H X 25'W
SERVICE MAIN
15'H X 25'W
38'
38'
1400'
200'
SEE DETAIL 1
22'H X 16'W
EMPLACEMENT DRIFTS
14'H X 21'W
PANEL ACCESS DRIFTS
BARRIER PILLAR
63'W
23' DIA.
PERIMETER DRIFT
14'H X 16'W
MIDPANEL DRIFT
N
GRAPHIC SCALE
200' 0 200' 400' 600'
3696 0 1/87 REV. FOR SCP/CDR
3696 A 11/86 ISSUED FOR SCP/CDR AMR JG RH
SANDIA NATIONAL LABORATORIES
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SNL CONTRACT NO. 47-7368: CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
PANEL LAYOUT
COMMINGLED WASTE
VERTICAL EMPLACEMENT
DZ VA WS
RN
5/8/86 UNC 14213
1"=200' SS/MN637 R07020

Figure 4-37.

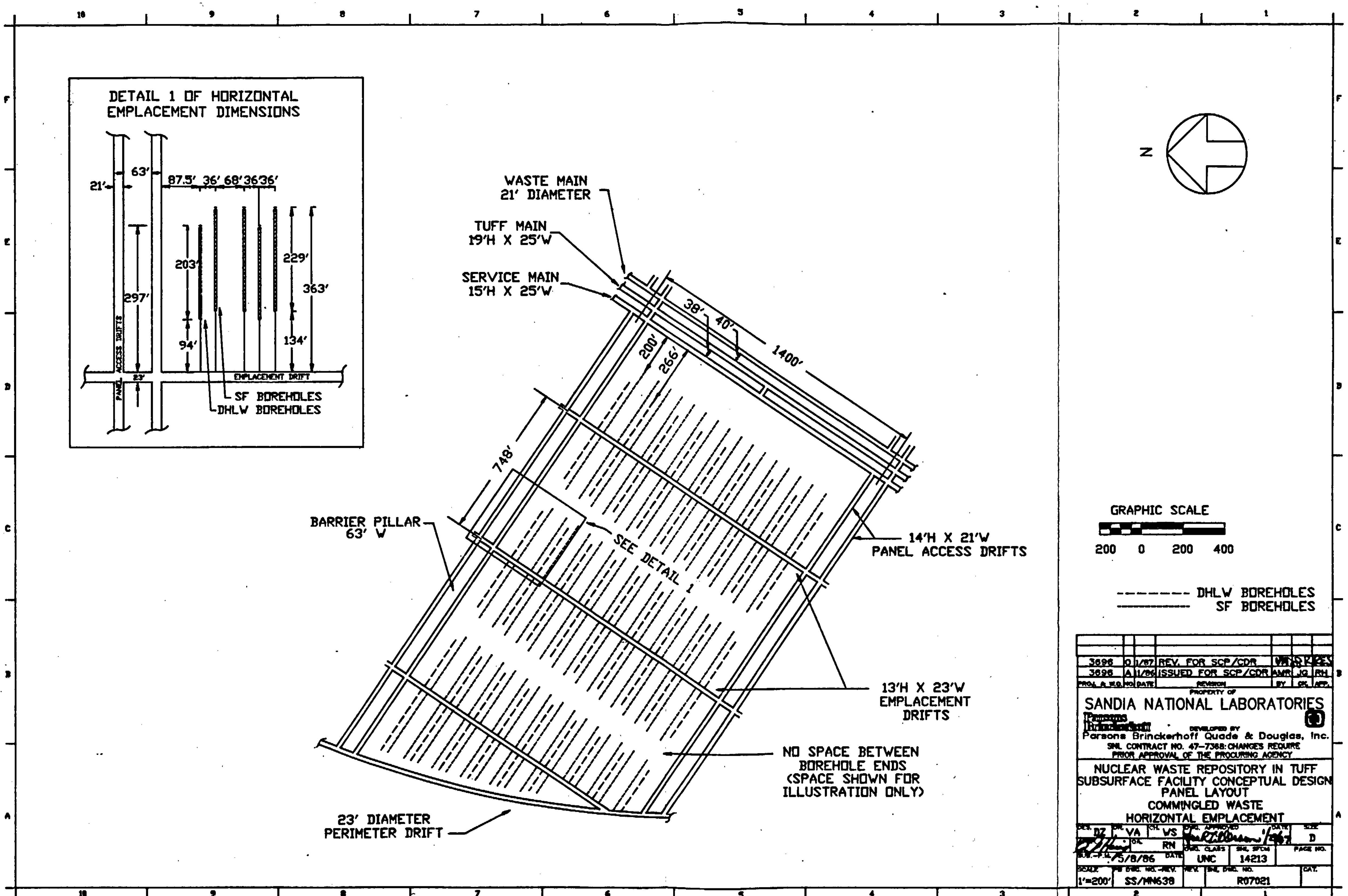

DETAIL 1 OF HORIZONTAL EMPLACEMENT DIMENSIONS
21'
63'
87.5' 36' 68' 36 36'
297'
203'
94'
229'
134'
363'
23'
PANEL ACCESS DRIFTS
EMPLACEMENT DRIFT
SF BOREHOLES
DHLW BOREHOLES
WASTE MAIN 21' DIAMETER
TUFF MAIN 19'H X 25'W
SERVICE MAIN 15'H X 25'W
38'
40'
1400'
200'
266'
748'
BARRIER PILLAR 63' W
SEE DETAIL 1
14'H X 21'W PANEL ACCESS DRIFTS
13'H X 23'W EMPLACEMENT DRIFTS
NO SPACE BETWEEN BOREHOLE ENDS (SPACE SHOWN FOR ILLUSTRATION ONLY)
23' DIAMETER PERIMETER DRIFT
N
GRAPHIC SCALE
200 0 200 400
DHLW BOREHOLES
SF BOREHOLES
3696 0 1/87 REV. FOR SCP/CDR
3696 A 1/86 ISSUED FOR SCP/CDR AMR JG RH
PROJ. & W.O. NO. DATE REVISION BY CK. APP.
PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
Parsons Brinckerhoff Quade & Douglas, Inc.
SNL CONTRACT NO. 47-7368: CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
PANEL LAYOUT
COMMINGLED WASTE
HORIZONTAL EMPLACEMENT
DES. DZ
DR. VA
CH. VS
QA RN
5/8/86
SIZE D
DWG. CLASS UNC
SNL SFCM 14213
SCALE 1'=200'
SS/MN638
SNL DWG. NO. R07021

Figure 4-38.

- Areal power density (APD) and, therefore, the number of waste containers emplaced in the panels, is essentially the same in both configurations because only slight variations result from emplacement in the irregular areas at the perimeter drift.

- The standoff distance from the mains to the closest waste container in the panel is approximately 200 ft. The area between the mains and the closest waste container is not included when calculating the APD.

- For commingling purposes (the interspersing of spent fuel and DHLW containers in different boreholes in the same panel or even in the same borehole in the event of use of multiple containers), the ratio of DHLW packages to spent fuel packages is the same in both the vertical and horizontal layouts.

A heat conduction code (SIM) was used to perform a thermal analysis for both configurations to determine temperatures over time at the emplacement borehole wall, at a point 3.28 ft from the borehole wall, at the emplacement drift, and at the panel access drift (Appendix A).

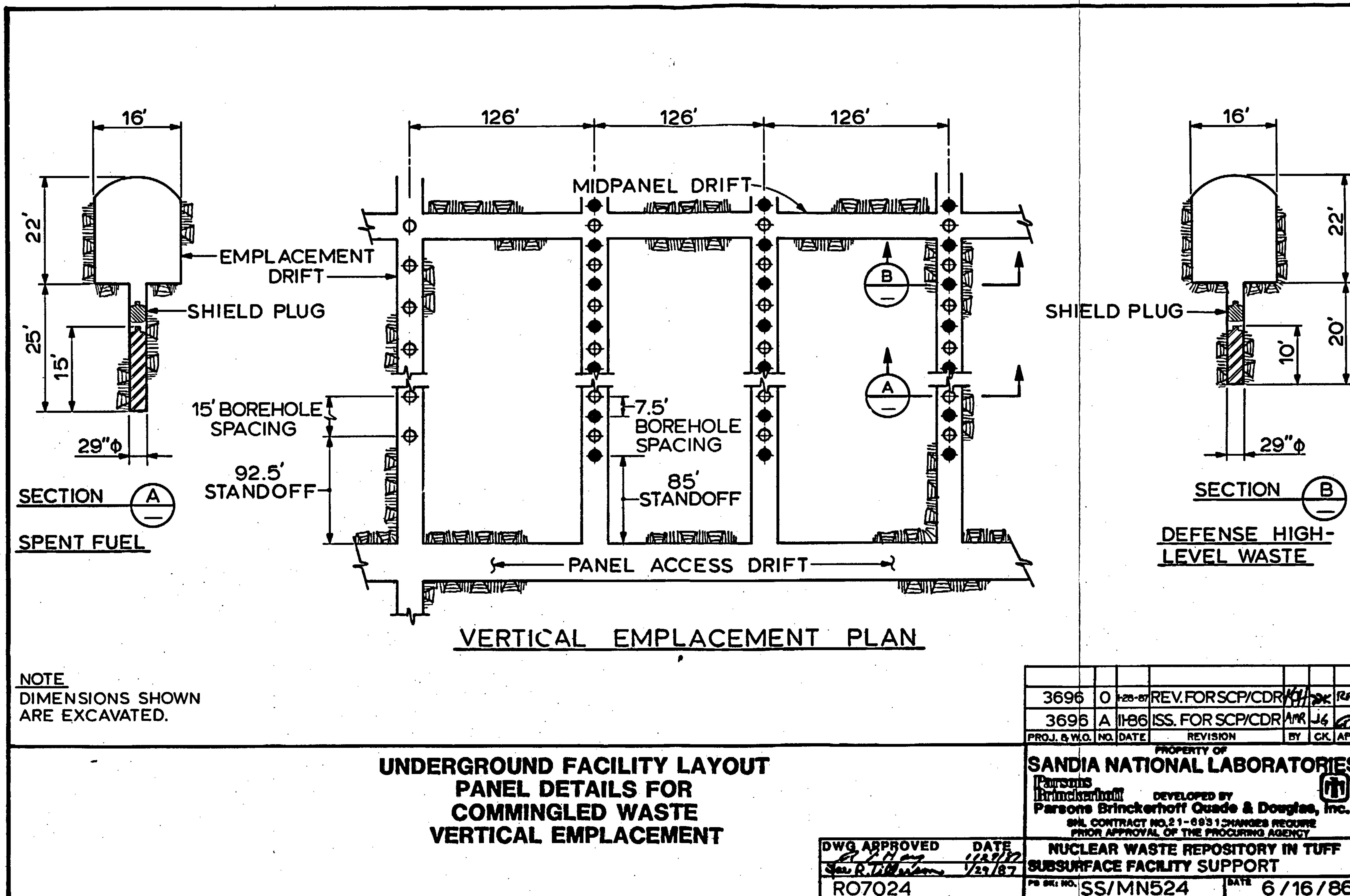
Detailed descriptions of the vertical and horizontal waste emplacement configurations and the design rationale are provided below.

4.4.2.2.1 <u>Layout of the Panel in the Vertical Emplacement Configuration</u>

The emplacement panel in the vertical configuration (Figures 4-37 and 4-39) consists of a series of equally spaced emplacement drifts that run perpendicular to the panel access drifts and parallel to the mains. A midpanel drift, which runs parallel to the access drift, divides the panel into two 700-ft segments. The midpanel drift is necessary for ventilation control.

Criteria that must be addressed in developing drift and borehole spacing include the APD and constraints for temperatures of the borehole wall and access drifts. An APD of 57 kW/acre, a maximum borehole wall temperature of 235°C, and an access drift temperature limit of 50°C for 50 yr were used in developing the drift layout shown. [The 235°C is 40°C less than the actual limit. This lower value is used for design purposes to account for uncertainties in the thermal outputs of the waste and the thermal properties of the rock (Appendix K).] The methods used to determine the APD are described by St. John (1985). The thermal analysis program (SIM) was used to evaluate the temperature constraints for all layout spacings considered. The dimensions of the various drifts that make up the vertical emplacement panel are shown in Figure 4-31. The opening of the panel access drift is controlled by the size of the mining equipment, the opening of the emplacement drift by the size of the waste transporter, and the size of the midpanel drift by ventilation flow requirements.

Borehole spacing in the emplacement drift is controlled by the value of the APD, the maximum allowable temperature of the borehole wall, and the strength and stability of the drift floor between adjacent boreholes. Based on equipment considerations alone, the minimum acceptable distance between two borehole walls is equal to twice the diameter of the borehole, which, for 29-in.-diameter boreholes, results in a minimum spacing


16'
22'
25'
15'
EMPLACEMENT DRIFT
SHIELD PLUG
29"ϕ
SECTION A
SPENT FUEL
126'
126'
126'
MIDPANEL DRIFT
B
A
15' BOREHOLE SPACING
92.5' STANDOFF
7.5' BOREHOLE SPACING
85' STANDOFF
PANEL ACCESS DRIFT
VERTICAL EMPLACEMENT PLAN
16'
22'
20'
10'
SHIELD PLUG
29"ϕ
SECTION B
DEFENSE HIGH-LEVEL WASTE
NOTE
DIMENSIONS SHOWN ARE EXCAVATED.
3696 0 REV. FOR SCP/CDR
3696 A 11-86 ISS. FOR SCP/CDR
PROJ. & W.O. NO. DATE REVISION BY CK. APP.
PROPERTY OF
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DEVELOPED BY
Parsons Brinckerhoff Quade & Douglas, Inc.
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY SUPPORT
UNDERGROUND FACILITY LAYOUT
PANEL DETAILS FOR
COMMINGLED WASTE
VERTICAL EMPLACEMENT
DWG APPROVED DATE
1/29/87
RO7024
SS/MN524
DATE 6/16/86

Figure 4-39.

of 7.25 ft from centerline to centerline. This value of 7.25 ft is used in the conceptual design as a minimum value. When combined with thermal and structural constraints, these considerations yield a borehole spacing of 15 ft between spent fuel packages when a DHLW package is interposed. To be conservative, in Figure 4-39, the borehole spacing is 15 ft between spent fuel packages in all cases.

The layouts for the conceptual design are shown in Figures 4-37 and 4-39. Each full-length drift in which waste is commingled has storage space for 75 spent fuel and 76 DHLW containers. The minimum spacing between spent fuel and DHLW boreholes is 7.5 ft. The end sections of the emplacement drifts adjacent to the panel access drift are left free of boreholes to allow for (1) transporter entry, (2) an air door, and (3) a zone in which drift height adjusts from 14 ft (in the panel access drift) to 22 ft (in the emplacement drift) (Figure 4-40). The standoff distance between the first emplacement borehole and the access drift is a variable that can be adjusted to limit the temperature in the panel access drift to below 50°C for 50 yr. The standoff distance in the current design is 85 ft. Spent fuel boreholes are 25 ft deep and DHLW boreholes are 20 ft deep so that a distance of 10 ft between the waste container and the drift floor can be provided to maintain adequate radiation shielding and thermal insulation.

The design receipt rate for DHLW and spent fuel containers dictates that waste be commingled in three of every four emplacement drifts. The fourth drift can be used for additional containers, if necessary, because the spacing of spent fuel boreholes (15 ft) allows room for an additional borehole in between. The cooler DHLW containers are located at the ends of each drift in which both types of containers are emplaced. The spacing between emplacement drift centerlines is 126 ft.

4.4.2.2.2 Layout of the Panel in the Horizontal Emplacement Configuration

The emplacement panel in the horizontal configuration is made up of a series of widely spaced emplacement drifts into which 37-in.-diameter horizontal boreholes are drilled. Figure 4-38 shows a conceptual design of a panel in the horizontal emplacement configuration.

Stinebaugh and Robb (1987) have performed a cost evaluation to determine a practical horizontal borehole length for spent fuel using an assumed standoff of 100 ft. That report indicates that constructing emplacement boreholes of lengths greater than 350 ft results in only a small cost savings. The distance between the centerlines of emplacement drifts is 748 ft.

The constraints of APD and temperatures of borehole walls and drifts also apply to horizontal emplacement. In addition, the horizontal emplacement drift is limited to the 50°C/50-yr goal. The spacing of horizontal boreholes is constrained by the temperature at the borehole wall. Spent fuel boreholes must be spaced at least 68 ft apart to keep the temperature of the emplacement drift under 50°C.

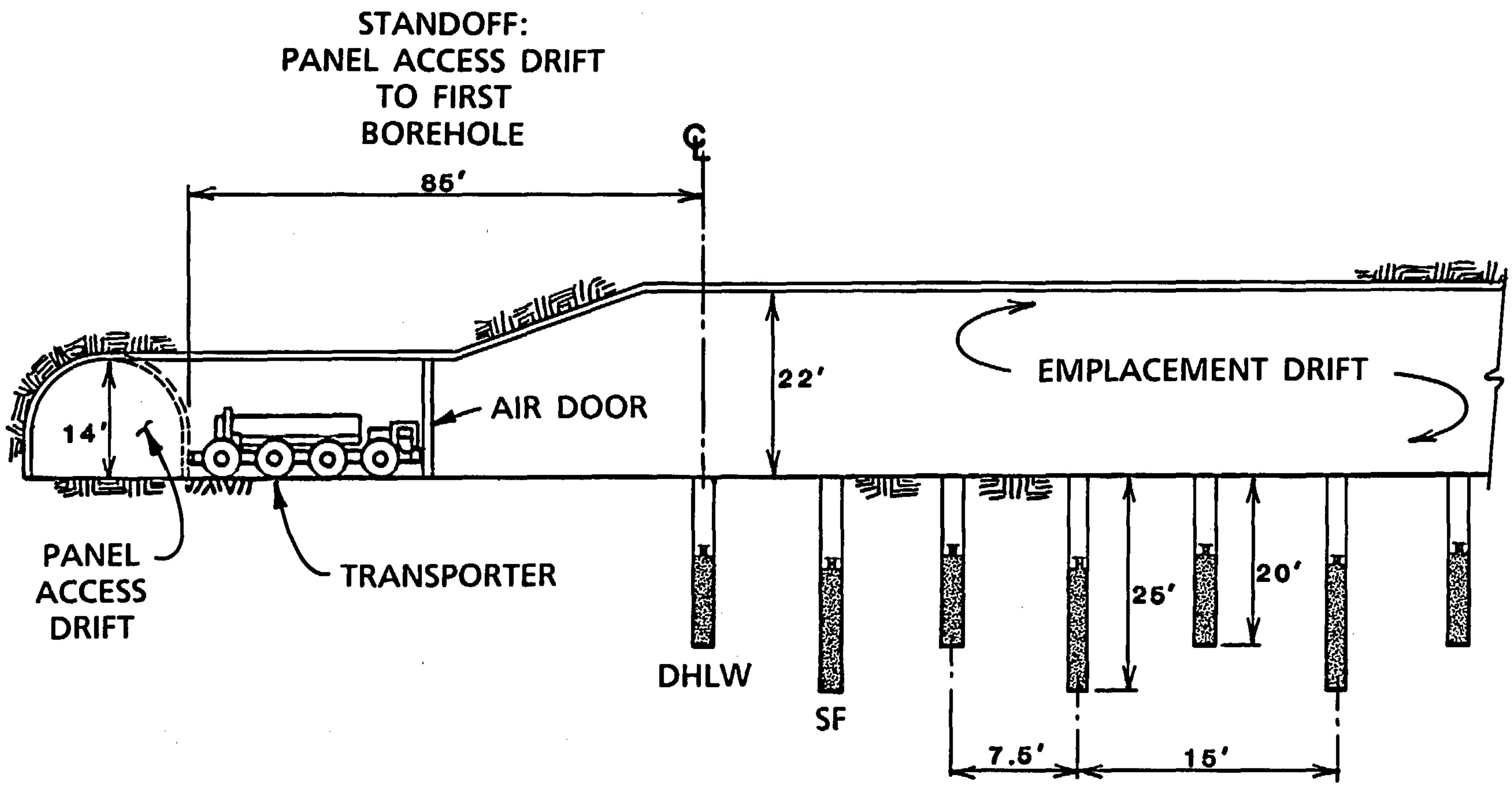


Figure 4-40. Side View of Standoff in a Vertical Emplacement Drift in Which Waste Is Commingled (Modified from Stinebaugh and Frostenson, 1986.)

DHLW containers are commingled with spent fuel containers by placing 18 DHLW containers in boreholes between the spent fuel boreholes (Figure 4-41). The number of boreholes and the number of containers per borehole are determined by the layout and the ratio of DHLW to spent fuel containers. The dummy containers shown in Figure 4-41 are used to push the waste containers into the borehole to obtain the necessary standoff. The spacing between spent fuel and DHLW boreholes is controlled by temperature constraints on the waste package and borehole wall.

Cross sections of the panel access drift and the emplacement drift are shown in Figure 4-32. The size of the panel access drift is dictated by the size of the mining equipment, and the size of the emplacement drift is dictated by the dimensions of the transporter.

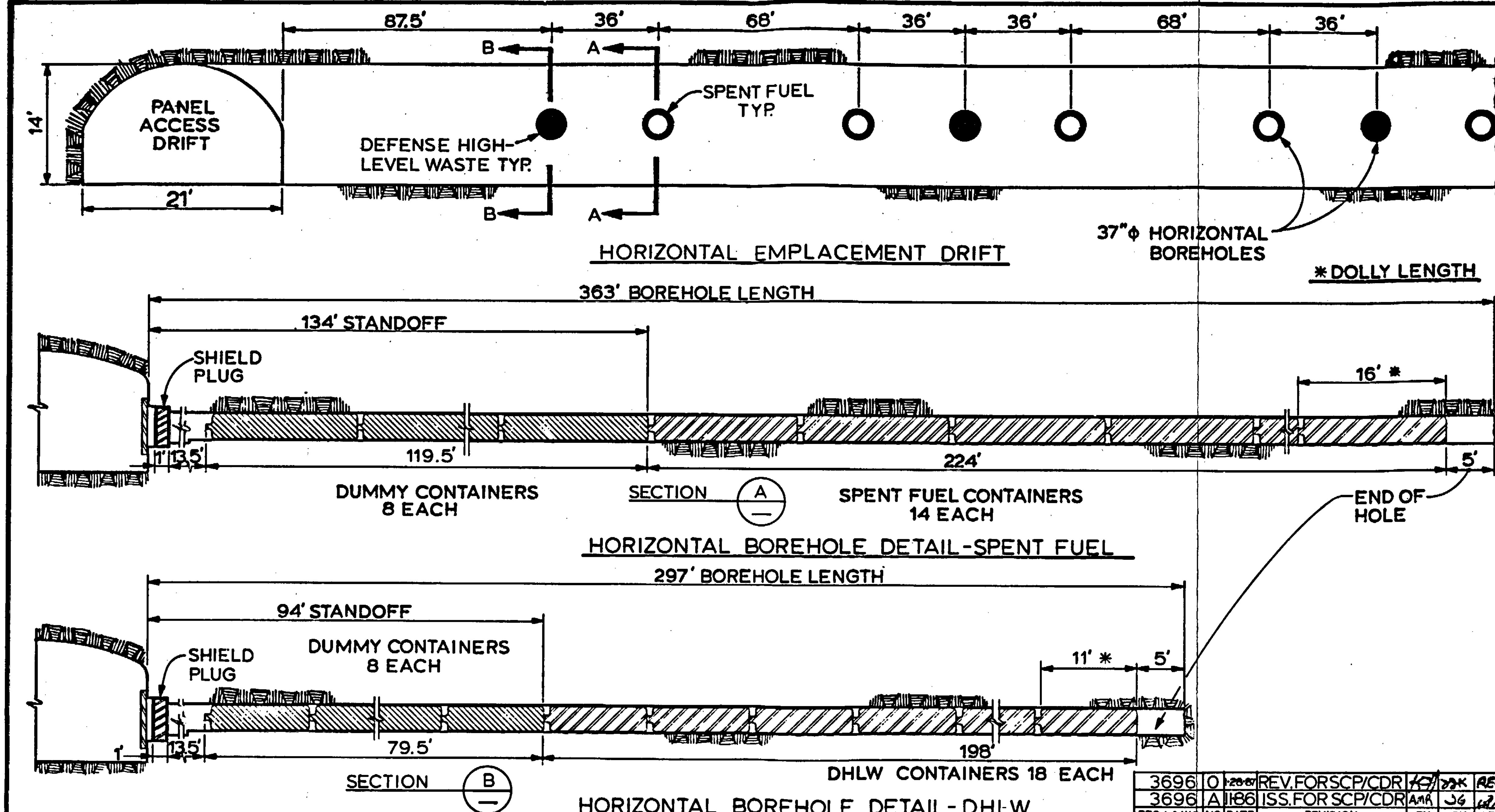
Thermal analysis indicates that a standoff of at least 130 ft is necessary in a spent fuel borehole to ensure that the temperature in the emplacement drift is limited to less than 50°C over a period of 50 yr; thus, the horizontal borehole for spent fuel used for the conceptual design holds 14 waste containers and is 363 ft long. For DHLW, a 94-ft standoff is sufficient to satisfy these temperature constraints, and a 297-ft borehole holds 18 DHLW containers. As shown in Figure 4-41, dummy containers are used to push the waste containers into the boreholes to create the necessary standoff. To reduce costs, an effort will be made to eliminate the dummy containers in future designs.

The minimum allowable standoff between the first spent fuel emplacement borehole and the panel access drift is determined by thermal analysis to be about 120 ft. A borehole containing cooler DHLW packages is placed nearest the access drift, permitting a standoff distance of 87.5 ft, as shown in Figure 4-41. These distances will limit the temperature in the panel access drift to the 50°C/50-yr goal.

Panel dimensions are irregular at the perimeter drift. Layout adjustments to more effectively use these areas are available. The adjustments include

- reduced borehole length,
- reduced standoff,
- higher temperature allowance in emplacement drifts, and
- higher APD allowance near the perimeter zone.

In summary, emplacement drifts are spaced 748 ft from centerline to centerline. In each full-length emplacement drift in which waste types are commingled are 32 boreholes for spent fuel containers (16 per side) and 18 boreholes for DHLW (9 per side). Each spent fuel borehole is 363 ft in length, has a 134-ft standoff, and holds 14 waste containers. Each DHLW borehole is 297 ft in length, has a 94-ft standoff, and holds 18 containers. Centerline spacing between adjacent spent fuel boreholes is 68 ft, and centerline spacing between DHLW boreholes and spent fuel holes is 36 ft. The standoff distances from the wall of the nearest panel access drift to the centerlines of the first DHLW borehole and the first spent fuel borehole are 87.5 ft and 123.5 ft, respectively.



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3696	0	1-28-87	REV. FOR SCP/CDR	[illegible]	[illegible]	RES
3696	A	1186	ISS. FOR SCP/CDR	AMR	JG	[illegible]

NOTES -
1. DIMENSIONS SHOWN ARE EXCAVATED.
2. DETAILS BETWEEN BOREHOLE AND CONTAINERS NOT SHOWN.

UNDERGROUND FACILITY LAYOUT PANEL DETAILS FOR COMMINGLED WASTE HORIZONTAL EMPLACEMENT

NOT TO SCALE

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SNL CONTRACT NO. 21-6931 CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY

DWG. APPROVED	DATE
[signature]	1/29/87
[signature]	1/29/87
R07037	

NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY SUPPORT
PB SK. NO. SS/MN523 DATE 4/4/86

Figure 4-41.

4.4.3 Underground Systems

This section identifies and describes the major underground systems needed to support the ongoing mining operations.

4.4.3.1 Ventilation Control System

Two ventilation systems, one for waste emplacement and one for development, operate continuously throughout normal repository operations. The ventilation systems are designed so that controlled leakage of air occurs from the development system, through the bulkheads and double doors that separate the two systems, to the waste emplacement system. To control leakage of air, a pressure differential between the two systems (the pressure in the development area is higher than that in the emplacement area) is continuously maintained by an exhausting ventilation system for the waste emplacement area circuit and a forcing ventilation system for the development area circuit. A detailed description of the ventilation systems and their operations is provided in Section 3.4. The key components of the ventilation system (which limit uncontrolled leakage, direct air to the required areas, permit access between areas of high pressure differentials, and separate development from waste emplacement operations) are bulkheads, air regulators, doors, airlocks, and auxiliary fans with ventilation ducting. Each of these components is described below.

Bulkheads, which are also referred to as "stoppings," are wall-like structures usually constructed of fabricated steel, concrete cinderblock, or some combination of these materials. The purpose of a bulkhead is to minimize air leakage across an airway in which access is not essential. Bulkheads are used in the crosscuts that connect the waste, tuff, and service mains, and between the panel access drifts. To separate the two ventilation systems, temporary bulkheads are used in the waste main and perimeter drifts. Sealants may be applied to further reduce leakage across a bulkhead.

Air regulators control the quantity of ventilation in a particular airway. Regulators are commonly a bulkhead with a sliding door that can be adjusted to control the amount of airflow through the opening.

Doors in the underground facility are placed in areas where air leakage is not desired but access to the airway is necessary. The door size is typically governed by equipment size. These structures are relatively permanent and require periodic maintenance. In areas of high pressure differentials, doors are used in pairs to form airlocks to permit passage of personnel, equipment, and supplies.

The locations of ventilation controls, such as regulators, doors, and bulkheads, are shown in Figures 3-31, 3-32, 3-33, and 3-34.

Ventilation requirements in development headings change constantly. Auxiliary ventilation fans provide air to the operating face by using ventilation tubing or ducting, which is extended as the face advances. This portable system is susceptible to leaks and must be constantly maintained. When the developing drift has been completed and the auxiliary ventilation system is no longer necessary, the system is dismantled, moved to the next developing drift, and reinstalled.

4.4.3.2 System for Handling Mined Tuff

A conveyor haulage system is recommended for handling tuff excavated during the development and construction of the repository because it

- provides a cost-effective alternative to using mobile equipment and lessens the distance over which mined tuff must be hauled using load/haul/dump (LHD) units;

- is readily adaptable for use with conventional drill-and-blast mining methods and mechanized tunnel-boring machine (TBM) methods;

- can easily traverse grades;

- offers the best dust control and permits continuous flow of materials while avoiding the confusion, delays, and safety hazards inherent in mobile equipment haulage systems; and

- could be reversed with modifications and, if required, would be usable for backfilling.

All conveyors in the system are of wire-rope, side-frame construction and are supported by rock bolts and chains from the roofs of drifts as shown in Figure 4-42. The conveyor structure consists of carrying or troughing idlers, chain supports, tensioning posts (for side-frame ropes), return idlers, and side frames, all of which are relatively lightweight components that can be easily handled and stored. An important feature of the conveyor is that intermediate sections are suspended from the roofs by chains in underground drifts. The overall concept for handling excavated tuff is depicted in a flow diagram (Figure 3-24).

Permanent conveyors and transfer points are installed in the tuff main and tuff ramp and on the surface from the tuff ramp portal to the tuff pile. Temporary conveyors are used only in the development areas. An LHD hauls broken tuff from the advancing emplacement and access drifts to a feeder/breaker, where the rock is crushed and fed onto the first conveyor belt section. In this process, an average LHD haul is about 350 to 400 ft one way. As the haul extends to about 600 or 700 ft, the belt and feeder/breaker are extended in 200- to 400-ft increments to maintain the average hauling distances.

All conveyors and components are designed in accordance with criteria and standards outlined in the Conveyor Equipment Manufacturers Association publication (CEMA, 1979) and in accordance with 30 CFR 57. All conveyors are controlled at the underground control center and are powered from the main power distribution system. The conveyor system starts and shuts down, as necessary, to provide control and efficient operations. Each individual unit of the system is equipped with a manually operated emergency shut-down switch.

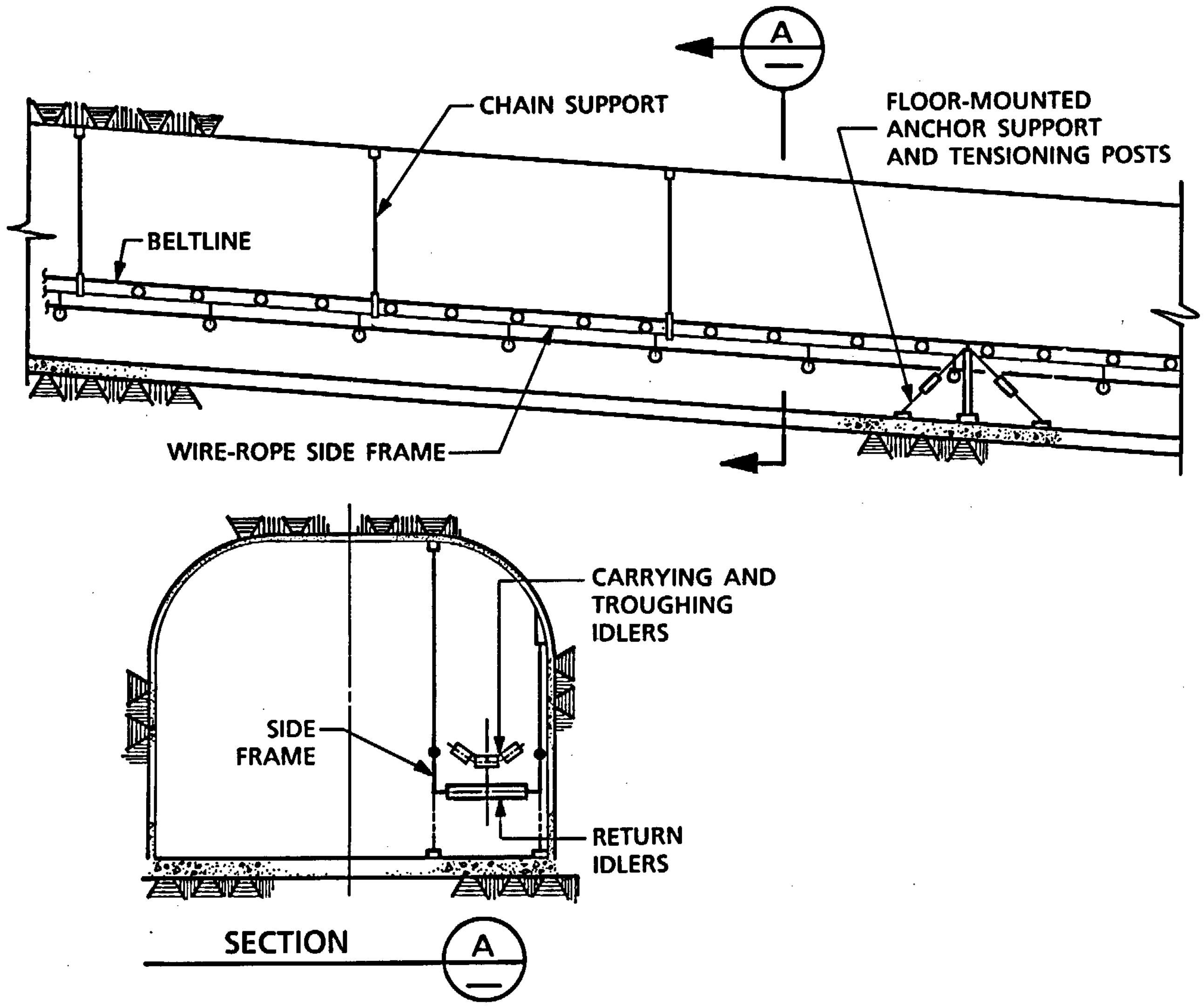

Figure 4-42. Typical Ropebelt Conveyor (Modified from Stinebaugh and Frostenson, 1986.)

4.4.3.3 Utilities

4.4.3.3.1 Electric Power

Power is delivered to subsurface operations through two separate accesses: the men-and-materials shaft and the tuff ramp. Normal and standby switchgear assemblies, located near the development area shops, are interconnected via tie breakers to allow redundant operation of primary and secondary sources.

Lighting load centers in the subsurface facilities are served by the standby switchgear assemblies to ensure that the redundant system remains energized and dry. Movable load centers for subsurface operation, fans, and drilling equipment are served from the normal switchgear assembly.

Electrical equipment in the subsurface facilities is considered to be located in a wet environment, subject to dripping water (not immersion). The power system underground is a radial network that uses a distribution voltage of 13.8 kV. Motors above a certain size (200 hp and larger) are powered by 4,160 V. Underground power for small motors (under 200 hp) is 480 V. Lighting and small tools use 120 V.

The electrical lines in the main access drifts are permanent. Power in the emplacement areas is converted from temporary to permanent installation after development has been completed.

The power supply to the drifts and headings in the development area is temporary because it will be necessary to extend the system and to vary the electrical loads. When the large amounts of electricity are no longer needed to develop an area, the transformers, load centers, and wire are retrieved and installed in another developing area.

4.4.3.3.2 Compressed Air

Compressed air is used in the maintenance shop areas and in the development area. Compressed air in the maintenance shop areas is permanently installed. Compressed air needs in the development areas are met by portable, electrically powered compressors, which are handled as temporary installations that are moved and used as necessary.

4.4.3.3.3 Water Supply

All water piped underground is potable. A pipeline supplies water from the central surface facilities to the water storage tank near the men-and-materials shaft. From there, water is piped down the shaft to the underground facilities. The water storage tank for these facilities is sized for 24-hr potable and process demand plus 2-hr fire demand; a single system is used for these functions.

At the underground level, pressure is reduced to normal operating levels. To prevent contamination, potable water is supplied to the underground facility by a dedicated piping system. Backflow preventers are installed in the process water system to eliminate backflow of turbid water. Process water is used in the development areas for drilling, suppressing, and cooling equipment. Permanent process water lines are installed in the service main from which temporary lines feed the emplacement panels under development.

4.4.3.3.4 Chilled Water

A chilled water system is needed to cool the air in the emplacement drifts for the purpose of inspection, maintenance, and backfilling during closure. Sections 3.4.2.3 and 3.4.3.3 describe air-cooling scenarios and the overall cooling capacity of the system. The cooling needs for the horizontal emplacement configuration are somewhat lower than those for the vertical configuration because the standoff distances are larger and the drifts are cooler in the horizontal configuration. A chilled-water plant near the collar of the men-and-materials shaft supplies the necessary water through pipes in the shaft and service main.

4.4.3.3.5 Sanitary Services

Toilets and sinks are provided in the shop areas as needed to serve the personnel who work in these areas. Temporary toilets and sinks are provided near working locations in the development area. A vacuum system, which uses permanent piping in the shop areas and temporary piping in the development area, collects the waste in a holding tank located near the development area shop. This waste is brought to the surface for disposal.

4.4.3.3.6 Communications

The communications network includes telephone, radio communication, intercom and paging, and sound-powered communication. The telephone system provides direct communications among underground telephone instruments, the DOE network at the NTS, the offsite commercial system, and the federal telecommunications system. A four-channel radio system allows communications among emplacement vehicles and a master base station. The master station interfaces with the telephone system. Before being used either on the surface or underground, the radio system must be carefully evaluated to ensure its compatibility with the use of explosives. The intercom and paging system allows voice paging and intercommunications between selected areas of the repository. Critical communication systems that require continuous power are supplied by UPS or battery-powered systems. Standby power is available for critical communication systems that can withstand short power interruptions (up to 1 min). All hardwire communications are temporary in the development areas and will become permanent installations after development has been completed.

4.4.3.4 Water-Handling System

Throughout the construction, operations, and caretaker phases of the underground facility, a water-handling system will be active for control of water from either mining operations or natural ground water. Because the emplacement horizon is above the water table, water inflow is expected only if perched water is encountered; otherwise, the drainage system is designed for handling water used for development. The main elements of the system include

- pump columns in the men-and-materials and emplacement area exhaust shafts,

- water-collecting sumps near the base of the men-and-materials and emplacement area exhaust shafts,

- permanent pump installations at the sumps near the men-and-materials and emplacement area exhaust shafts, and

- permanent gathering lines in the main drifts.

Temporary water-handling facilities are envisioned for gathering and pumping water back to the permanent installations. These facilities are installed and removed as necessary. Water used for washdown and other purposes in the underground service areas is collected and removed by pumping or by tank trucks. The purpose of the water-handling system is to collect excess process water and natural ground water as close to their sources as possible. A passive element of the water-handling system is the natural drainage pattern created by the designed slope of the drifts. Although it is not expected that ground water will infiltrate the emplacement area in significant quantities, the drifts are designed so that any water, whether from ground water or from operations in the underground facilities, is diverted away from the waste emplacement drifts. Figure 4-33 illustrates the resulting natural drainage plan for the fully developed underground facility. After excavation has been completed, all areas will drain in the direction of a sump located near the bottom of the emplacement area exhaust shaft, the lowest point in the underground facility.

4.4.3.5 Data Acquisition and Monitoring System

A data acquisition system (DAS) fulfills the functions of data acquisition, monitoring, control, and alarm. The DAS for the subsurface facilities consists of a distributed network of remote stations on the surface and underground. Each remote station is a self-contained unit that is programmed to act upon data received via hardware and/or software control. All data paths are redundant.

The DAS monitors ventilation flow for temperature, pressure differentials, radioactivity, and gas content. In the event of radioactivity in the emplacement area exhaust airstream, the monitors make a quantitative determination, generate an alarm, and initiate the diversion of exhaust air to the filter system at the collar of the emplacement area exhaust shaft. The DAS also monitors the primary power supply and sets the control system automatically to start the emergency generator, to transfer the power load, and to initiate an alarm located at a central station. An alarm circuit displays failure of or a malfunction in the system. The DAS is also designed to monitor other utilities, as necessary. By means of a rock-monitoring system, the DAS helps in assessing rock stability and rock motions in emplacement drifts and elsewhere in the subsurface facilities, as necessary, until the end of the performance confirmation period.

4.5 Normal Repository Operations

4.5.1 Development of Emplacement Drifts

4.5.1.1 Drift Construction

The underground openings are constructed using both mechanical mining and drill-and-blast methods. TBMs are used for mechanical mining, and it is planned to use these machines for mining the waste ramp, the tuff ramp, the waste main, and the perimeter drift. Drill-and-blast mining will be used for the tuff main, the panel access drifts, the service main, and the waste emplacement drifts. Drill-and-blast methods are well suited for mining the waste emplacement drifts because these methods provide flexibility that can be advantageous in designing the underground layout and in the event that unanticipated conditions encountered in the development of the underground facility dictate changes in layout.

TBMs are used for long, straight runs when a circular cross section is desired. Drill-and-blast mining is used where the length of a straight run is short and when it is not necessary to have a circular cross section.

The mining methods selected for this design are subject to change as new developments are made in mechanical mining systems. Currently, mechanical mining systems are being developed that can mine noncircular openings. If these systems are proven viable in rock whose properties are similiar to those of Yucca Mountain tuff, they will be evaluated for application in future designs.

Figures 3-22 and 3-27 depict the operations involved in mining emplacement drifts using drill-and-blast methods. A cycle for drill-and-blast mining involves five major operations: (1) drilling the holes for loading explosives, (2) loading explosives, (3) detonating the explosives, (4) removing the broken rock, and (5) installing the necessary ground support system. (Section 3.3.1.3 contains a discussion of the ground support systems proposed for the Yucca Mountain site.) The drill-and-blast mining operations depicted on Figures 3-22 and 3-27 are common to all drill-and-blast mining. A complete description of the operations involved in drill-and-blast mining is presented in Section 3.3.1.

A typical operating cycle for a TBM is illustrated in Figure 3-21. The cycle consists of advancing the drift the length of the stroke of the hydraulic thrust cylinders, then releasing the gripper pads, tramming the machine forward, resetting the gripper pads, and repeating the drilling cycle.

In the drifts where drill-and-blast mining is being used, the tuff is removed from the working face by LHDs. These units haul the tuff to a conveyor that transports the tuff to the surface. The tuff removal system is shown in Figures 3-22 and 3-27 for vertical and horizontal emplacement, respectively. The entire tuff-handling system is shown schematically in Figure 3-24. The tuff is transported from the TBMs to the surface entirely by conveyor.

When a vertical or horizontal emplacement drift is excavated using drill-and-blast mining, the advance rate is 10 ft/day, assuming a 2-shift operation and 6 hr of productive time per shift. The advance rate of the TBM is estimated to be 8 ft/hr. Based on the currently projected number of waste containers to be emplaced annually (Table 3-6), mining operations must be under way concurrently in 10 drifts for vertical emplacement and 6 drifts for horizontal emplacement so that the emplacement drifts necessary to support the stipulated disposal rates are provided. A detailed analysis of the mining operations, including advance rates and equipment requirements, will be included in the repository operations plan, which is now being prepared.

The major equipment required to support drill-and-blast and TBM mining operations is identified below.

4.5.1.1.1 Drill Machine

This machine (jumbo) is used to drill the loading holes for explosives in drill-and-blast mining. Use of dual-boom, electric/hydraulic drill jumbos is planned. These machines use a diesel motor for tramming and electric motors to drive hydraulic percussion drills. Electric power is supplied to the drill jumbo through a trailing cable connected to the installed power source.

4.5.1.1.2 Load/Haul/Dump Unit

The LHD is a haulage vehicle adapted for underground service. Diesel-powered LHDs are used to move the tuff from the mining areas to the belt conveyor system. The machines planned for the repository are equipped with buckets that have a capacity of approximately 5 yd^3.

4.5.1.1.3 Rock-Bolting Machine

The rock-bolting machine (jumbo) is a three-boom, electric/hydraulic trailer-mounted system designed to install in a single operation the wire mesh and rock bolts needed for tunnel support. The jumbo has a diesel-powered tramming motor for moving from one location to another.

4.5.1.1.4 Scaling Machine

Scaling is the process of removing loose rock from the crown (back) and walls (ribs) of a drift after blasting and during routine maintenance. A scaling machine consists of a hydraulically powered pick mounted on an articulated boom. The scaler is mounted on a rubber-tired, diesel-powered carrier.

4.5.1.1.5 Tunnel-Boring Machine

A TBM is an electrically powered, full-face excavating machine that cuts a circular opening in rock. Cutting action is provided by hardened steel disks mounted on the rotating face of the machine. Forward thrust on the rotating face is developed by hydraulic cylinders. The thrust and torque reaction forces are achieved by hydraulically actuated gripper pads that extend outward to the tunnel wall.

The drifts in the repository must be inspected periodically. The frequency of inspection will be determined as operating experience is acquired. Initially, it is planned that the drifts will be inspected annually. Maintenance will be done if these inspections reveal a potential problem. Based on conclusions drawn from analyses performed to date, catastrophic failures or failures that require major maintenance are not expected during the operating life of the repository (St. John, 1987; St. John and Mitchell, 1987). Minor maintenance is expected, which is limited to such things as the replacement of sections of wire mesh and the installation of additional rock bolts.

4.5.1.2 Installation of Utilities

4.5.1.2.1 Power

Three categories of power are provided in the underground facility: normal power, standby power, and uninterruptible power.

Normal power is supplied to the underground facility by two independent routes--one through the men-and-materials shaft and the other through the tuff ramp. Substations are located at the bottom of the men-and-materials shaft for stepping down voltage and controlling distribution. Normal power is distributed on permanently installed wiring that extends through the main drifts to the entrance of the panel access drifts. From the entrance of the panel access drift, the power is distributed to the emplacement drifts on temporarily installed cables. Portable, temporary, voltage-reduction transformers are used at the entrances to the emplacement drifts to supply power for development and waste emplacement operations.

Standby power is provided by diesel-powered generators installed at the surface. The standby power is distributed over the same system used for normal power. The major items included in the demand for standby power are the men-and-materials hoist and the underground ventilation systems. The determination of standby power capacity has not been completed and will take into account the possibility of supporting systems at less than full operating capacity during disruptions of normal power.

The main systems to be provided with uninterruptible power are the instrumentation systems used to monitor the performance of repository experiments, including the computer systems used for controlling experiments and recording data. Uninterruptible power will also be provided for emergency lighting and communications.

4.5.1.2.2 Water

Both potable and process water are needed underground. Potable water is provided in insulated, refillable containers brought underground each working day. Process water is piped underground in pipes located in the tuff ramp or the men-and-materials shaft. Process water is supplied from batch tanks, which are refilled as the water is used. The use of batch tanks is necessary to limit the amount of water that can enter the underground facility in the event that a water supply line ruptures.

4.5.1.2.3 Compressed Air

The only permanently installed compressed air systems are the compressors used to supply air to the shops in the development and waste emplacement areas. Compressed air needs at other locations are provided by portable, electrically driven compressors.

4.5.1.3 Underground Ventilation System

The function of the underground ventilation system is to furnish fresh air to the working areas of the underground facility. Air quality is provided by supplying air quantities adequate to maintain oxygen levels and the proper working temperature, and to dilute the contaminants dumped into the air stream by equipment or operations. Air quantities are determined by the equipment being used, the number of people at the location being ventilated, and the type of operation being performed. A full discussion of the ventilation system is presented in Section 3.4.

The underground ventilation system is composed of two parts, one of which provides air to support development activities. The second part provides air for waste emplacement and retrieval operations. The two parts of the system are functionally independent. To maintain this independence, it is necessary to construct temporary barriers (bulkheads) between the two systems. These barriers are moved when it is necessary to transfer a completed waste emplacement panel from the ventilation system for development to that for waste emplacement. The barriers between these systems are constructed in a manner that minimizes leakage from one system to the other. To control the leakage that does occur between the development and emplacement systems, the pressure in the waste emplacement side is maintained at a lower level than the pressure in the development side. Maintenance of this differential ensures that all leakage flows from the development to the waste emplacement system.

To further enhance the independence of the two systems, each has its own dedicated air supply and exhaust conduits. The ventilation for the development area is supplied by the men-and-materials shaft and is exhausted from the tuff ramp. The system for the waste emplacement area is supplied by the waste ramp and the exploratory shafts. Air from the waste emplacement area ventilation system is exhausted through the waste emplacement area exhaust shaft. The minimum pressure differentials between the two systems are given on Figures 3-31, 3-32, 3-33, and 3-34. As shown in Figure 3-31, the pressure differential between the development and waste emplacement systems is calculated to be approximately 5.2 in. of water (between Panels 5 and 6). These same figures identify the temperatures at various junctions in the repository and at the shaft and ramp entries.

Before waste emplacement activities are completed in a panel, the next panel will have been completely readied for waste emplacement. Transferring waste emplacement activities to the next panel requires only that the emplacement area ventilation system be redirected to the next panel and that flow regulators be balanced to provide the proper air flows. The panel access drifts for the completed panel are closed off by the installation of bulkheads. The bulkheads have doors that can be opened to reestablish ventilation flows and to admit personnel and equipment for inspection and repairs.

4.5.2 Development of Emplacement Boreholes

4.5.2.1 Vertical Emplacement Boreholes

The currently planned drilling operation for vertical boreholes is a two-step process initiated by a small-diameter pilot-hole drill and completed by a large drill that reams the pilot hole to the specified diameter. A detailed description of the drilling system for vertical boreholes is provided by The Robbins Company (1984). The diameter of the vertical borehole in the Robbins report is larger than the 29-in.-diameter borehole in the conceptual design; this difference does not affect the feasibility of using this approach to drill vertical boreholes. Figure 3-22 shows the two-step drilling process used in a typical emplacement drift. The equipment needed to develop vertical boreholes is described below.

4.5.2.1.1 Pilot-Hole Drill

The first step consists of drilling an 11-in.-diameter pilot hole 32 ft deep, using a standard raise drill modified to accept a 10-in.-diameter drill stem. The raise drill is mounted on a crawler platform for mobility. The crawler platform also carries a hydraulic power pack, which supplies power to the rotary drive motor, the thrust cylinders, and other auxiliary equipment. The operator's control console is also stowed on the crawler platform while the drill is being moved.

4.5.2.1.2 Reaming Drill

The second step in developing vertical emplacement boreholes consists of opening the pilot hole to a 29-in. diameter and to a depth of 25 ft. This step is performed by a crawler-mounted drill that uses a vacuum system for removing the drill cuttings. This drill is based on currently available components, but development will be required to ensure that these components perform as a system. The cutting head of this drill is held in alignment with the pilot hole by a pilot shaft mounted on the forward end of the drill head. The drill head accommodates carbide-insert or rolling disc cutters.

The vertical emplacement borehole is lined with a partial liner that (1) keeps the pintle of the waste container clear of debris (which could impede retrieval) and (2) supports the borehole shielding plug and various pieces of equipment used for emplacement and retrieval.

4.5.2.2 Horizontal Emplacement Boreholes

The system for boring horizontal emplacement boreholes is currently being developed. A detailed description of the equipment currently proposed for drilling horizontal emplacement boreholes is presented by The Robbins Company (1987). The drilling system is a new design based on currently available components and technology. The in-hole drill is a scaled-down version of a currently available TBM. The drill head, cutter design, power, and thrust requirements are based on extensive experience with TBMs and drilling blind holes. The vacuum cuttings removal system was designed based on experience with pneumatic transport of rock cuttings in tunnel boring and drilling. As it is currently designed, the drill drills a 37-in.-diameter borehole to the approximate length (350 ft) planned for horizontal emplacement boreholes. The system comprises the major parts described below.

4.5.2.2.1 <u>In-Hole Drill</u>

The motor of the in-hole drill is located in the drill head. The motor turns the drill head, which is equipped with rolling, carbide-insert cutters. The drill is connected to the borehole liner, which provides thrust to the drill and counteracts the drilling torque. The drill head can be steered to maintain alignment. Steering is accomplished by hydraulically actuating wedges that push against the borehole wall. A laser guidance system determines the position of the drill so that corrective adjustments can be made to maintain the straightness of the borehole.

4.5.2.2.2 <u>Borehole Liner</u>

The borehole is lined as it is drilled. The liner has an outside diameter of 36 in. and a wall thickness of 0.5 in. The liner is inserted in the borehole in 8-ft sections and welded together to form a continuous liner. An automatic welding machine located near the drill derrick is used for the welding operation. The drill head can be disconnected from the liner after the borehole has been completed. Removal is accomplished by pulling the drill head back through the liner.

4.5.2.2.3 <u>Drill Derrick</u>

The drill derrick provides thrust to the drill through a traversing head driven by hydraulic cylinders. The drilling thrust and torque are transmitted to the drift walls by reaction cylinders mounted on the derrick.

4.5.2.2.4 <u>Tuff-Removal System</u>

As a consequence of the design goal of minimizing the amount of water or other materials that enter the borehole during drilling, a vacuum system is used to remove the cuttings. This system consists of vacuum pumps, vacuum lines, and filter boxes. During operation, clean air, drawn to the drill head through the liner, passes over the drill head, where it sweeps up the cuttings. The cuttings-laden air is drawn into the vacuum system through return pipes. The return air is routed through filter boxes, where the cuttings are removed.

4.5.3 <u>Waste Emplacement Operations</u>

Waste emplacement operations involve preparing individual boreholes for emplacement, transferring waste containers from the waste-handling buildings to the emplacement boreholes, and closing the boreholes. The specific procedures and equipment used to perform these operations depend on the emplacement configuration.

4.5.3.1 Vertical Configuration

The location, spacing, and diameter of emplacement boreholes for the vertical configuration are shown in Figure 4-39.

Figure 4-43 is a schematic diagram showing the steps involved in preparing a vertical borehole for emplacement. A support plate is installed in the bottom of the borehole to support the waste container and to distribute the weight of the container over the bottom of the borehole. A special forklift transports a temporary borehole shielding closure to the borehole. The closure, which provides shielding during emplacement operations, is then aligned, installed, and leveled.

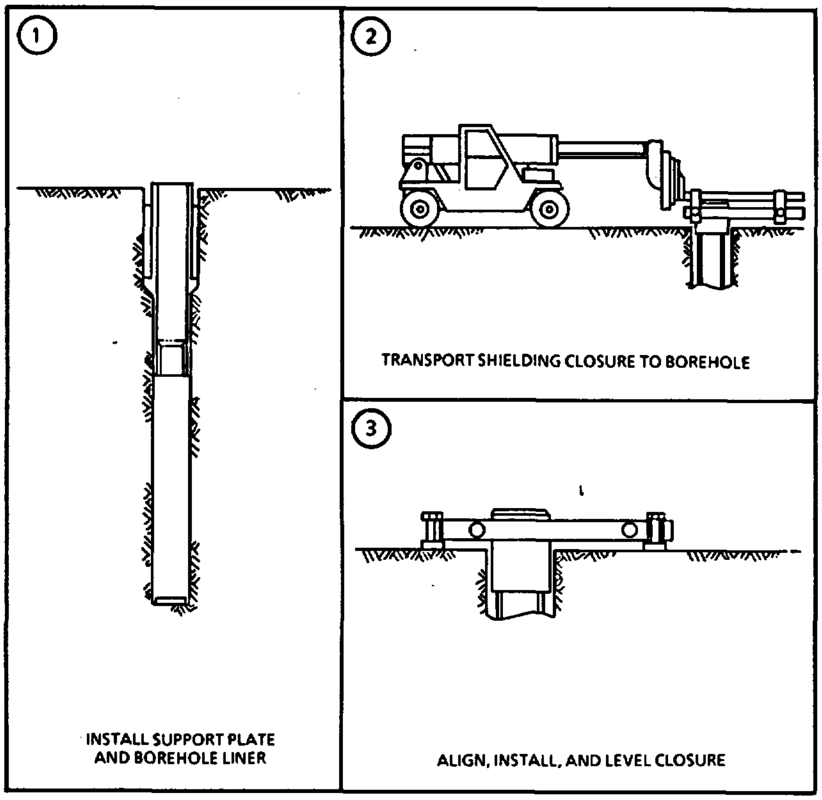

Figure 4-43. Preparation of Vertical Borehole for Emplacement (Stinebaugh and Frostenson, 1986.)

Transfer of a single waste container from the surface facility to a vertical borehole is illustrated in Figure 4-44. After the container has been lifted from the surface storage vault into the transporter cask, the transporter is driven underground to the emplacement borehole and positioned over a temporary shielding closure. The cask, which carries the

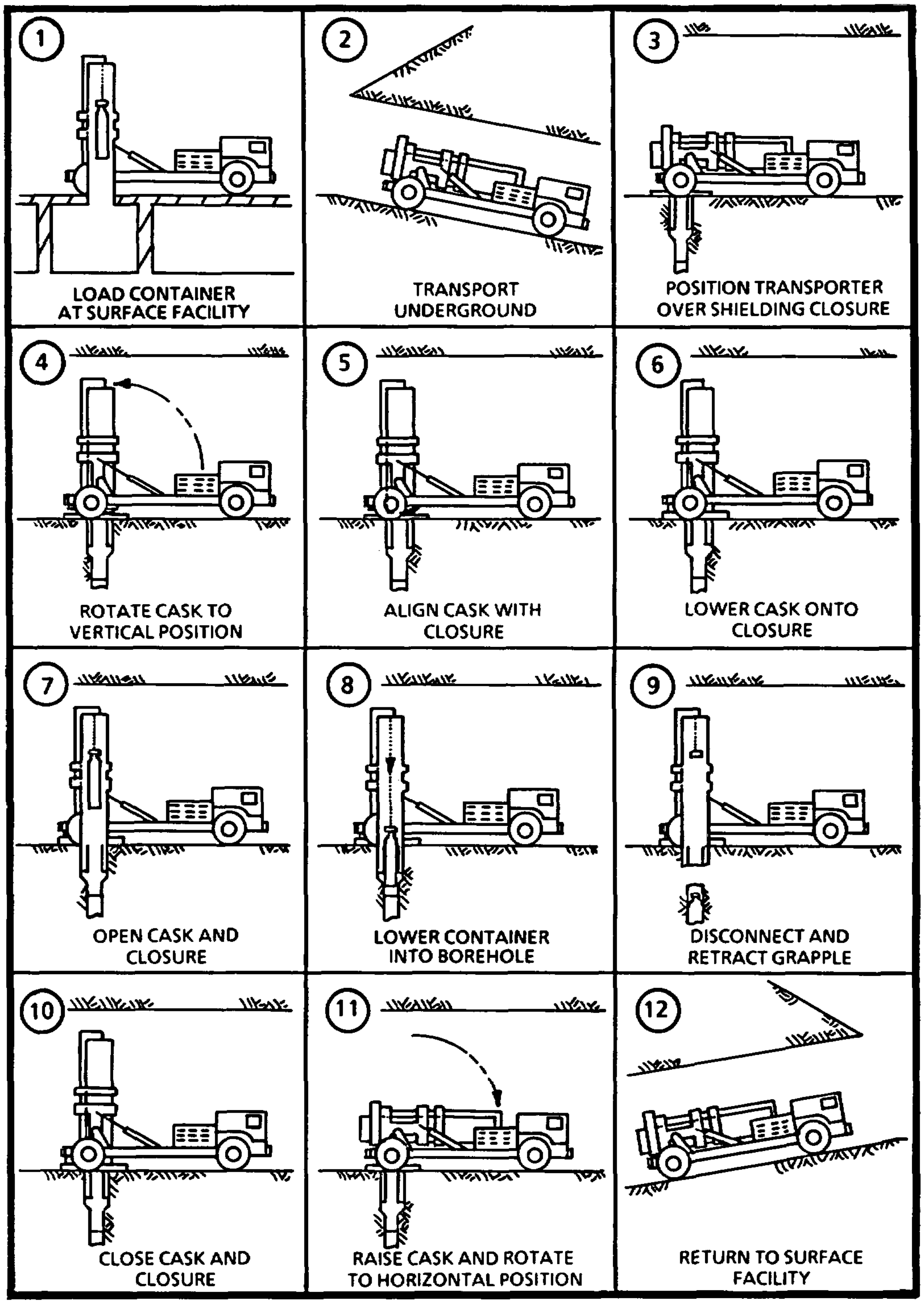

Figure 4-44. Emplacement of a Waste Container in the Vertical Configuration (Stinebaugh and Frostenson, 1986.)

container and provides primary shielding for the transporter operators, is then rotated to a vertical position, and the shield doors are opened. The waste container is lowered into the borehole, and the grapple is disconnected from the pintle on the waste container and retracted into the cask. The shield doors are then closed, the cask is rotated to its transport position, and the transporter is returned to the surface facility.

After the waste has been emplaced, final borehole closure is accomplished by replacing the temporary shielding closure with a shield plug and borehole cover, allowing the shielding closure to be used for waste emplacement operations at other boreholes. Closure is accomplished using a shielded plug installer transported by a special forklift (Figure 4-45). The shield plug installer is positioned over the borehole shielding closure, the shield doors are opened, and the shield plug is lowered into the borehole. The grapple is disconnected from the shield plug and retracted into the shield plug installer, and the shield doors are closed. The borehole shielding closure is then removed, and the borehole cover is installed.

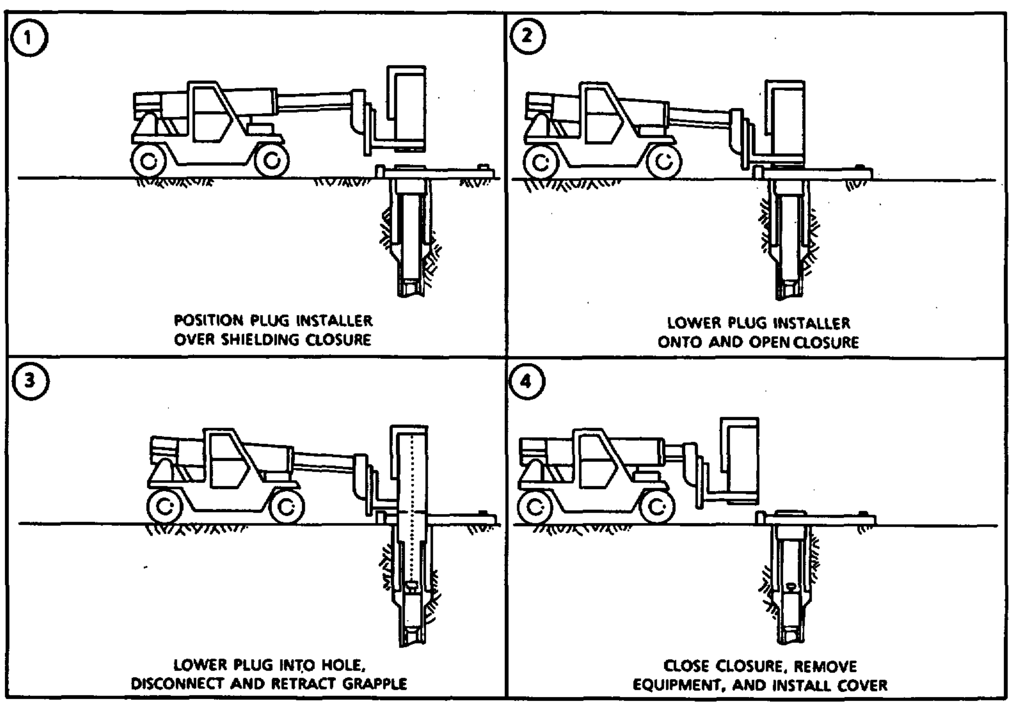

Figure 4-45. Borehole Closure Operations in the Vertical Configuration (Stinebaugh and Frostenson, 1986.)

An isometric drawing of the waste transporter is shown in the transport mode in Figure 4-46 and in the emplacement mode in Figure 4-47. The transporter and the other equipment needed to emplace waste in the vertical configuration are described in Appendix D of this report.

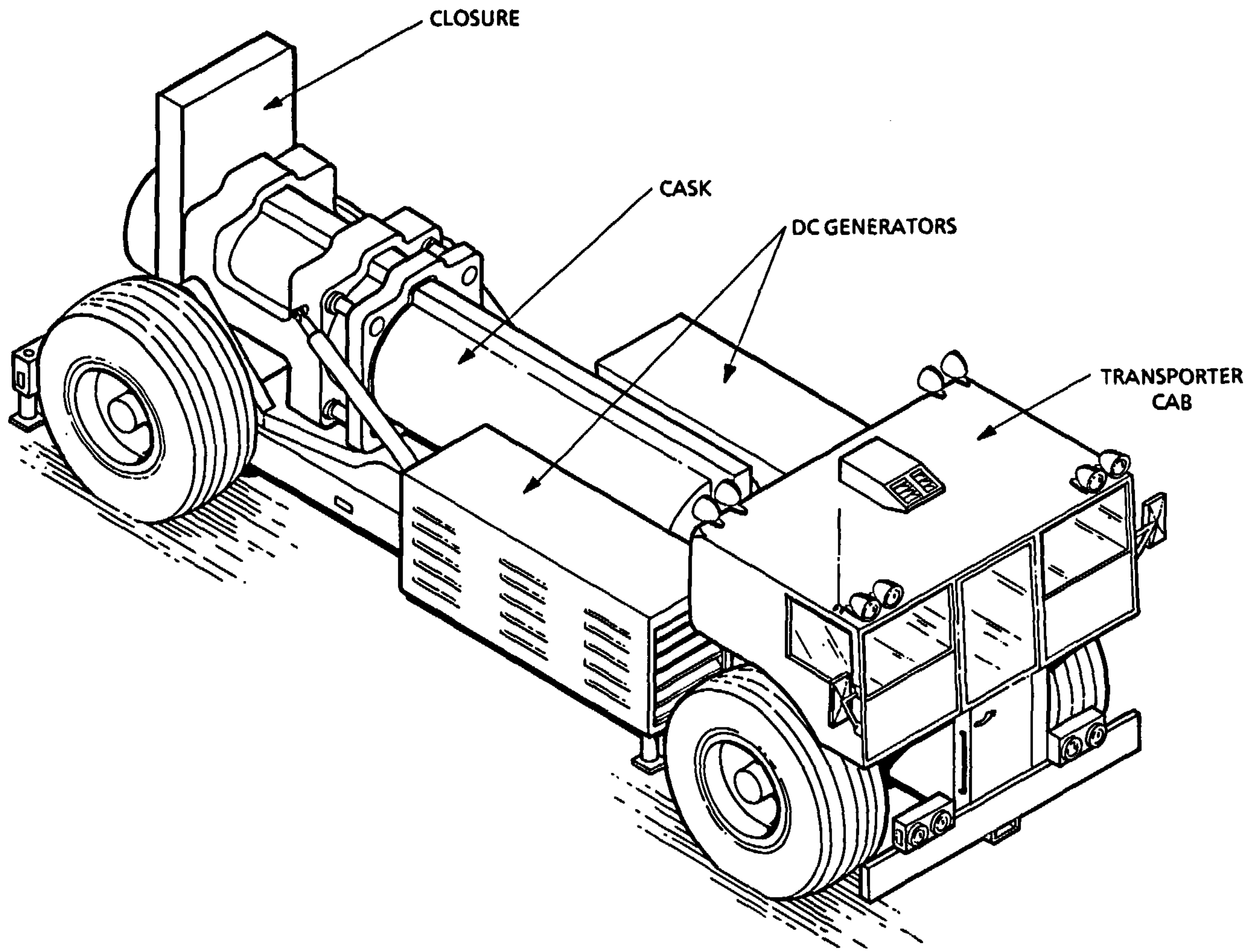

Figure 4-46. Waste Transporter in the Transport Mode in the Vertical Configuration (Stinebaugh and Frostenson, 1986.)

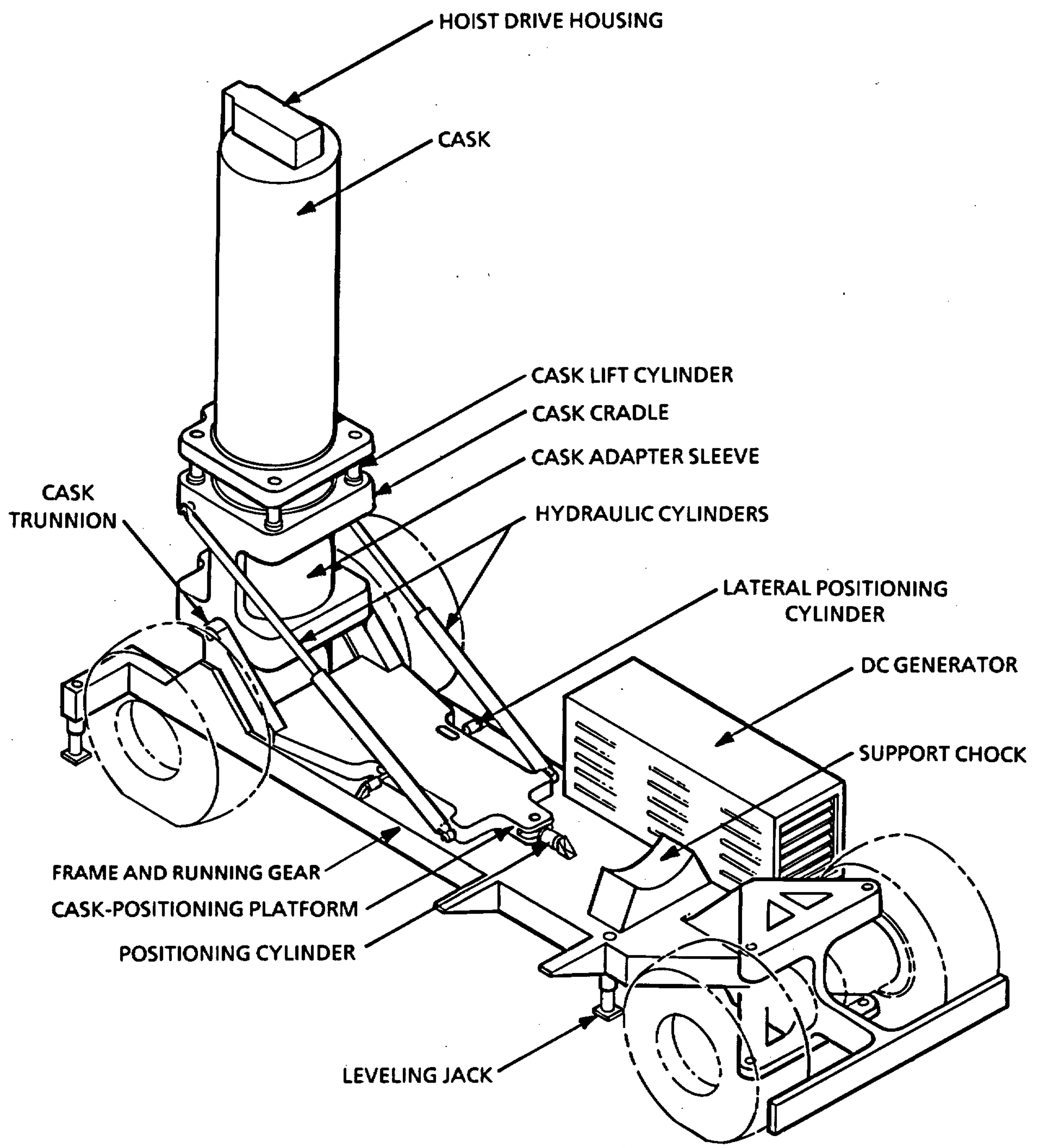

Figure 4-47. Waste Transporter in the Emplacement Mode in the Vertical Configuration (Stinebaugh and Frostenson, 1986.)

4.5.3.2 Horizontal Configuration

The location, spacing, and size of emplacement boreholes for the horizontal configuration are shown in Figure 4-41.

Figure 4-48 shows the steps involved in preparing a horizontal borehole for emplacement. The borehole liner is installed during drilling, followed by installation of an entry liner and dolly release cam. An interface plate is then installed on the entry liner flange. A special forklift is used to transport the borehole shielding closure to the borehole. The closure, which is used to provide shielding during emplacement operations, is then aligned and bolted to the interface plate.

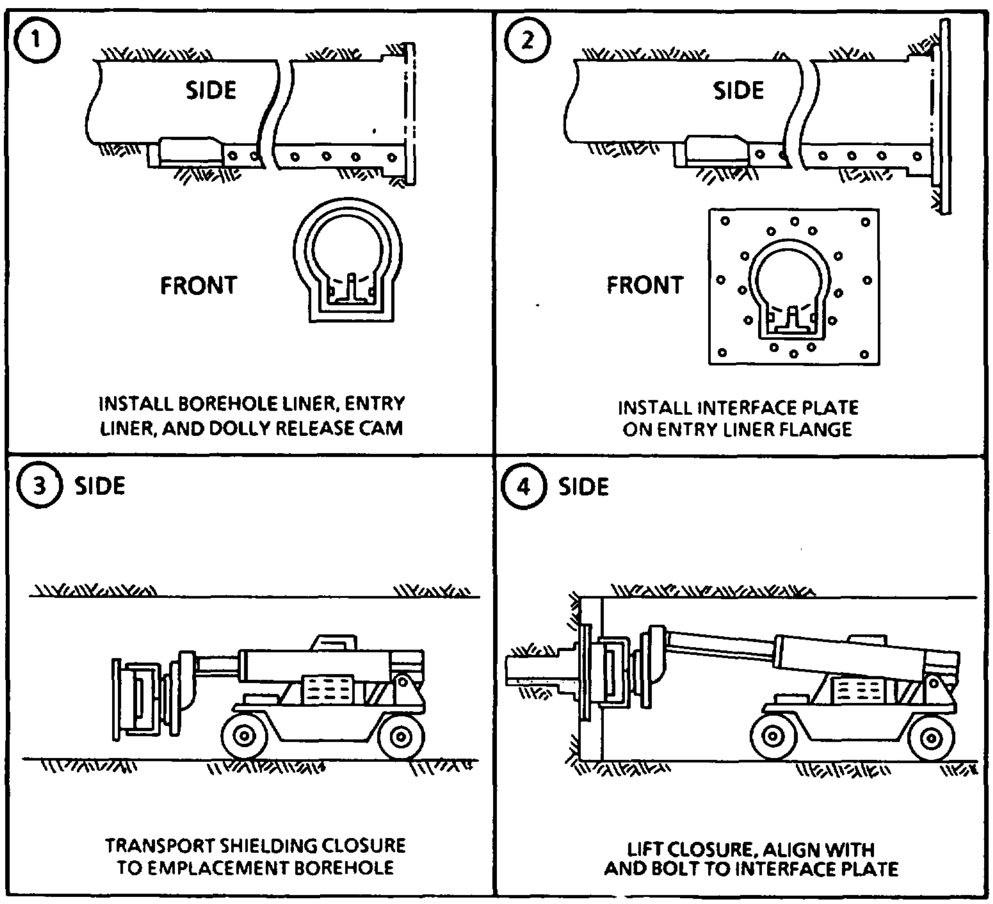

Figure 4-48. Preparation of a Horizontal Borehole for Emplacement (Stinebaugh et al., 1986)

Transfer of a single waste container from the surface facility to a horizontal borehole is illustrated in Figure 4-49. In this configuration, each waste container is carried on its side on a dolly. After transferring a single waste container and its dolly from the surface storage

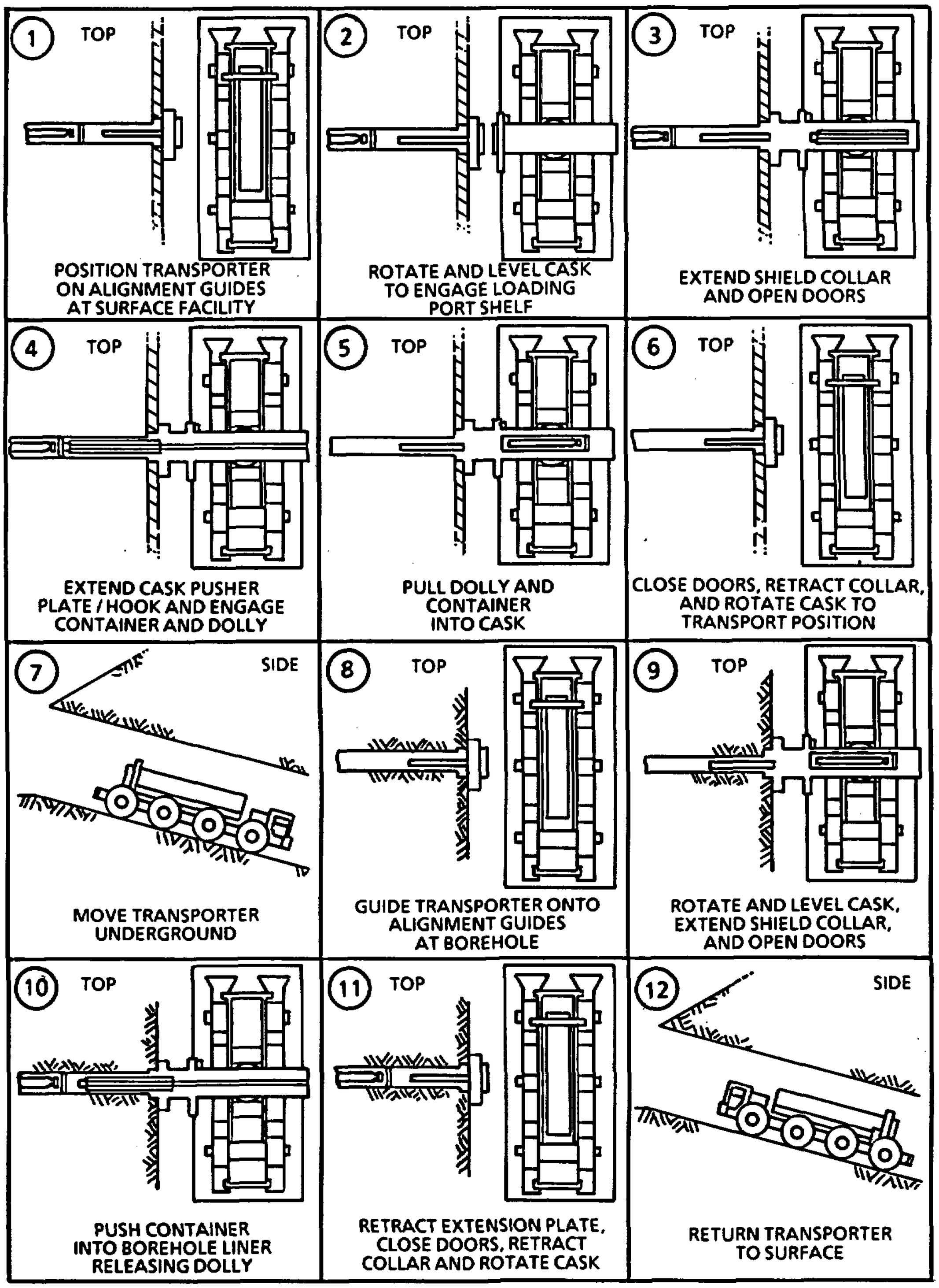

Figure 4-49. Emplacement of a Waste Container in the Horizontal Configuration (Stinebaugh et al., 1986.)

vault to the transporter cask, the transporter is driven to the emplacement borehole and is positioned at a temporary shielding closure. The cask is then rotated 90°, and the shielding doors are opened. The waste container and dolly are pushed into the borehole by the extension plate of the cask emplacement and retrieval mechanism, and the extension plate is disconnected from the dolly and retracted into the cask. The shield doors are then closed, the cask is rotated to its transport position, and the transporter is returned to the surface facility. This procedure is repeated until the borehole has been filled to design capacity.

Standoff between the last container emplaced and the emplacement drift to delay the onset of elevated temperatures in the emplacement drift can be accomplished in at least three ways. The first way is to use dummy containers or empty dollies, which are emplaced in the borehole in the same manner as that used for a waste container. The second method is to use a pusher mechanism equipped with hydraulic cylinders and coupled tubing to push the waste containers to the desired position. In the third method, the last few containers emplaced in each borehole could be filled with DHLW, which has very low thermal output. Use of the third option would depend on whether commingling of DHLW and spent fuel in the same borehole is acceptable.

After all waste containers for a given borehole have been emplaced and standoff operations have been completed, final borehole closure is accomplished by replacing the temporary borehole shielding closure with a shield plug and borehole cover, which allows the shielding closure to be used for waste emplacement operations at other boreholes. Closure is accomplished using a shielded plug installer transported by a special forklift (Figure 4-50). The shield plug installer is positioned at the borehole shielding closure, the shield doors are opened, and the shield plug is inserted in the borehole. The shield doors are then closed, the borehole shielding closure is removed, and the borehole cover is installed.

An isometric drawing of the waste transporter in the transport mode is shown in Figure 4-51 and in the emplacement mode in Figure 4-52. The transporter and the other equipment needed to emplace waste in the horizontal configuration are described in Appendix D of this report.

4.5.4 Waste Removal Operations for Performance Confirmation

Waste emplacement equipment will be designed so that it can also be used for removing containers for the purpose of performance confirmation. Because of site characteristics and repository design, conditions during waste removal operations are not generally expected to differ significantly from emplacement conditions. Some of the differences that do exist have been considered during development of the equipment concepts and will be considered during future, more detailed design of the emplacement equipment. For example, emplacement equipment will be designed to operate normally at the elevated borehole temperatures (greater than 200°C) that are expected during removal operations. Also, emplacement equipment will be designed to operate in a removal mode and to have the capability of developing the higher forces that may occur during removal.

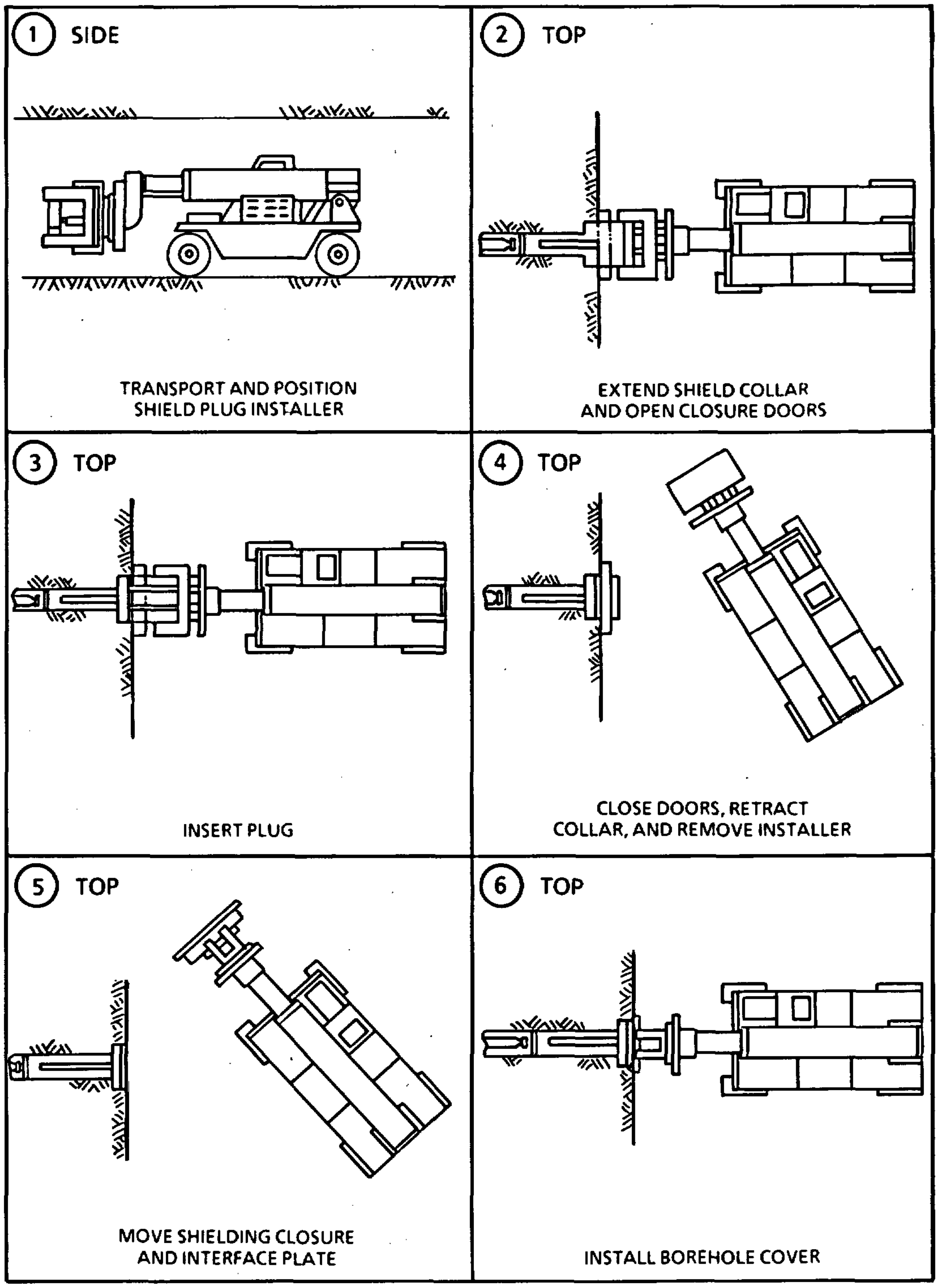

Figure 4-50. Borehole Closure Operations in the Horizontal Configuration (Stinebaugh et al., 1986.)

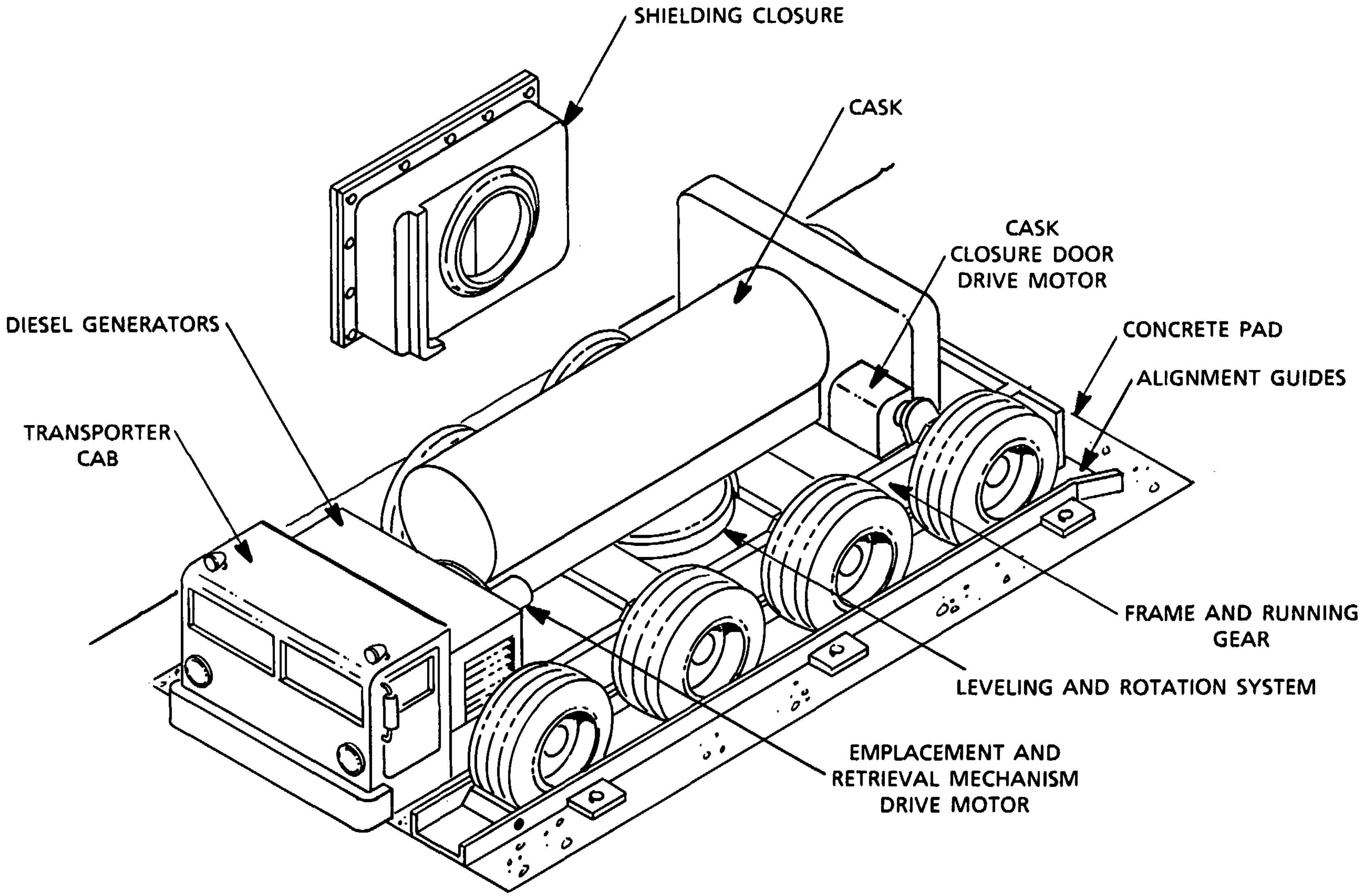

Figure 4-51. Waste Transporter in the Transport Mode in the Horizontal Configuration (Stinebaugh et al., 1986.)

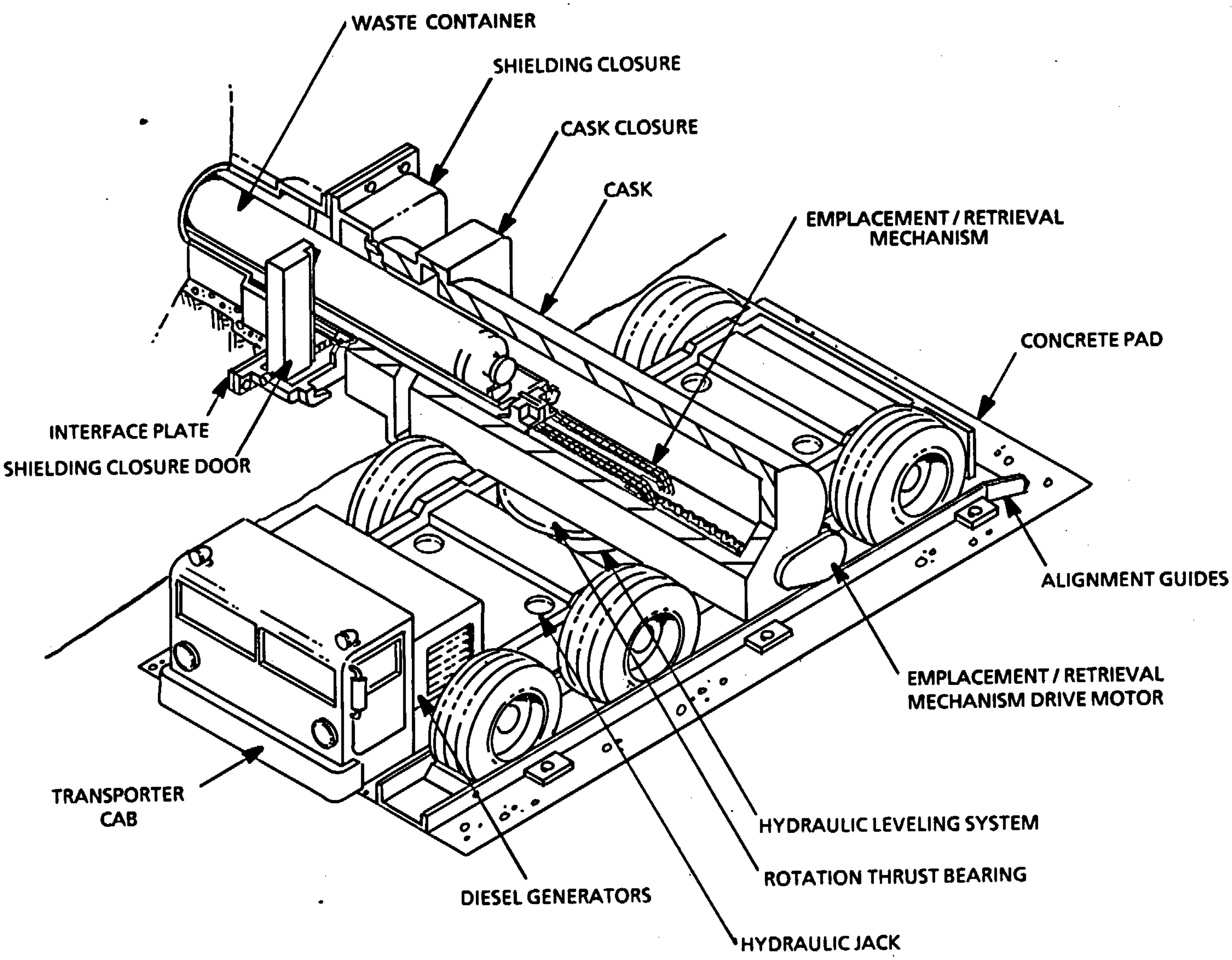

Figure 4-52. Waste Transporter in the Emplacement Mode in the Horizontal Configuration (Stinebaugh et al., 1986.)

4.5.4.1 Vertical Configuration

In the vertical configuration, the operations involved in removing waste under normal conditions for performance confirmation are conceptually the reverse of the operations performed to emplace waste, and the equipment for waste removal is the same as that for emplacement. Removal operations may be somewhat more difficult because of uncertainties regarding the conditions of the boreholes and containers. Preparation of the borehole for waste removal, which involves replacing the shield plug with the temporary borehole shielding closure, is shown in Figure 4-53. Removal of waste from the borehole and transport to the performance confirmation building are illustrated in Figure 4-54.

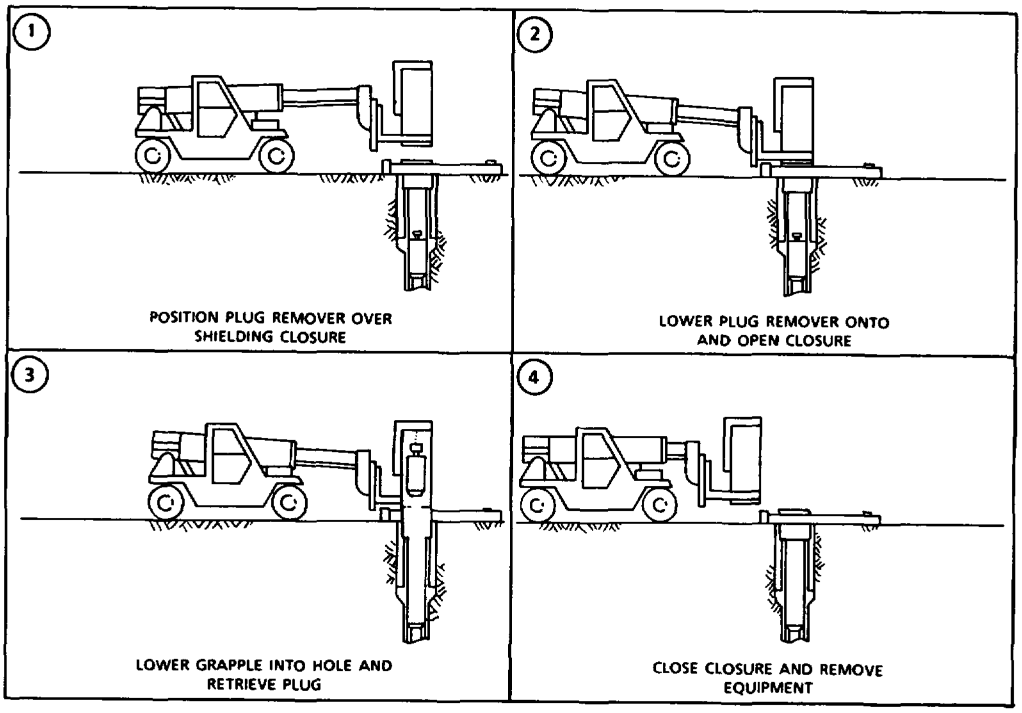

Figure 4-53. Preparation of the Vertical Borehole for Waste Removal (Stinebaugh and Frostenson, 1986.)

4.5.4.2 Horizontal Configuration

Figure 4-55 shows preparation of the horizontal borehole, which involves replacing the shield plug with the temporary borehole shielding closure.

Two concepts are under consideration for removing waste containers from horizontal boreholes (Section 3.2 and Appendix J). The first of these concepts has been presented in an earlier Sandia report (Stinebaugh et al., 1986) and is currently considered the reference design concept.

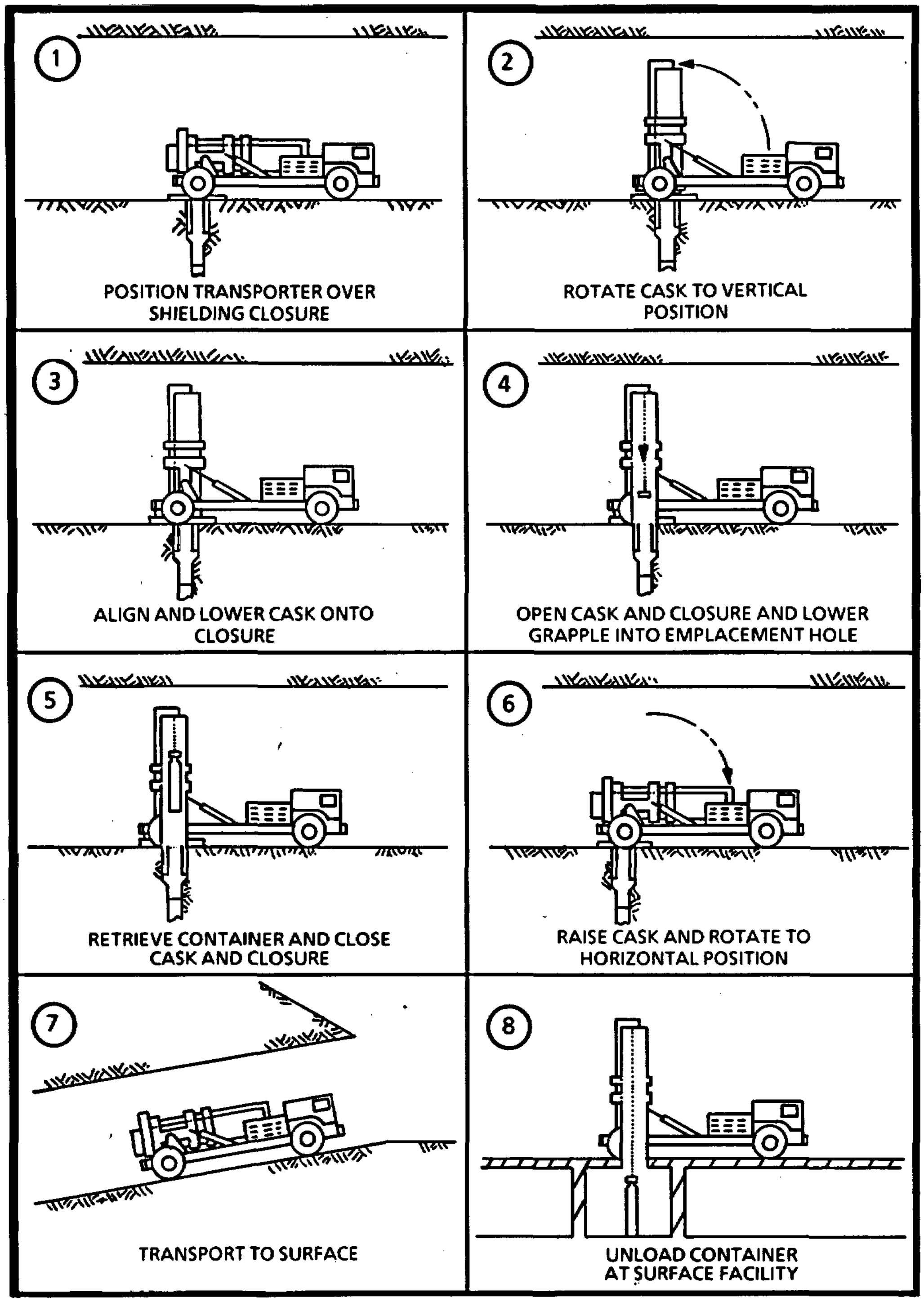

Figure 4-54. Removal of Waste for Performance Confirmation in the Vertical Configuration (Stinebaugh and Frostenson, 1986.)

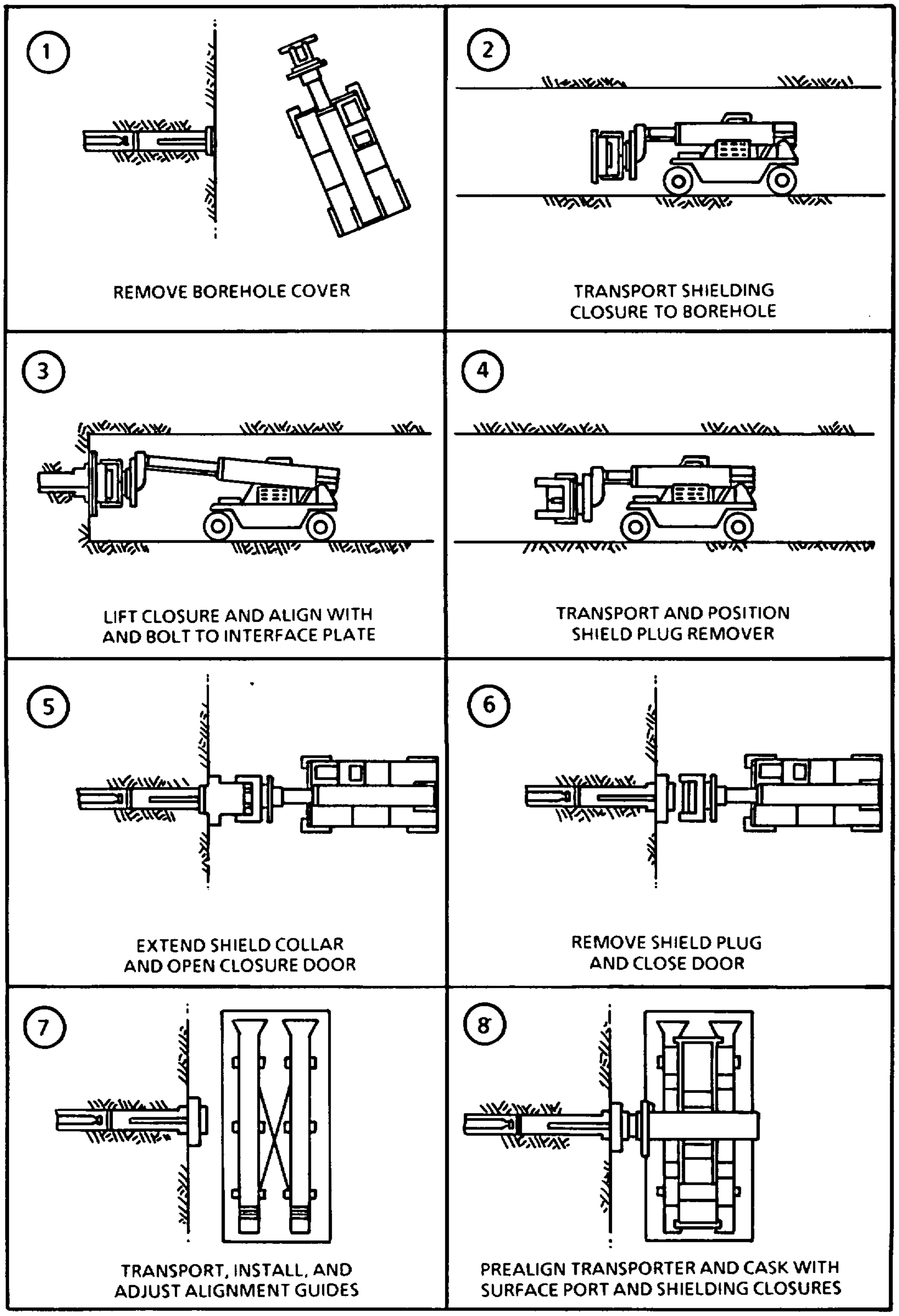

Figure 4-55. Preparation of the Horizontal Borehole for Waste Removal (Stinebaugh et al., 1986.)

The second is presented as an alternative design concept and is currently under consideration because it improves the ability to retrieve waste under off-normal conditions.

4.5.4.2.1 Baseline Concept for Waste Removal

Coupled waste container dollies are used in the reference waste removal concept. As each waste container and dolly unit is emplaced in the borehole by the cask mechanism, the dolly hooks onto the dolly of the waste container positioned at the borehole entrance, and the entire dolly train is pushed into the borehole. Similarly, as each waste container and dolly unit is removed from the borehole by the cask mechanism, the entire dolly train is pulled toward the borehole entrance, and the waste container being removed is unhooked from the train. Operations required to remove a waste container from a borehole and transport it to the performance confirmation building are illustrated in Figure 4-56.

4.5.4.2.2 Alternative Concept for Waste Removal

An alternative concept for removing waste containers from horizontal boreholes uses a design in which the dollies are not coupled. In this design, all containers are pushed into the borehole as each container is emplaced; however, because the dollies are not coupled, each container to be removed must first be pulled from its disposal position in the borehole to the standard removal position near the borehole entrance. The concept uses a retrieval cart to pull each container to the standard removal position.

Design considerations related to the retrieval cart system are described in Appendix J.

4.6 Systems, Structures, and Components Important to Safety or Waste Isolation

Systems, structures, and components are classified in two categories (1) items important to safety and (2) items important to waste isolation. This section focuses on the results of the analyses that identify items in both of these categories. This identification requires the definition of each category and the development of logical and objective methods to identify items in each category. The definitions of these categories are discussed in Section 2.7; however, as each category is discussed, the definition will be repeated. The methods used to identify items belonging in each category are discussed in detail in Section 7.4 and will be explained only briefly here.

4.6.1 Items Important to Safety

Items important to safety are defined in 10 CFR 60.2 as "those engineered structures, systems, and components essential to the prevention or mitigation of an accident that could result in a radiation dose to the whole body, or any organ, of 0.5 rem or greater at or beyond the nearest boundary of the unrestricted area at any time until the completion of permanent closure." Although the definition places no qualifications on

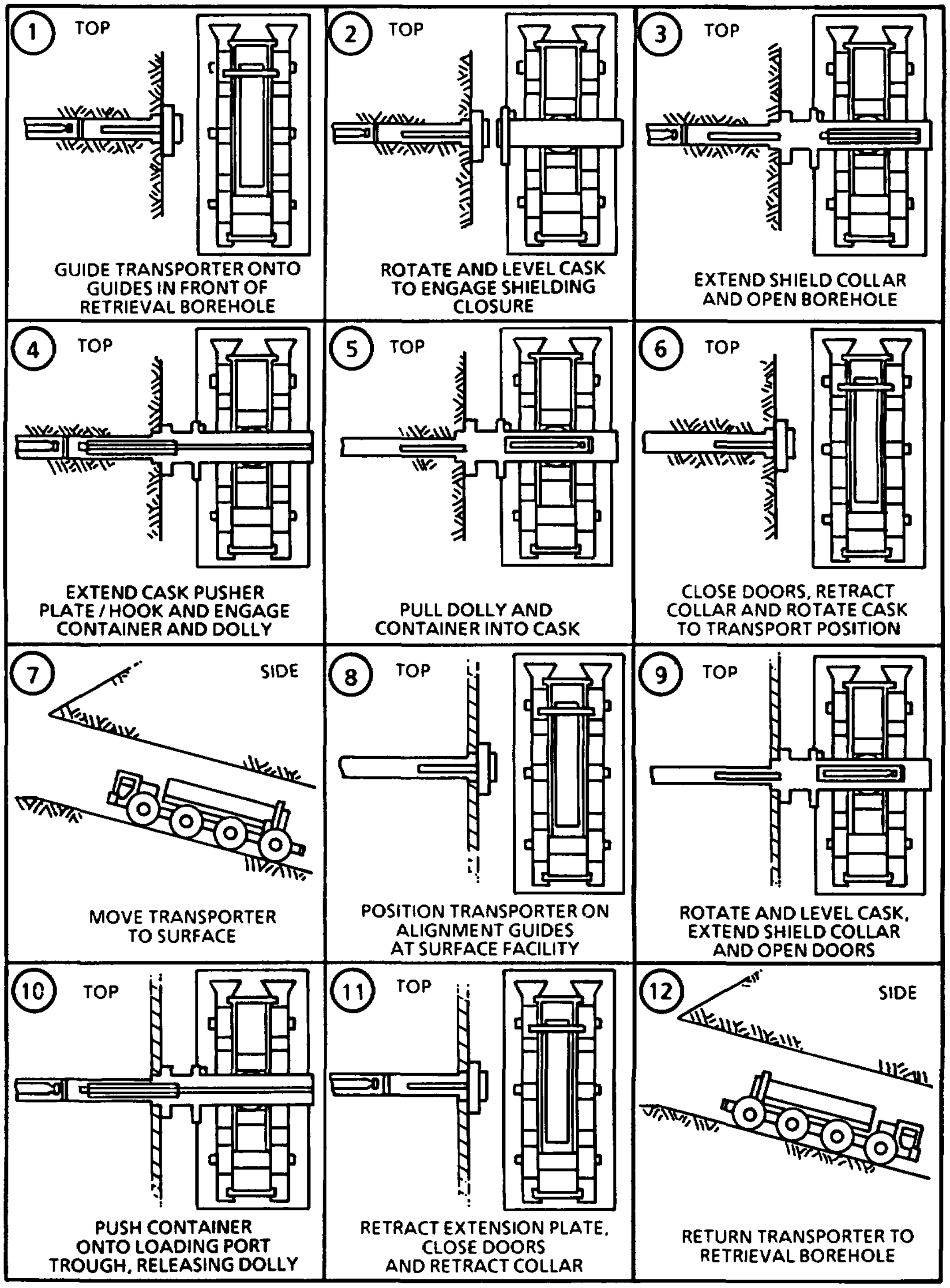

Figure 4-56. Baseline Concept for the Removal of Waste for Performance Confirmation in the Horizontal Configuration (Stinebaugh et al., 1986.)

the accidents used to identify items important to safety, the accidents must be credible, having a probability of occurrence of 10^{-5}/yr or greater (DOE, 1986b).

The methods used to identify these items consist of seven basic steps:

- develop facility and system models of the repository;
- identify and screen initiating events that could lead to accidents that might release radionuclides into the environment;
- perform an accident scenario analysis using event and fault trees;
- perform parallel assessments of the probability and consequences of each accident scenario;
- use these assessments to quantify the event trees;
- screen the accident scenarios for those that lead to conditions exceeding the criteria given in the definition of important to safety; and
- analyze those accident scenarios that exceeded the screening criteria to identify which systems, structures, or components involved in the scenario are important to safety.

Section 7.4.1 explains in detail the process and analyses described above.

After performance of the first six steps of the above analysis, it was determined that there were no accident scenarios that exceed the screening criteria; i.e., no accident scenarios resulted in an offsite release of radioactivity in excess of 0.5 rem that also had a probability of occurrence greater than 10^{-5}/yr. Because no accident scenarios exceeded the screening criteria, no systems, structures, or components were classified as important to safety. However, there were some systems, structures, and components classified as "potentially important to safety." Table 4-6 lists items potentially important to safety for the Yucca Mountain repository.

Future work on the design of the repository will include information and ideas developed during the analysis performed to determine items important to safety. As the design of the repository progresses and more details are known, this analysis will be repeated, a revised list of items potentially important to safety will be developed, and any items on that list that are important to safety will be identified. Information developed in future analyses of items important to safety will be used in improving the safety of the repository.

4.6.2 Items Important to Waste Isolation

Items important to waste isolation are defined in Section 2.7.2 as the barriers, structures, systems, and components that are relied on to achieve the postclosure performance objectives in 10 CFR 60, Subpart E.

TABLE 4-6

ITEMS POTENTIALLY IMPORTANT TO SAFETY FOR THE YUCCA MOUNTAIN REPOSITORY

Item	Location	Initiating Events
Crane, Shipping Cask	Cask-receiving and preparation area	Crane drops a shipping cask.
Hot Cell Structure	Waste-packaging hot cell	Earthquake causes hot cell structure failure.
Crane	Cask-unloading hot cell Consolidation hot cell Waste-packaging hot cell	Earthquake causes crane to drop on fuel assemblies.
Vehicle Stop	Cask-receiving and preparation area	Vehicle with cask falls in cask preparation pit (detailed analysis not performed).
Fire Protection System	Waste-handling buildings	Fire involving radioactive material is a dispersion parameter (detailed analysis not performed).
Cask Transfer Mechanism	Surface storage vault	CTM drops container with consolidated fuel rods.
Transporter Cask	Underground facility and ramp	Transporter coasts down the waste ramp and strikes the wall of the ramp or main access drift.

The Q-List contains the engineered barriers that meet this definition. The activities list contains the activities that might adversely affect the natural barriers that meet the definition of "important to waste isolation."

The process that has been used to select items for the Q-List and the activities list is described in Section 7.4.2 of this report. The preliminary Q-List includes the waste container. The preliminary activities list includes activities that have the potential for adversely affecting the waste isolation capabilities of the Topopah Spring welded unit, the Calico Hills nonwelded zeolitic unit, the Calico Hills vitric unit, and the saturated zone.

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