BSC

Design Calculation or Analysis Cover Sheet

Complete only applicable items.

1. QA: N/A

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Fire Protection	800-M0A-FP00-00100-000-00A

5. Title

Subsurface Repository Fire Hazard Analysis

6. Group

Mechanical/Fire Protection

7. Document Status Designation

☐ Preliminary ☒ Committed ☐ Confirmed ☐ Cancelled/Superseded

8. Notes/Comments

This analysis supersedes the Subsurface Repository Fire Hazard Analysis, 800-30R-PF00-00100-000-00A.

Attachments	Total Number of Pages
This analysis does not contain attachments	N/A

RECORD OF REVISIONS

9. No.	10. Reason For Revision	11. Total # of Pgs.	12. Last Pg. #	13. Originator (Print/Sign/Date)	14. Checker (Print/Sign/Date)	15. EGS (Print/Sign/Date)	16. Approved/Accepted (Print/Sign/Date)
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DISCLAIMER

The analyses contained in this document were developed by the Bechtel SAIC Company, LLC (BSC) and are intended solely for the use of BSC in its work for the Yucca Mountain Project.

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ACRONYMS AND ABBREVIATIONS

ACRONYMS

BSC	Bechtel SAIC Company, LLC
CCCF	Central Control Center Facility
CFR	Code of Federal Regulations
CRWMS	Civilian Radioactive Waste Management System
DBF	design basis fire
DCMIS	digital control and management information system
DIRS	Document Input Reference System
DOE	U.S. Department of Energy
ECRB	Enhanced Characterization of the Repository Block
ERSs	emergency refuge stations
ESF	Exploratory Studies Facility
FHA	Fire Hazard Analysis
FRO	Fire/Rescue Organization
HEMF	Heavy Equipment Maintenance Facility
IEEE	Institute of Electrical and Electronics Engineers
ITS	important to safety
ITWI	important to waste isolation
LSC	Life Safety Code
MPFL	maximum possible fire loss
MSHA	Mine Safety and Health Administration
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
RHH	repository host horizon
SC	safety category
SCSR	self-contained self-rescuer
SONET	Synchronous Optical Network
SR	self rescuer
SSC	structure, system or component

TAD	transport/aging disposal canister
TEV	Transport and Emplacement Vehicle
WP	waste package
YMP	Yucca Mountain Project

ABBREVIATIONS

Btu	British Thermal Unit
°C	degree Centigrade
cfm	cubic feet per minute
°F	degree Fahrenheit
ft	feet
hr	hour
m	meter
m^3/s	cubic meters per second

1. PURPOSE

This Fire Hazard Analysis (FHA) evaluates comprehensively and qualitatively the risk from fire within individual fire areas to ascertain whether the BSC *Fire Protection Program* fire safety objectives are met (Reference 2.1.2, Section 4.2).

1.1 OBJECTIVE

The objective of this FHA is to assure the requirements established for the comprehensive fire and related hazards protection program for the subsurface repository (emplacement only) are sufficient to minimize the potential for:

- The occurrence of fire or related events.
- A fire that causes an unacceptable onsite or offsite release of hazardous or radioactive material that will threaten the health and safety of employees, the public, or the environment.
- Vital DOE programs suffering unacceptable interruption as a result of fire and related hazards.
- Property losses from a fire and related events exceeding limits established by DOE.
- Critical process controls and safety class systems being damaged as a result of fire and related events.

(Reference 2.2.1.13, Section 4.2(1)

The fire hazard analysis accomplishes the following objectives:

- Considers potential in-situ and transient fire hazards.
- Determines the consequences of fire in any location in the emplacement area on the ability to minimize and control the release of radioactivity to the environment; and
- Specifies measures for fire prevention, fire detection, fire suppression, and fire containment for the fire area containing structure, systems and components (SSC) Important to Safety (ITS) in accordance with U.S. Nuclear Regulatory Commission (NRC) Guidelines and Regulations.

(Reference 2.2.1.16, Chapter C, Section 1.2)

This analysis will be revised as necessary to reflect plant design and operational changes.

1.2 SCOPE

This FHA identifies proposed design features, fire and explosion hazards and provides a reasonable basis for the design of fire protection systems and features that will provide a proper level of personnel safety and property protection. This is accomplished by reviewing the proposed subsurface repository design and operation descriptions. It confirms the design is in accordance with the appropriate codes, standards and project documents (including Integrated Safety Management (ISM)) and provides classification, identification, and assessment of the fire and explosion hazards within the various fire zones.

This FHA documents the recommendations for mitigating identified fire hazards and adverse effects of fire-extinguishing agents. The subsurface repository *Underground Layout Configuration for L.A.,* (Reference 2.2.1.5) describes the facility design. This FHA is used to support the License Application.

The site areas and facilities interfacing with the Subsurface Repository FHA are beyond the scope of this analysis and are separately addressed in the *Site Fire Hazard Analysis*. (Reference 2.2.1.19)

1.3 LIMITATIONS

- This FHA is limited to the subsurface emplacement side of the repository as described in the *Basis of Design for the TAD Canister Based Repository Design Concept* (Reference 2.2.1.9, Section 8). A separate FHA will be performed for the subsurface repository construction (development) activity during detailed engineering design.

- The description of the facility, equipment, and fire protection features is based on information available for the analysis. Figure 1 through Figure 7 of this document is used as an aid to describe the subsurface repository for this analysis. The layout figures are taken from the *Underground Layout Configuration for LA* (Reference 2.2.1.5, Figures 1, 5, 7 through 10). The FHA will be updated during detailed design when additional design information is available.

- Where initial design information does not allow for a complete analysis, specific assumptions related to the design are documented in Section 3.

- The identification of systems, structures, and components (SSCs) categorized as important to safety (ITS) is preliminary. All SSCs classified as ITS are documented in the *Basis of Design for the TAD Canister-Based Repository Design Concept* (Reference 2.2.1.9).

- Detailed design information, such as cable routing, will be developed in future designs and may result in changes to the combustible material quantities in some fire zones.

- Combustible material quantities for each fire area are preliminary and are based on engineering judgment. Detailed design information such as cable routing and the specific types of cabling material will be developed in detail design. This information may change the amount of combustible material quantities within some fire zones. Detail design will allow for evaluation of cable routing and exposed cabling.

The results from this document are not to be used directly for procurement, fabrication, or construction.

2. REFERENCES

2.1 PROJECT PROCEDURES/DIRECTIVES

2.1.1 EG-PRO-3DP-G04B-00037, Rev. 9. *Calculations and Analyses*. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070717.0004.

2.1.2 EM-DIR-02, Rev. 0. *Fire Protection Program (FPP)*. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20060227.0010. [DIRS 176726]

2.1.3 Dyer, J.R. 2000. "*Exploratory Studies Facility (ESF) Fire Fighting Policy*." Letter from J.R. Dyer (DOE/YMSCO) to G.E. Dials (CRWMS M&O), November 8, 2000, OPE: RBB-0104. ACC: MOL.20001204.0312. [DIRS 155248]

2.2 DESIGN INPUTS

This section identifies and documents technical product inputs and sources of input used in the development of this document.

2.2.1 Criteria

The fire protection design criteria supporting the preliminary and final design of the subsurface repository are based on information in the *Project Design Criteria Document* (Reference 2.2.1.3, Section 4.9.1).

2.2.1.1 BSC 2004. *Preliminary Hazards Analysis for License Application Study.* 000-30R-HPYK-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040610.0002. [DIRS 167313]

2.2.1.2 BSC 2004. *Wildfire Exposure Calculation.* 000-00C-MGR0-00400-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040211.001; ENG.20050816.0011. [DIRS 168205]

2.2.1.3 BSC 2006. *Project Design Criteria Document*. 000-3DR-MGR0-00100-000-006. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061201.0005. [DIRS 178308]

2.2.1.4 BSC 2003. *Underground Layout Configuration.* 800-P0C-MGR0-00100-000-00E. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20031002.0007; ENG.20050817.0005. [DIRS 165572]

2.2.1.5 BSC 2007. *Underground Layout Configuration for LA.* 800-KMC-SS00-00200-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070727.0004. [DIRS 179640]

2.2.1.6 BSC 2007. *Integrated System Operation Report; Subsurface Facility*. 000-30R-MGR0-02400-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070223.0007. [DIRS 179669]

2.2.1.7 BSC 2004. *Subsurface Repository Piping & Instrument Diagram Fire Alarm & Detection System.* 800-M60-PF00-00101-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040120.0011 [DIRS 167070]

2.2.1.8 BSC 2007. *WP Transport & Emplacement Vehicle Process & Instrumentation Diagram (Sheet 1 of 2).* 800-M60-HE00-00101-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070131.0001. [DIRS 182300]

2.2.1.9 BSC 2006. *Basis of Design for the TAD Canister-Based Repository Design Concept.* 000-3DR-MGR0-00300-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061023.0002. [DIRS 177636]

2.2.1.10 BSC 2007. *Subsurface Emplacement Ventilation System Design Analysis.* 800-KVC-VUE0-00400-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070425.0003; ENG.20070508.0001. [DIRS 180537]

2.2.1.11 BSC 2003. *Design Analysis for the Yucca Mountain Project Communications System.* 000-EFR-EC00-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030820.0011. [DIRS 165551]

2.2.1.12 DOE G 440.1-5. 1995. *Implementation Guide for Use with DOE Orders 420.1 and 440.1 Fire Safety Program.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20050518.0094. [DIRS 144423]

2.2.1.13 DOE O 420.1A. 2002. *Facility Safety.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20050411.0135. [DIRS 159450]

2.2.1.14 DOE-STD-1066-99. 1999. *Fire Protection Design Criteria.* Washington, D.C.: U.S. Department of Energy. TIC: 249984. [DIRS 154954]

2.2.1.15 NFPA 2003. *Fire Protection Handbook.* 19th Edition. Two volumes. Quincy, Massachusetts: National Fire Protection Association. TIC: 254223. ISBN: 0-87765-474-3. [DIRS 161692]

2.2.1.16 Regulatory Guide 1.189. 2001. *Fire Protection for Operating Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20060105.0191. [DIRS 155040]

2.2.1.17 Not used.

2.2.1.18 BSC 2007. *Shaft Collars and Fan Layout General Arrangement Analysis.* 800-KVC-VU00-00400-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070716.0026

2.2.1.19 BSC 2007. *Site Fire Hazard Analysis.* 000-M0A-FP00-00200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070814.0003

2.2.1.20 MSA (Mine Safety Appliances) 2002. *Life-Saver™ 60, Self-Contained Self Rescuer (SCSR) 60-Minute Breathing Apparatus, Instruction Manual.* TAL 202 (L) Rev. 3, 815799. Pittsburgh, Pennsylvania: Mine Safety Appliances. TIC: 255349. [DIRS 166304]

2.2.2 Codes and Standards

2.2.2.1 29 CFR 1910. Labor: Occupational Safety and Health Standards. Internet Accessible. [DIRS 177507]

2.2.2.2 29 CFR 1926. Labor: Safety and Health Regulations for Construction. Internet Accessible. [DIRS 177634]

2.2.2.3 Deleted

2.2.2.4 IEEE Std 1202-2006. *IEEE Standard for Flame-Propagation Testing of Wire and Cables for Use in Cable Tray in Industrial and Commercial Occupancies.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258697. ISBN: 0-7381-5000-2. [DIRS 177949]

2.2.2.5 NFPA 10. 2006. *Standard for Portable Fire Extinguishers.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258708. ISBN: 0-87765-646-0. [DIRS 177964]

2.2.2.6 NFPA 30. 2006. *Flammable and Combustible Liquids Code, with Errata.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258720. ISBN: 0-87765-648-7. [DIRS 177974]

2.2.2.7 NFPA 51B. 2003. *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 255487. ISBN: 0-87765—648-7. [DIRS 1668980]

2.2.2.8 NFPA 68. 2004. *Guide for Venting of Deflagrations, with Errata No. 68-02-1.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258044. ISBN: 0-87765-649-5. [DIRS 176265]

2.2.2.9 NFPA 70. 2005. *National Electrical Code, with Tentative Interim Amendment.* 2005 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258735. ISBN: 0-87765-649-5. [DIRS 177982]

2.2.2.10 NFPA 72. 2006. *National Fire Alarm Code.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258740. ISBN: 0-87765-650-9. [DIRS 177984]

2.2.2.11 NFPA 101. 2006. *Life Safety Code, with Errata and Tentative Interim Amendments.* 2006 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258709. ISBN: 0-87765-651-7. [DIRS 177965]

2.2.2.12 NFPA 221. 2005. *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls.* 2006 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258552. ISBN: 0-87765-652-5. [DIRS 177544]

2.2.2.13 NFPA 502. 2005. *Standard for Road Tunnels, Bridges and Other Limited Access Highways, with Errata.* 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258731. ISBN: 0-87765-654—1. [DIRS 177978]

2.2.2.14 NFPA 780. 2004. *Standard for the Installation of Lightning Protection Systems.* 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257246. ISBN: 0-87765-654-1. [DIRS 173517]

2.2.2.15 NFPA 1144. 2002. *Standard for Protection of Life and Property from Wildfire.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253676. ISBN: 0-87765-656-8. [DIRS 160936]

2.2.2.16 NFPA 2001. 2004. *Standard for Clean Agent Fire Extinguishing Systems.* 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257207. ISBN: 0-87765-658-4. [DIRS 172600]

2.3 DESIGN CONSTRAINTS

No Design Constraints were identified in the development of this FHA.

2.4 DESIGN OUTPUTS

This calculation/analysis will be used as input for other calculations/analyses.

The conclusion of this fire hazard analysis ensures this facility complies with the objectives identified in Section 1.1. The results of this analysis identify fire safety deficiencies in the current design and identify required design features to mitigate each deficiency. The required design features are in Section 7.

3. ASSUMPTIONS

3.1 ASSUMPTIONS REQUIRING VERIFICATION

The following assumptions require verification, and are therefore being tracked in the CalcTrac Database.

3.1.1 Fire Fighting

Assumption: Fire protection systems provide for, and credit access to, a fully staffed, completely equipped and adequately trained Fire/Rescue Organization (FRO) capable and committed to respond to fires and related emergencies onsite in a timely and effective manner.

Rationale: In order to provide defense-in-depth, manual fire fighting capability will be required. A YMP full-time site FRO is anticipated to be established and fully functional prior to start of operations. This assumption is based on the discussions of the *Fire Protection Program* (Reference 2.1.2).

3.1.2 Maximum Possible Fire Loss

Assumption: The Maximum Possible Fire Loss (MPFL) of a fire zone is the assessed value of the property excluding its land value. The value of an individual fire zone is currently unknown. Therefore, it assumed that this value will not exceed \$50-million. This loss determination will also include direct and indirect costs associated with the fire and clean-up operations (Reference 2.2.1.12, Section IV, 4.7).

Rationale: During detailed design, if the MPFL is found to exceed \$50 million, redundant fire suppression will be provided (Reference 2.2.1.14, Section 5.1.1).

3.1.3 Combustible Materials Quantities

Assumption: An assessment of combustible material loading in each fire area/zone will be deferred until detailed design at which time the following categorization of quantities will be applied.

Quantity	Average Combustible Load (CL) (Btu/sq.ft.)	Isolated Concentrations (Btu/sq.ft.)	Equivalent Fire Severity (Hours)
Very Low	CL < 20,000	CL < 40,000	0.25
Low	20,000 < CL < 80,000	CL < 160,000	1.00
Moderate	80,000 < CL < 160,000	CL < 320,000	2.00
High	160,000 < CL < 240,000	CL < 480,000	3.00

Rationale As the design develops, quantification of combustible loads will be possible (See Section 1.3). The terms used in the table are defined in the *Fire Protection Handbook* (Reference 2.2.1.15, Section 12, Chapter 5). Combustible material loads are derived from the *Fire Protection Handbook* (Reference 2.2.1.15, Table 12.5.1) and equivalent fire severity modeled on British fire loading studies (Reference 2.2.1.15, Section 12, Chapter 5).

3.1.4 Occupancy Classification

Assumption: The emplacement fire area is assumed classified for life safety occupancy as Special Purpose Industrial.

Rationale: The fire hazards in the emplacement fire area are very-low to low (Assumption 3.1.3). The life safety occupancy classification is similar to those assigned to the Surface Nuclear Facilities. Therefore, it is reasonable to classify the emplacement area as equivalent to "Special Purpose Industrial." A special purpose industrial occupancy conducts low hazard industrial operations in facilities suitable only for particular types of operations. Such occupancy is characterized by a low density of employee population.

3.1.5 Non-Nuclear Hazards Analysis

Assumption: The non-nuclear external and internal hazards analyzed in this document are anticipated to be similar to those established for the previous design concepts, as documented in the current *Preliminary Hazards Analysis for License Application Study* (Reference). For this analysis, the Subsurface Repository is assumed similar to the previous Subsurface Repository Facility.

Rationale: The analysis of non-nuclear hazards, for the TAD-based design, will be documented in a future revision to the *Preliminary Hazards Analysis for License Application Study*. Previous design iterations analyzed the external and internal hazards for the Subsurface Repository. Therefore, it is reasonable to assume that these facilities and systems will identify the same hazards.

3.2 ASSUMPTIONS NOT REQUIRING VERIFICATION

3.2.1 Design Basis Fire

Assumption: The design basis fire (DBF) in the subsurface repository assumes and evaluates the consequences of the single worst-case fire that can be postulated for the hazards within a fire zone. This includes both fixed and transient combustibles. It also assumes the fire will occur while the installed automatic fire protection system malfunctions, and there will be no manual response to suppress the fire. The fire is assumed to consume all available combustibles within the fire zone. It is assumed that a fire may occur at any time but is not postulated to occur simultaneously with another design basis event.

Rationale: The assumption is based on DOE G 440.1-5, Section IV, paragraph 4.6 & 4.7 (Reference 2.2.1.12) which indicated the "FHA should assume and evaluate the consequences of a single, worst-case automatic fire protection system malfunction." And in determining the value of the MPFL, the basic assumption should be that there is no manual or automatic suppression. This allows the fire protection engineer to determine the fire protection mitigating design features for the worst-case fire.

3.2.2 High-Value Property

Assumption: High-Value property is assumed to be individual pieces of equipment and/or individual systems with a value exceeding $1 million (Reference 2.2.1.14, Section 5.3.1).

Rationale: The assigned values do not require verification because they represent costs to establish a rough order-of-magnitude dollar estimate for property loss and only approximate values are required for this FHA. An order-of-magnitude change in these values will not impact the conclusions of this FHA.

3.2.3 Reference Drawings

Assumption: The reference drawings used as the basis for this document are adequate/suitable to describe the facility functions.

Rationale: The drawings comprise the best available information when this FHA was prepared (Reference 2.2.1.5). As information that is more detailed is developed, this document will be revised. Revisions are planned during the detail design phases. In addition, this FHA will be reviewed annually after construction is complete, and will be revised as appropriate.

3.2.4 Training

Assumption: All onsite personnel with unescorted access to the subsurface will be trained in the use of portable fire extinguishers for fighting incipient stage fires.

Rationale: BSC Training, in conjunction with Safety and Health, will develop a training course for incipient stage fire fighting. The training course will be available for all onsite personnel with unescorted access in the subsurface. This is current Office of Repository Development policy (Reference 2.1.3).

3.2.5 Isolation Barrier

Assumption: Subsurface isolation barriers located between emplacement side of the repository and the development side are assumed to provide a fire resistance equivalent to 3-hours.

Rationale: The fire-resistance rating of the isolation barrier is required to be a minimum of 3-hours. This bounds an exposure fire from likely combustible liquid fire event scenarios in the development (construction) areas so as not to expose a Waste Package (WP) in the emplacement area of the repository. (Reference 2.2.1.3, Section 4.9.1.6)

4. METHODOLOGY

4.1 QUALITY ASSURANCE

This FHA was prepared in accordance with EG-PRO-3DP-G04B-00037, *Calculations and Analysis* (Reference 2.1.1). The fire protection structures, systems or components (SSCs) are classified as Non-Safety Category (Non-SC) and neither important to safety (ITS), nor important to waste isolation (ITWI) as indicated in the *Basis of Design for the TAD Canister-Based Repository Design Concept* (Reference 2.2.1.9, Section 18.1.2), and the fire protection functions they perform are non-ITS. Therefore, the approved version is designated as QA: N/A.

4.2 COMPUTER SOFTWARE AND MODEL USAGE

No software routines or models are used and no calculations are performed in the development of this analysis.

4.3 GENERAL

This analysis was prepared by qualified Fire Protection Engineers as directed by DOE O 420.1A, (Reference 2.2.1.13, Section 4.2.1), and as defined in DOE Standard 1066 (Reference 2.2.1.14, Section 4).

The FHA begins with a review of the project documents (basis of design, design criteria, and functional/operational requirements), regulatory requirements, industry codes/standards and drawings.

The FHA objectives are accomplished through the employment of a "defense-in-depth" approach to fire protection in order to achieve the required degree of personnel, facility, and environmental safety. Defense-in-depth means that fire safety is an integral part of all activities and that facilities are designed with both active and passive fire protection features such that reliance will not be placed on only one means to ensure an acceptable level of fire safety (Reference 2.2.1.12, Section III, paragraph 2.0).

The FHA utilizes a deterministic approach in each fire area/zone to identify potential fire hazards inherent in the design. The FHA identifies the fire protection features that mitigate these hazards. It assures the facility design and processes can be safely controlled and stabilized during and after a fire event. The FHA seeks to demonstrate that, as the results of a fire, facilities and processes presenting a potential for radioactive or toxic chemical release are properly controlled and designed to allow for a "safe state" configuration.

The primary documents used in the review, identification, and classification of the fire hazards are:

- Basis of Design for the TAD Canister-Based Repository Design Concept (Reference 2.2.1.9)

- Project Design Criteria Document (Reference 2.2.1.3)

The consequences of an assumed single, worst-case, fire event (Assumption 3.2.1) are determined, and then fire protection design features are identified to mitigate or control the event.

This FHA contains, but is not limited to, an assessment of the following fire safety issues;

- The NRC fire protection requirements and guidance that apply
- Amounts, types, configurations, and locations of cable insulation and other combustible materials
- In-situ fire hazards
- Automatic fire detection and suppression capability
- Layout and configuration of SSCs ITS
- Reliance on and qualifications of fire barriers
- Location and type of manual firefighting equipment and accessibility for manual fire fighting

(Reference 2.2.1.16, Chapter C, Section 1.2, pages 18 and 19)

This FHA contains, but is not limited to, a conservative assessment of the following fire safety issues:

- Description of construction
- Description of critical process equipment
- Description of high-value property
- Description of fire hazards
- Description of operations
- Potential for a toxic, biological and/or radiation incident due to a fire
- Damage potential: Maximum Possible Fire Loss (MPFL)
- Fire protection features
- Protection of essential safety class systems
- Life safety considerations
- Recovery potential
- Exposure fire potential and the potential for a fire spread between two fire areas.

(Reference 2.2.1.12, Section IV, Paragraph 4.5)

The fire safety items below are generic and apply equally to all fire areas described. They include the following:

- Natural Hazards (Section 6.1.4)
- Emergency Planning (Section 6.1.3.5)
- Fire/Rescue Organization (FRO) response (Section 6.1.3.7)
- Security and safeguards considerations related to fire protection (Section 6.1.1.6)
- Effect of significant fire safety deficiencies (Section 6.2).

(Reference 2.2.1.12, Section IV, Paragraph 4.5)

4.4 FUNCTION AND ARRANGEMENT

4.4.1 Fire Area Boundaries

Fire area boundaries are a function of the subsurface repository construction chronology. Initially, the repository is one fire area, based on the NRC definition of Fire Area (Reference 2.2.1.3, Section 4.9.1.16.3). This is during the development phase. When waste emplacement begins, there are two fire areas. One is the Development Fire Area, the other is the Emplacement Fire Area described here. These two fire areas are physically separated by ventilation/isolation barriers. Finally, after completion of development, the repository reverts to one fire area after the isolation barriers are removed.

A fire area is defined as: "….that portion of a building or plant that is separated from other areas by fire barriers, including components of construction such as beams, joists, columns, penetration seals or closures, fire doors, and fire dampers. Fire barriers that define the boundaries of a fire area should have a fire-resistance rating of 3-hours or more…." (Reference 2.2.1.16, Section 4.1.2.1).

Consequently the ventilation/isolation barriers at the development/emplacement fire areas interface have a minimum fire-resistance rating of 3-hours (References 2.2.1.3, Section 4.9.1.16.2 with equivalently rated openings, dampers and penetration seals. The development and emplacement fire areas are considered as separate and distinct fire areas. The effects of fire contamination from one fire area to the other are adequately addressed by the barrier design constraints.

4.4.2 General Layout Description

The subsurface repository is developed in a series of modules or panels; the first panel provides early access for emplacement of waste (Reference 2.2.1.9, Section 2.2.1.10). For fire hazard analysis and fire protection design and planning purposes, each panel is defined as bounding a unique, separate, fire zone within the Emplacement Fire Area. The existing North Ramp is included with the Panel 1 fire zone and the existing South Ramp is included with the Panel 2 fire zone. The new North Construction Ramp is included with the Panel 3 fire zone. See Table 2 for fire zone designations. In addition, the Observation Drift (used for performance confirmation) is designated as a separate fire zone.

In this analysis, fire zones are numbered using the following methodology:

FZ – XXX – XX

Fire Zone Designator **FZ**
Panel or Drift **- PNL/PC**
Fire Area Number **- 01**

Table 1. Fire Zone Designations

Fire Zone	Emplacement Panel Number	Available Drift Length (Meters)
FZ-PNL-01	Panel 1	3,392 1
FZ-PNL-02	Panel 2	18,876 1
FZ-PNL-03	Panel 3	26,286 1
FZ-PNL-04	Panel 4	16,719 1
FZ-PC-01	Observation Drift	971 2 (Plan Length)

1. Source: Reference 2.2.1.5, Table 10
2. Source: Reference 2.2.1.5, Table 3

Panels 1, 2, 3, and 4 (Figure 1) are located in the primary block area of the repository host horizon (RHH). These panels accommodate the 70,000 metric tons of heavy metal case for license application. (Reference 2.2.1.9, Section 8.2.1.2)

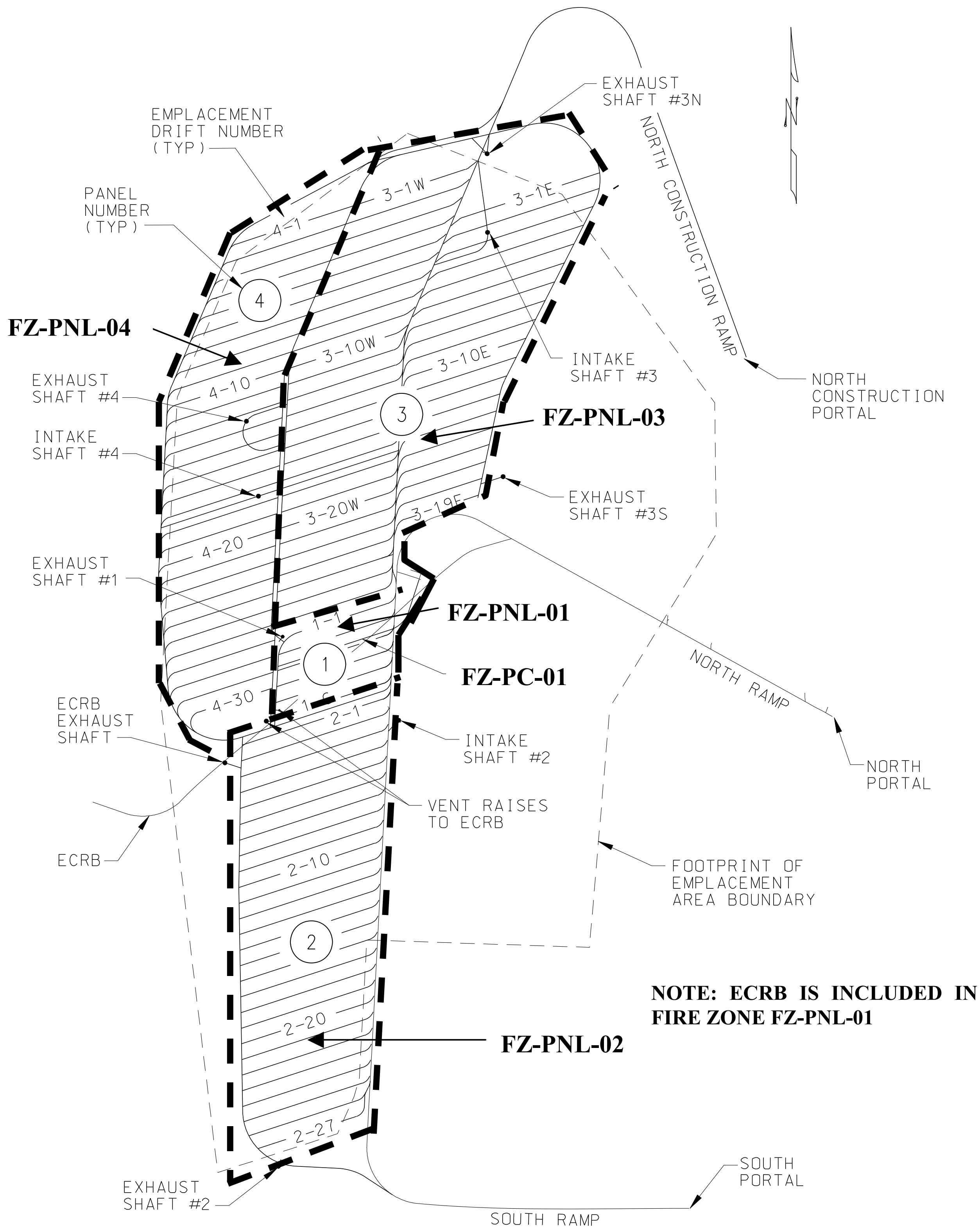
The Exploratory Studies Facility (ESF), the East-West Cross Drift, also known as the Enhanced Characterization of the Repository Block (ECRB), and the Thermal Testing Facility Alcove are incorporated into the underground layout." (Reference 2.2.1.4, Section 5.1.2)

4.4.3 Existing Ramps and Mains

"The ESF is located as an integral part of the underground layout configuration such that the ramps in the ESF provide access to the RHH. As shown in Figure 1, each panel consists of an access main on the intake side of the emplacement drifts and an exhaust main at the exhaust side of the emplacement drifts. The access mains and exhaust mains are located in the same plane as the emplacement drifts." (Reference 2.2.1.4, Section 8.2)

4.4.4 Thermal Testing Facility Alcove

"The Thermal Testing Facility Alcove (Figure 7) is incorporated into the underground layout. This alcove provides access for an Observation Drift below the first few emplacement drifts in Panel 1 of the repository." (Reference 2.2.1.4, Section 5.1.2.3)



Source: (Reference 2.2.1.5. Figure 1)

Figure 1. Underground Layout Configuration

4.4.5 North Construction Ramp

For access to the north end of the repository, a new North Construction Ramp will be excavated (See Figure 1) that connects with the ESF. This ramp is sized at 7.62-m (25-ft) similar to the ESF ramps. To protect from potential flooding, the initial 10-m (33-ft) lead-in section (from the portal) of the ramp is sloped up at a minimum of +1.0 percent grade.

The North Construction Ramp will only be used for construction access and supply ventilation, allowing the existing North Ramp to be used exclusively for waste emplacement activities. The North Construction Ramp will not be used for emplacement activities and is used solely for construction access and muck handling (Reference 2.2.1.4, Section 8.3).

4.4.6 Fire Zone Description

The Fire Zones (emplacement panels and Observation Drift) are described in Sections 6.3.1.1.1, 6.3.2.1.1, 6.3.3.1.1, 6.3.4.1.1, and 6.3.5.1.1.

4.4.7 Ventilation System Description

4.4.7.1 General

The subsurface ventilation systems consist of development and emplacement ventilation systems that provide the required quality and quantity of ambient air to all underground facilities during both development and emplacement activities. The ventilation system for both the development and emplacement activities are operating simultaneously. Isolation barriers are provided to separate the two ventilation systems during concurrent construction and emplacement.

The development ventilation system provides the required air for equipment operation and for the health and safety of personnel in the subsurface during the construction of the emplacement drifts. The emplacement ventilation system provides air for thermal management of the emplacement drifts by removing heat from waste packages in the drifts and for the health and safety of personnel in the Observation Drift and access mains. (Reference 2.2.1.10, Section 6.3)

4.4.7.2 Emplacement Ventilation System

The emplacement ventilation components include exhaust fans, turnout bulkheads, emplacement access doors, airflow regulators, isolation barriers, ventilation instrumentation, controls, and monitoring equipment. The portal openings and three intake shafts provide the outdoor air intake pathway to the repository and airflow regulators installed in the turnout bulkheads provide the measured airflow supply to emplacement drifts. The emplacement access doors are sized to accommodate the Transport Emplacement Vehicle and to provide a controlled and/or restricted access to emplacement drifts. The isolation barriers separate the development and emplacement ventilation systems. The exhaust fans at the shaft collar exhaust air to outdoor. The surface dual exhaust fan installations with variable frequency drives and the emplacement drift turnout bulkheads with adjustable airflow regulators provide the means to vary emplacement drift airflow rates for repository thermal requirements. The turnout bulkhead contains the emplacement access doors, airflow regulator, and associated hardware and monitoring instrumentation.

The emplacement ventilation system outdoor air enters the north ramp, north construction ramp, south ramp, and air intake shafts and passes through the access main. Fresh air from the access mains enters the emplacement drift or the Observation Drift via airflow regulators that control the airflow quantities. As air passes over the waste packages, it removes heat from waste packages and expands in volume. The air then travels to the exhaust mains and exhausts to the surface through the exhaust shafts and the ECRB shaft. The exhaust shafts are inaccessible by humans due to elevated temperatures. (Reference 2.2.1.10, Section 6.4)

The emplacement ventilation system is designed to supply airflow quantities of 32,000 cfm (15-m^3/s) to each of the individual emplacement drifts A negative pressure of at least 0.1 in w.g. is maintained at the isolation barrier between emplacement and development areas. This is to prevent any air leakage from potentially higher contamination emplacement areas to other less contaminated or clean development areas. The supply air is drawn through the repository by fans located on the exhaust shafts at the surface. The air enters the emplacement drifts through airflow regulators installed in the turnout bulkheads and exhaust to outside via exhaust mains and exhaust fans located at the exhaust shaft collars. (Reference 2.2.1.10, Section 6.4)

4.4.7.3 Observation Drift Ventilation

The emplacement ventilation system supports the Observation Drift airflow volume of 46,000 cfm necessary for personnel and equipment requirements. The ambient air in Panel 1 access main flows through the Observation Drift, to the exhaust main and is then exhausted to the surface via an exhaust shaft. Ventilation air flow is controlled through the use of bulkheads and regulators at each end of the Observation Drift. The concept of air flow regulators is similar to the emplacement drift installation. The alcove located off the Observation Drift has a ducted ventilation system. Depending on frequency and/or equipment monitoring needs for performance confirmation (PC) activities, the emplacement ventilation system provides continuous airflow in the Observation Drift to satisfy personnel and instrument ventilation requirements. (Reference 2.2.1.10, Section 6.6)

4.4.7.4 Separation of Construction from Emplacement

The subsurface ventilation system for the emplacement drifts and the development areas are separated by fire rated isolation barriers, which are self-closing and equipped with audible and visual warning devices. The barriers are required to protect and control workers access to areas of elevated radiation, and possible contamination, in the Emplacement Drifts.(Reference 2.2.1.10, Section 6.2.2.4)

4.4.7.5 Fire and Smoke Protection

The emplacement fire area is separated from the development portions of the repositoryby fire barriers which include suitably rated components of construction, fire doors, and fire dampers. Airflow regulators installed within turnout bulkheads are normally open but can be closed remotely to isolate the emplacement drifts and prevent smoke from entering the emplacement drifts. (Reference 2.2.1.10, Section 6.13)

4.4.8 General Operations Description

4.4.8.1 General

Emplacement begins in Panel 1 and continues to Panel 2 through Panel 4. Emplacement for the different panels is nearly identical as described in the following paragraphs.

The Transport Emplacement Vehicle (TEV) transports the loaded and sealed WP/pallet from the surface facilities to the subsurface emplacement area. Transportation starts at the surface facility, passes through the North Portal, and proceeds underground via the North Ramp and access mains to its designated emplacement drift.

4.4.8.2 Transport Emplacement Vehicle

The TEV is an electrically powered, remotely controlled, rail based vehicle. The conceptual design is to maintain as wide a rail gauge as practicable within the constraints of the emplacement drift's operating envelope dimension and similarly to maintain as low as possible a center of gravity of the loaded vehicle to provide vehicle stability and to minimize the potential for vehicle tip over. (Reference 2.2.1.6, Appendix A4)

Major TEV components include a radiation shielded enclosure with two swinging front-opening doors, a vertically-moving rear shield door and horizontally-retractable-shielded base plate that forms a shield enclosure base. The TEV shielded enclosure is assembled as a composite sequence of materials that includes a six-inch thick layer of a fire-resistant, synthetic polymer material, such as NS-4-FR, that provides neutron shielding. The internal construction of the shielded enclosure includes a structural configuration that locates and lifts a waste package and the emplacement pallet using only integral emplacement pallet lifting features. The shielded enclosure's moving portions feature electrically operated mechanical locks, and electrical or mechanical interlocks. The shield enclosure is surrounded on three sides by a structural chassis that provides location and support for horizontal pivoted wheel blocks. The drive systems include positional, speed, and load monitoring devices to provide a constant feedback and confirmation to the on-board programmable logic control system and to the Central Control Center on the condition, position, and speed of the lifting devices during operation. The TEV is provided with a fire suppression system with integral detection and alarms to protect the electronic components located in the control enclosure. The fire suppression, detection and alarm systems are described in Section 6.1.2.2 & 6.1.2.3. (Reference 2.2.1.6, Appendix A4)

The transportation and emplacement process begins in the load-out areas of the surface facilities where the waste package and the emplacement pallet are placed inside the TEV by remote controlled equipment . The shield enclosure of the TEV is raised to its travel height, the front doors are closed and locked and the TEV exits the surface facility. At a maximum design speed of one hundred and fifty (150) feet per minute. The TEV travels to the North Portal, down the North Ramp, through the access main to the turnout for the designated emplacement drift. Waste package transport and emplacement operations are performed through a combination of TEV equipment functions implemented by the on-board programmable logic controller and operational commands provided remotely by operators in the Central Control Center.

Within the emplacement drifts, operational considerations require that waste package be first emplaced at the emplacement drift exhaust end and progress back to the emplacement drift entrance. Precise spacing of the waste package is also an operational requirement.

In the emplacement drift the TEV travels to a predetermined location where it stops and confirms its location to the Central Control Center. Upon conformation of the position in the emplacement drift, the TEV lifting features raise to support the weight of the shield enclosure, the waste package, and the emplacement pallet. When the waste package is correctly positioned, the TEV shield enclosure is lowered to its lowest position placing the waste package and pallet on the emplacement drift invert structure.

The TEV then moves away from the waste package and emplacement pallet a predetermined distance and stops. The TEV shielded enclosure, is raised to its traveling height, the shielded enclosure base plate is retracted back under the shielded enclosure, the rear shield door is lowered, and the shielded enclosure front doors are closed. Following these operations both shield doors, are locked. When these actions are completed, the TEV travels back to the emplacement drift entrance and into the turnout.

After the TEV exits the subsurface through the North Portal, if required the TEV proceeds through a series of rail switches to reverse its travel direction. This ensures that the shielded enclosure front shield doors are facing forward. The TEV then returns to the surface nuclear facilities to start another emplacement cycle (Reference 2.2.1.6, Section A3.1.3).

4.4.9 Maintenance Operations

The Subsurface Emplacement areas of the repository repair and maintenance activities are based upon off-normal events that could occur within this facility. Accident and repair and maintenance activities for the emplacement operations will be developed as the repository design matures.

5. LIST OF ATTACHMENTS

This analysis does not contain attachments

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6. FIRE HAZARD ANALYSIS

6.1 GENERAL FEATURES

The FHA identifies the fire protection system design features necessary to minimize both the occurrence and the consequences of fire for the individual fire areas within the facility. The Subsurface Repository fire zones are shown in Figure 1. The design features necessary to meet the design objectives are identified in the following sections.

6.1.1 Life Safety Considerations

6.1.1.1 General

Life safety provisions of the design are provided in accordance with tenability criteria for subsurface personnel (to be established in future analysis). Compliance with the tenability criteria is considered to provide equivalence to the Life Safety Code (LSC) (Reference 2.2.2.11) for the subsurface facility.

6.1.1.2 Occupancy

The emplacement fire zones are classified for occupancy as described below:

Table 2. Emplacement Fire Zone Occupancy Classifications

Fire Zone	Emplacement Panel/Drift Number	Occupancy Classification [1]
FZ-PNL-01	Panel 1/ 1-1 thru 1-6	Special Purpose Industrial
FZ-PNL-02	Panel 2 / 2-1 thru 2-27	Special Purpose Industrial
FZ-PNL-03	Panel 3 / 3-1W thru 3-26W and 3-1E thru 3-19E	Special Purpose Industrial
FZ-PNL-04	Panel 4 / 4-1 thru 4-30	Special Purpose Industrial
FZ-PC-01	Observation Drift	Special Purpose Industrial

[1] Based on assumption 3.1.4

6.1.1.3 Means of Egress Features

Several exit points from a fire hazard or other emergency are available to personnel working in the emplacement phase of the repository. These include:

- The North Portal
- The designated ventilation intake shafts
- The South Portal
- The North Construction Portal.

Egress routes will change over time with each expansion of the emplacement area. The emergency action plan (Section 6.1.3.5) is dynamic in nature and requires frequent revisions to stay current with the construction and emplacement activities.

The intake shafts are one of the several exit points from a fire hazard or other emergency that may be available to personnel working in the emplacement side of the repository. Intake shaft evacuation if used will require a suitable lifting system. Detailed evacuation plans and requirements for evacuation will be included in the emergency action plan prior to repository operations.

In conjunction with the designated egress routes, emergency refuge stations (ERSs) will be incorporated into the subsurface design to provide safe havens to refuge personnel until conditions permit safe evacuation.

6.1.1.4 Illumination and Marking of the Means of Egress

The illumination and marking of the repository means of egress complies with Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1910 (Reference 2.2.2.1, Part 37(q)) which requires that exits and access to exits be marked by readily visible illuminated signs (Reference 2.2.1.3, Section 4.9.1.1.3).

6.1.1.5 Evacuation Time

The evacuation time for an individual is the entire span of time that elapses from the ignition of a fire until that individual arrives at a safe location.

Evacuation time = Delay time + Travel time
= Time to notification + Reaction time + Pre-evacuation activity time + Travel time
(Reference 2.2.1.15, Section 4, Chapter 2)

It is expected that the premovement time (i.e., time to notification, reaction time, and pre-evacuation activity time combined) in the subsurface repository could be considerable. The time to notification is the time elapsed before conditions develop to the point where an alarm sounds or where an individual begins to sense the cues of the fire itself. The reaction time is the time it takes an individual to perceive the alarm or fire cue and decide to act. The pre-evacuation time includes the time that elapses while an individual prepares to leave or seek refuge.

The final component in the evacuation time calculation is travel time. Travel time is defined here as the time to move to a safe location.

Premovement (or delay) times can last for several minutes. Several factors can result in variations in delay times. These include:

- Effectiveness of different cues
- Effectiveness of training

The YMP is committed to providing all personnel who are required to work and/or visit subsurface operations with the training and personal protective equipment necessary to enable those personnel to evacuate the subsurface repository or to reach a place of safety. Emergency refuge stations will be designed and located at strategic locations (to be determined as the detailed design matures) in the subsurface if necessary to maintain a safe means of egress.

The time of day, how much of the shift is complete, etc., affect personnel fatigue and have the potential to significantly affect delay times.

Personal Respiratory Protection-All subsurface personnel are required to be trained in the use of, and to carry personal respiratory protection. Two types are available: the standard self-rescuer (SR) and the self-contained, oxygen-generating, self-rescuer (SCSR).

The standard SR is suitable for escape from fire where there is sufficient oxygen. These units remove carbon monoxide generated in a fire and are rated for about 60 minutes. These units do not include eye protection. Consequently, activity in even moderate amounts of smoke is extremely difficult.

The SCSRs are NIOSH/MSHA rated for 60 minutes of use in moderate to heavy working conditions but can be effective for up to 4-hours or longer when the wearer remains at rest or is breathing easily (Reference 2.2.1.20, Page 5), as when awaiting rescue. They include eye goggles, which makes movement in smoke possible. The SCSRs give personnel the means to walkout or get to a place of refuge (ERS) when travel times exceed 30 minutes, and also provide protection against exposure to other harmful gases that may be present besides carbon monoxide.

Significant life safety improvements are achievable by providing SRs and SCSRs. For the subsurface operations both SRs and SCSRs will be available to subsurface personnel.

Alarms-A subsurface-wide alarm system will be provided to warn personnel of potential emergencies and hazards.

6.1.1.6 Security and Safeguard Considerations Related to Fire Protection

Access into the emplacement area of the repository will be limited to personnel authorized by security.

6.1.2 Fire Protection Features

The fire protection system consists of the following subsystems:

- Firewater
- Fire suppression
- Fire detection
- Fire alarm
- Fire notification
- Explosion protection
- Fire barriers

Note-Further discussion of these subsystems in this analysis will use the term “system.”

6.1.2.1 Fire Water System

No fire-water distribution system is installed in the subsurface emplacement side of the repository. . (See Section 6.1.2.2)

6.1.2.2 Fire Suppression System

Fire Suppression-The fire suppression system provides appropriate aqueous and non-aqueous suppression and include the protected facility distribution and delivery means for the fire suppression agents.

Fixed and transient fuel loads in the subsurface are small. Fixed loading is mostly electrical equipment and electrical and instrument cables and transient loading is mostly the mobile equipment that have their own on-board protection systems.

Fire suppression systems are provided for the subsurface load centers and the mobile equipment. The suppression systems consist of pre-engineered fixed/mobile automatic gaseous fire suppression systems. The load centers are located in electrical niches off the access mains in the subsurface north ramp and the four panels. The suppression systems are automatic fire-extinguishing systems, and automatic fire detection and alarm systems. The mobile equipment, consisting of the transport emplacement vehicle (TEV) is also provided with pre-engineered automatic gaseous suppression systems to protect the vehicles electrical/control enclosures. The on-board suppression systems have redundancy built in and are equipped with automatic fire detection and alarm systems. If a primary on-board system fails, the redundant, backup system is available for protection. The fire alarm system interfaces with both the fixed and mobile fire suppression systems as described in the following section.(Reference 2.2.1.3, Section 4.9.1.10.1).

Other fire suppression equipment consists of portable fire extinguishers. Extinguishers are selected and located in the main access tunnels, Observation Drift, Observation Drift Alcove, Thermal Testing Facility and the North Ramp, in accordance with NFPA 10 (Reference 2.2.2.5) and 29 CFR 1910 (Reference 2.2.2.1). The pre-engineered suppression systems are designed and installed in accordance with NFPA 2001 (Reference 2.2.2.16) and (Reference 2.2.1.3, Section 4.9.1.7).

6.1.2.3 Fire Detection and Alarm Systems

Fire Detection-The fire detection systems provide the capability to automatically detect fires or fire by-products. This includes various detection panel(s), monitoring detectors, and other fire protection system actuation devices i.e. manual pull stations.

The fire detection system consists of detectors and manual pull stations located at each electrical load center, and in the personnel egress routes of the North Ramp, Observation Drift, Thermal Testing Facility and Observation Drift Alcove located underneath Panel 1 Emplacement Drift 3. Fire detection notification is distinctive and unique so that there is no confusion with other plant system alarms. The fire detection systems are capable of operation with or without offsite power (Reference 2.2.1.3, Section 4.9.1.12.2).

Fire detection systems are also provided for each of the ventilation control buildings; located adjacent to the intake and exhaust shaft collars on the surface. The detection systems will consist of smoke detectors and manual pull stations interfacing with the alarm panel in each control building.

The detectors are selected and installed in accordance with NFPA 72 (Reference 2.2.2.10) and (Reference 2.2.1.3, Section 4.9.1.12).

Fire Alarm-The fire alarm system includes panel(s) and conductors controlling other fire protection subsystems of detectors, system actuation means, indicator devices, annunciation(s), non-fire system equipment interface controls, occupant and Fire Department notification means, and other respective fire protection subsystem signal output(s).

The subsurface fire alarm system provides fire alarm panels in electrical niches located off the access drifts of the emplacement panels. The fire alarm panels interconnect and interface with the site fire alarm system and send signals, fire, supervisory and trouble alarms to the main fire alarm panel in the Fire, Rescue and Medical Facility. Additional signals are sent to the continuously monitored fire alarm panel in the control room of the Central Control Center Facility (CCCF), Area 240. All fire alarm panels are UL-listed (Reference 2.2.1.3, Section 4.9.1.1.5) and are provided with 24-hr battery backup to the normal power supply (Reference 2.2.1.3, Section 4.9.1.12).

The fire alarm system consist of local, automatic and manual, audible and visual fire alarm devices for personnel notification and activation fire alarms from the fixed/mobile equipment/systems. Specific alarm methods and devices are selected during detailed engineering. Local fire alarm signals are transmitted to the central fire alarm panel in the Fire, Rescue and Medical Facility (Facility 63A) and the CCCF, Area 240 (Reference 2.2.1.3, Section 4.9.1.10.1). The fire alarm systems provide signal status for alarm, supervisory, and system trouble conditions.

Activation alarms from emplacement equipment on-board suppression systems are transmitted by wireless to the synchronous optical network (SONET). The SONET network transmits these fire alarm signals to the central fire alarm panel in the Fire, Rescue and Medical Facility (Facility 63A) (Reference 2.2.1.3, Figure 4.3.7.2). Signals are sent from the Main Fire Alarm Panel in the Fire Rescue & Medical Facility (Area 63A) to both the Primary Alarm Station in the CCCF (Area 240) and to the Secondary Alarm Station in the Cask Receipt and Security Station (Area 30B) (See Figure 2).

The subsurface fire alarm system also includes fire alarm panels at each of the ventilation shaft control buildings. The control buildings consist of electrical equipment to support fan operations, including an instrument room, shop area and storage. Control buildings are located at the surface adjacent to the intake and exhaust shafts. Fire alarms for these building will include local audible and visual indicating devices for personnel notification and signals are sent to the central fire alarm panel in the Fire, Rescue and Medical Facility (Facility 63A) (Reference 2.2.1.3, Section 4.9.1.10.1). The ventilation control building fire alarm systems provide signal status to the site wide fire alarm system for alarm, supervisory, and system trouble conditions.

The fire alarm systems provide the means for fire protection systems to interface with other plant systems. Alarm systems are designed and installed in accordance with NFPA 72 (Reference 2.2.2.10).

The fire detection and alarm piping and instrument diagram is shown in Figure 2.

6.1.2.4 Explosion Protection System

Explosion Protection-The explosion protection system provides the required integrated means to contain, detect and suppress, or limit overpressure from an explosive condition.
The rock is inert, therefore, the potential for an explosion in the emplacement side of the repository is considered extremely unlikely. The underground ventilation system is monitored and provides warning of any underground environmental conditions potentially dangerous to personnel.

The use of explosives in the subsurface development side of the repository will be address separately in the Development Subsurface Fire Hazard Analysis..

Welding gases brought in for maintenance is strictly inventoried and follows the requirements of NFPA 51B (Reference 2.2.2.7).

Battery explosion prevention on back-up power systems for mobile equipment controls primarily rely on proper battery selection. Batteries are selected to minimize hydrogen off-gassing. If TEV ’s use continuous on-board battery charging (to be determined), current-limiting devices are required. It is expected that TEV battery charging is done on the surface, off-vehicle, in well-ventilated areas. The batteries carried by the TEV will only provide backup power for communication system and will be sized accordingly. The batteries will not provide power for any TEV movement.

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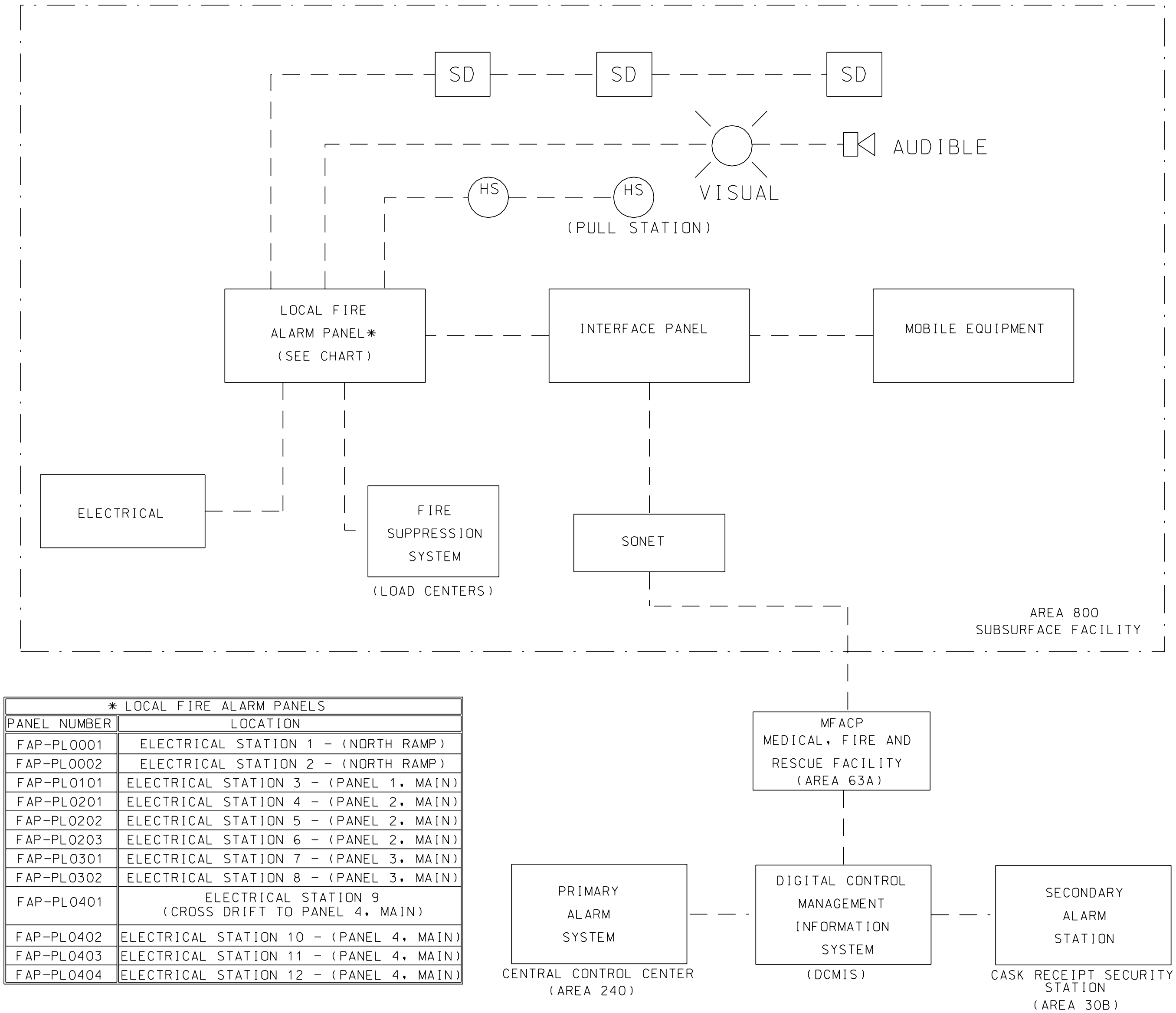

* LOCAL FIRE ALARM PANELS	
PANEL NUMBER	LOCATION
FAP-PL0001	ELECTRICAL STATION 1 - (NORTH RAMP)
FAP-PL0002	ELECTRICAL STATION 2 - (NORTH RAMP)
FAP-PL0101	ELECTRICAL STATION 3 - (PANEL 1, MAIN)
FAP-PL0201	ELECTRICAL STATION 4 - (PANEL 2, MAIN)
FAP-PL0202	ELECTRICAL STATION 5 - (PANEL 2, MAIN)
FAP-PL0203	ELECTRICAL STATION 6 - (PANEL 2, MAIN)
FAP-PL0301	ELECTRICAL STATION 7 - (PANEL 3, MAIN)
FAP-PL0302	ELECTRICAL STATION 8 - (PANEL 3, MAIN)
FAP-PL0401	ELECTRICAL STATION 9 (CROSS DRIFT TO PANEL 4, MAIN)
FAP-PL0402	ELECTRICAL STATION 10 - (PANEL 4, MAIN)
FAP-PL0403	ELECTRICAL STATION 11 - (PANEL 4, MAIN)
FAP-PL0404	ELECTRICAL STATION 12 - (PANEL 4, MAIN)

Figure 2. Fire Alarm & Detection Piping and Instrument Diagram

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6.1.2.5 Fire Barriers and Protection of Penetrations

Fire Barriers-The passive fire protection system consists of fire-rated isolation barriers and construction, which provides thermal fire resistance and smoke containment between facility spaces or equipment to shield the effects of fire or smoke.

The fire barriers subsystem consists of physical fire-rated barriers that separate the emplacement facility from the development facility. In addition to providing fire-rated barriers, the barriers function as ventilation separators, and safeguards and security barriers. Some construction barriers are also used solely to control airflow in the development area. Barriers between construction and repository operations are equipped with man-doors. While it is not intended that these be used as primary means of egress, the emergency management plan considers this option. The fire barriers subsystem will be designed to comply with NFPA 221 (Reference 2.2.2.12) and qualified by a nationally recognized testing laboratories.

6.1.2.6 Exposure Fire Protection

The probability of a fire igniting in the North Ramp, the primary access to the emplacement phase of the repository, due to exposure from an ongoing fire outside the Portal entrance is very low. Storage of construction flammable and combustible materials is not permitted within 100-ft of the portals in accordance with OSHA regulations (Reference 2.2.2.2, Part 800(m)(7)). In addition, any fuel storage systems used complies with the requirements of NFPA 30 (Reference 2.2.2.6).

The probability of fire exposure from the development (construction) fire area encroaching into the emplacement fire area is extremely remote due to the physical separation by fire-rated ventilation/isolation barriers (See also Section 4.4.1), separation distance, and lack of continuous combustibles. The isolation barriers are fire-rated and the ventilation systems operate totally independently (Reference 2.2.1.10, Sections 6.3).

6.1.2.7 Fire Water Drainage

Since fire-water systems are not being proposed for installation in the subsurface repository, this is not applicable.
Fire water will be provided in the subsurface development side of the repository and will be addressed in the subsurface development fire hazard analysis.

6.1.2.8 Ventilation and Smoke Control

The ventilation system provides fresh air for personnel, thermal management of emplaced WPs, and smoke removal in case of fire emergencies. The ventilation intake and exhaust rates (See Section 4.4.7) are based on the thermal management goals. Smoke removal is achieved by drawing the smoke through the tunnels by the exhaust fans. The goal is to provide a safe path for personnel egress. The DBF (See Section 6.3.1.8) smoke and combustion byproduct flow and concentration has not yet been evaluated with the ventilation design. Specific personal protective equipment requirements will be determined after completion of this evaluation.

6.1.3 Special Topics

6.1.3.1 Cable Trays

The predominant combustible material (and combustible fuel loading) in the subsurface repository is electrical cable insulation.

Electrical cabling specified for the YMP are required to meet the testing requirements of IEEE STD 1202, *Standard for Flame Testing of Cables for Use in Cable Trays in Industrial and Commercial Occupancies* (Reference 2.2.2.4), (Reference 2.2.1.3, Section 4.3.1.3.6).

Electrical power distribution system design (switchgear, rectifiers, transformers, and cables) are provided in accordance with NFPA 70 (Reference 2.2.2.9) and (Reference 2.2.1.3, Section 4.3.1.1.1).

6.1.3.2 Cabling - Important to Safety System (ITS)

No SSCs ITS, that use electrical cables, have been identified in the subsurface repository; therefore, this is not applicable.

6.1.3.3 Compensatory Measures for Impairments to Fire Protection Systems

If a fire protection system is taken out of service for repair or maintenance, the compensatory measures include the following:

- Notify the on-site Fire Department of the impairment and the duration of the impairment.
- Post a fire-watch during the duration of the impairment.
- Inform all subsurface personnel of the impairment.
- Suspend all hot-work during the impairment.

6.1.3.4 Control of Transient Combustible Materials

Transient combustible material are those combustible material that are not permanently installed in a given fire area. Transient combustible materials primarily include waste materials generated from plant operations and maintenance activities. The control of transient combustibles materials is an essential element of the defense-in-depth approach to fire protection. Prior to operations, an active administrative control program will be implemented to control the quantity of combustible materials permitted in a given fire zone. This program is based on the combustible fuel loading and the findings of the fire hazard analysis for the given fire zone (Reference 2.1.2, Section 4.4 and Attachment 1).

6.1.3.5 Emergency Planning

Prior to operations, pre-fire plans are prepared for use by the FRO. The pre-fire plans will provide pertinent information about the subsurface repository and for each fire zone within the subsurface repository (Reference 2.1.2, Section 7.2.6).

6.1.3.6 Fire Barriers and Protection of Penetrations

Fire Areas are separated from each other by 3-hour fire-rated barriers (Reference 2.2.1.3, Section 4.9.1.16.2). Fire barrier design is provided in accordance with NFPA 221 (Reference 2.2.2.12).

Where fire-rated assemblies (ventilation barriers) are either partially or fully penetrated by pipes, ducts, conduits, raceways or other such elements, fire barrier penetration material is placed in and around the penetration to maintain the fire-resistance rating of the assembly. Personnel doors that serve as exits from security areas will comply with the YMP security requirements.

All openings in fire barriers are protected consistent with the designated fire-resistance rating of the barrier (Reference 2.2.1.3, Section 4.9.1.16.7).

6.1.3.7 Fire Department Response

Upon actuation of the subsurface repository's fire alarm system, either automatically or manually, the on-site Fire Department will be automatically notified and it will respond in accordance with pre-established emergency procedures (Assumption 3.1.1).

6.1.4 Impact of Natural Hazards on Fire Safety

The *Preliminary Hazards Analysis for License Application Study* identifies 18 external hazards, and 15 internal hazards in the preclosure safety analysis that may be applicable to the Subsurface Emplacement Repository (Assumption 3.1.5 and Reference , Section 5.1). The analysis identifies the required mitigation/control features, the defense-in-depth mitigation/control features, along with the mitigated hazards classification, required of industrial systems necessary to mitigate the effects of the particular hazards. A list of the hazards applicable to the fire protection SSCs for the Subsurface Repository is given in Table 3 and Table 4. The fire protection systems and equipment inside the Subsurface Repository are protected by the structure.

Table 3. External Hazards

External Hazards	Source
Aircraft Crash	Reference 2.2.1.1, SE1089, p. lll-1122
Drift Degradation	Reference 2.2.1.1, UE1090, p. lll-1123
Extreme Wind	Reference 2.2.1.1, SE1091, p. lll-1124
Range Fire	Reference 2.2.1.1, SE1092, p. lll-1125
Flooding	Reference 2.2.1.1, SE1093, p. lll-1126
Industrial-Activity-Induced Accident	Reference 2.2.1.1, SE1094, p. lll-1127
Lightning	Reference 2.2.1.1, SE1095, p. lll-1128
Loss of Offsite/Onsite Power	Reference 2.2.1.1, SE1096, p. lll-1129
Military-Activity-Induced Accident	Reference 2.2.1.1, SE1097, p. lll-1130
Rainstorm	Reference 2.2.1.1, SE1098, p. lll-1131
Seismic Activity, Earthquake	Reference 2.2.1.1, SE1099, p. lll-1132
Seismic Activity, Surface Fault Displacement	Reference 2.2.1.1, SE1100, p. lll-1133
Seismic Activity, Subsurface Fault Displacement	Reference 2.2.1.1, UE1101, p. lll-1134
Fracturing	Reference 2.2.1.1, UE1102, p. lll-1135
Tornado	Reference 2.2.1.1, SE1103, p. lll-1136
Volcanism- Ash Fall	Reference 2.2.1.1, SE1104, p. lll-1137
Extreme Temperature	Reference 2.2.1.1, SE1105, p. lll-1138
Sandstorm	Reference 2.2.1.1, SE1379, p. lll-1155

Table 4. Internal Hazards

Internal Hazard	Source
Collision/Crushing	Reference 2.2.1.1, S11106, p. III-1139
Chemical Contamination	Reference 2.2.1.1, SI1107, p. III-1140
Flooding	Reference 2.2.1.1, SI1108, p. III-1141
Explosion/Implosion	Reference 2.2.1.1, SI1109, p. III-1142
Fire	Reference 2.2.1.1, SI1110, p. III-1143
Radiation	Reference 2.2.1.1, SI1111, p. III-1144
Thermal	Reference 2.2.1.1, SI1112, p. III-1145
Magnetic	Reference 2.2.1.1, SI1113, p. III-1146
Electrical	Reference 2.2.1.1, SI1114, p. III-1147
Fissile	Reference 2.2.1.1, SI1115, p. III-1149
ALARA	Reference 2.2.1.1, SI1116, p. III-1150
Criticality	Reference 2.2.1.1, SI1117, p. III-1151
High Energy	Reference 2.2.1.1, SI1118, p. III-1152
Radon	Reference 2.2.1.1, SI1119, p. III-1153
Silica Dust	Reference 2.2.1.1, SI1120, p. III-1154

6.1.4.1 Potential Hazards Impacting Fire Safety

The external hazards identified in Table 3 have a potential to impact the fire protection design features identified in this FHA. The location and structural characteristics of the subsurface facilities mitigate most of the hazards except for drift degradation and seismic activity events, range fires, lightning, and loss of offsite power which may have limited impact on fire safety and will be considered in the design of fire protection systems. The mitigation of these hazards includes:

- **Aircraft Crash**- The siting of the shafts is expected to preclude debris from an aircraft crash from damaging the air shaft and a resulting fire propagating down the air shaft into the subsurface.

- **Drift Degradation**-The design of drift ground control is sufficiently robust such that drift degradation/fracturing affects on fire safety will be limited (Reference 2.2.1.3, Section 4.5.2.7). No mitigation is required.

- **Range Fire**-The YMP FRO will be equipped and capable of controlling and extinguishing wildfires that originate on or move through the YMP site (Assumption 3.1.1).

- **Lightning**-Lightning protection is provided in compliance with NFPA 780 (Reference 2.2.2.14).

- **Loss of Offsite/Onsite Power**-All electrical components installed in fire protection systems are installed per code requirements and have battery back-up in accordance with NFPA 72 (Reference 2.2.2.10) for proprietary systems.

- **Seismic Activities**- The YMP fire protection systems are designed in accordance with the applicable NFPA Standards (Reference 2.2.1.3, Section 4.9.1.1.2). The NFPA Standards provide design guidance for addressing seismic design issues. The specific seismic design criteria for the YMP fire protection systems will be identified at a later date.

The internal hazards identified in Table 4 have a potential to impact the fire protection design features identified in this FHA. The mitigation of these hazards includes:

- **Collision/Crushing**- Fire protection equipment locations in the subsurface will be scrutinized to minimize collisions, drops, and impacts with equipment that could result in fire protection equipment damage and/or personnel injury and mitigation will consider design features and administrative controls.

- **Explosion/Implosion**-No specific explosion or implosion hazards on the emplacement side of the repository that affect fire protection systems and/or components have been identified.

- **Chemical Contamination /Radon /Flooding /Radiation /Criticality /Magnetic /Electrical /Fissile /Silica Dust /High Energy /Thermal** – The mitigation of these internal hazards are discussed in each Scenario Analysis Summary of the Preliminary Hazard Analysis for License Application Study (Reference 2.2.1.1) Specific negative impact on the fire protection systems produced by these hazards has not been identified.

- **Fire**-Mitigation of potential events is discussed in Section 6.3.

- **ALARA**- The design and operation of the various fire protection systems includes the ALARA principles to minimize operator radiation exposure limits.

6.1.5 Spurious Actuation of Equipment

Fire damage is capable of resulting in the following types of circuit faults: hot shorts, open circuits, and shorts to ground. Spurious actuation of components caused by these circuit faults are evaluated to ensure safety and the functions of safe state. Components could be energized or de-energized by one or more of these circuits faults. For example, dampers could fail closed, fans could fail running or not running, and electrical distribution breakers could fail open or closed.

The potential for, and the effects of, spurious actuation will be evaluated when detailed information on the design and routing of electrical circuits becomes available.

6.2 EFFECT OF SIGNIFICANT FIRE SAFETY DEFICIENCIES

Initial design will preclude significant fire safety deficiencies. After operations commence, the fire protection systems will be re-evaluated to identify and mitigate deficiencies.

6.3 FIRE HAZARD ANALYSIS

6.3.1 Fire Zone FZ-PNL-01

6.3.1.1 Construction/Operations

6.3.1.1.1 Fire zone FZ-PNL-01 (Panel 1) Description

The initial emplacement panel (Panel 1), fire zone FZ-PNL-01 (Table 2), is located within the central section of the overall layout (Figure 1) and utilizes the North Ramp for access to the repository horizon. The size of the panel is small in comparison to the other panels in the repository. This enables the panel to be developed and outfitted ready for waste emplacement (Reference 2.2.1.9, Section 2.2.1.10).
FZ-PNL-01 consists of six emplacement drifts (Figure 3, #17 to #22), which are 5.5-m (18-feet) in diameter and accessed by a turnout. FZ-PNL-01 has a total available waste emplacement length of 3392-m (11,130-ft). (Reference 2.2.1.5, Table 10).

Panel 1 has an Observation Drift, fire zone FA-PC-01 (Section 6.3.5) located beneath the emplacement horizon. The Observation Drift (Figure 3, #1 starts from Thermal Testing Facility Alcove (Figure 3) and crosses beneath the Access Main (Figure 3) turning onto the same azimuth as the emplacement drifts.

The ECBR is included in fire zone FZ-PNL-01 and is interconnected with the Panel 1 ventilation system through a vent raise from the exhaust main of Panel 1 up to the ECRB. The function of the ECRB will change as Panel 1 is developed and turned over to emplacement.

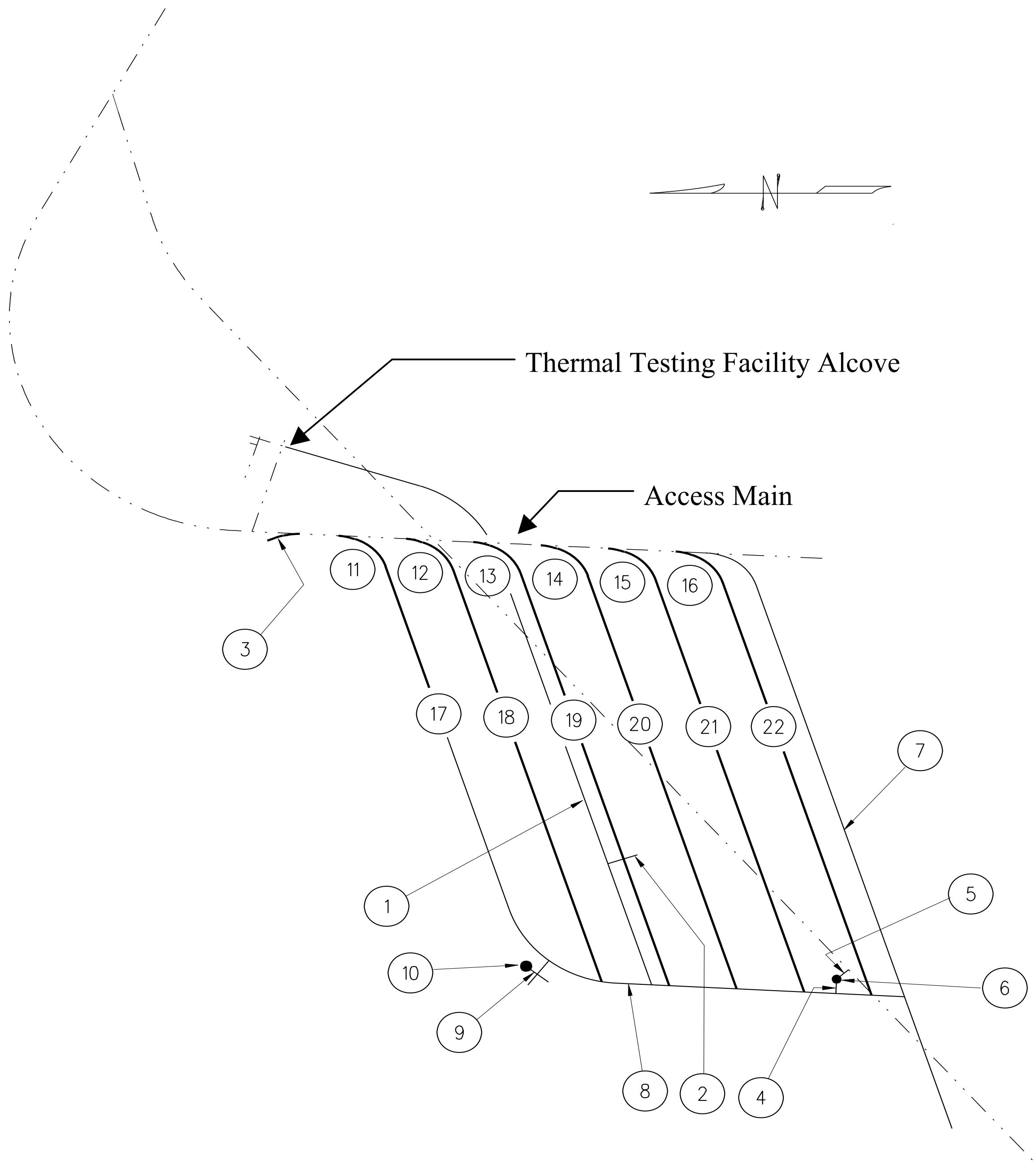
The emplacement area of FZ-PNL-01 is developed from the north to the south. Constructing the panel in this manner makes it possible to turn over the panel for emplacement in stages; the first three drifts will be turned over in the first package.

6.3.1.2 High-Value Property

The high-value properties (Assumption 3.2.2) in the emplacement phase of the repository will be:

- Waste Packages
- Transport and emplacement vehicle (TEV)
- Electrical Distribution Equipment
- Performance confirmation data acquisition equipment
- Repository Ventilation Fans
- Hoists
- Drip Shield Gantry

Dollar values will be addressed as the equipment design progresses.



Source: Reference 2.2.1.5, Figure 7

Figure 3. Panel 1

6.3.1.3 Description of Fire Hazards

The major contributing causes to most underground fires are poor maintenance, poor housekeeping, and the ready availability of fuel. In the emplacement area, combustibles, both in-situ and transient are not normally readily available. The permanent construction components in the access ramp, access mains, emplacement and ventilation drifts, and observation and post-closure test drifts are of non-combustible construction. The electrically-powered mobile-equipment used to transport, emplace, inspect, and recover the WPs will be constructed primarily of non-combustible materials. Equipment maintenance is performed on the surface, subsurface maintenance is strictly controlled, and materials are inventoried to minimize the risks from combustible materials used in the subsurface areas.

Fires due to short-circuits in electrical systems are the most likely remaining contributing cause of fires in the emplacement phase of the repository. The fixed electrical distribution system is designed to meet the nationally recognized electrical codes and standards (NFPA 70) (Reference 2.2.2.9). Installation to these standards minimizes, but does not totally remove the probability of an electrical short-circuit starting a fire.

6.3.1.3.1 Waste Emplacement/Retrieval & Recovery Equipment (Normal Conditions)

<u>Term definition:</u>

- “Retrieval” is used to indicate removal of the entire inventory of WPs from the underground.
- “Recovery” is used to indicate selective removal of a small set of WPs from the underground.
- “Normal Conditions” refers to a subsurface environment that is performing essentially as expected (e.g., retrieval or recovery after forced ventilation of an emplacement drift).

Note-Normal waste retrieval and recovery operations will use the TEV emplacement equipment.

6.3.1.3.1.1 Hazards

Transport and Emplacement Vehicle (TEV) -The TEV is classified SC (ITS) (Table 1) and has:

- Multiple electrically-powered drive-motors
- Rechargeable storage batteries for communication system backup power
- Third-rail power system
- Air conditioned electrical enclosures
- Electrically-powered door-operators
- Control and communications systems.

These systems present very low fire hazards (Assumption 3.1.3).

6.3.1.3.1.2 Mitigation

WP Transport Emplacement Vehicle (TEV)-The WP TEV is operated remotely during emplacement, and is SC (ITS). Their electrical/control enclosures are protected by redundant automatic detection and fire-extinguishing systems (Reference 2.2.1.3, Section 4.9.1.8). The systems detect the fire then discharge inside the electrical/control enclosures to immediately extinguish fires caused by electrical shorts and arcing. Electrical cables, external to the control enclosure will be contained within metal conduit.

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6.3.1.3.2 Waste Recovery & Restoration Equipment (Off-Normal Conditions)

Term definition:

- "Off-Normal Conditions" refers to an occurrence of an event or condition outside the bounds of routine operations but within the range of analyzed conditions for the SSC.

6.3.1.3.2.1 Hazards

Electrically-powered equipment is used for the majority of the off-normal recovery processes. Diesel-powered equipment could also be used for some off-normal recovery processes.

Electrically-powered equipment presents very low fire hazards (Assumption 3.1.3). Diesel-powered equipment presents higher fire hazards due to hot internal combustion engines and on-board diesel fuel storage tanks.

6.3.1.3.2.2 Mitigation

Electrically-Powered Equipment-Waste package recovery during off-normal operations requires some specialty equipment. Electrically-powered specialty-equipment (some of which are listed in Section 6.3.1.3.2.1) are analyzed individually, when more information becomes available, for the need for on-board automatic fire-extinguishing systems.

Diesel-Powered Equipment-Diesel-powered specialty equipment, if used, are protected by redundant automatic fire-extinguishing systems (Reference 2.2.1.3, Section 4.9.1.8). The systems operate automatically, and have the ability to be actuated manually.

6.3.1.3.3 Waste Packages

6.3.1.3.3.1 Hazards

Waste Packages-The waste packages are assigned a SC (ITS and ITWI) classification (See Table 1).

The waste packages are of non-combustible construction and will present no fire hazard.

6.3.1.3.3.2 Mitigation

None required

6.3.1.3.4 Fixed Electrical Equipment

6.3.1.3.4.1 Hazards

Electrical Distribution Systems-The electrical distribution systems are assigned Non-SC (Not ITS or ITWI) classifications (Table 1) and include switchgear, transformers and cables. These all have the potential to cause a fire.

6.3.1.3.4.2 Mitigation

Electrical Distribution Systems-The switchgear, and transformers will be located in dedicated niches/alcoves. This locates the equipment outside the transportation corridor, preventing physical damage in the unlikely event of a transporter or other vehicle accident. The switchgear and transformers are installed in NEMA-rated enclosures isolating these as sources of ignition. The electrical enclosures are also provided with automatic fire detection and extinguishing systems. Electrical cables will be fire-resistant (See Section 6.1.3.1).

6.3.1.3.5 Synchronous Optical Network (SONET)

6.3.1.3.5.1 Hazards

SONET-The SONET is assigned a Non-SC (Not ITS or ITWI) classification (Table 1). The SONET uses a fiberoptic dual-ring network to connect the surface systems to subsurface processes and communicate with mobile emplacement equipment (Reference 2.2.1.9, Section 25.1.1). The network is a continuous loop that interfaces with the surface SONET system in the CCCF. The CCCF communicates with the central fire alarm panel in the Fire, Rescue & Medical Facility (Facility 63A) by the Digital Control and Management Information System (DCMIS). The SONET system will have a low potential to cause a fire.

6.3.1.3.5.2 Mitigation

If a fire damages the network to a monitoring/control supervisory station, the redundant network will maintain necessary monitoring and control functions. Thus, a fire would not cause loss of function of a system. However, depending on the final routing of these systems, fire protection may be required for the network systems. In addition, fiberoptics cable jacketing is fire resistant and is installed in accordance with NFPA 70 (Reference 2.2.2.9).

6.3.1.3.6 Digital Control and Management Information System (DCMIS)

6.3.1.3.6.1 Hazards

DCMIS-The DCMIS is assigned a Non-SC (Not ITS or ITWI) classification (Table 1). "The DCMIS network provides the backbone over which the various components communicate. The DCMIS network is comprised of two sub-networks: a control network and a supervisory network. Both networks are redundant. The DCMIS monitors, controls and provide data storage and alarm status for both surface and subsurface repository operations (2.2.1.9, Sections 26.2). The DCMIS interfaces to the communications system (SONET) for transmission of fire alarm signals. The DCMIS has a low potential to cause a fire.

6.3.1.3.6.2 Mitigation

If a fire damages the network, the redundant network maintains necessary communication functions. Thus, a fire would not cause loss of function of a system. However, depending on the final routing of these systems, fire protection may be required for the network systems.

6.3.1.3.7 Infrastructure

6.3.1.3.7.1 Hazards

The following infrastructures are assigned SC (ITS or ITWI), or Non-SC (Not ITS or ITWI) classifications (Table 1):

Emplacement Drift System:

- Invert (Ballast) (SC) (ITWI)
- Invert (Steel) (Non-SC) (Not ITS or ITWI)
- WP Emplacement Pallet (SC) (ITWI)

Ground Control:

- Emplacement Drifts (Non-SC) (Not ITS or ITWI)

Subsurface Facility System:

- Emplacement Drifts (Non-SC) (Not ITS or ITWI)

All of these infrastructures will be of non-combustible construction and will present no fire hazard.

6.3.1.3.7.2 Mitigation

None required.

6.3.1.3.8 Other

6.3.1.3.8.1 Hazards

Other hazards include maintenance activities using welding gases and any resulting accumulation of trash, oily rags or other combustible materials.

6.3.1.3.8.2 Mitigation

Administrative controls comply with the *Fire Protection Program* (Reference 2.1.2, page 20).

6.3.1.3.8.3 Transport Hazards

Electric motor driven personnel and equipment transport vehicles will be used for accessing emplacement facilities for operations and maintenance.

6.3.1.3.8.4 Mitigation

Emplacement operations and maintenance will be provided under strict administrative controls and personnel accessing the repository will be trained in emergency operations and incipient fire fighting procedures to limit or prevent hazards.

6.3.1.4 Life Safety Considerations

6.3.1.4.1 Occupancy

The occupancy considerations are discussed in Section 6.1.1.2. These discussions apply equally to FZ-PNL-01

6.3.1.4.2 Ventilation

The ventilation system for Panel 1 emplacement draws supply air from the North Portal into the North Ramp and through the Panel 1 emplacement drifts. Air is exhausted to atmosphere by exhaust fans installed at the Exhaust Shaft #1 collar on the surface. The exhaust structure consists of two parallel exhaust fans connected to the exhaust shaft collar by ductwork. In the parallel fan configuration, if one fan fails or is off-line for maintenance, the second fan could remain operational and produce approximately 70 percent of the original air volume. With multiple ventilation shafts, each having two fans, a single fan down for maintenance will not have major impact on the repository air volume (Reference 2.2.1.18, Section 6.4).

The primary function of the emplacement ventilation system is to supply sufficient quantities of air within the repository, to sustain safe working conditions for personnel, and assure that the thermal requirements of the repository are met. Based on the multiple intakes and exhaust shafts provided throughout the repository and the parallel exhaust fan configuration sufficient airflow is assured.

The ventilation control buildings located adjacent to the exhaust fan assemblies on the surface provide the associated equipment for the fan operations and is considered part of the subsurface facilities.

The major contributing causes of most fires in the ventilation control building will be poor maintenance, poor housekeeping, and the ready availability of fuel. In the ventilation shaft control buildings, combustibles, both in-situ and transient are not normally readily available. The permanent construction components in the building and the fan structure are of non-combustible construction. The electrically-powered equipment used to power the exhaust fans will be constructed primarily of non-combustible materials. Equipment maintenance is strictly controlled, and materials are inventoried to minimize the risks from combustible materials used in and around the ventilation shaft and control building. Fire detection and alarm systems are provided throughout the building providing early warning notification. Fire Department will be automatically notified and it will respond in accordance with pre-established emergency procedures (Assumption 3.1.1). The analysis of the fan control facilities and associated equipment will be developed further as the design matures.

6.3.1.4.3 Egress

See Sections 6.1.1.3, 6.1.1.4 and 6.1.1.5.

6.3.1.5 Exposure Fire Potential/Potential for Fire Spread Between Fire Areas

The probability of fire exposure from the development fire area encroaching into the panel FZ-PNL-01 of the emplacement fire area is extremely remote. The isolation barriers between fire areas are fire-rated (Assumption 3.2.5) and the ventilation system operate totally independently (See Section 6.1.2.6).

6.3.1.6 Fire Protection Features

The objective of the *Fire Protection Program* is to provide the means to prevent, control, , and extinguish subsurface fires.

6.3.1.6.1 Fire Prevention

Fire prevention practices fall into three categories: limiting fuel sources; limiting ignition sources; and limiting ignition source contact.

6.3.1.6.1.1 Limiting Fuel Sources

Uses of low (or reduced) hazard materials are required. Fire-resistant hydraulic fluids, hydraulic hoses, fiberoptics, and electric-cable insulation is used to the maximum extent possible.

Sealed bearings on mobile equipment are used, primarily for environmental containment, thus reducing exposure of greases.

Transient combustibles and materials will be limited and controlled by administrative procedure in compliance with the *Fire Protection Program* (Reference 2.1.2, page 20).

6.3.1.6.1.2 Limiting Ignition Sources

High- and medium-voltage power-distribution equipment is installed in appropriately designed NEMA-rated enclosures, thus isolating this source of ignition. Transformers are dry types, also in NEMA-rated enclosures. In case of an electrical fire inside a cabinet, the risk of fire propagation to adjoining equipment is considered very low (Assumption 3.1.3). Circuits have fuse, thermal cutout, multiple relay, and over-current protection built-in.

6.3.1.6.1.3 Limiting Fuel and Ignition Source Contact

The primary hazard occurs during maintenance operations. Precautions are observed during welding and cutting operations, and follow NFPA 51B (Reference 2.2.2.7) and 29 CFR 1910 (Reference 2.2.2.1) requirements. Nearby combustibles are covered with fire-resistant materials or moved. Fire extinguishers are readily available and a trained fire-watch posted for as long as necessary to guard against smoldering fires.

6.3.1.6.2 Explosion Prevention

Explosion Prevention is discussed in Section 6.1.2.4 and applies equally to this section.

6.3.1.6.3 Fire Protection

Fire Protection is discussed in Section 6.1.2.2 and applies equally to this section.

6.3.1.6.3.1 Choice of Extinguishing Agents

Clean-Agents-"Clean Agent" is the generic term used by NFPA to describe "halon replacement" extinguishing agents (Reference 2.2.2.16, Section 1-2.1). Two agents were used in the ESF. These are "FM-200 and FE-36." Both are potential candidates for protection of electrical equipment and portable mobile equipment in the subsurface repository.

Water-Water is not recommended as an extinguishing agent for use in the subsurface repository. The fire suppression system proposed for both the mobile equipment and the electrical load centers require an inert type of extinguishing agent. A water based suppression system would require shutting-down the power supplies of the mobile equipment and the electric load centers to avoid shorting-out of circuits and damaging the electrical components. The clean agent can be discharged within the control enclosures of the mobile equipment and the load centers without shorting out or damaging electrical/control equipment.

6.3.1.6.3.2 Recommended Extinguishing Agents

The recommended repository extinguishing-agent for primary fire protection is a Clean-agent type system, which is recommended specifically for use in confined locations, such as electrical enclosures, and vehicle operator cabs. These systems present a low hazard to personnel and will not obscure vision when the agent is released.

6.3.1.6.3.3 Pre-engineered Extinguishing Systems

Automatic pre-engineered clean agent extinguishing systems are installed on electric-powered TEV. The clean agent suppression systems are located in the vehicle's electrical control and sensing systems enclosures and activation alarms are transmitted by wireless signals to the synchronous optical network (SONET). The SONET network transmits these fire alarm signals to the main fire alarm panel in the Fire, Rescue and Medical Facility (Facility 63A). The suppression systems are listed by nationally recognized testing laboratories for their intended purpose (Reference 2.2.1.3, Section 4.9.1.7.2) and will be installed to be fully equivalent to OSHA (29 CFR 1926) (Reference 2.2.2.2, Part 800(k)(10)(ii)] and NFPA 2001 (Reference 2.2.2.16) requirements. These systems are activated automatically by on-board fire detection systems that are integrated with the extinguishing systems and other tunnel fire alarm systems.

Automatic pre-engineered clean agent extinguishing systems are also provided for the subsurface electrical load centers. (Reference 2.2.1.3, Section 4.9.1.1.1) The suppression systems will automatically actuated by detectors located within the load center enclosures. Fire alarm, trouble and supervisory signals will be displayed locally and transmitted to the central fire alarm panel in the Fire, Rescue and Medical Facility (Facility 63A) and the CCCF (Area 240) (Reference 2.2.1.3, Section 4.9.1.10.1).

6.3.1.6.3.4 Detection and Alarm Systems

Dedicated automatic and manual fire detection and alarm systems are installed throughout the repository (See Section 6.1.2.3). The detection and alarm systems are installed in compliance with NFPA 72. (Reference 2.2.2.10)

6.3.1.6.3.5 Portable Extinguishers

Incipient firefighting response is manual, using portable multipurpose dry-chemical and clean agent extinguishers. Portable fire extinguishers are selected and installed in compliance with NFPA 10 (Reference 2.2.2.5) and 29 CFR 1910 (Reference 2.2.2.1). Specific extinguisher spacing is determined as the system design proceeds.

6.3.1.7 Potential for Toxic or Radiological Incident Due to a Fire

The potential for a toxic, biological and/or radiological incident due to a fire will not be significant:

- Most material used for construction is essentially inert.

- Burning electrical cables can emit potentially toxic gases as products of combustion. The risk of combustion occurring is low, due to the use of high temperature and fire-rated cable and by separating the power cables from any non fire-rated instrument cables.

- Biological materials will not be present.

- Radioactive materials, although present, are contained in the sealed WPs.

6.3.1.8 Design Basis Fire Scenario –Damage Potential: Maximum Possible Fire Loss (MPFL)

Two fire scenarios are postulated for the subsurface repository, 1) an electrical cable tray exposure fire of the TEV (See Section 6.3.1.3.1.1 and 6.3.1.3.4), and 2) a maintenance railcar fire in an adjacent construction drift (See section 6.3.1.3.2.2). Neither fire is expected to have an MPFL that exceeds $50-million (Assumption 3.1.2).

To prevent an exposure fire in the development area from exposing a WP in the repository, a fire-resistance rating of each ventilation isolation barrier needs to be 3-hours minimum (Assumption 3.2.5).

6.3.1.9 Protection of Essential Safety Class Systems

Safety category (SC) SSCs are those that have an ITS or ITWI significance as described by the safety category definitions in Section 4.1.

Safety category (SC) (ITS or ITWI) and Non-SC (Not ITS or ITWI) SSCs that have been identified in this document as potential fire hazards are:

- Transport and Emplacement Vehicle (**SC**) (ITS) (See Section 6.3.1.3.1)
- Electrical Power Distribution (**Non-SC**) (Not ITS or ITWI) (See Section 6.3.1.3.4)
- SONET (**Non-SC**) (Not ITS or ITWI) (See Section 6.3.1.3.5)

Potential fire hazards for these systems are identified in Section 6.3.1.3. Mitigation of hazards to SC (ITS or ITWI) systems are provided by following the recommendations in Section 6.3.1.3.1.2. Implementation of the installed hazard mitigation will provide a satisfactory level of fire protection that will meet applicable NRC regulations and DOE fire protection orders.

6.3.1.10 Critical Process Equipment

This is not applicable to the subsurface repository.

6.3.1.11 Recovery Potential

The ability to recover from a credible subsurface fire is considered acceptable. Physical damage to the facility and its contents would be limited by the proposed fire protection systems and the use of fire-resistant or noncombustible material for construction and operation.

The adverse effects from fire protection systems should not be significant because water-based systems have not been selected (Reference 2.2.1.3, Section 4.9.1.3.3).

Unacceptable levels of damage, caused by a credible fire, are not postulated due to the use of redundant fire-extinguishing systems for SC (ITS or ITWI) systems.

6.3.1.12 Consequences of a Fire Protection System Failure

Failure of the detection system to alarm in the CCCF could result from an alarm system fault, or the system could have been intentionally removed from service for maintenance. A system fault would produce a trouble alarm in the CCCF. Either a system fault or an intentional removal of the alarm system from service would result in compensatory measures that might include stationing a fire watch in the fire zone who could detect and report a fire in the incipient stage. Such a fire would be extinguished using portable fire extinguishers.

If an on-board suppression system failed, the redundant system would still function. A system failure would produce a trouble alarm in the CCCF.

6.3.1.13 Conclusion

Potential fire hazards for both SC and Non-SC SSCs are identified for these systems in Section 6.3.1.3.

Mitigation of hazards to SC (ITS or ITWI) systems are provided by following the recommendations in Section 6.3.1.3.1.2. Implementation of the installed hazard mitigation provides a satisfactory level of fire protection that will meet applicable NRC regulations and DOE fire protection orders.

6.3.2 Fire Zone FZ-PNL-02

6.3.2.1 Construction/Operations

6.3.2.1.1 Fire Zone FZ-PNL-02 (Panel 2) Description

The second emplacement panel (Panel 2), fire zone FZ-PNL-02 (Table 1), is located within the southern section of the overall layout (Figure 1). Figure 4 shows the various openings that are constructed for FZ-PNL-02. A short new main loop provides the western limit of the panel. FZ-PNL-02 utilizes the existing ESF as its intake main.

FZ-PNL-02 consists of 27 emplacement drifts 5.5-m (18-feet) in diameter (Figure 4, #36 to #62) which are accessed by turnouts. Panel 2 has a total available drift length of 18,876-m (61,938-ft) (Reference 2.2.1.5, Table 10) and includes the South Ramp.

The emplacement area of FZ-PNL-02 is developed from the north to the south. Intake Shaft #2 supplies fresh air to the north end of FZ-PNL-02 (Figure 4, #6) and the South Ramp provides fresh air for the south end of Panel 2. Return air from FZ-PNL-02 north end and south end exhaust through the ECRB Exhaust Shaft (Figure 4, #8) and Exhaust Shaft #2 (Figure 4, #4), respectively.

6.3.2.2 High-Value Property

High-value property is discussed in Section 6.3.1.2. This discussion applies equally to FZ-PNL-02.

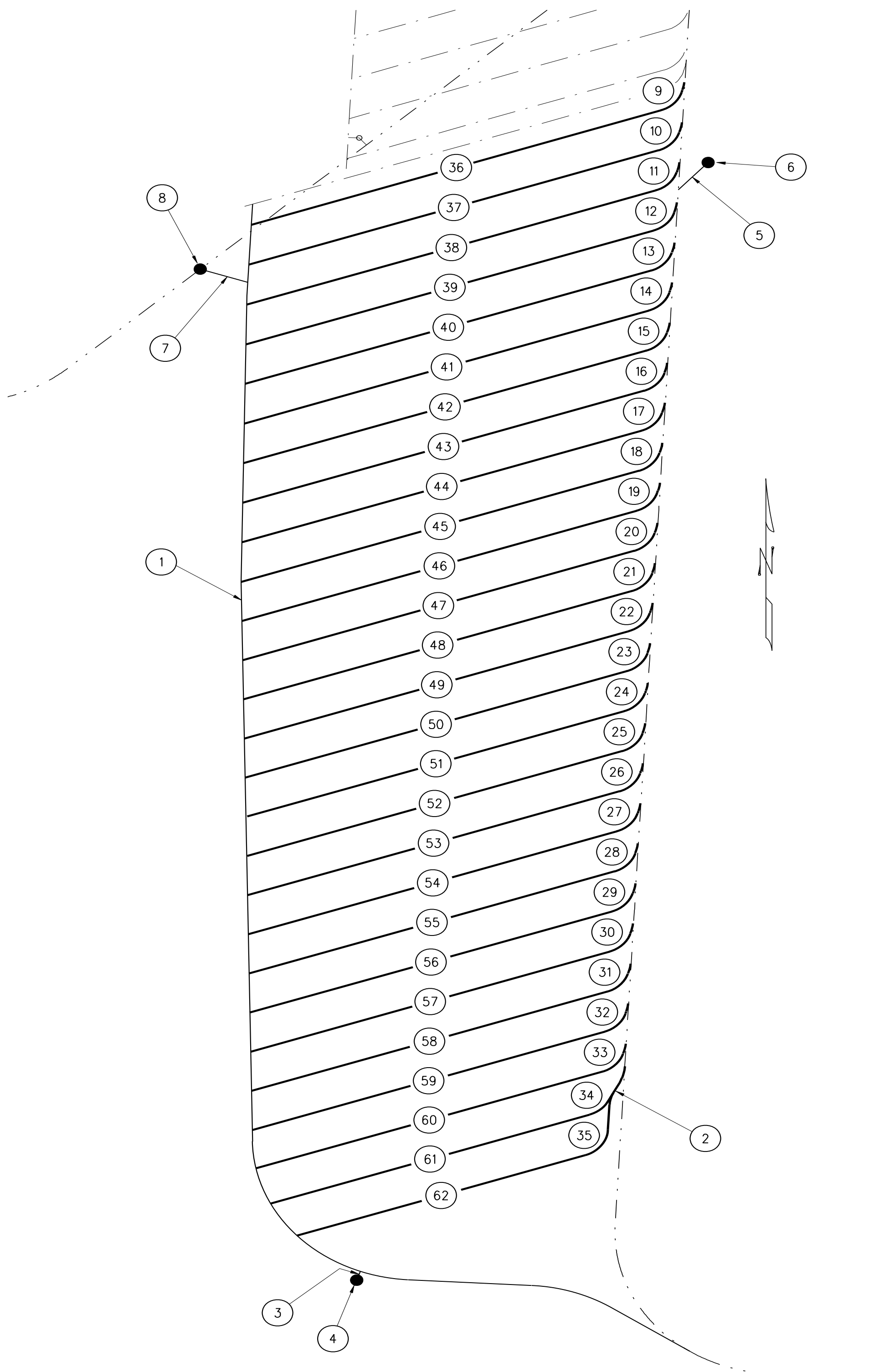
6.3.2.3 Description of Fire Hazards

Fire hazards are discussed in Sections 6.3.1.3 through 6.3.1.3.8.2. These discussions apply equally to FZ-PNL-02.

6.3.2.4 Life Safety Considerations

6.3.2.4.1 Occupancy

The occupancy considerations are discussed in Section 6.1.1.2. These discussions apply equally to FZ-PNL-02.



Source: Reference 2.2.1.5, Figure 8

Figure 5. Panel 2

6.3.2.4.2 Ventilation

Ventilation to Panel 2 consist of intake Shaft #2 supplying fresh air for the north end of Panel 2 and the South Ramp provides fresh air for the south end of Panel 2. Return air from the north and south ends of Panel 2 exhaust through the ECRB Exhaust Shaft and Exhaust Shaft #2 respectively. The exhaust shaft structures consist of two exhaust fans connected in parallel to the exhaust shaft collar by ductwork. In the parallel fan installation, if one fan fails or is off-line for maintenance, the second fan could remain operational and produce approximately 70 percent of the original air volume. With multiple ventilation shafts, each having two fans, a single fan down for maintenance will not have major impact on the repository air volume. (Reference 2.2.1.10, Section 6.11)

The primary function of the emplacement ventilation system is to supply sufficient quantities of air within the repository, to sustain safe working conditions for personnel, and assure that the thermal requirements of the repository are met. Based on the multiple intakes and exhaust shafts provided throughout the repository and the parallel exhaust fan configuration sufficient airflow is assured. (Reference 2.2.1.10, Section 6.12)

The major contributing causes of most fires in the ventilation control building will be poor maintenance, poor housekeeping, and the ready availability of fuel. In the ventilation shaft control buildings, combustibles, both in-situ and transient are not normally readily available. The permanent construction components in the building and the fan structure are of non-combustible construction. The electrically-powered equipment used to power the exhaust fans will be constructed primarily of non-combustible materials. Equipment maintenance is strictly controlled, and materials are inventoried to minimize the risks from combustible materials used in and around the ventilation shaft and control building. Fire detection and alarm systems are provided throughout the building providing early warning notification. Fire Department will be automatically notified and it will respond in accordance with pre-established emergency procedures (Assumption 3.1.1).

6.3.2.4.3 Egress

Egress considerations are discussed in Section 6.1.1.3, 6.1.1.4, 6.1.1.5 and 6.3.1.4.3. These discussions apply equally to FZ-PNL-02.

6.3.2.5 Exposure Fire Potential/Potential for Fire Spread Between Fire Areas

The probability of fire exposure from the development (construction) fire area encroaching into the FZ-PNL-02 fire zone of the emplacement fire area is extremely remote. The isolation barriers between fire areas are fire-rated (Assumption 3.2.5) and the ventilation systems operate totally independently (See Section 6.1.2.6).

6.3.2.6 Fire Protection Features

Fire protection features are discussed in Sections 6.3.1.6.3.1 through 6.3.1.6.3.5. These discussions apply equally to FZ-PNL-02.

6.3.2.7 Potential for Toxic or Radiological Incident Due to a Fire

The potential for a toxic, biological and/or radiological incident due to a fire is discussed in Section 6.3.1.7. This discussion applies equally to FZ-PNL-02.

6.3.2.8 Design Basis Fire Scenario –Damage Potential: Maximum Possible Fire Loss

The DBF is discussed in Section 6.3.1.8 (See also Assumption 3.1.3).

6.3.2.9 Protection of Essential Safety Class Systems

Protection of ITS SSCs is discussed in Section 6.3.1.9. This discussion applies equally to FZ-PNL-02.

6.3.2.10 Critical Process Equipment

This is not applicable to the subsurface repository.

6.3.2.11 Recovery Potential

The ability to recover from a credible subsurface fire is discussed in Section 6.3.1.11. This discussion applies equally to FZ-PNL-02.

6.3.2.12 Consequences of a Fire Protection System Failure

Consequences of a fire protection system failure are discussed in Section 6.3.1.12.

6.3.2.13 Conclusions

Potential fire hazards for both SC and Non-SC SSCs are identified for these systems in Section 6.3.1.3.

Mitigation of hazards to SC (ITS or ITWI) systems are provided by following the recommendations in Section 6.3.1.3.1.2. Implementation of the installed hazard mitigation provides a satisfactory level of fire protection that will meet applicable NRC regulations and DOE fire protection orders.

6.3.3 Fire Zone FZ-PNL-03

6.3.3.1 Construction/Operations

6.3.3.1.1 Fire Zone FZ-PNL-03 (Panel 3) Description

The third emplacement panel (Panel 3), fire zone FA-PNL-03 (Table 2), is located within the primary block of the RHH and is developed to the immediate north of fire zone FZ-PNL-01 (Figure 1) and uses the new North Construction Ramp (See Section 4.4.5) for construction access. This fire zone is divided into two sub-zones, the east and the west. The zones share a common intake main that runs down the middle of the panel. The outside perimeter of the fire zone forms the exhaust main. Figure 5 shows the various openings that are constructed for fire zone FZ-PNL-03.

Panel 3 east has nineteen emplacement drifts and Panel 3 west has twenty-six emplacement drifts. Both the east and west drifts are 5.5-m (18-ft) in diameter (Figure 5, west #47 to #72 and east #92 to #110) which are access by turnouts. Panel 3 has total available drift length of 26,286-m (86,230-ft). The 26 drifts located in the west sub-zone make up 15,246-m (50,014-ft) of emplacement length and 19 drifts located in the east sub-zone make up 11,040-m (36,216-ft) of emplacement length (Reference 2.2.1.5, Table 10).
The emplacement panel, FZ-PNL-03 begins as the North Construction Ramp (Figure 5, #1), advancing in a southerly direction, transitioning into Panel 3 Access Main (Figure 5, #2). The Access Main changes azimuth towards the Panel 1 Connector Drift in the vicinity of Panel 3 West Turnout #10 (Figure 5, #30).

6.3.3.2 High-Value Property

High-value property is discussed in Section 6.3.1.2 discussion applies equally to FZ-PNL-03.

6.3.3.3 Description of Fire Hazards

Fire hazards are discussed in Sections 6.3.1.3 through 6.3.1.3.8.2. These discussions apply equally to FZ-PNL-03.

6.3.3.4 Life Safety Considerations

6.3.3.4.1 Occupancy

The occupancy considerations are discussed in Section 6.1.1.2. These discussions apply equally to FZ-PNL-03.

6.3.3.4.2 Ventilation

Fresh air sources for the south, central and north sections of Panel 3 are the North Ramp, Intake Shaft #4, and Intake Shaft #3 respectively. Exhaust Shaft #4 and Exhaust Shaft #3N services both east and west sides of the central and northern areas of Panel 3. Exhaust Shaft #3S services the south end of Panel 3 East. Exhaust Shaft #1, located in Panel 1, exhausts the south end of Panel 3 West supplemented by an exhaust Vent Raise to the ECRB. The exhaust shaft structures all consist of two exhaust fans connected in parallel to the exhaust shaft collar by ductwork. In the parallel fan configuration, if one fan fails or is off-line for maintenance, the second fan could remain operational and produce approximately 70 percent of the original air volume. With multiple exhaust shafts, each having two fans, a single fan down for maintenance will not have major impact on the repository air volume (Reference 2.2.1.10, Section 6.11).

The primary function of the emplacement ventilation system is to supply sufficient quantities of air within the repository to sustain safe working conditions for personnel, and assure that the thermal requirements of the repository are met. Based on the multiple intakes and exhaust shafts provided throughout the repository and the parallel exhaust fan configuration sufficient airflow is assured (Reference 2.2.1.10, Section 6.12).

During development, Exhaust Shaft #3N provides fresh air for construction via the Exhaust Shaft #3N Construction Access.

The major contributing causes of most fires in the ventilation control building will be poor maintenance, poor housekeeping, and the ready availability of fuel. In the ventilation shaft control buildings, combustibles, both in-situ and transient are not normally readily available. The permanent construction components in the building and the fan structure are of non-combustible construction. The electrically-powered equipment used to power the exhaust fans will be constructed primarily of non-combustible materials. Equipment maintenance is strictly controlled, and materials are inventoried to minimize the risks from combustible materials used in and around the ventilation shaft and control building. Fire detection and alarm systems are provided throughout the control buildings providing early warning notification. Fire Department will be automatically notified and will respond in accordance with pre-established emergency procedures (Assumption 3.1.1).

6.3.3.4.3 Egress

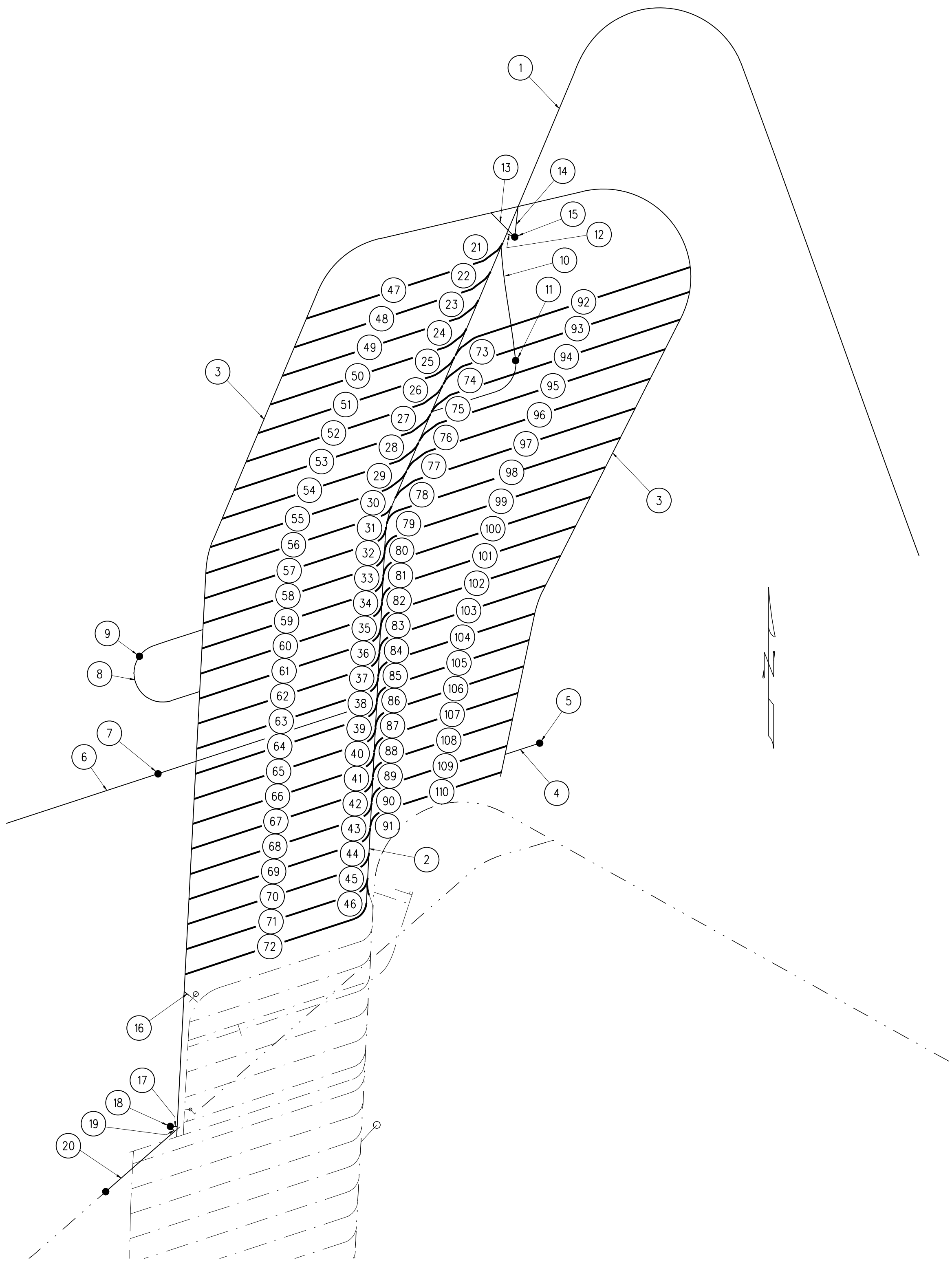
Egress considerations are discussed in Section 6.1.1.3, 6.1.1.4, 6.1.1.5 and 6.3.1.4.3. These discussions apply equally to FZ-PNL-03.

6.3.3.5 Exposure Fire Potential/Potential for Fire Spread between Fire Areas

The probability of fire exposure from the development (construction) fire area encroaching into the FZ-PNL-03 fire zone of the emplacement fire area is extremely remote. The isolation barriers between fire areas are fire-rated (Assumption 3.2.5) and the ventilation systems operate totally independently (See Section 6.1.2.6).

6.3.3.6 Fire Protection Features

Fire protection features are discussed in Sections 6.3.1.6.3.1 through 6.3.1.6.3.5. These discussions apply equally to FZ-PNL-03.



Source: Reference 2.2.1.5, Figure 9

Figure 6. Panel 3

6.3.3.7 Potential for Toxic or Radiological Incident Due to a Fire

The potential for a toxic, biological and/or radiological incident due to a fire is discussed in Section 6.3.1.7. This discussion applies equally to FZ-PNL-03.

6.3.3.8 Design Basis Fire Scenario –Damage Potential: Maximum Possible Fire Loss

The DBF is discussed in Section 6.3.1.8 (See also Assumption 3.1.3).

6.3.3.9 Protection of Essential Safety Class Systems

Protection of ITS SSCs is discussed in Section 6.3.1.9. This discussion applies equally to FZ-PNL-03.

6.3.3.10 Critical Process Equipment

This is not applicable to the subsurface repository.

6.3.3.11 Recovery Potential

The ability to recover from a credible subsurface fire is discussed in Section 6.3.1.11. This discussion applies equally to FZ-PNL-03.

6.3.3.12 Consequences of a Fire Protection System Failure

Consequences of a fire protection system failure are discussed in Section 6.3.1.12.

6.3.3.13 Conclusions

Potential fire hazards for both SC and Non-SC SSCs are identified for these systems in Section 6.3.1.3.

Mitigation of hazards to SC (ITS or ITWI) systems are provided by following the recommendations in Sections 6.3.1.3.1.2. Implementation of the installed hazard mitigation provides a satisfactory level of fire protection that meets applicable NRC regulations and DOE fire protection orders.

6.3.4 Fire Zone FZ-PNL-04

6.3.4.1 Construction/Operations

6.3.4.1.1 Fire Zone FZ-PNL-04 (Panel 4) Description

The fourth emplacement panel (Panel 4), fire zone FZ-PNL-04 (Table 2), is located within the primary area of the RHH to the western limit of the repository footprint area (Figure 1). Figure 1 shows the various openings that are constructed for FZ-PNL-04. Panel 4 consist of thirty emplacement drifts, 5.5-m in diameter (Figure 6, #34 through #63) that are accessed by a turnout 7 x 8 meters (23 x 26 feet) and a total available drift length of 16,719-m (54,857-ft) (Reference 2.2.1.5, Table 6 & 10).

Panel 4 Exhaust Main is comprised of three segments. The northern segment is a shared exhaust main with Panel 3 West up to Emplacement Drift #9 (Figure 6, #42). A central portion from Emplacement Draft #10 to Emplacement Draft #26, parallels Panel 3, West Exhaust Main (Figure 6, #43 to #59). The south section of the exhaust main services the remaining four emplacement drifts in Panel 4 and is an exhaust conduit for Panel 3 West exhaust.
Panel 4 shares ventilation shafts with Panel 3. Fresh air for the south end of Panel 4, is supplied from Intake Shaft #4 and Intake Shaft #3 services the north end of Panel 4. Exhaust Shaft #3N services the north end of Panel 4, Exhaust Shaft #4 services the central area and the ECRB Exhaust Shaft services the south end of Panel 4.

6.3.4.2 High-Value Property

High-value property is discussed in Section 6.3.1.2. This discussion applies equally to FZ-PNL-04.

6.3.4.3 Description of Fire Hazards

Fire hazards are discussed in Sections 6.3.1.3 through 6.3.1.3.8.2. These discussions apply equally to FZ-PNL-04.

6.3.4.4 Life Safety Considerations

6.3.4.4.1 Occupancy

The occupancy considerations are discussed in Section 6.1.1.2. These discussions apply equally to FZ-PNL-04.

6.3.4.4.2 Ventilation

Panel 4 shares ventilation shafts with Panel 3. Fresh air for the south end of Panel 4 is supplied from Intake Shaft #4 and Intake Shaft #3 services the north end of Panel 4. Exhaust Shaft #3N services the north end of Panel 4, Exhaust Shaft #4 services the central area and the ECRB Exhaust Shaft services the south end of Panel 4. The exhaust shaft structures consist of two exhaust fans connected in parallel to the exhaust shaft collar by ductwork. In the parallel fan configuration, if one fan fails or is off-line for maintenance, the second fan could remain operational and produce approximately 70 percent of the original air volume. With multiple exhaust shafts, each having two fans, a single fan down for maintenance will not have major impact on the repository air volume (Reference 2.2.1.10, Section 6.11).

The primary function of the emplacement ventilation system is to supply sufficient quantities of air within the repository, to sustain safe working conditions for personnel, and assure that the thermal requirements of the repository are met. Based on the multiple intakes and exhaust shafts provided throughout the repository and the parallel exhaust fan configuration sufficient airflow is assured (Reference 2.2.1.10, Section 6.12).

The major contributing causes of a fire in the ventilation control building are poor maintenance, poor housekeeping, and the ready availability of fuel. In the ventilation shaft control buildings, combustibles, both in-situ and transient are not normally readily available. The construction components in the building and the fan structure are of non-combustible construction. The electrically-powered equipment used to power the exhaust fans will be constructed primarily of non-combustible materials. Equipment maintenance is strictly controlled, and materials are inventoried to minimize the risks from combustible materials used in and around the ventilation shaft and control building. Fire detection and alarm systems will be provided throughout the building providing early warning notification. Fire Department will be automatically notified and it will respond in accordance with pre-established emergency procedures (Assumption 3.1.1).

6.3.4.4.3 Egress

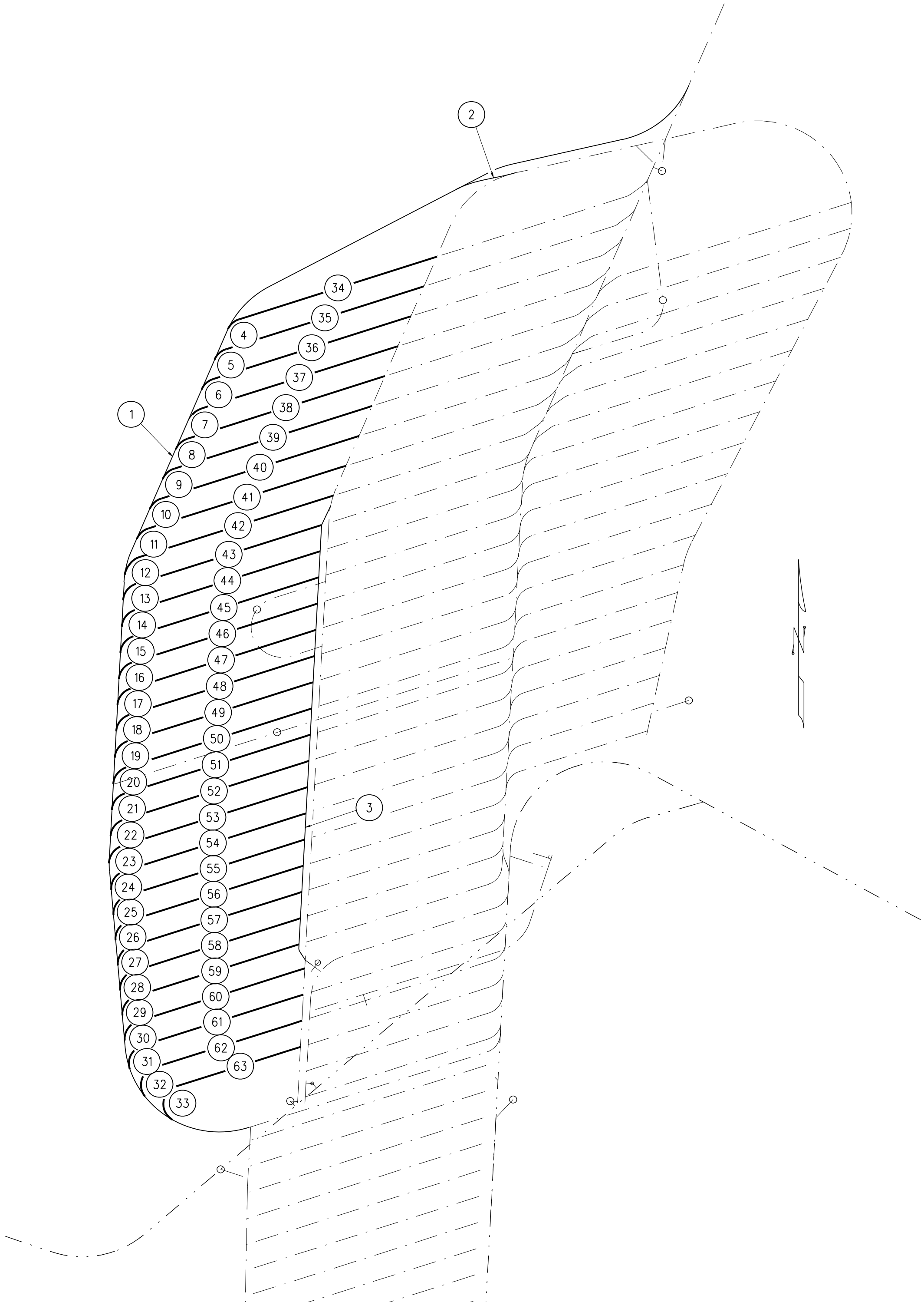
Egress considerations are discussed in Section 6.1.1.3, 6.1.1.4, 6.1.1.5 and 6.3.1.4.3. These discussions apply equally to FZ-PNL-04.

6.3.4.5 Exposure Fire Potential/Potential for Fire Spread between Fire Areas

The probability of fire exposure from the development (construction) fire area encroaching into the FZ-PNL-04 fire zone of the emplacement fire area is extremely remote. The isolation barriers between fire areas are fire-rated (Assumption 3.2.5) and the ventilation systems operate totally independently (See Section 6.1.2.6).

6.3.4.6 Fire Protection Features

Fire protection features are discussed in Sections 6.3.1.6.3.1 through 6.3.1.6.3.5. These discussions apply equally to FZ-PNL-04.



Source: Reference 2.2.1.5, Figure 10

Figure 8. Panel 4

6.3.4.7 Potential for Toxic or Radiological Incident Due to a Fire

The potential for a toxic, biological and/or radiological incident due to a fire is discussed in Section 6.3.1.7. This discussion applies equally to FZ-PNL-04.

6.3.4.8 Design Basis Fire Scenario –Damage Potential: Maximum Possible Fire Loss

The DBF is discussed in Section 6.3.1.8. (See also Assumption 3.1.3)

6.3.4.9 Protection of Essential Safety Class Systems

Protection of ITS SSCs is discussed in Section 6.3.1.9. This discussion applies equally to FZ-PNL-04.

6.3.4.10 Critical Process Equipment

This is not applicable to the subsurface repository.

6.3.4.11 Recovery Potential

The ability to recover from a credible subsurface fire is discussed in Section 6.3.1.11. This discussion applies equally to FZ-PNL-04.

6.3.4.12 Consequences of a Fire Protection System Failure

Consequences of a fire protection system failure are discussed in Section 6.3.1.12.

6.3.4.13 Conclusions

Potential fire hazards for both SC and Non-SC SSCs are identified for these systems in Section 6.3.1.3.

Mitigation of hazards to SC (ITS or ITWI) systems are provided by following the recommendations in Sections 6.3.1.3.1.2. Implementation of the installed hazard mitigation provides a satisfactory level of fire protection that will meet applicable NRC regulations and DOE fire protection orders.

6.3.5 Fire Zone FZ-PC-01

6.3.5.1 Construction/Operations

6.3.5.1.1 Fire Zone FZ-PC-01 (Observation Drift) Description

The Observation Drift, fire zone FZ-PC-01 (Table 2) and the Thermal Test Alcove are located in Panel 1. The Observation Drift starts from the Thermal Test Alcove and crosses beneath the Access Main turning onto the same azimuth as the Emplacement Drift #3. The Observation Drift is parallel and 20 m (66 ft) north of the Emplacement Drift # 3 and rise to intersect Panel 1 Exhaust Main (Figure 7).

The Observation Drift and the Observation Drift Alcove (Figure 7) are both sized 5-m x 5-m (16-ft x 16-ft). The 20-m (66-ft) offset helps maintain a stable pillar between the emplacement drift and the Observation Drift when the Observation Drift ramps up to connect with the Exhaust Main. The Test Alcove is located below the Emplacement Drift a minimum of 10-m (33-ft) from crown to invert in order to maintain a stable pillar.

FZ-PC-01, the Observation Drift and Test Alcove (Figure 7) have a total plan drift length of 971-m (3186-ft) and alcove length of 40-m (131 ft) (Reference 2.2.1.5, Table 3).

6.3.5.2 High-Value Property

High-value property in the Observation Drift has not been determined yet. It is expected that some of the monitoring/testing equipment could have a value in excess of one million dollars. In the event that high-value property is located in the Observation Drift, automatic fire suppression systems will be provided for fire protection. The specific means of protection will be determined when this information becomes available.

6.3.5.3 Description of Fire Hazards

Fire hazards are discussed in Section 6.3.1.3. Many of these discussions apply equally to FZ-PC-01. In addition, unique hazards may be introduced into this area by the specialist testing equipment that is used in performance confirmation. This equipment has not yet been defined.

6.3.5.4 Life Safety Considerations

6.3.5.4.1 Occupancy

The occupancy considerations are discussed in Section 6.1.1.2. These discussions apply equally to FZ-PC-01.

6.3.5.4.2 Ventilation

Ventilation considerations are discussed in Section 6.3.1.4.2. These discussions apply equally to FZ-PC-01.

6.3.5.4.3 Egress

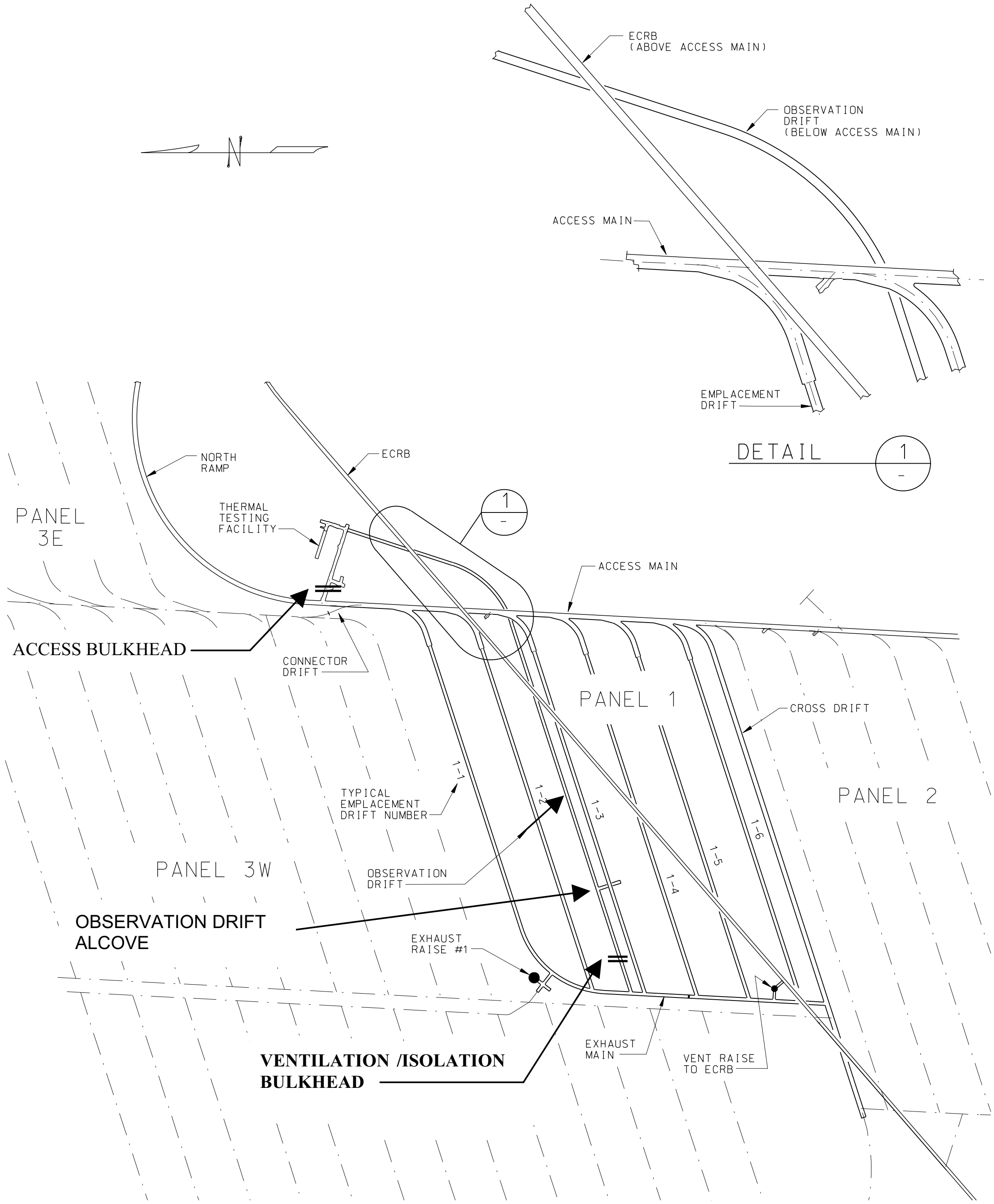
Egress considerations are discussed in Section 6.1.1.3, 6.1.1.4, 6.1.1.5 and 6.3.1.4.3. These discussions apply equally to FZ-PC-01.

6.3.5.5 Exposure Fire Potential/Potential for Fire Spread between Fire Areas

The probability of fire exposure from the development (construction) fire area encroaching into the FZ-PC-01 fire zone of the emplacement fire area is very remote. The isolation barriers between fire areas are fire-rated (Assumption 3.2.5) and the ventilation systems operate totally independently (See Section 6.1.2.6). In addition, this drift is physically remote from any development activities.

6.3.5.6 Fire Protection Features

Fire protection features are discussed in Section 6.3.1.6.3.1 through 6.3.1.6.3.5. These discussions apply equally to FZ-PC-01.



Source: Reference 2.2.1.5, Figure 5

Figure 9. Observation Drift and Alcove

6.3.5.7 Potential for Toxic or Radiological Incident Due to a Fire

The potential for a toxic, biological and/or radiological incident due to a fire is discussed in Section 6.3.1.7. This discussion applies equally to FZ-PC-01.

6.3.5.8 Design Basis Fire Scenario –Damage Potential: Maximum Possible Fire Loss

See Assumption 3.1.2 for basis for MPFL loss. A DBF has not yet been determined for this fire zone. When the testing equipment has been identified, an evaluation of the fire hazards will be made and the DBF identified.

6.3.5.9 Protection of Essential Safety Class Systems

Protection of ITS SSCs is discussed in Section 6.3.1.9. This discussion applies equally to FZ-PC-01.

6.3.5.10 Critical Process Equipment

This is not applicable to the subsurface repository.

6.3.5.11 Recovery Potential

The ability to recover from a credible subsurface fire is discussed in Section 6.3.1.11. This discussion applies equally to FZ-PC-01.

6.3.5.12 Consequences of a Fire Protection System Failure

Failure of the smoke detection system to alarm in the CCCF could result from an alarm system fault, or the system could have been intentionally removed from service for maintenance. A system fault would produce a trouble alarm in the CCCF. Either a system fault or an intentional removal of the alarm system from service would result in compensatory measures that might include stationing a fire watch in the fire zone who could detect and report a fire in the incipient stage. Such a fire would be extinguished using portable fire extinguishers.

6.3.5.13 Conclusions

Since a DBF has not yet been identified and evaluated, it is premature to make a conclusion regarding fire and life safety for this fire zone. When the performance confirmation testing equipment and their operations are defined, this fire zone's hazards and required mitigation will be evaluated.

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7. REQUIRED DESIGN FEATURES

The assessment of this FHA, for the Emplacement Fire Area, is that implementation of the required hazard mitigation and life safety provisions (See Section 7.1) provide an acceptable level of fire protection that meets applicable NRC regulations, DOE fire protection orders, and OSHA regulations. Failure to provide the required mitigation features will render analysis conclusions invalid.

7.1 REQUIRED HAZARD MITIGATION

The following hazard mitigation is required to meet the NRC regulations and DOE Orders in addition to the criteria of Sections 2.2.1 and 2.2.2:

- Provide ERSs or equivalent means of life-safety (See Section 6.1.1.3).
- Provide personal SRs and SCSRs (See Section 6.1.1.5).
- Construct the isolation/ventilation barriers between fire areas (Emplacement/Development) with a fire-resistance rating of 3-hours (See Section 4.4.1).
- Install detection and alarm system throughout the personnel egress routes of the North Ramp, Observation Drift, Thermal Testing Facility and the Observation Drift Alcove (See Sections 6.1.2.3 & 6.3.1.6.3.4).
- Install portable fire extinguishers in the access mains, Observation Drift, alcove and thermal testing facility (See Sections 6.1.2.2 & 6.3.1.6.3.5).
- Install redundant automatic fire detection and fire-extinguishing systems onboard the WP TEV (See Sections 6.3.1.6.3 & 6.3.1.12).
- Select power back-up batteries to minimize hydrogen off gassing (See Section 6.3.1.6.2).
- Install redundant automatic fire-extinguishing systems for the subsurface electrical distribution equipment located in electrical niches adjacent to the main access mains. (See Section 6.3.1.3.4.2).
- Install electrical distribution equipment in alcoves (See Section 6.3.1.3.4.2).
- Install electrical distribution equipment in cabinets (See Sections 6.3.1.3.4.2 & 6.3.1.6.1.2).
- Use fire-resistant cable insulation (See Sections 6.1.3.1 & 6.3.1.6.1.1).
- Use fire-retardant hydraulic fluids (See Section 6.3.1.6.1.1).

- Develop fire procedures for compensatory measures during impairments to fire protection systems (See Section 6.1.3.3).

8. RESULTS AND CONCLUSIONS

8.1 CONCLUSIONS

This FHA identifies fire hazards and identifies their mitigation for subsurface repository fire protection systems. The mitigation establishes the necessary level of fire protection to meet NRC regulations and DOE fire protection orders that ensure fire containment, adequate life safety provisions, and minimize property loss. Equipment requiring automatic fire-extinguishing systems is identified.

Mitigation of hazards to SC and Non-SC systems is provided by following the requirements Section 7. Implementation of the installed hazard mitigation provides a satisfactory level of fire protection that meets applicable NRC regulations and DOE fire protection orders.

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