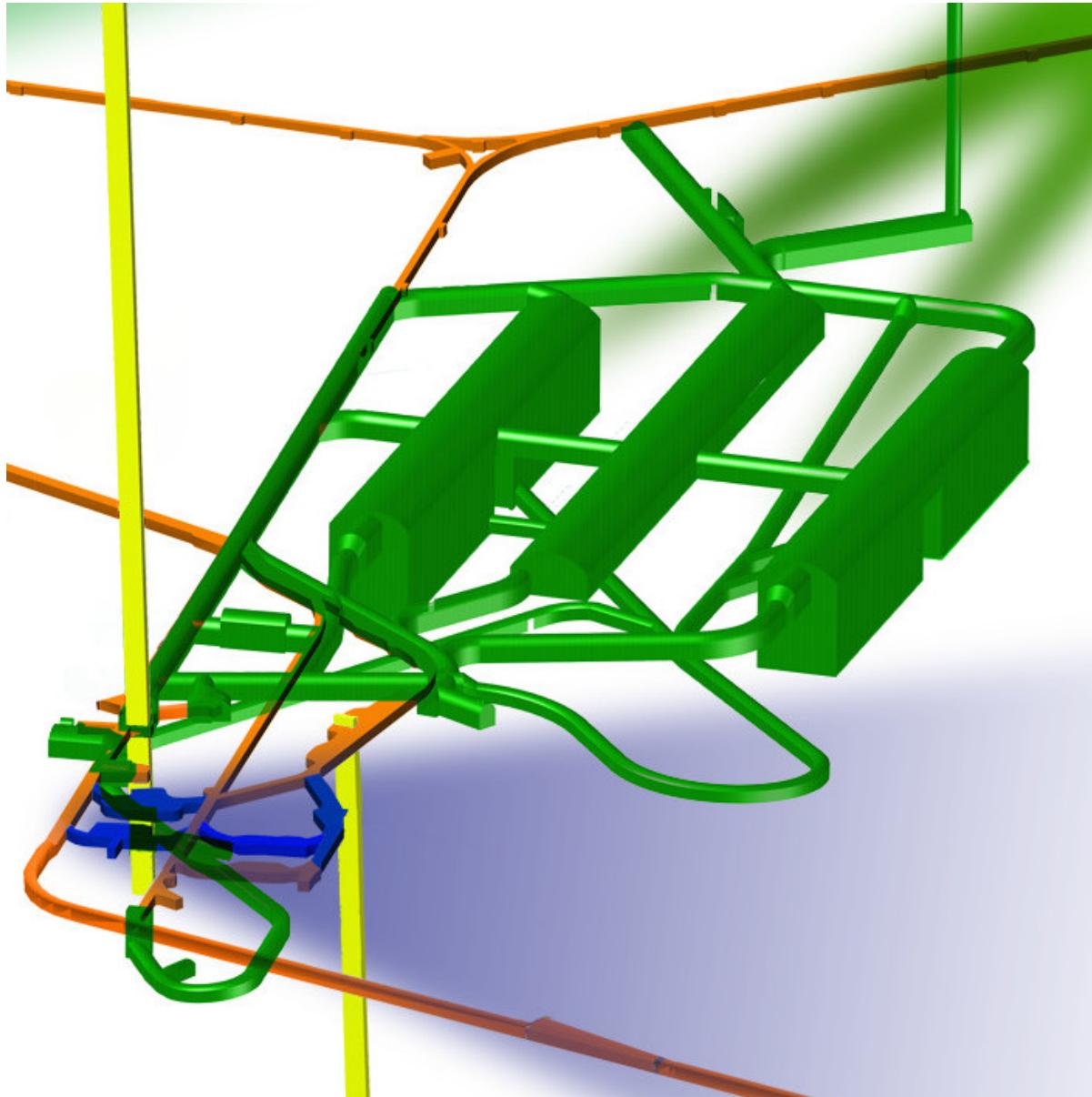


<sup>1</sup>  
<sup>2</sup>  
The Long-Baseline Neutrino Facility (LBNF)  
Far Site Conventional Facilities

<sup>3</sup>  
Preliminary Design Report



<sup>4</sup>

<sup>5</sup>

October 9, 2015



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5

# **Todo list**

1	I moved next sentence from ch 5 to here 10/9 . . . . .	3
2	ref . . . . .	3
3	add citation, doc 117 . . . . .	10
4	where are these defined? . . . . .	13
5	beyond those identified in the (year) assessment of the existing facility conditions done for (this needs some context) . . . . .	16
6	...who owned and operated the Homestake Mine on the site until (whatever year)? (this needs context) . . . . .	16
7	year . . . . .	16
8	who is HDR? . . . . .	19
9	citation . . . . .	19
10	you evaluate for an assessment? Not clear what you want to say here. 'evaluated or assessed with regard to these aspects'? 'given a preliminary evaluation to see if they're ready for an assessment'? I'm confused (same comment next bullet) . . . . .	19
11	cite . . . . .	20
12	range of the? . . . . .	21
13	citation . . . . .	22
14	Need a sentence saying something about why ross complex is important, to lead into next sentence, e.g., "the FSCF is located in the Ross Complex" . . . . .	24
15	cite . . . . .	24
16	add north pointing arrow . . . . .	25
17	image fuzzy; orig available? . . . . .	25
18	supporting? . . . . .	27
19	reference cryo design doc . . . . .	27
20	With all this description of concrete slabs, they should be labeled in the figure . . . . .	27
21	explain or replace 'dry facilities' . . . . .	27
22	Need orig; too fuzzy . . . . .	29
23	Not a word about the hoist building; change subsection title? . . . . .	29
24	a word on why it's necessary or beneficial? . . . . .	32
25	rehabilitated? . . . . .	32
26	because it's not heated now? Is this so that people can work in it? . . . . .	32
27	much of the? . . . . .	32
28	this is on project? . . . . .	32
29	'minor demolition'? sounds like an oxymoron . . . . .	32
30	ref . . . . .	33
31	Almost everywhere we use 'cavern' not 'cavity'; am trying to make it consistent . . . . .	35

1 can we add 'rock stability' or something to make the requirements sound more complete? . . . .	35
2 it reduces the TOTAL volume below the excavated volume; the fiducial volume is even smaller; I	
3        don't think you want 'fiducial' here; it's not defined and doesn't need to be . . . . .	36
4 compared to what? . . . . .	36
5 what aspects are complex? . . . . .	36
6 how do you know if they're not excavated yet? And are we talking about all the caverns, or a	
7        specific one? . . . . .	36
8 what is this unit? liter per ? . . . . .	36
9 'concrete invert' is a phrase I don't know, but may be ok . . . . .	36
10 Placement of rock bolts? . . . . .	37
11 is this an enclosed room within the CUC? . . . . .	37
12 is this not the primary, driving requirement for having everything outside the detector cavern? . .	37
13 not clear how it 'optimizes' ventilation; needs more explanation. Or is it that it's a freer space	
14        so you can put venting wherever you want? . . . . .	37
15 you optimize a drift so that you can accommodate a larger load in the shaft? I don't get it. What	
16        are you doing with the utilities? They need to be installed in the drift or passed through it? .	37
17 this space (with a descriptive yet unclear name!) is not defined . . . . .	38
18 excavation? . . . . .	38
19 I changed pit to chamber . . . . .	38
20 This isn't clear; part of the problem is that the figure doesn't show exactly where the mucking	
21        ramp starts. . . . .	39
22 'from the 4850L' in a detector chamber? what level is the ramp at? . . . . .	39
23 the rest of the pgraph describes one way . . . . .	39
24 this area again! is it like a staging area where you put stuff while you're working? . . . . .	39
25 in other words, detector module 3 will not be started while chamber 4 is being excavated? . . .	39
26 for modules 3 nd 4? . . . . .	39
27 to or from? . . . . .	39
28 I removed 'infrequent' because it removed the focus from the space issue and made it sound less	
29        important . . . . .	40
30 what does it mean 'consider'? Limitations will be imposed on LBNF due to the needs of the	
31        other tenants? please clarify . . . . .	41
32 ref . . . . .	41
33 I reworded according to the way I understood it. It this right? . . . . .	41
34 why call this out specifically? . . . . .	41
35 conceptual ok? . . . . .	42
36 give year. . . . .	42
37 xref and citation . . . . .	42
38 ref . . . . .	43
39 year . . . . .	43
40 reference . . . . .	43
41 do people know what a 'shaft collar' is? . . . . .	44
42 on figure, what's 'mT'? can't be milli-ton! . . . . .	44
43 above it sounds like it's been in operation since the beginning and still is . . . . .	44
44 because that requires less work? what's connection between config and allowing egress? . . . . .	44
45 I have no idea what prev sentence means, i.e. how these things relate to each other. Wait, is	
46        ground support something in the rock walls around the shaft? then lacing is some kind of	
47        non-solid wall around the cage that carries people? . . . . .	44

1	the requirements are defined by the existing configuration? . . . . .	46
2	ref . . . . .	46
3	ref . . . . .	46
4	what's a 'set' and is 'size' really thickness? Are the timbers the structural pieces that are placed between compartments? . . . . .	46
5	built from wood? . . . . .	46
7	citation . . . . .	47
8	That's a mouthful. Exhaust air will go through spray chamber. Spray chamber's primary function is to keep the chilled water cold and direct the extracted heat into borehole. Borehold connects to 3500L near Oro Hondo shaft. Then heat goes up Oro Hondo to fan at surface? Is fan sucking the air up (if not, why do we care about the fan)? Is the idea that the exhaust air mixes with the heat and gets transported to the surface the same way? . . . . .	47
11	what is cfm unit and on what piece of infrastructure is this a requirement? Clarify relationship between ventilation (I think of fresh air for people to breathe) and heat extraction . . . . .	48
14	through each detector chamber? . . . . .	48
16	I guess cryo systems will be operating for excav of chambers 2 (partial), 3 and 4? . . . . .	48
17	at the what? seems like you want it to alarm at any level that could be affected . . . . .	51
18	emergency devices? not sure what we're referring to here . . . . .	51
19	pls clarify prev sentence. I don't understand. To me grounding doesn't have to do with duration, it provides a safe path for current . . . . .	51
21	and where 5 ohms isn't possible? . . . . .	51
22	what's a substation underground? This could use a picture . . . . .	51
23	detector grounding reqs? . . . . .	52
24	SURF supplies the required...? . . . . .	52
25	suppression . . . . .	52
26	50% WHAT? . . . . .	53
27	should the rest of this go under Ventilation? . . . . .	53
28	Ton can't be the right unit; needs a per unit time unit . . . . .	53
29	in the borehole or exhaust shaft? . . . . .	53
30	cut off at what point? unlcear . . . . .	53
31	citation . . . . .	54
32	Ross? . . . . .	54
33	what part is CF responsible for? Should this be in the last chapter? . . . . .	54
34	Josh says: Need to determine whether this terminology is acceptable from Pepin . . . . .	56
35	what consitutes the conveying system? . . . . .	56
36	of the shaft? . . . . .	58
37	from what to what? . . . . .	59
38	give approx year . . . . .	59
39	the first 60-100 ft aren't within the tunnels? where are they with respect to the tunnels? . . . . .	60
40	how does this compare to a rebuild? . . . . .	61

# <sup>1</sup> Chapter 1

## <sup>2</sup> Introduction

cf-intro

tro-fscf

### <sup>3</sup> 1.1 The Long-Baseline Neutrino Facility for DUNE

<sup>4</sup> The global neutrino physics community is developing a multi-decade physics program to measure  
<sup>5</sup> unknown parameters of the Standard Model of particle physics and search for new phenomena.  
<sup>6</sup> The program will be carried out as an international, leading-edge, dual-site experiment for neutrino  
<sup>7</sup> science and proton decay studies, which is known as the *Deep Underground Neutrino Experiment*  
<sup>8</sup> (*DUNE*), supported by the *Long-Baseline Neutrino Facility* (*LBNF*).

<sup>9</sup> To achieve its ambitious physics objectives as a world-class facility, this program has been conceived  
<sup>10</sup> around three central components:

- <sup>11</sup> 1. an intense, wide-band neutrino beam
- <sup>12</sup> 2. a fine-grained near neutrino detector just downstream of the neutrino source
- <sup>13</sup> 3. a massive liquid argon time-projection chamber (LArTPC) deployed as a far neutrino detector  
<sup>14</sup> deep underground, 1,300 km downstream; this distance between the neutrino source and far  
<sup>15</sup> detector – the *baseline* – is measured along the line of travel through the Earth

<sup>16</sup> The neutrino beam and near detector will be installed at the Fermi National Accelerator Laboratory  
<sup>17</sup> (Fermilab), in Batavia, Illinois. The far detector will be installed at the Sanford Underground  
<sup>18</sup> Research Facility (SURF) in Lead, South Dakota. The experiment’s detectors at the two sites will  
<sup>19</sup> be designed, built, commissioned and operated by the international DUNE Collaboration. LBNF  
<sup>20</sup> is the facility designed to support the experiment. LBNF will comprise

- <sup>21</sup> • the world’s highest-intensity neutrino beam at Fermilab
- <sup>22</sup> • a set of underground caverns to house the DUNE far detector modules at SURF
- <sup>23</sup> • a beamline measurement system at the near site

- 1     • conventional facilities at both the near and far sites
  - 2     • cryogenics infrastructure to support the DUNE detector at the far site
- 3 LBNF is hosted by Fermilab and its design and construction is organized as a DOE/Fermilab  
4 project incorporating international partners.

## 5 **1.2 Strategy and Requirements**

6 The strategy for executing the scientific program was presented in the LBNF/DUNE Conceptual  
7 Design Report (CDR)<sup>cd-r-cdr</sup>[1]. The program has been developed to meet the requirements set out in the  
8 P5 report<sup>p5-report-2014</sup>[2] and takes into account the recommendations of the European Strategy for Particle  
9 Physics<sup>euro-strat-2013</sup>[3]. It adopts a model in which U.S. and international funding agencies share costs on  
10 the DUNE detectors, and the European Organization for Nuclear Research (CERN) and other  
11 participants provide in-kind contributions to the supporting infrastructure of LBNF. LBNF and  
12 DUNE will be tightly coordinated as DUNE collaborators design the detectors and infrastructure  
13 that will carry out the scientific program.

14 The requirements on LBNF derive from the DUNE Collaboration science requirements<sup>dune-sci-req</sup>[4], which  
15 drive the space and functional needs of the far detector construction and operation, and from  
16 Environment, Safety and Health (ES&H) and facility operations requirements. The LBNF and  
17 DUNE requirements are maintained together in<sup>dune-sci-req</sup>[4]. Conventional Facility requirements are detailed  
18 in the Arup 100% Preliminary Design Report<sup>arup:fsci100pdr</sup>[5].

19 The DUNE far detector is designed as a set of four 10-kt fiducial mass modules. The caverns and  
20 the services to the caverns will be as similar to one another as possible in order to implement  
21 efficiency in design, construction and operation. Figure 1.1 shows the layout of the underground  
22 caverns that will house the detector modules, and the separate cavern that will house utilities and  
23 cryogenics systems.

24 While the SURF site already meets many of the requirements from the geological, scientific and  
25 engineering standpoints, significant work is required to provide the space and infrastructure for  
26 the experiment's installation and operation.

27 This PDR presents the scope of the LBNF Far Site Conventional Facilities (FSCF) at SURF, the  
28 present and future states of the site, evaluation and assessment of its facilities and the provisioning  
29 of associated infrastructure such as power, water, plumbing, ventilation, etc. Also described are  
30 the tasks and processes planned for developing the surface and underground structures and the  
31 requisite safety measures.

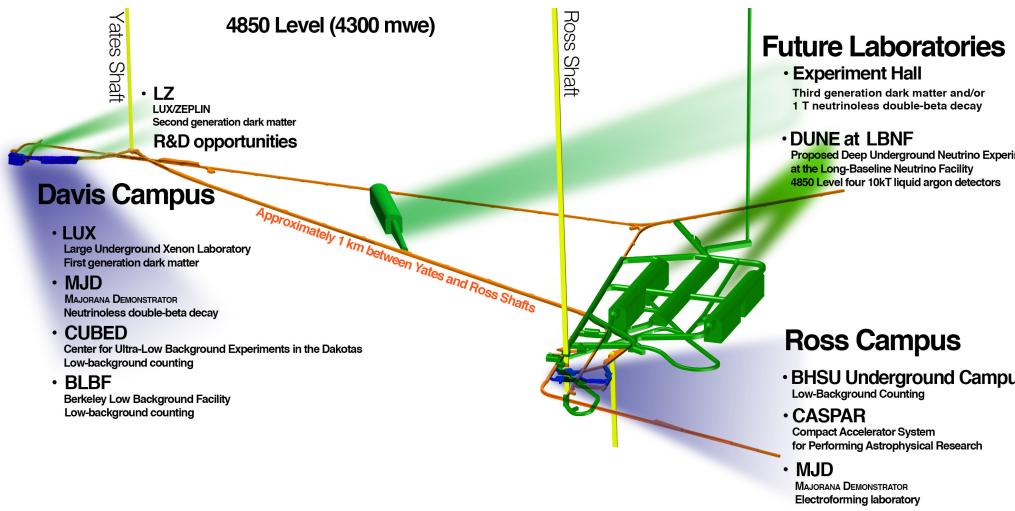


Figure 1.1: Underground cavern layout (SRK, Courtesy SURF)

fig:unde

## 1.3 Introduction to the Far Site Conventional Facilities

- <sup>1</sup> The scope of the FSCF includes design and construction for facilities on the surface and underground at SURF for DUNE.
- <sup>4</sup> The primary element of the Far Site Conventional Facilities (FSCF) is the set of underground spaces required to install, operate and support the multi-module cryogenic DUNE far detector.

<sup>6</sup> I moved next sentence from ch 5 to here 10/9

- <sup>7</sup> The deep-underground installation is required to shield the sensitive detector from cosmic rays, as detailed in the Report on the Depth Requirements for a Massive Detector at Homestake

<sup>9</sup> ref

- <sup>10</sup> . The 4850L is deeper than what is absolutely required, but is used because of existing access at this level. The underground conventional facilities include new excavated spaces at the 4850L for the detector modules, utility spaces for experiment equipment, utility spaces for facility equipment, drifts for access, and spaces required for construction. Underground infrastructure that FSCF must provide for DUNE includes power to experiment equipment, cooling systems for that equipment and cyberinfrastructure for data collection. Underground infrastructure required for the facility includes domestic (potable) water, industrial water for process use and fire suppression, fire detection and alarm systems, normal and standby power systems, a sump-pump drainage system for native and leak water around the detector, water drainage to the facility-wide pump discharge system, and cyberinfrastructure for communications and security. In addition to providing new spaces and infrastructure underground, FSCF enlarges some existing spaces for use, such as the access drifts from the Ross Shaft to the new caverns, and provides infrastructure for these spaces.

- 1 New piping is provided in the shaft for cryogens (gas argon transfer line and nitrogen compressor  
2 suction and discharge lines) and water as well as for power cables and cyberinfrastructure.
- 3 About 50 buildings and utilities exist above-ground at SURF, a few of which will be utilized  
4 for LBNF. The scope of the surface FSCF includes only that work necessary for LBNF; it does  
5 not include the general rehabilitation of buildings on the site, which remains the responsibility  
6 of SURF. Electrical substations and distribution will be upgraded to increase power and provide  
7 standby capability for life safety. An existing building will be remodeled to house both office  
8 space and an experiment/facility control room, and a new building will be constructed near the  
9 existing Ross Shaft to support cryogen transfer from the surface to the 4850L. To reduce the risk of  
10 failure of aging but essential support equipment during the construction and installation periods,  
11 several SURF infrastructure-reliability activities are included in the earlier phases of the LBNF  
12 Project. These include completion of the Ross Shaft rehabilitation, rebuilding of hoist motors, and  
13 replacement of the Oro Hondo fan. Failure of any of this aging infrastructure could limit or stop  
14 access to the underground.

## 15 **1.4 The LBNF Far Site CF Preliminary Design Report**

- 16 The *LBNF Far Site Conventional Facilities Preliminary Design Report* describes the preliminary  
17 designs for the conventional facilities planned for the Sanford Underground Research Facility  
18 (SURF), the LBNF Far Site. This document is an evolution of *LBNF/DUNE CDR Annex 3C:*  
19 *Conventional Facilities (CF) at the Far Site*, which was prepared for the LBNF/DUNE CD-1-  
20 Refresh Review in July 2015. The original LBNF/DUNE Conceptual Design Report volumes  
21 have been updated [6, 7, 8, 9] as required to provide context for the LBNF Far Site Conventional  
22 Facilities design.
- 23 The scope of this Preliminary Design Report (PDR) is limited to the LBNF Far Site Conventional  
24 Facilities (FSCF); the cryogenics infrastructure is not included.
- 25 1. This chapter provides a short introduction to LBNF, DUNE and the FSCF.
- 26 2. Chapter 2 summarizes the management structure for LBNF.
- 27 3. Chapter 3 describes the existing site conditions at SURF.
- 28 4. Chapter 4 describes the existing and planned surface buildings that will support the DUNE  
29 far detector, planned for installation at the 4850L of SURF.
- 30 5. Chapter 5 discusses the planned underground excavation.
- 31 6. Chapter 6 describes the underground infrastructure necessary to facilitate installation and  
32 operation of the DUNE far detector modules.
- 33 7. Chapter ?? describes the restoration and maintenance activities required at the SURF site

1       that are included in the overall LBNF Project and planned to be executed as early Site  
2       Preparation.

3 This PDR is supported by a Design Report from the independent engineering firm, Arup, USA<sup>arup:fscf100pd</sup>[5].

# <sup>1</sup> Chapter 2

## <sup>2</sup> Project Management

intro-pm

### <sup>3</sup> 2.1 Project Structure and Responsibilities

<sup>4</sup> The LBNF Project is charged by Fermilab and DOE to design and construct conventional and technical facilities needed to support the DUNE Collaboration. LBNF is organized as a DOE/Fermilab project incorporating in-kind contributions from international partners. At this time, the major international partner is CERN, the European Organization for Nuclear Research. LBNF works closely with DUNE through several coordinating groups to ensure scientific direction and coordination for executing the LBNF Project such that the requirements of the program are met.

<sup>10</sup> LBNF works closely with SURF management to coordinate design and construction for the far site conventional facilities for the DUNE far detector. CERN is providing cryogenics equipment and engineering as part of the cryogenics infrastructure at SURF. The design and construction of LBNF is supported by other laboratories and consultants/contractors that provide scientific, engineering, and technical expertise. A full description of LBNF Project Management is contained in the LBNF/DUNE Project Management Plan<sup>[?]</sup>.

<sup>16</sup> LBNF coordinates with DUNE through regular technical team interactions between the two Projects as well as more formally through the Joint Management Team where day-to-day management coordination occurs, and the Experiment-Facility Interface Group, where major issues regarding interfaces and items affecting both Projects are discussed. In addition, the Projects share common Project Office staff and systems, and include a single, integrated project resource-loaded schedule and configuration management system.

<sup>22</sup> LBNF consists of two major L2 subprojects, Far Site Facilities and Near Site Facilities, coordinated through a central Project Office located at Fermilab. Each L2 Project consists of two large L3 subprojects corresponding to the conventional and technical facilities, respectively, at each site. The project organizational structure, which includes leadership from major partners, is shown in Figure ??.

<sup>27</sup> The LBNF Project team consists of members from Fermilab, CERN, South Dakota Science and

<sup>1</sup> Technology Authority (SDSTA), and Brookhaven National Laboratory (BNL). The team, including  
<sup>2</sup> members of the Project Office as well as the L2 and L3 managers for the individual subprojects,  
<sup>3</sup> is assembled by the Project Director. The Project team is shown in Figure 2.2. Line management  
<sup>4</sup> for environment, safety and health, and quality assurance flows through the Project Director.

<sup>5</sup> Through their delegated authority and in consultation with major stakeholders, the L2 Project  
<sup>6</sup> Managers determine which of their lower-tier managers will be Control Account Managers (CAMs)  
<sup>7</sup> for the Project WBS. L2 and L3 Project Managers are directly responsible for generating and  
<sup>8</sup> maintaining the cost estimate, schedule, and resource requirements for their subprojects and for  
<sup>9</sup> meeting the goals of their subprojects within the accepted baseline cost and schedule.

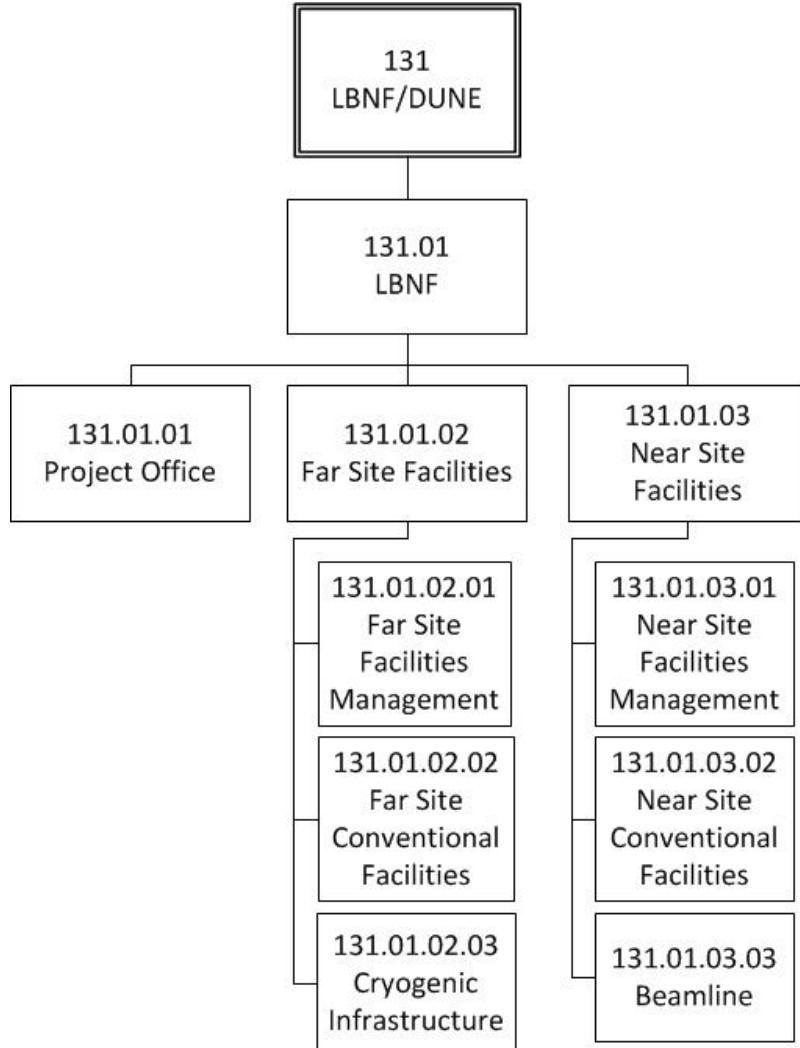


Figure 2.1: LBNF Work Breakdown Structure (WBS) to Level 3 (L3)

## <sup>10</sup> 2.2 SDSTA and SURF

<sup>11</sup> LBNF plans to construct facilities at SURF to house and support the DUNE far detector. SURF  
<sup>12</sup> is owned by the state of South Dakota and managed by the SDSTA.

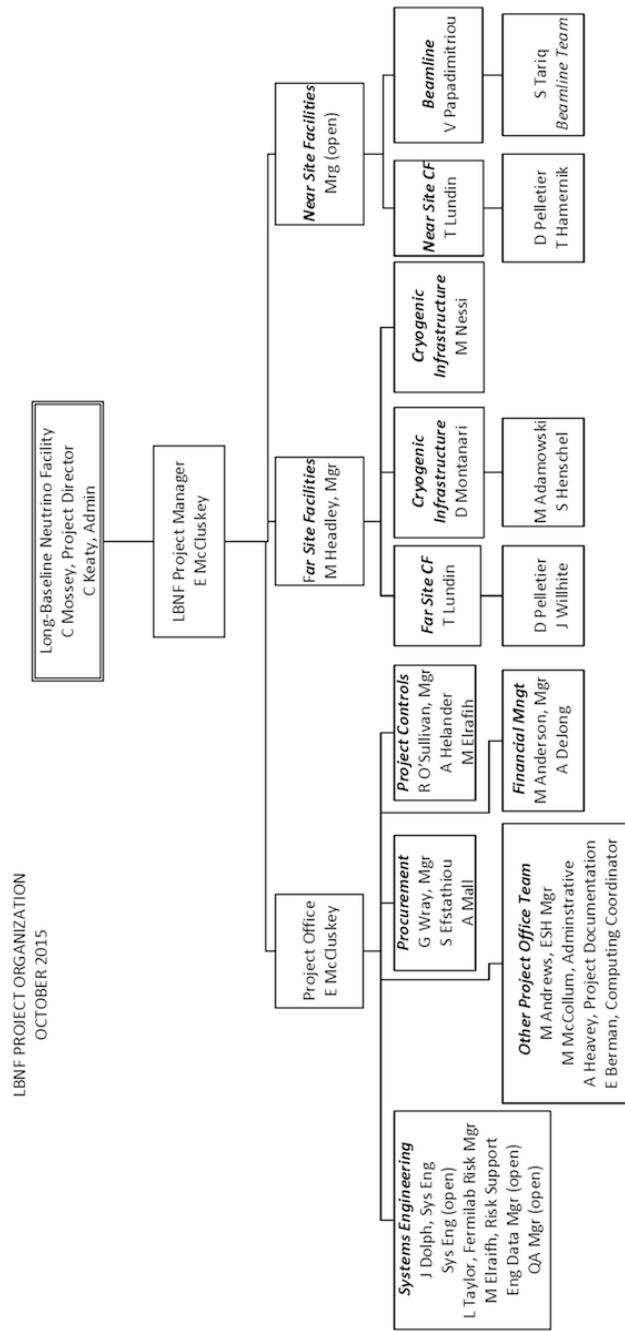


Figure 2.2: LBNF Organization

fig:lbnf

- 1 Current SURF activities include operations necessary for allowing safe access to the 4850L of the  
2 former mine, which houses the existing and under-development science experiments. The DOE  
3 is presently funding SDSTA ongoing operations through Lawrence Berkeley National Laboratory  
4 (LBNL) and its SURF Operations Office through FY16; starting in FY17 it is expected that this  
5 will change, and that funding will flow through Fermilab.
- 6 The LBNF Far Site Facilities Manager is also an employee of SDSTA and is contracted to Fer-  
7 milab to provide management and coordination of the Far Site Conventional Facilities (CF) and  
8 Cryogenics Infrastructure subprojects. LBNF contracts directly with SDSTA for the design of the  
9 required CF at SURF; whereas the actual construction of the CF will be directly contracted from  
10 Fermilab. Coordination between SDSTA and the LBNF Project is necessary to ensure efficient  
11 operations at SURF. This will be facilitated via an agreement between SDSTA and Fermilab (not  
12 yet available) that defines responsibilities and methods for working jointly on LBNF Project design  
13 and construction. A separate agreement will be written for LBNF Operations.

## 14 **2.3 CERN**

- 15 The European Organization for Nuclear Research (CERN) is expected to significantly contribute  
16 to LBNF with technical components that are required to support the deployment of both the  
17 DUNE detectors and the neutrino beamline.

## 18 **2.4 Coordination within LBNF**

- 19 The LBNF Project organization is headed by the LBNF Project Director, who is also the Fermilab  
20 Deputy Director for LBNF; this person reports directly to the Fermilab Director.

21 Within FermilabâŽs organization, the LBNF organization includes two new divisions – Far-Site  
22 Facilities and Near-Site Facilities – as well as a project office, all led by the LBNF Project Director.  
23 They have been created to execute the Far Site Facilities and Near Site Facilities subprojects. The  
24 heads of these divisions report to the LBNF Project Manager. Any personnel working more than  
25 half-time on these subprojects would typically be expected to become a member of one of these  
26 divisions, while other contributors will likely be matrixed into part-time roles from other Fermilab  
27 Divisions. The heads of the other Fermilab Divisions work with the L2 and L3 project managers  
28 to supply the needed resources on an annual basis.

29 The LBNF WBS defines the scope of work. All changes to the WBS must be approved by the  
30 LBNF Project Manager prior to implementation. The current WBS is shown in Figure 2.1. For  
31 work on specific tasks required for the LBNF Project at the SURF site, SDSTA assigns engineers  
32 and others as required. This is listed in the resource-loaded schedule as contracted work from  
33 Fermilab for Far Site CF activities. CERN and Fermilab are developing a common cryogenics  
34 team to design and produce the Cryogenics Infrastructure subproject deliverables for the far site.  
35 CERN provides engineers and other staff as needed to complete their agreed-upon deliverables.

1 LBNF has formed several management groups with responsibilities as described below. More detail  
2 is provided in the PMP

3 add citation, doc 117

4 .  
5 LBNF uses a *Project Management Board* to provide formal advice to the Project Director on  
6 matters of importance to the LBNF Project as a whole. Such matters include (but are not limited  
7 to) those that

- 8 • have significant technical, cost, or schedule impact on the Project
- 9 • have impacts on more than one L2 subproject
- 10 • affect the management systems for the Project
- 11 • have impacts on or result from changes to other Projects on which LBNF is dependent
- 12 • result from external reviews or reviews called by the Project Director

13 The Project Management Board serves as the

- 14 • LBNF Change Control Board, as described in the Configuration Management Plan [?]
- 15 • Risk Management Board, as described in the Fermilab Risk Management Procedure for  
16 Projects [?]

17 The Far Site CF (FSCF) Project has engaged three international experts in hard-rock underground  
18 construction to advise it periodically through the design and construction process regarding ex-  
19 cavation at SURF. This team, the FSCF *Neutrino Cavity Advisory Board (NCAB)*, meets at  
20 the request of the FSCF-PM, generally on-site, to discuss specific technical issues. The NCAB  
21 produces a report with its findings and conclusions for Project information and action.

## 22 **2.5 LBNF/DUNE Advisory and Coordinating Structures**

23 A set of structures has been established to provide coordination among the participating funding  
24 agencies, oversight of the LBNF and DUNE projects, and coordination and communication between  
25 the two projects. These structures and the relationships among them are shown in Figure 2.3 and  
26 are described in this section.

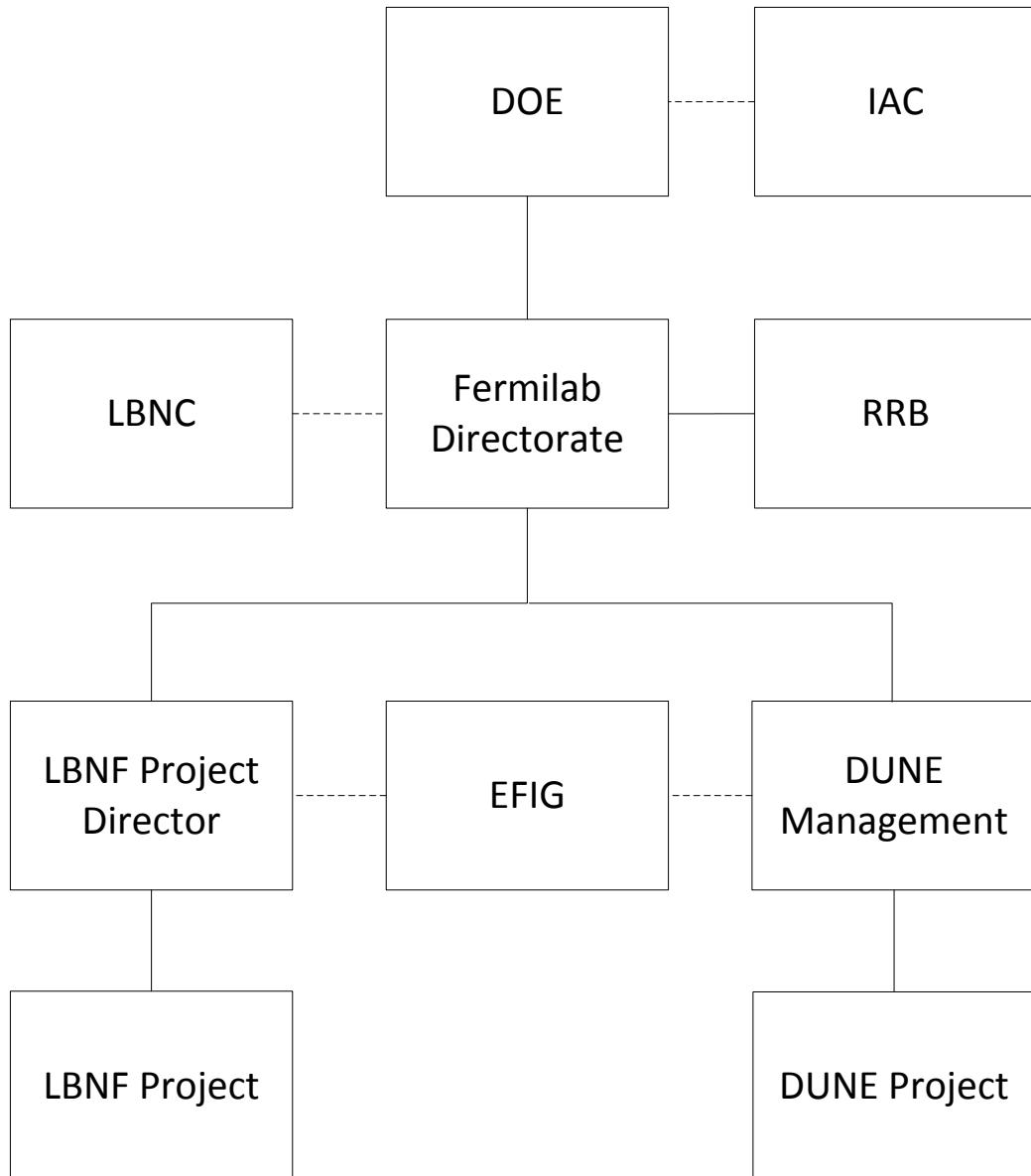


Figure 2.3: Joint LBNF/DUNE management structure

fig:lbnf

## **2.5.1 International Advisory Council (IAC)**

The International Advisory Council (IAC) is composed of regional representatives, such as CERN, and representatives of funding agencies that make major contributions to LBNF infrastructure or to DUNE. The IAC acts as the highest-level international advisory body to the U.S. DOE and the FNAL Directorate, and facilitates high-level global coordination across the entire enterprise (LBNF and DUNE). The IAC is chaired by the DOE Office of Science Associate Director for High Energy Physics and includes the FNAL Director in its membership. The council meets as needed and provides pertinent advice to LBNF and DUNE through the Fermilab Director.

Specific responsibilities of the IAC include, but are not limited to, the following:

- During the formative stages of LBNF and DUNE the IAC helps to coordinate the sharing of responsibilities among the agencies for the construction of LBNF and DUNE. Individual agency responsibilities for LBNF will be established in bilateral international agreements with the DOE. Agency contributions to DUNE will be formalized through separate agreements.
  - The IAC assists in resolving issues, especially those that cannot be resolved at the Resources Review Boards (RRB) level, e.g., issues that require substantial redistributions of responsibilities among the funding agencies.
  - The IAC assists as needed in the coordination, synthesis and evaluation of input from Project reports charged by individual funding agencies, LBNF and DUNE Project management, and/or the IAC itself, leading to recommendations for action by the managing bodies.
- The DUNE Co-Spokespersons and/or other participants within the Fermilab neutrino program will be invited to sessions of the IAC as needed. Council membership may increase as additional funding agencies from

## **2.5.2 Resources Review Boards (RRB)**

The Resources Review Boards (RRB) are composed of representatives from all funding agencies that sponsor LBNF and DUNE, and from the Fermilab management. The RRB provides focused monitoring and detailed oversight of each of the Projects. The Fermilab Director in coordination with the DUNE RC defines its membership. A representative from the Fermilab Directorate chairs the boards and organizes regular meetings to ensure the flow of resources needed for the smooth progress of the enterprise and for its successful completion.

The managements of the DUNE Collaboration and the LBNF Project participate in the RRB meetings and make regular reports to the RRB on technical, managerial, financial and administrative matters, as well as on status and progress of the DUNE Collaboration. DUNE Finance Board members who serve as National Contacts from the sponsoring funding agencies will be invited to RRB sessions.

1 Two groups exist within the RRB: RRB-LBNF and RRB-DUNE. Each of these groups monitors  
2 progress and addresses the issues specific to its area while the whole RRB deals with matters that  
3 concern the entire enterprise. The RRB meet biannually; these meetings start with a plenary  
4 opening session and are followed by RRB-LBNF and RRB-DUNE sessions. As DUNE progresses  
5 toward experimental operations, RRB-Computing sessions will convene.

6 The RRB employs standing DUNE and LBNF *Scrutiny Groups* as needed to assist in its responsi-  
7 bilities. The scrutiny groups operate under the RRB, and provide detailed information on financial  
8 and personnel resources, costing, and other elements under the purview of the RRB.

9 Responsibilities of the RRB include

10 • assisting the DOE and the FNAL Directorate, with coordinating and developing any required  
11 international agreements between partners

12 • monitoring and overseeing the Common Projects and the use of the Common Funds

13      where are these defined?

14 • monitoring and overseeing general financial and personnel support

15 • assisting the DOE and the FNAL Directorate with resolving issues that may require reallo-  
16 cation of responsibilities among the Project's funding agencies

17 • reaching consensus on a maintenance and operation procedure, and monitoring its function

18 • approving the annual Common Fund budget of DUNE for construction and for maintenance  
19 and operation

### 20 **2.5.3 Fermilab, the Host Laboratory**

21 As the host laboratory, Fermilab has a direct responsibility for the design, construction, commis-  
22 sioning and operation of the facilities and infrastructure (i.e., LBNF) that support the science  
23 program. In this capacity, Fermilab reports directly to the DOE through the Fermilab Site Office  
24 (FSO). Fermilab also has an important oversight role for the DUNE Project itself as well as an  
25 important coordination role in ensuring that interfaces between the two Projects are completely  
26 understood.

27 Fermilab's oversight of the DUNE Collaboration and detector construction project is carried out  
28 through

29 • regular meetings with the Collaboration leadership

30 • approving the selection of Collaboration spokespersons

- 1     • providing the Technical and Resource Coordinators
- 2     • convening and chairing the Resources Review Boards
- 3     • regular scientific reviews by the Physics Advisory Committee (PAC) and Long-Baseline Neu-
- 4         trino Committee (LBNC)
- 5     • Director's Reviews of specific management, technical, cost and schedule aspects of the de-
- 6         tector construction project
- 7     • other reviews as needed

#### 8     **2.5.4 DUNE Collaboration**

9     The Collaboration, in consultation with the Fermilab Director, is responsible for forming the  
10    international DUNE Project team responsible for designing and constructing the detectors. The  
11    Technical Coordinator (TC) and Resource Coordinator (RC) serve as the lead managers of this  
12    international project team and are selected jointly by the spokespersons and the Fermilab Director.  
13    Because the international DUNE Project incorporates contributions from a number of different  
14    funding agencies, it is responsible for satisfying individual tracking and reporting requirements  
15    associated with the different contributions.

#### 16    **2.5.5 Long-Baseline Neutrino Committee (LBNC)**

17    The Long-Baseline Neutrino Committee (LBNC), composed of internationally prominent scientists  
18    with relevant expertise, provides external scientific peer review for LBNF and DUNE regularly.  
19    The LBNC reviews the scientific, technical and managerial decisions and preparations for the  
20    neutrino program. It acts in effect as an adjunct to the Fermilab Physics Advisory Committee  
21    (PAC), meeting on a more frequent basis than the PAC. The LBNC may employ DUNE and LBNF  
22    Scrutiny Groups for more detailed reports and evaluations. The LBNC members are appointed by  
23    the Fermilab Director.

#### 24    **2.5.6 Experiment-Facility Interface Group (EFIG)**

25    Close and continuous coordination between DUNE and LBNF is required to ensure the success  
26    of the combined enterprise. An Experiment-Facility Interface Group (EFIG) was established in  
27    January 2015 to oversee and ensure the required coordination both during the design/construction  
28    and operational phases of the program. This group covers areas including:

- 29     • interface between the near and far detectors and the corresponding conventional facilities

- 1     ● interface between the detector systems provided by DUNE and the technical infrastructure
  - 2         provided by LBNF
  - 3     ● design and operation of the LBNF neutrino beamline
- 4     The EFIG is chaired by the two deputy directors of Fermilab. Its membership includes the LBNF  
5     Project Director and Project Manager, and the DUNE Co-Spokespersons, Technical Coordinator,  
6     Resource Coordinator and the CERN-LBNF Project Manager. In consultation with the DUNE  
7     and LBNF management, the EFIG Chairs will extend the membership as needed to carry out the  
8     coordination function. In addition, the DOE Federal Project Director for LBNF, the Fermilab  
9     Chief Project Officer, and a designated representative of the SDSTA will serve ex officio. The  
10    EFIG Chairs designate a Secretary of the EFIG, who keeps minutes of the meetings and performs  
11    other tasks as requested by the Chair.
- 12    It is the responsibility of the EFIG Chairs to report EFIG proceedings to the Fermilab Director and  
13    other stakeholders. It is the responsibility of the DUNE spokespersons to report EFIG proceedings  
14    to the rest of the Collaboration. The EFIG meets weekly or as needed.

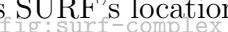
# <sup>1</sup> Chapter 3

## <sup>2</sup> Existing Site Conditions

<sup>3</sup> site-cond  
The SDSTA currently operates and maintains the Sanford Underground Research Facility (SURF)  
<sup>4</sup> at the former Homestake mine in Lead, South Dakota. The SURF property comprises 186 acres  
<sup>5</sup> on the surface and 7,700 acres underground. The SURF Surface Campus includes approximately  
<sup>6</sup> 253,000 gross square feet (gsf) of existing structures. Using a combination of private funds through  
<sup>7</sup> T. Denny Sanford, South Dakota Legislature-appropriated funding, and a federal Department of  
<sup>8</sup> Housing and Urban Development (HUD) Grant, the SDSTA has made significant progress in  
<sup>9</sup> stabilizing and rehabilitating the SURF facility to provide for safe access and prepare the site for  
<sup>10</sup> new laboratory construction. These efforts have included dewatering of the underground facility  
<sup>11</sup> and mitigating and reducing risks

<sup>12</sup> beyond those identified in the (year) assessment of the existing facility conditions done for  
(this needs some context)

<sup>13</sup> the former Deep Underground Science and Engineering Laboratory (DUSEL).

<sup>14</sup>  Figure 3.1 shows SURF's location within the region as a part of the northern Black Hills of South  
<sup>15</sup>  Dakota. Figure 3.2 outlines the SURF site in relationship to the city of Lead, South Dakota, and  
<sup>16</sup> points out various significant features of Lead including the surrounding property that still remains  
<sup>17</sup> under the ownership of Barrick Gold Corporation.

<sup>18</sup> ...who owned and operated the Homestake Mine on the site until (whatever year)? (this needs  
context)

### <sup>19</sup> 3.1 Existing Site Conditions Evaluation

<sup>20</sup> The facility conditions as of

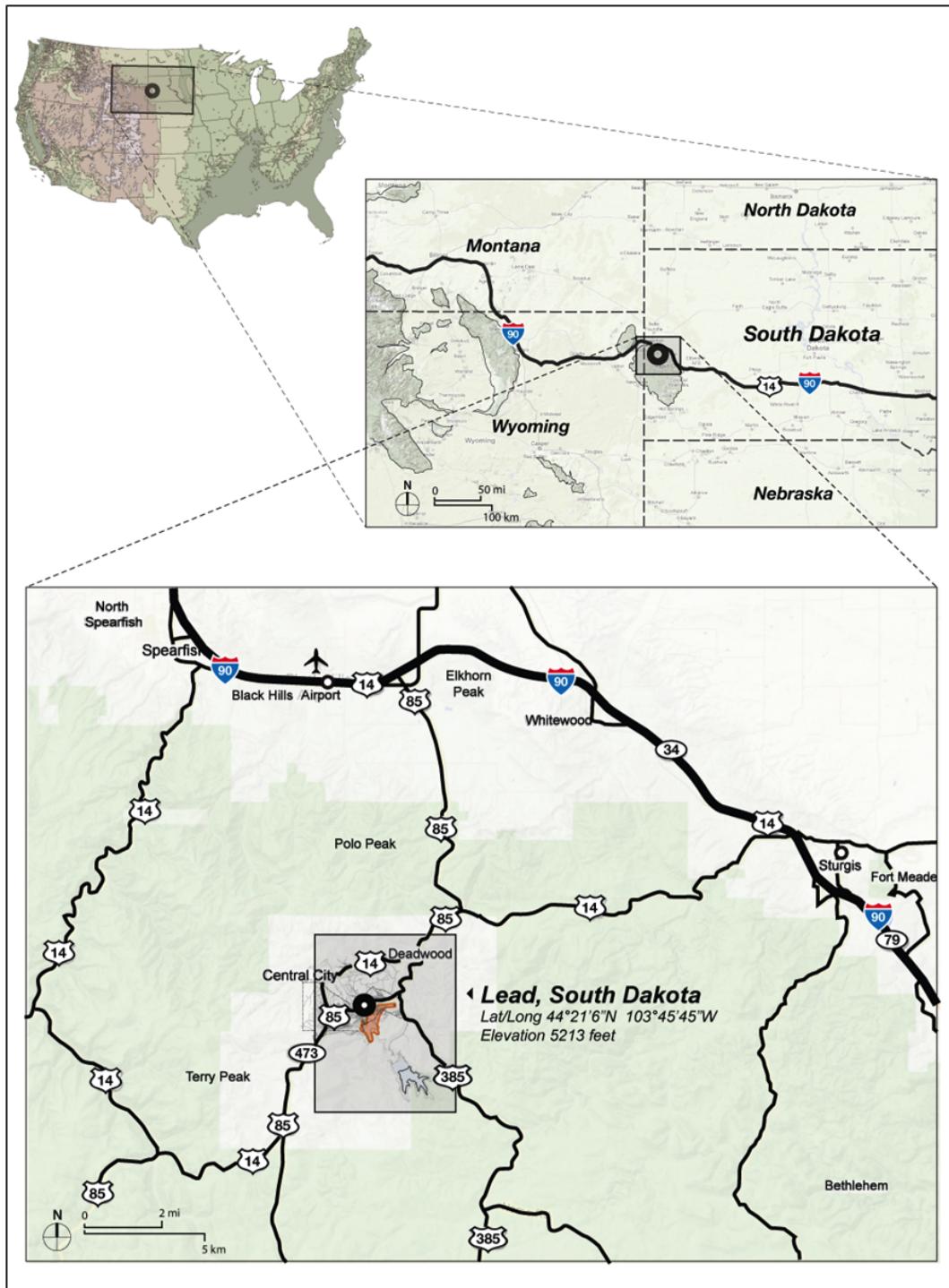


Figure 3.1: Regional context showing the city of Lead, South Dakota. (Dangermond Keane Architecture, Courtesy SURF)

fig:regi

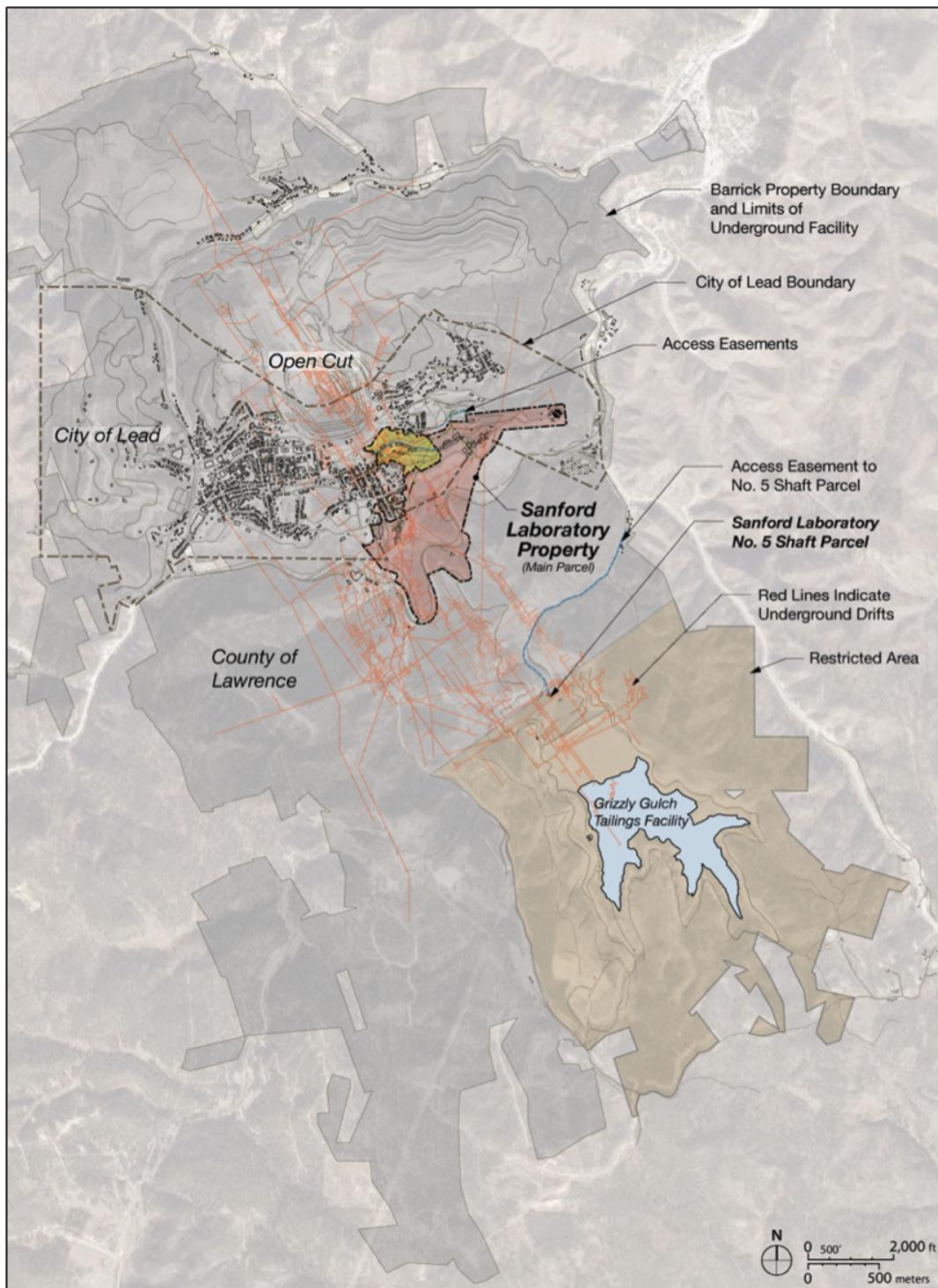


Figure 3.2: SURF Complex shown in the context of the city of Lead, South Dakota, and the property remaining under ownership of Barrick. Area shown in yellow is a potential future expansion of the SDSTA property. [Dangermond Keane Architecture, Courtesy of SURF]

fig:surf

1 year

2 were assessed by HDR

3 who is HDR?

4 as part of the DUSEL Preliminary Design to evaluate the condition of existing facilities and  
5 structures on the Yates, and Ross Campuses. They are documented in the DUSEL PDR, Section  
6 5.2.4, [10]

7 citation

8 . The portions of DUSEL's assessment pertinent to the LBNF Project are included here; they  
9 have been edited to reflect current activities and conditions. References to the DUSEL Project are  
10 from that time, and are now considered historic.

11 The HDR assessments reviewed the condition of buildings that were proposed for continued use  
12 in their then-current function, new use, or potential demolition. Assessments for buildings were  
13 performed on their architectural, structural, mechanical/electrical/plumbing (MEP), civil, envi-  
14 ronmental, and historic aspects. Site assessments looked at civil, landscape, environmental, and  
15 historic aspects. Facility-wide utilities such as electrical, steam distribution lines, water and sewer  
16 systems were also assessed. In particular:

- 17 • Buildings proposed for reuse were evaluated for preliminary architectural and full structural,  
18 environmental, and historic assessments.

19 you evaluate for an assessment? Not clear what you want to say here. 'evaluated or as-  
sessed with regard to these aspects'? 'given a preliminary evaluation to see if they're  
ready for an assessment'? I'm confused (same comment next bullet)

- 20 • Buildings proposed for demolition were evaluated for preliminary historic assessments.
- 21 • Preliminary MEP assessments were performed on the Ross Substation, #5 Shaft fan, Oro  
22 Hondo fan, Oro Hondo substation, and on the general site utilities for the Ross, Yates, and  
23 Ellison Campuses.
- 24 • The waste water treatment plant (WWTP) received preliminary architectural and structural  
25 assessments and a full MEP assessment.
- 26 • Preliminary civil assessments of the Kirk Portal site and Kirk to Ross access road were also  
27 completed.
- 28 The assessment was completed in three phases and the detailed reports are included in the appen-  
29 dices of the DUSEL PDR as:

- 1 • Phase I Report, Site Assessment for Surface Facilities and Campus Infrastructure to Support
- 2 Laboratory Construction and Operations (DUSEL PDR Appendix 5.E)
- 3 • Phase II Site and Surface Facility Assessment Project Report (DUSEL PDR Appendix 5.F)
- 4 • Phase II Roof Framing Assessment (DUSEL PDR Appendix 5.G)

## 5 **3.2 Evaluation of Geology and Existing Excavations**

6 The accessible underground mine workings at SURF within the footprint of the former Homestake  
7 Gold Mine are extensive. Over the life of the gold mine, over 360 miles of drifts (tunnels) were  
8 mined, and shafts and winzes were sunk to gain access to depths in excess of 8,000 feet. A number  
9 of underground workings are being refurbished by SURF, and new experiments are being installed  
10 at the 4850L, the same level as proposed for the LBNF underground facilities. Geotechnical  
11 investigations and initial geotechnical analyses were completed by Arup, USA

12 cite

13 for the DUSEL Preliminary Design and are described in detail in the DUSEL PDR. Additional  
14 geotechnical investigation and analyses were performed, also by Arup, in 2014 specific to LBNF.  
15 This section provides summaries of these two efforts, including work completed for DUSEL that is  
16 applicable to LBNF (the text is excerpted from the DUSEL Preliminary Design Report, Chapter 5  
17 Section 3). Much of the work completed for the alternative detector technology considered during  
18 the DUSEL timeframe, a water Cherenkov detector (WCD), is also applicable to the current LBNF  
19 design at the 4850L.

### 20 **3.2.1 Geologic Setting**

21 SURF is sited within a metamorphic complex containing the Poorman, Homestake, Ellison and  
22 Northwestern Formations (oldest to youngest), which are sedimentary and volcanic in origin. An  
23 amphibolite unit (Yates Member) is present within the lower known portions of the Poorman  
24 Formation. The LBNF caverns have been located in the Poorman formation to isolate them from  
25 the remainder of the level. The layout adopted on the 4850L attempts to optimize the needs for  
26 ventilation isolation, access control, and orientation relative to the beamline.

### 27 **3.2.2 Rock Mass Characteristics: LBNF**

28 Following a similar strategy as DUSEL, LBNF initiated a second geotechnical program in 2013 to  
29 evaluate the specific location under consideration and evaluate its appropriateness for the proposed  
30 design. This was undertaken in two phases. The first phase was a mapping of the existing spaces

1 surrounding the proposed rock mass using both visual techniques and laser scanning to understand  
2 the rock mass and to inform the scope of the second phase. The second phase included drilling  
3 of four HQ (2.5-in diameter) core holes ranging in length from 477 to 801 feet as well as two 6-in  
4 diameter core holes ~30 ft each. The smaller diameter cores were then evaluated for the following  
5 characteristics:

- 6     • core recovery percent  
7     • rock quality designation (RQD) percent  
8     • rock type, including color, texture, degree of weathering, and strength  
9     • mineralogy and presence of magnetic sulfides  
10    • character of discontinuities, joint spacing, orientation, aperture  
11    • roughness, alteration, and infill (if applicable)

12 Representative samples were selected from the overall core to test material strength and chemi-  
13 cal characteristics. The [fig:core-loc](#) geotechnical site investigations area on the 4850L, showing boreholes is  
14 presented in Figure 3.3.

15 The holes from which the smaller diameter core was removed were studied in several ways. An  
16 absolute survey was conducted to allow the core holes to be plotted relative to cavern designs. An  
17 optical televiewer was passed through each small hole to visualize the rock mass. This technique  
18 allows visualization of foliation, joint openings, healed joints, and geological contact between rock  
19 types. An acoustical imaging device was also used in one hole to complement the optical informa-  
20 tion. The permeability of the rock was tested by pressurizing the small holes at various intervals to  
21 determine whether joints allowed for the flow of water outside of the holes (hydraulic conductivity).  
22 In all cases, the hydraulic conductivity was well below what can be accomplished using manmade  
23 techniques such as grouting. Two of the small holes were plugged and instrumented to determine  
24 whether water would flow into the holes over time. This test found very low flow rates (.0013 –  
25 .0087 gpm). Ongoing evaluation of pressure build in these holes was inconclusive, as blast-induced  
26 fracturing near the existing drifts allow the holes to depressurize outside of the

27 range of the?

28 test instruments.

29 The larger (6-in) diameter cores and holes were used for strength and stress testing. In situ stress  
30 was tested by drilling a smaller diameter hole first, then gluing a strain gauge at 30 – 36 feet within  
31 the depth. As the larger diameter core was removed, this strain gauge recorded the relaxation of the  
32 rock. The removed core was re-drilled to provide smaller diameter samples at specific orientations  
33 for strength testing, as the strength of the material varies based on applied force direction relative  
34 to the foliation of the rock. These samples were also tested for time-dependent movement.

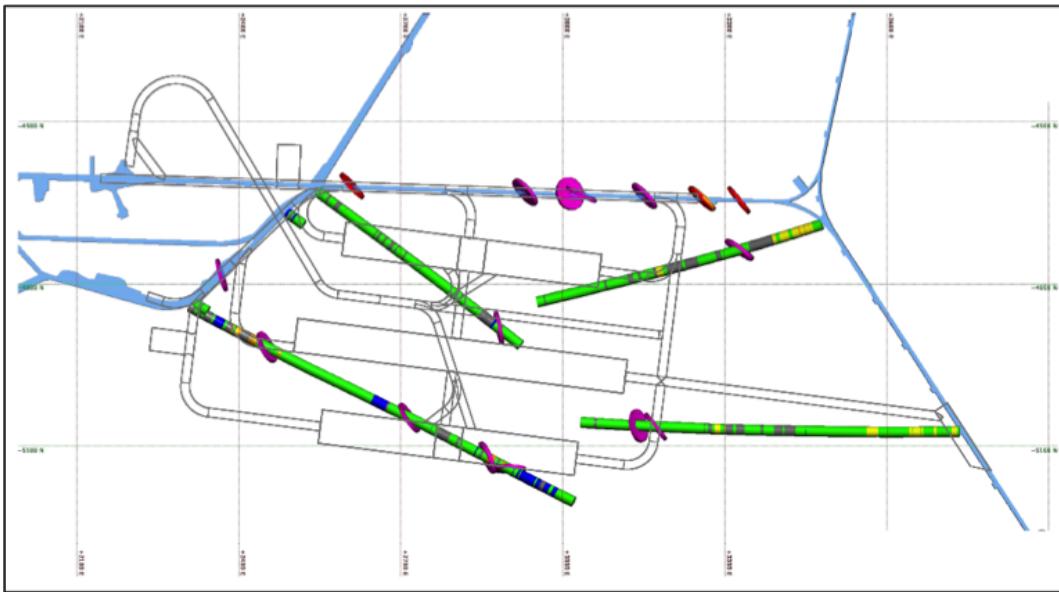


Figure 3.3: LBNF core locations and geological features

fig:core

1 LBNF reviewed the analysis performed by Arup by enlisting industry leaders as part of a Neutrino  
2 Cavity Advisory Board (NCAB). This board reviewed the approach and results of the geotechnical  
3 investigation program as well as the preliminary excavation design. Their conclusions indicated  
4 that no additional drilling would be required to provide design information for the project and the  
5 overall design approach was appropriate. The board provided many recommendations that will  
6 advance the design, for example, replacement of wire mesh with fiber-reinforced shotcrete in all  
7 excavations, reduction of the distance between caverns, and optimization of the ground support  
8 aimed at replacing cable support wherever possible.

9 For further details, see Arup's Geotechnical Interpretive Report [11].

10 citation

### 11 3.2.3 Geologic Conclusions

12 Recovery of rock cores was performed along with geologic mapping to determine if discontinuities  
13 in the rock mass exist that could cause difficulties in the excavation and maintenance of the planned  
14 caverns. In general, the proposed locations of the excavations appear to be free of problematic  
15 structures. This information, along with measurement of in situ stresses, has allowed numerical  
16 modeling of the stresses associated with the anticipated excavations. A sample of some of the  
17 initial modeling is provided in Figure 3.4.

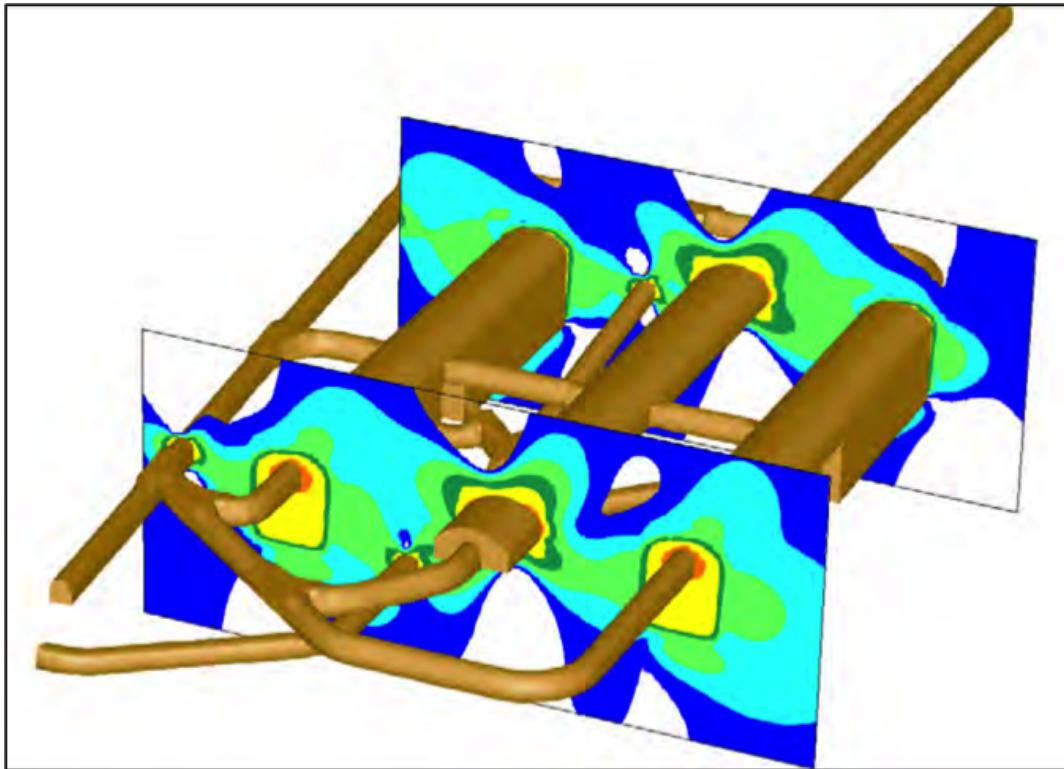


Figure 3.4: Contour of stress safety factor indicating influences between caverns

fig:cont

# <sup>1</sup> Chapter 4

## <sup>2</sup> Surface Facility

### <sup>3</sup> 4.1 Existing Surface Facility

<sup>4</sup> The SURF property of 186 acres includes steep terrain and man-made cuts dating from its mining  
<sup>5</sup> history. There are approximately 50 buildings and associated site infrastructure in various states  
<sup>6</sup> of repair.

<sup>7</sup> Need a sentence saying something about why ross complex is important, to lead into next sentence, e.g., “the FSCF is located in the Ross Complex”

<sup>8</sup> A select few of these buildings at the Ross Complex will be upgraded and rehabilitated as necessary  
<sup>9</sup> for use by LBNF, as will the main utilities. A layout of the overall SURF architectural site plan  
<sup>10</sup> for the LBNF Project is found in Figure 4.1.

<sup>11</sup> The Ross Complex will house the facility construction operations, the Command and Control  
<sup>12</sup> Center for the experiment and facility and a new Cryogenics Compressor building, and will continue  
<sup>13</sup> to house the SURF maintenance and operations functions. Layout of the surface facilities in the  
<sup>14</sup> vicinity of the Ross Shaft is shown in Figure 4.2.

### <sup>15</sup> 4.2 Surface Buildings

<sup>16</sup> Surface buildings for LBNF, existing and planned, include those necessary for safe access and  
<sup>17</sup> egress to the underground through the Ross Shaft and for office space. The existing buildings will  
<sup>18</sup> be rehabilitated to comply to codes and to the experiment’s requirements. The Ross Dry building  
<sup>19</sup> will be modified to provide space for a surface control room (the Command and Control Center)  
<sup>20</sup> and offices. The description in this section is excerpted from the 100% Preliminary Design Report

<sup>21</sup>

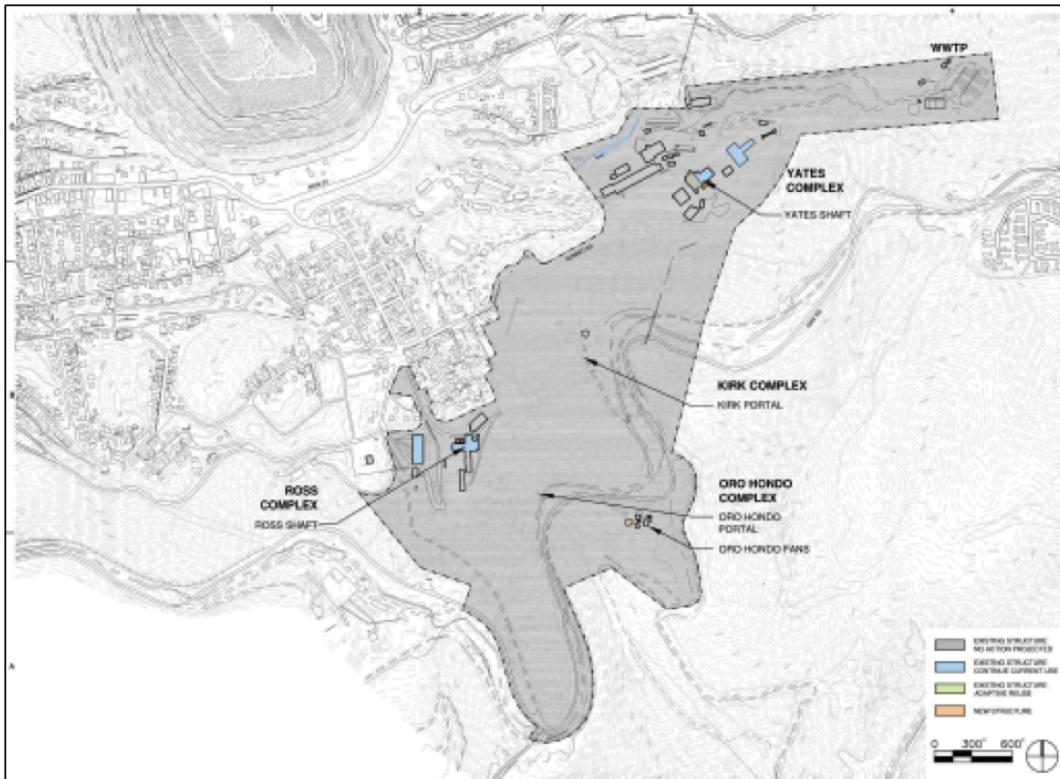


Figure 4.1: Architectural site plan (HDR)

add north pointing arrow

image fuzzy; orig available?

fig:arch

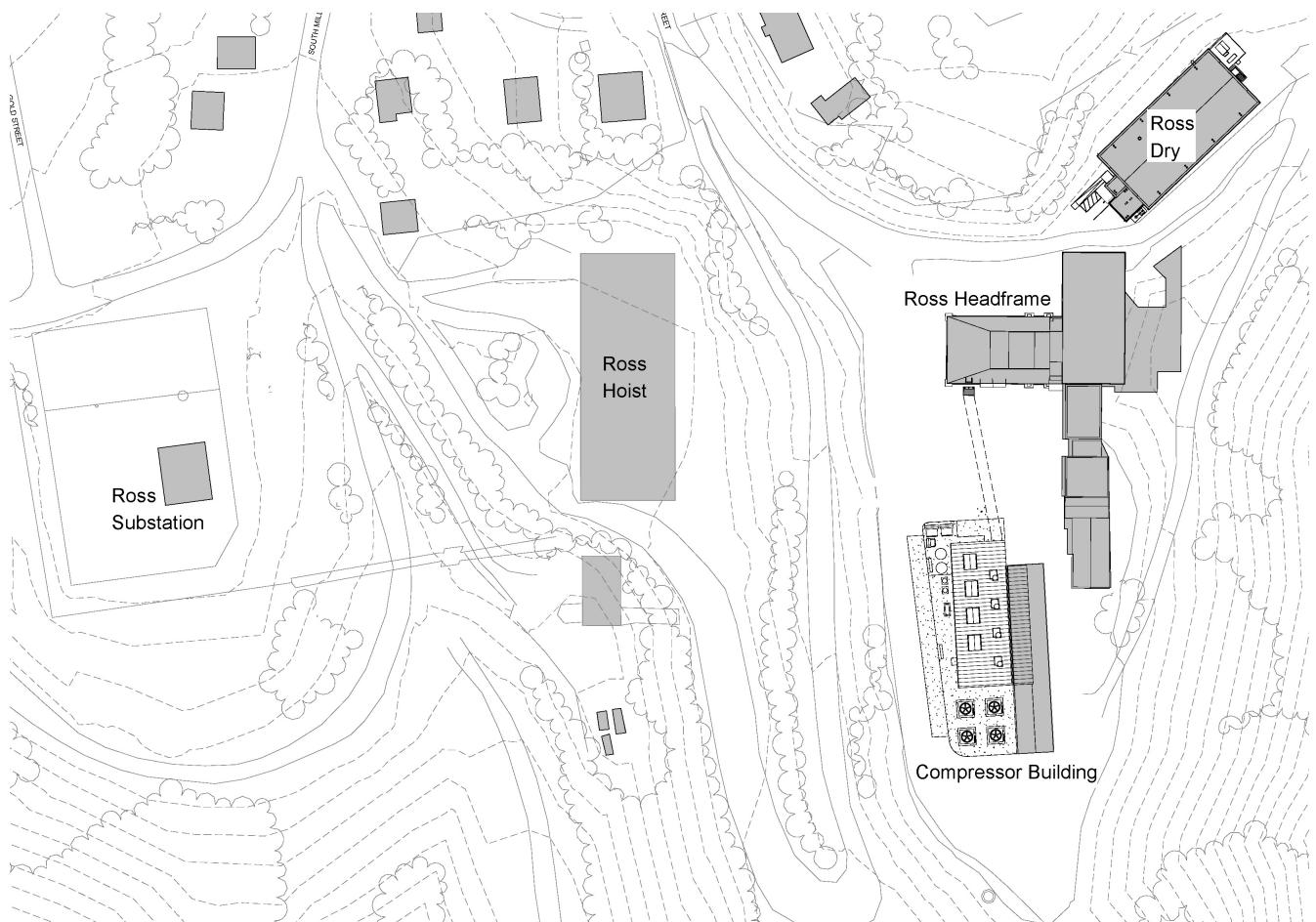


Figure 4.2: Ross Complex architectural site plan (Arup)

fig:ross

1 cite

2 provided by Arup, USA.

3 A new building and surrounding concrete slabs are planned in order to provide space for the equipment required for conversion of liquid argon and liquid nitrogen to gaseous form and compression of the nitrogen gas for delivery through the shaft to the underground. The location of this building was selected based on proximity to the shaft and accessibility for trucks, as thousands of truckloads of argon will be required to fill the detectors underground.

8 In addition to housing

9 supporting?

10 nitrogen compressors inside the building, concrete slabs will be placed around the building for installation of argon and nitrogen receiving dewars (into which the trucks will unload), vaporizers to boil the liquids into gas, an electrical transformer to supply power to the four 1,500-Hp compressors, a standby generator, and cooling towers to reject heat generated through compression. All equipment except the cooling towers and associated circulation pumps is provided by the LBNF Cryogenics Infrastructure

16 reference cryo design doc

17 . The architectural layout of this building and surrounding equipment is provided in Figure 4.3. fig:compressor-l

18 With all this description of concrete slabs, they should be labeled in the figure

### 19 4.2.1 Ross Dry Building

-rossdry  
20 The Ross Dry building is in use by SURF to provide office and meeting space in addition to men's and women's dry facilities

22 explain or replace 'dry facilities'

23 and emergency response capabilities. As a scope option, the design includes a complete renovation of this building to upgrade these existing capabilities and to add space for an above-ground Control and Command Center. (This control center itself is not a scope option; it could be placed in a different location.) This design includes flexible space that can be tailored to evolving needs as the project transitions from construction to operations.

28 The exterior of the Ross Dry Building is shown in Figure 4.4. The proposed renovations are shown in Figures 4.5 and 4.6. fig:ross-dry-ext  
fig:cmd-togtmd-center-maintainer-basement

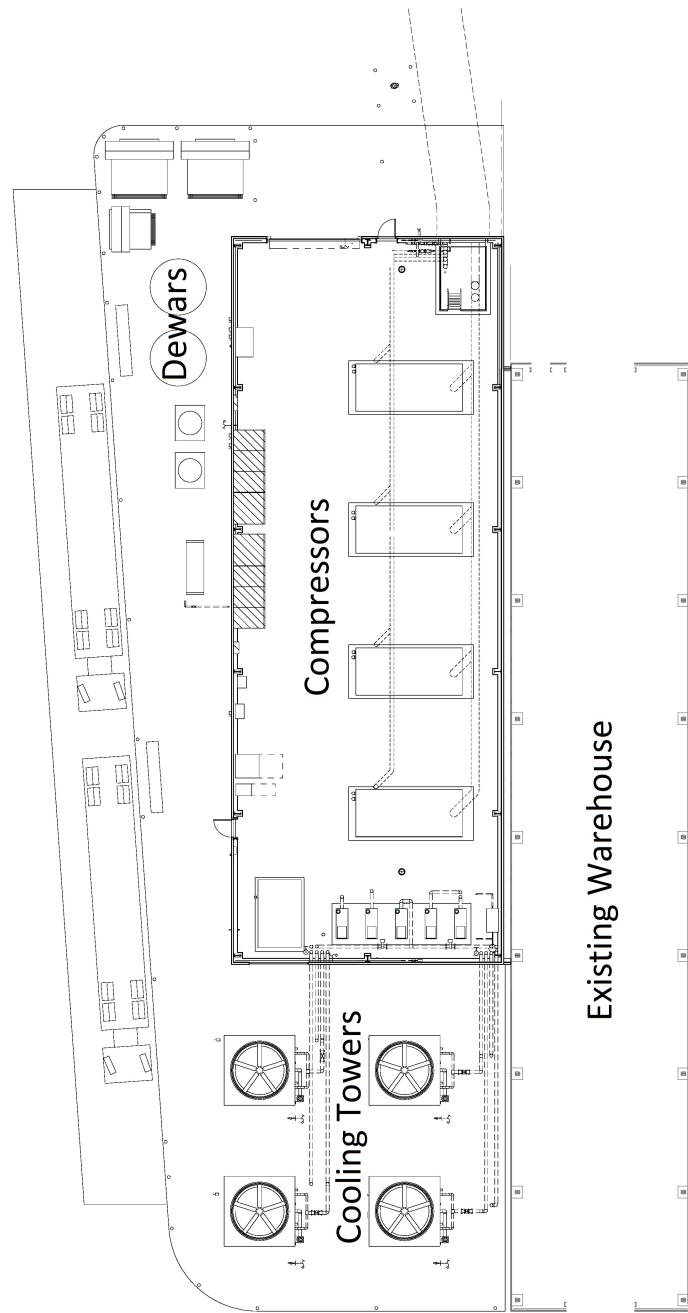


Figure 4.3: Architectural layout of LBNF Cryogenics Compressor Building

fig:comp



Figure 4.4: Photo of Ross Dry exterior (HDR)

Need orig; too fuzzy

fig:ross

## 4.2.2 Ross Headframe and Hoist Buildings

- 1 The Ross Headframe Building will be the main entry point for construction activities and for  
2 ongoing operations and maintenance functions. In addition, gas pipes from the LBNF Cryogenics  
3 Compressor Building will pass through this building on the way to the shaft.  
4  
5 Following shaft rehabilitation, the LBNF Project will include structural reinforcement of the Ross  
6 Headframe to meet current codes and standards. The headframe will also be modified to accom-  
7 modate loads with dimensions longer than it can currently accommodate. This project will occur  
8 concurrently with other site preparation activities planned to be performed outside of the CD-3a  
9 scope, as described in Chapter 7.

10 Not a word about the hoist building; change subsection title?

## 4.2.3 Yates Headframe Building

- 11 The Yates Shaft, which terminates in the headframe building at the Yates Campus, will be  
12 used for delivery of personnel and materials underground during construction and operation of  
13 LBNF/DUNE. The building and shaft will in fact be critical to LBNF during the installation of  
14 gas piping through the Ross Shaft, during which time the Ross Shaft will be restricted to that  
15

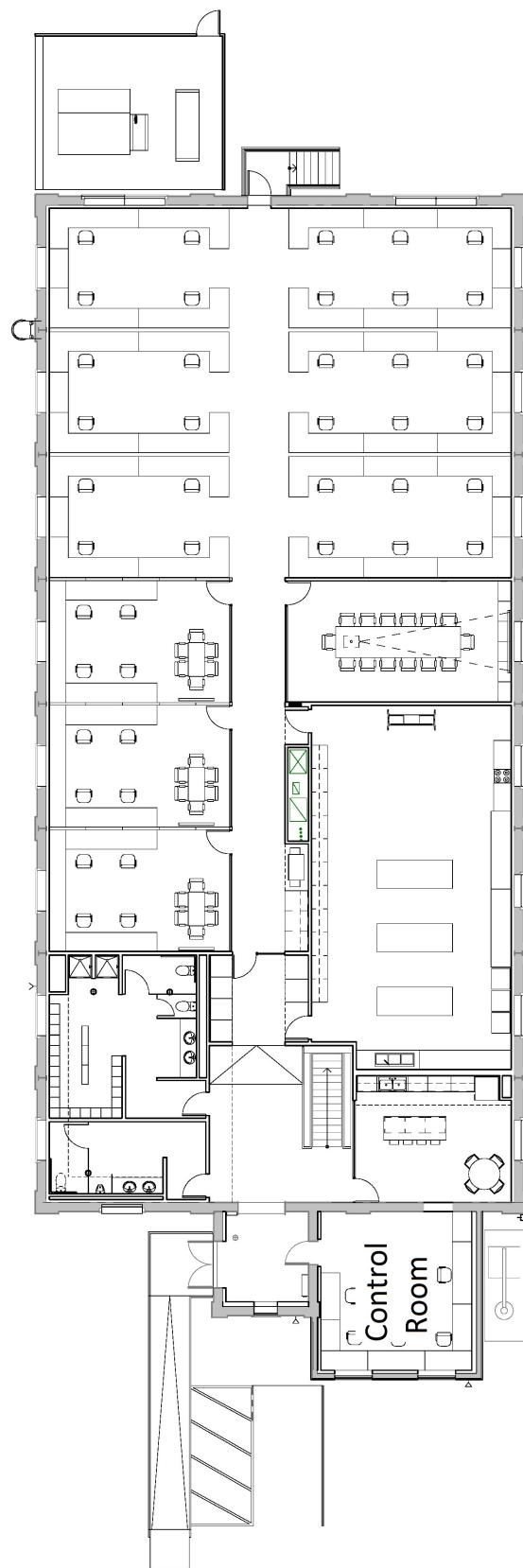


Figure 4.5: Ross Dry Building renovation, main floor, showing the planned location for the control room (Command and Control Center).

fig:cmd-

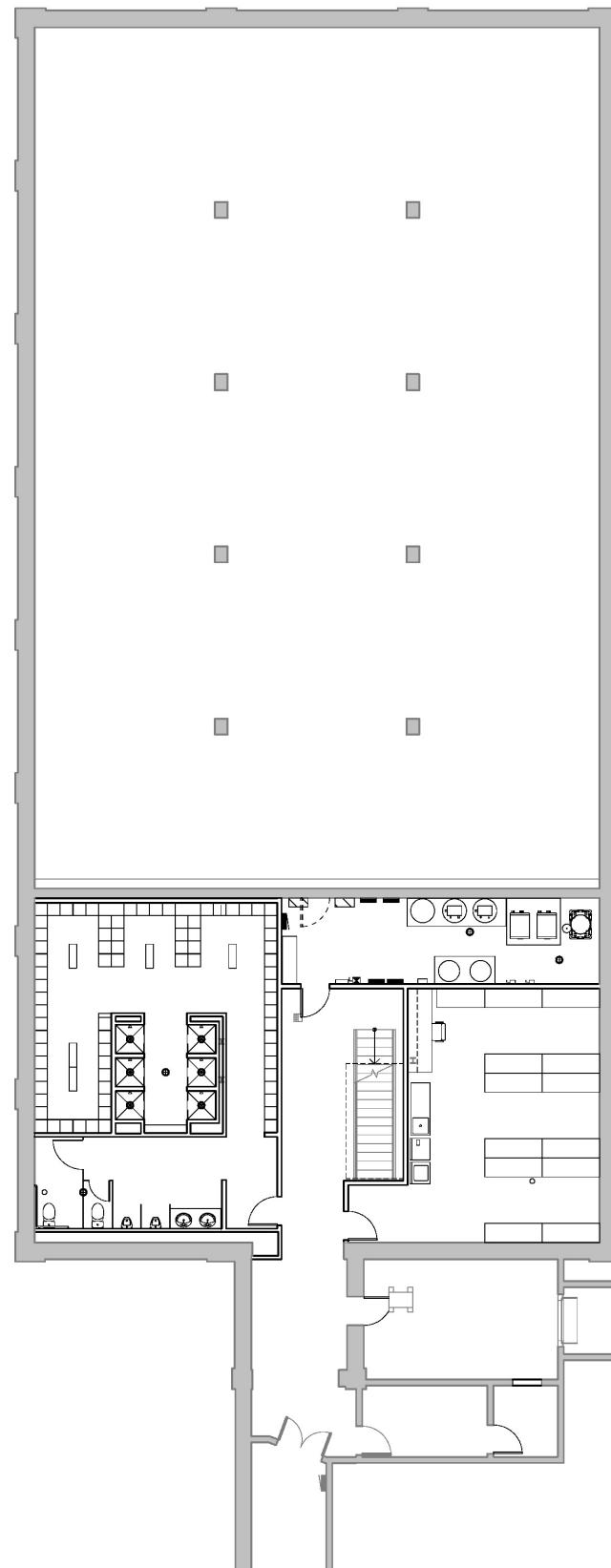


Figure 4.6: Ross Dry Building renovation, basement.

fig:cmd-

1 activity plus emergency egress. The LBNF Project will therefore include structural reinforcement  
2 of the Yates Headframe to meet current codes and standards, to be completed prior to the in-  
3 stallation of gas piping through the Ross shaft. Installation of a redundant fiber optic backbone  
4 through the Yates Shaft is reserved as a LBNF scope option.

5 a word on why it's necessary or beneficial?

#### 6 **4.2.4 Ross Crusher Building**

7 The existing Ross Crusher Building is a high-bay space that contains rock-crushing equipment  
8 used for construction operations. The exterior of the building will be repaired

9 rehabilitated?

10 to create a warm, usable shell.

11 because it's not heated now? Is this so that people can work in it?

12 The upgrade of the existing crusher equipment is part of the waste rock handling work scope (see  
13 ~~sec:fisc1-und-waste-rock~~ Section 6.7) and not part of the building rehabilitation.

### 14 **4.3 New Surface Infrastructure**

15 Surface infrastructure includes items such as retaining walls and parking lots, as well as utilities  
16 to service both buildings and underground areas.

17 much of the?

18 Existing infrastructure requires both rehabilitation and upgrades to meet code and LBNF require-  
19 ments.

20 this is on project?

21 No new roads or parking lots are required for LBNF at SURF. However, the Ross Complex site  
22 will require minor demolition

23 'minor demolition'? sounds like an oxymoron

24 of power lines and a fire hydrant that are no longer used in order to provide adequate accessibility

- <sup>1</sup> for truck traffic to the new Cryogenics Compressor Building. An existing space will be designated
- <sup>2</sup> for handicap parking adjacent to the Ross Dry Building. Additional road work is required for
- <sup>3</sup> truck transportation of waste rock, as described in the waste rock handling section.

<sup>4</sup> ref

# <sup>1</sup> Chapter 5

## <sup>2</sup> Underground Excavation

- <sup>3</sup> The LBNF and DUNE design teams have worked together to define the excavated spaces required at  
<sup>4</sup> the 4850L for the DUNE far detector. These spaces include caverns to house the detector modules,  
<sup>5</sup> drifts for access and utility routing, a cavern to house utilities and the cryogenics infrastructure (the  
<sup>6</sup> Central Utility Cavern) and extra spaces to support construction and installation. Mucking drifts  
<sup>7</sup> connected to the Ross Shaft for waste-rock handling and a shop area for underground assembly  
<sup>8</sup> and maintenance of excavation equipment will likely be required. In addition, a spray chamber is  
<sup>9</sup> planned to provide for heat rejection from the chilled water system. All spaces are identified on  
<sup>10</sup> the 100% Preliminary Design excavation drawings produced by Arup[5]. The spaces are shown in  
<sup>11</sup> Figure 5.1.

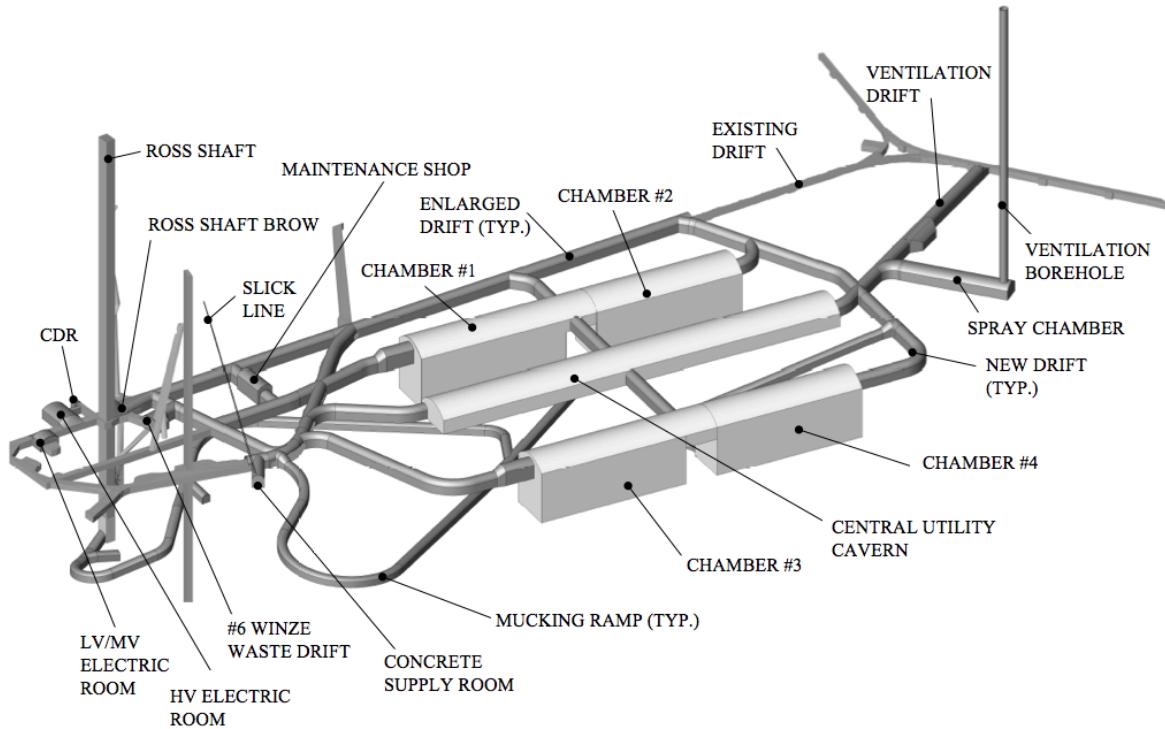


Figure 5.1: Spaces required for LBNF at 4850L (SURF)

## 1 5.1 LBNF Caverns

### 2 5.1.1 Detector Caverns

3 Almost everywhere we use ‘cavern’ not ‘cavity’; am trying to make it consistent

4 The requirements for the detector caverns, e.g., size and depth,

5 can we add ‘rock stability’ or something to make the requirements sound more complete?

6 are documented in [4]. The overall dimensions of the main caverns are shown in Figure 5.2. The  
7 DUNE detector modules will be housed in four chambers within two main caverns at the 4850L.

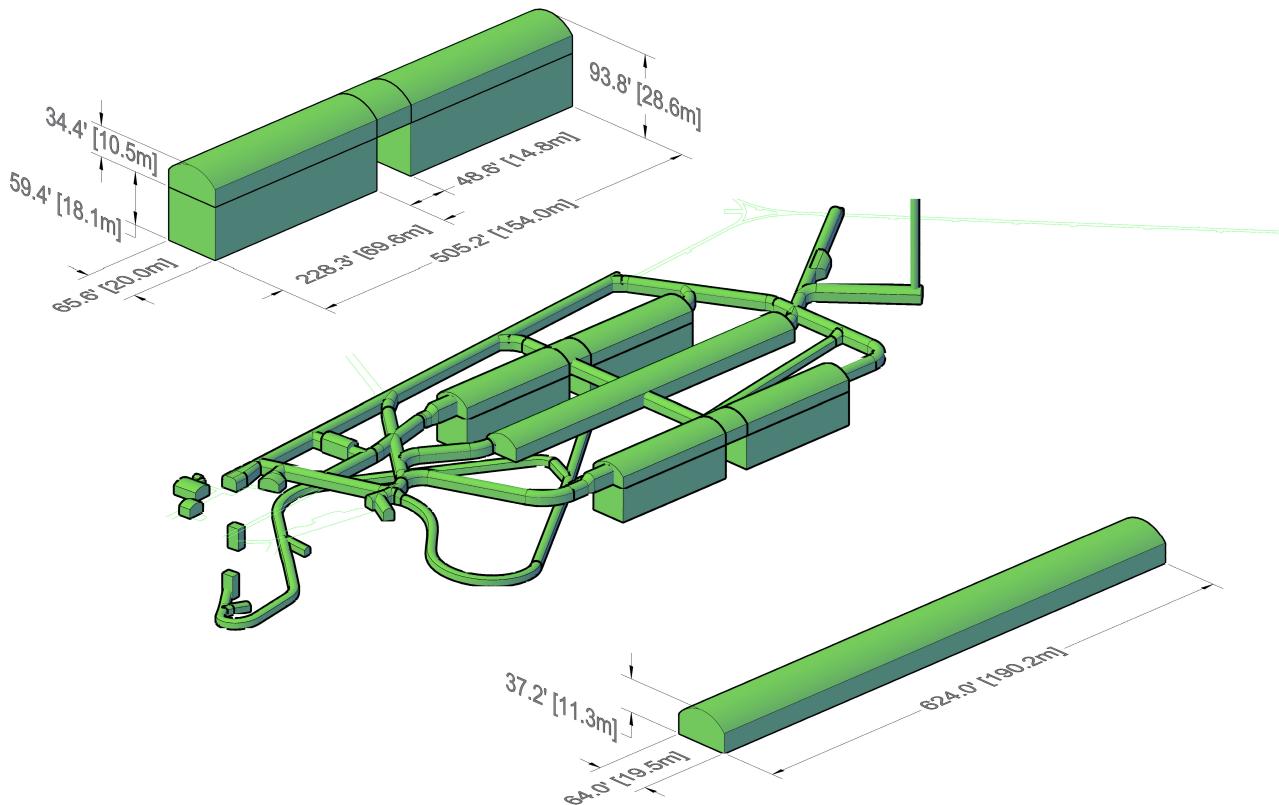


Figure 5.2: Dimensions of the main LBNF cavern excavations (final dimensions will be slightly smaller). (SURF)

8 The size of a detector module is limited by both rock strength and the maximum dimensions of  
9 anode and cathode plane arrays that can be produced, lowered through the shaft and installed.  
10 Space occupied by the free-standing steel structure, the vessel’s insulating liner, and an intentional  
11 exclusion zone reduce the fiducial volume of the detector to less than the volume of the excavation.

1

it reduces the TOTAL volume below the excavated volume; the fiducial volume is even smaller;  
I don't think you want 'fiducial' here; it's not defined and doesn't need to be

2

3 Current assessment of rock quality for this formation indicates that caverns of the sizes indicated  
4 in Figure 5.2 are reasonable.

5 Preliminary modeling in both 2D and 3D of the proposed excavations has been done. The 2D  
6 models indicated that the intact rock strength and joint strength have the greatest impact

7

compared to what?

8 , and the 3D results confirmed that the complex geometry of the design is possible.

9

what aspects are complex?

10 The far detector caverns and drifts will be supported using galvanized rock bolts/cables, wire  
11 mesh, and fiber-reinforced shotcrete to allow a lifetime of 30 years. The floor of the cavern has  
12 been evaluated and does not require support.

13 how do you know if they're not excavated yet? And are we talking about all the caverns, or a  
specific one?

14 Groundwater is another factor to consider when planning the excavations. All experience, analysis,  
15 and field testing at the 4850L of SURF indicate that the volume of water to be encountered will  
16 be very minor ( $\ll 1$  lpm),

17 what is this unit? liter per ?

18 but that the locations of these small seeps are unpredictable. A groundwater drainage system will  
19 be placed behind the shotcrete in the arch and walls of the far detector cavern rock excavation  
20 to collect the seepage and eliminate the potential for hydrostatic pressure build-up behind the  
21 shotcrete. Channels will be placed in the concrete invert

22 'concrete invert' is a phrase I don't know, but may be ok

23 to drain groundwater to the sump system.

## 5.1.2 Structure and Cranes

- <sup>1</sup> The LBNF caverns require monorail cranes to facilitate the construction of the cryostats and detector components.

<sup>4</sup> Placement of rock bolts?

- <sup>5</sup> Rock bolts will be coordinated with the excavation contractor to provide anchorage to support these monorails.

## 5.2 LBNF Central Utility Cavern

- <sup>7</sup> LBNF requires space for cryogenics equipment outside the detector chambers. Space is also required for conventional facilities utilities. It is planned to excavate an independent central cavern, called the Central Utility Cavern, to house the experiment's cryogenics systems, the electrical equipment to supply power for both facility and experiment needs, sump pump access and controls, fire sprinkler room

<sup>13</sup> is this an enclosed room within the CUC?

- <sup>14</sup> , air handling units (AHUs), a chilled-water system and ducting. The centralized location minimizes overall utility distribution and the associated costs. Furthermore, isolating the utilities from the experiment simplifies electrical ground isolation, making it easier to avoid interference with sensitive detector electronics

<sup>18</sup> is this not the primary, driving requirement for having everything outside the detector cavern?

- <sup>19</sup> , and also provides the opportunity to optimize ventilation to control the heat emanating from the equipment in the Central Utility Caverns.

<sup>21</sup> not clear how it 'optimizes' ventilation; needs more explanation. Or is it that it's a freer space so you can put venting wherever you want?

## 5.3 Access/Egress Drifts

<sup>22</sup> you optimize a drift so that you can accommodate a larger load in the shaft? I don't get it. What are you doing with the utilities? They need to be installed in the drift or passed through it?

<sup>23</sup>

1 In order to accommodate deliveries, the drift connections from the Ross Shaft to the new LBNF  
2 excavations will be optimized to accommodate the maximum load size possible through the shaft  
3 plus the utilities required to service the facility. At the writing of this document, an assumed size  
4 of 5m wide by 6m tall is used for all access and egress drifts. All new excavations, or drifts enlarged  
5 for LBNF will be provided with a shotcrete wall (rib) and ceiling (back) and a concrete floor (sill).

## 6 **5.4 Excavation Sequencing**

7 A key goal of LBNF and DUNE is to complete construction and start operation of the first 10-kt  
8 detector as early as possible. To this end, the excavation will be sequenced such that LBNF can  
9 begin installation of a cryostat in the first detector chamber while excavation continues into the  
10 second chamber in the same cavern. A temporary wall will be built in the detector installation  
11 laydown space

12 this space (with a descriptive yet unclear name!) is not defined

13 between detector chambers to isolate one from the other. This wall must be sturdy enough to  
14 withstand the air shock waves associated with drill-and-blast type construction.

15 excavation?

16 Vibration limits and controls must be further evaluated as the design advances to avoid damaging  
17 the cryostat as it is assembled next-door to the excavation of the second chamber.

18 In addition to controlling the impacts from blasting, logistical coordination is a key concern with a  
19 sequenced excavation schedule in which cryostat construction is concurrent with excavation. Cryo-  
20 stat and detector components will need to be delivered through the Ross Shaft, which will also be  
21 used for loads associated with excavation and other construction activities. A logistics study[10]  
22 has been performed to evaluate whether this can be done without impact on either civil or exper-  
23 iment construction. This study confirmed that with good coordination (led by the construction  
24 manager) this single shaft can support all anticipated material and personnel transport. The Yates  
25 shaft can provide some relief during high-intensity work periods, but this was not factored into in  
26 the study; therefore the results are conservative.

27 Most excavated material will travel through a mucking ramp starting at the base of each detector  
28 chamber

29 I changed pit to chamber

30 and ending at the waste dump near the Ross Shaft, as illustrated in Figure 5.1. This ramp is  
31 completely independent of all other traffic and is outfitted with a separate ventilation stream to  
32 keep diesel exhaust from the occupied spaces. During times when excavation is establishing the  
33 upper sections of the caverns and developing a means of dumping excavated material to this lower

fig:spaces-4850

1 elevation, material will need to be transported at the 4850L.

2 This isn't clear; part of the problem is that the figure doesn't show exactly where the mucking  
ramp starts.

3 To alleviate any potential interferences, the first phase of construction will establish a connection  
4 from the 4850L to the mucking ramp

5 'from the 4850L' in a detector chamber? what level is the ramp at?

6 , as well as ventilation paths to avoid contaminating the air in spaces that have been turned over  
7 for cryostat construction.

8 Delivery of cryostat components to the individual chambers can be accomplished in one of two  
9 ways.

10 the rest of the pgraph describes one way

11 All materials are delivered through the shafts to the 4850L, which is ~18m above the base of the  
12 chambers. During construction of the first cryostat, while excavation continues in the other areas,  
13 all materials will be delivered to the detector installation laydown area

14 this area again! is it like a staging area where you put stuff while you're working?

15 between the first and second detector chambers and/or to the west end of the first detector chamber.  
16 An overhead crane will be used to lower this material into the chambers. All excavation will be  
17 completed before any construction is required in the third and fourth detector chambers.

18 in other words, detector module 3 will not be started while chamber 4 is being excavated?

19 This leaves open the option of using the mucking ramp for delivery of cryostat components

20 for modules 3 nd 4?

21 . This ramp has been designed at an 8% grade to from

22 to or from?

23 the west side to allow for this possibility.

## 1   **5.5 Interfaces between DUNE, Existing Facilities, Cryogenics 2   and Excavation**

3 There are several points at which the experiment and the facility interface closely. These are  
4 coordinated between the design teams for DUNE, LBNF Cryogenics Infrastructure and LBNF  
5 Conventional Facilities, and design consultants. Sizing of spaces and components, and sequencing  
6 of construction figure among the key issues, listed here, that interfaces must address.

- 7   • The LBNF cryostats are freestanding structures requiring access for inspection around the  
8   structures' perimeters.

9   I removed ‘infrequent’ because it removed the focus from the space issue and made it  
sound less important

- 10   • The utility spaces to house the equipment for the cryogenics system are directly influenced  
11   by the size of the equipment.  
12   • The size and construction sequencing of the detector chambers are critical to the DUNE  
13   experiment strategy.

14 In addition to these interfaces, the LBNF excavation requires coordination with existing facilities  
15 and activities, in particular, with experiments located in relatively close (~100 m) proximity to  
16 the planned excavation. A test blast program has been designed to study the actual response of  
17 the rock mass in this area due to vibrations and air-blast overpressure created by drill-and-blast  
18 excavation techniques. This test blast program is currently being coordinated closely with the  
19 existing experiments and the test itself will be completed within the first quarter of FY16. The  
20 results of this test will either confirm that the planned excavation approach is appropriate, or  
21 indicate where modifications to the plan must be made.

# <sup>1</sup> Chapter 6

## <sup>2</sup> Underground Infrastructure

<sup>3</sup> The requirements for underground infrastructure for the LBNF Project will be satisfied by a combination of existing infrastructure, improvements to this infrastructure, and development of new infrastructure to suit specific needs. The Project must consider the other tenants underground at SURF for which infrastructure is required, including both the existing Davis Campus experiments and the Ross Campus Experiments. The Ross campus experiments in particular are in relatively close proximity ( $\sim 150$  m) to LBNF.

<sup>9</sup> what does it mean 'consider'? Limitations will be imposed on LBNF due to the needs of the other tenants? please clarify

<sup>10</sup> The infrastructure must support (1) the FSCF construction activities, (2) installation of the Cryogenics Infrastructure and the experiment, and (3) operation of all the equipment and the experiment. After analysis of these activities, the most stringent requirements that they impose were used to define the requirements for design.

<sup>14</sup> Among the requirements is the need for completing the following upgrades prior to the start of LBNF construction funding: Ross Shaft rehabilitation, maintenance and repair focused on the Yates Shaft, and ground-support activities at the 4850L between the Yates and Ross Shafts. Additional discussion of this work is included in Section 3.5

<sup>18</sup> ref

<sup>19</sup> .

<sup>20</sup> I reworded according to the way I understood it. Is this right?

<sup>21</sup> The preliminary design for LBNF underground infrastructure has been produced collaboratively, the primary designer being Arup, USA. The scope of this design covers infrastructure from the surface down through the shafts and drifts, to the excavations for the detector modules. Arup's design incorporates the experiment's utility requirements

1 why call this out specifically?

- 2 and was produced in coordination with LBNF, SURF and the excavation and surface design teams.
- 3 The utility infrastructure includes fire/life safety systems and strategies, permanent ventilation  
4 pathways, HVAC, power, plumbing systems, communications infrastructure, lighting and controls.  
5 The design is fully documented in Arup's LBNF 100% Preliminary Design Report<sup>arup:fscr100pdr</sup>[5] and in the  
6 conceptual

7 conceptual ok?

- 8 design drawings. This chapter includes a summary of that report.
- 9 Shaft rehabilitation and waste-rock handling design were previously provided for the DUSEL PDR  
10

11 give year.

- 12 and LBNF will follow this design. This chapter uses excerpts from the DUSEL Preliminary Design  
13 Report, Chapter 5.4 [10]

14 xref and citation

- 15 . The research supporting this work took place in whole or in part at SURF, which was then called  
16 the Sanford Underground Laboratory at Homestake in Lead, South Dakota. Funding for this work  
17 was provided by the National Science Foundation through Cooperative Agreements PHY-0717003  
18 and PHY-0940801. The assistance of the Sanford Underground Laboratory at Homestake and its  
19 personnel in providing physical access and general logistical and technical support is acknowledged.

## 20 6.1 Fire/Life Safety Systems

- 21 Life safety is a significant design criterion for underground facilities, focusing on events that could  
22 impact the ability to safely evacuate personnel, or if evacuation is not immediately possible, isolate  
23 personnel from potentially dangerous situations underground. Design for fire events includes both  
24 preventing the spread of fire and removing smoke and/or cryogenic gases through the ventilation  
25 system. The evaluation and establishment of requirements for cryogenic gas removal is performed  
26 by the Cryogenics Infrastructure project team and provided to FSCF.

- 27 Arup identified the life safety requirements and developed the design, utilizing applicable codes  
28 and standards, including *NFPA 520: Standard on Subterranean Spaces*, which requires adequate  
29 egress in the event of an emergency. Facility fire detection and suppression systems, as well as  
30 personnel occupancy requirements are defined in accordance with *NFPA 101: Life Safety Code*.

- 1 The design was reviewed by Aon Risk Solutions and the recommendations documented in *Fire*  
2 *Protection/Life Safety Assessment for the Conceptual Design of the Far Site of the Long Baseline*  
3 *Neutrino Experiment*

4 ref

5 [16]. Due to the unique nature of the experiment and its location, a number of potential variances  
6 will require approval from the authority having jurisdiction (AHJ). Significant examples include  
7 use of elevators for egress and use of drifts as air ducts. The AHJ for Lead, SD is familiar with the  
8 facility and the project, and is expected to provide reasonable and timely feedback for proposed  
9 variances.

10 Based on data provided by SURF, the maximum occupant load of the 4850L will be limited to 144  
11 following completion of the Ross Shaft Rehabilitation. This limit is based on both the ability of  
12 the shafts to provide egress within one hour and the capacity of the existing refuge chamber. This  
13 chamber can support the anticipated 42 Underground Operations staff, 50 science staff for LBNF  
14 (during installation), and 20 science staff associated with the existing experiments. A logistics  
15 study<sup>LBNF-logistics</sup>[10] completed by Arup that evaluated the occupancy load during CF construction confirms  
16 the adequacy of this number.

17 To limit the horizontal and vertical spread of any fire or smoke, egress routes will be separated from  
18 adjacent spaces via compartmentalization. This will also help limit the spread of any cryogenic  
19 gas leaks, or other leaks and spills. A minimum four-hour fire separation is required between the  
20 LBNF caverns and adjacent drifts, and a minimum two-hour fire separation for all rooms that  
21 connect directly to the egress drift at 4850L, as well as the shafts. Fire and life safety systems  
22 designed to meet these requirements are described in the following sections.

## 23 6.2 Shafts and Hoists

24 The Ross and Yates Shafts provide the only access/egress between the surface and the underground  
25 levels, and are therefore critical to the function of the facility. Both shafts provide service down  
26 to the 4850L, though not every intermediate level is serviced from both shafts. The shafts also  
27 provide a path for all utilities between the surface and the underground.

28 The Ross and Yates Shafts were both installed in the 1930s and have operated since installation.  
29 These shafts, along with their furnishings, hoists and cages, were well maintained during mining  
30 operations, but experienced some deterioration in the years after the mine closed. A complete  
31 assessment of the Ross and Yates Shafts was conducted for the DUSEL Project

32 year

33 , and is documented in the Arup Preliminary Infrastructure Assessment Report (DUSEL PDR  
34 Appendix 5.M [10]).

1 reference

## 2 6.2.1 Ross Shaft

3 The Ross Shaft will be used for facility construction, including waste rock removal, routine facility  
4 maintenance, and as an egress path for the finished underground campuses. It will also be used  
5 for primary access to the DUNE experiment. Excavation for LBNF cannot begin until the Ross  
6 Shaft is rehabilitated by SURF.

7 The Ross Shaft is rectangular in shape — 14 ft 0 in (4.27 m) by 19 ft 3 in (5.87 m), measured to  
8 the outside of the set steel. The shaft collar is at elevation 5,354.88 ft (1,632.17 m) and the 5000L  
9 is the bottom level at elevation 277.70 ft (84.64 m) above sea level.

10 do people know what a ‘shaft collar’ is?

11 Service is provided to 29 levels and five skip loading pockets. The shaft is divided into seven  
12 compartments: cage, counterweight, north skip, south skip, pipe, utility, and ladder way. Figure 6.1  
13 shows the shaft cross sectional layout.  
fig:ross-shaft

14 on figure, what's 'mT'? can't be milli-ton!

15 The Ross Shaft was in operation until the Homestake Gold Mine closed in 2003.

16 above it sounds like it's been in operation since the beginning and still is

17 Deterioration through corrosion and wear on the shaft steel, including studdles (vertical steel  
18 members placed between steel sets), sets, and bearing beams, prompted a full *strip and re-equip*  
19 project presently being performed by SURF. The set spacing is being increased from 6 ft to 18  
20 ft, but the general configuration of the shaft will remain the same to allow for emergency egress  
21 during rehabilitation.

22 because that requires less work? what's connection between config and allowing egress?

23 The shaft was installed with limited ground support, electing to utilize lacing to prevent spalled  
24 rock from reaching the personnel conveyances.

25 I have no idea what prev sentence means, i.e. how these things relate to each other. Wait, is  
ground support something in the rock walls around the shaft? then lacing is some kind of non-  
solid wall around the cage that carries people?

26 The new design replaces this system with a pattern bolting system to control rock movement.  
27 The requirements for this shaft are driven by a focus on safety, performance, and codes; they are

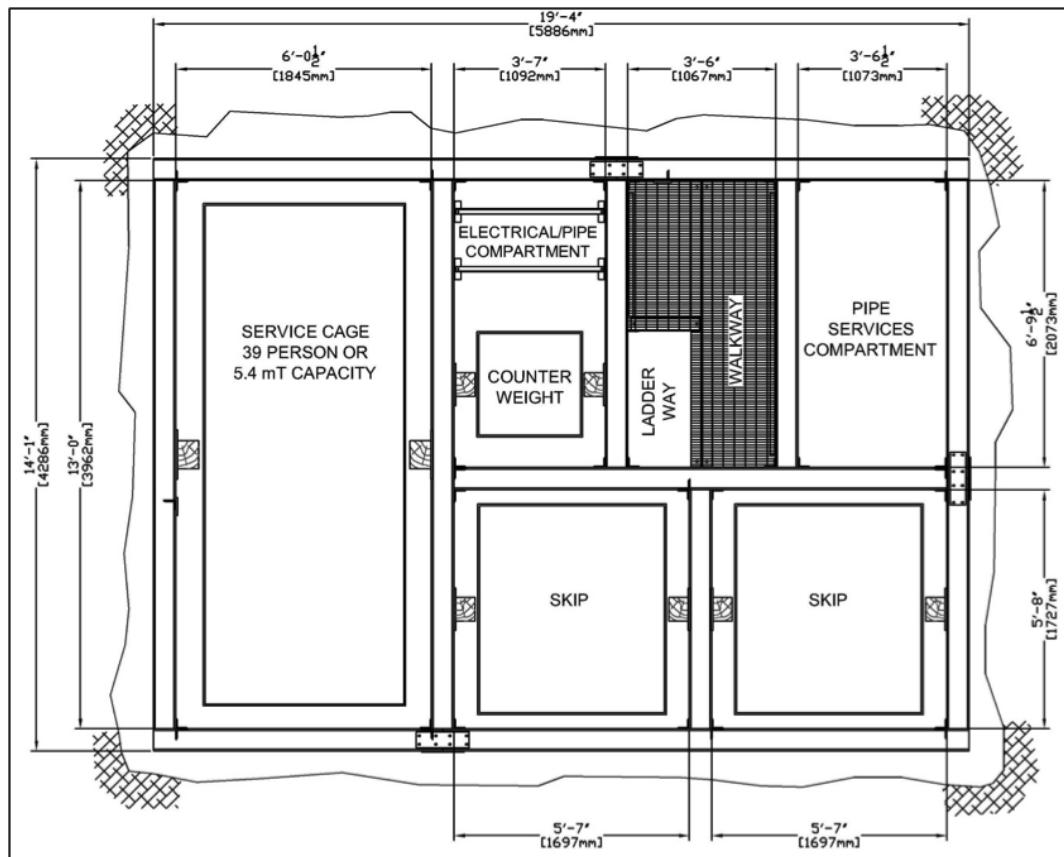


Figure 6.1: Ross Shaft, typical shaft set (SRK, Courtesy SURF)

fig:ross

1 defined by the existing configuration.

2 the requirements are defined by the existing configuration?

3 Shaft rehabilitation through calendar year 2016 is being executed by SURF with non-LBNF Project  
4 funds. The rehabilitation is just over 60% complete as of this report and completion is planned  
5 for 2017. Beginning in January 2017, the funding for the balance of the ~~rehabilitation~~ project  
6 will come from the LBNF Project as part of site preparation (Chapter 7). This will also include  
7 rehabilitation of the skip loading pocket for waste rock handling, and replacement of skips, cage,  
8 and ropes.

9 The production and service hoists at the Ross Shaft are located on the surface in a dedicated  
10 hoistroom west of the shaft. The service hoist operates the service cage and the production hoist  
11 operates the production skips. The DUSEL PDR

12 ref

13 describes the condition assessment of the electrical and mechanical hoisting systems which are  
14 described in detail in the Arup Preliminary Infrastructure Assessment Report (DUSEL PDR Ap-  
15 pendix 5.M [10]

16 ref

17 ). These electrical and mechanical systems will have standard maintenance performed on them to  
18 restore them to like-new condition, but will not be modified from the existing ~~design~~. All of this  
19 work is captured in the LBNF scope as part of site preparation (Chapter 7).

## 20 6.2.2 Yates Shaft

21 The Yates Shaft is rectangular in shape – 15 ft 0 in (4.572 m) by 27 ft 8 in (8.433 m) – measured  
22 to the outside of the set timbers. There are two cage compartments and two skip compartments  
23 as shown in Figure 6.2. In addition to the cage and skip compartments, two other compartments  
24 accommodate shaft services. The shaft collar is at 5,310.00 ft (1,618.49 m) elevation and the 4850L  
25 is the bottom level at elevation 376.46 ft (114.75 m) above sea level. Service is provided to 18  
26 levels plus four skip-loading pockets. Sets are made up of various length and size timbers located  
27 so as to maintain compartment spaces.

28 what's a 'set' and is 'size' really thickness? Are the timbers the structural pieces that are  
placed between compartments?

29 The Yates Shaft is timbered

30 built from wood?

1 except for a fully concrete-lined portion from the collar to the 300L. Recent repairs include full  
 2 set replacement from the concrete portion to the 800L and additional set repair below this level  
 3 where deemed critical.

4 The Yates Service Hoist and Production Hoist are planned to be used as they are, with maintenance  
 5 performed to bring them into like-new condition as part of site preparation (Chapter 7). Further  
 6 details regarding the condition of the Yates Hoists' electrical and mechanical condition can be  
 7 found in Section 2.2 of the Arup Preliminary Site Assessment Report (DUSEL PDR Appendix  
 8 5.M)

9 citation

10 .

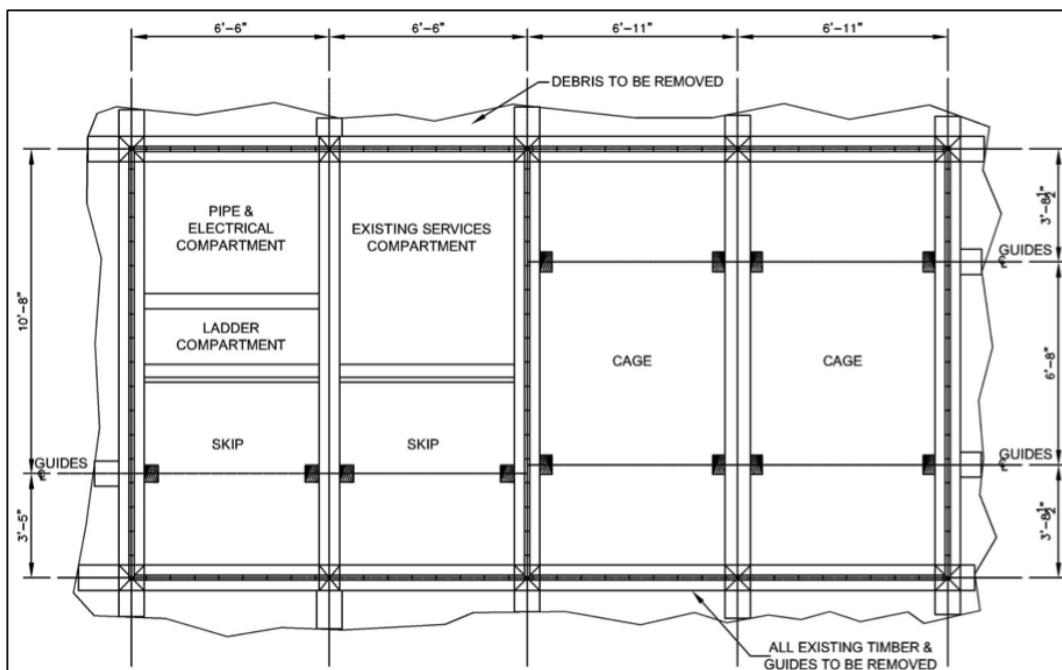


Figure 6.2: Existing Yates Shaft layout (Adapted from SRK, Courtesy SURF)

fig:yate

## 11 6.3 Ventilation

12 The ventilation system for LBNF/DUNE will utilize the existing mine ventilation system for most  
 13 of the distance to the surface, with modifications made near the LBNF caverns to improve capacity.  
 14 Fresh air for the LBNF caverns and the utility drifts will be provided by pulling air directly from  
 15 the existing drifts, which is supplied from the Yates and Ross Shafts. Air will be exhausted from  
 16 the LBNF cavities and utility drifts through a spray chamber rejecting heat from the LBNF chilled  
 17 water system into new borehole connecting to the 3500 level of the facility, a short distance from  
 18 the Oro Hondo shaft, which provide direct connection to the fan at the surface.

That's a mouthful. Exhaust air will go through spray chamber. Spray chamber's primary function is to keep the chilled water cold and direct the extracted heat into borehole. Borehole connects to 3500L near Oro Hondo shaft. Then heat goes up Oro Hondo to fan at surface? Is fan sucking the air up (if not, why do we care about the fan)? Is the idea that the exhaust air mixes with the heat and gets transported to the surface the same way?

1

2 230,000 cfm design is required for heat extraction.

3 what is cfm unit and on what piece of infrastructure is this a requirement? Clarify relationship between ventilation (I think of fresh air for people to breathe) and heat extraction

4 27,500 cfm passes through the each main experimental area

5 through each detector chamber?

6 and 21,500 through the central utility cavern, with the balance of the air required for heat rejection  
 7 coming directly from the shafts through connections to existing drifts. The environmental design  
 8 criteria for LBNF underground spaces are shown in Table 6.1.

Table 6.1: Environmental design criteria (Arup)

Room	Internal Temperature	Humidity Range	Min. Vent. Rate/ Fresh Air Changes	Occupancy (during assembly)
LBNF Cavities	40 – 82°F (10 – 28 °C)	15 – 85%	1	20(50) <sup>1</sup>
Access Drifts	Min 50°F (10°C)	Uncontrolled		Transient space
Utility spaces / Electrical rooms	50 – 95°F (10 – 35 °C)	Uncontrolled	1	
Storage Rooms	59 – 104°F (15 – 40 °C)	Uncontrolled	Min 15 cfm/person	Room-dependent

9 Per historical data, outdoor temperatures can drop below  $-20^{\circ}\text{F}$ ; therefore, the intake air requires  
 10 heating to prevent ice build-up in the shafts which could potentially disrupt hoisting operations  
 11 and damage shaft support members, cables and piping. The existing shaft heaters are expected to  
 12 be adequate for normal operation, but temporary supplemental heating may be necessary during  
 13 excavation due to higher demands. A study will be performed during final design to determine if  
 14 waste heat from the cryogenics systems surface compressors can be used for energy savings to heat  
 15 the intake air.

16 I guess cryo systems will be operating for excav of chambers 2 (partial), 3 and 4?

<sup>1</sup>During operations, occupancy of the LBNF cavities is 20. Temperature, humidity and filtration requirements in localized areas of these spaces may differ, dependent on requirements. This will be provided by the experiment installation design team. The internal conditions stated above will be used to inform the design of plant and services for each space unless specific requirements that differ from this are provided by LBNF/SURF or the lab experiment design teams.

## 1 6.4 Electrical

### 2 6.4.1 Normal Power

3 The estimated electrical loads for both the far detector and the underground infrastructure serving  
 4 the detector spaces are included in the facility load determination and design; the loads are listed  
 5 in Table 6.2.

6 Power for the far detector will originate from the Ross substation and be routed down the Ross  
 7 Shaft to the 4850L. One set of 15-kV mining cables will be installed down the Ross Shaft to the  
 8 4850L. These will be cable-rated for mine use, highly flame retardant, have low smoke toxicity,  
 9 high tensile strength and be self-supporting. At the 4850L, the 15-kV mining cables will terminate  
 10 in a 15-kV switchgear located in a new Ross underground substation. This will be provided early  
 11 in the construction process to allow it to be used for construction.

Table 6.2: Underground Electrical Loads

<b>Underground Electrical Load by Area</b>	<b>kW</b>
Cryostat 1&2 Detector Electronics	450
Cryostat 1&2 Argon Pumps	98
Cryostat 1&2 CF	350
<b>Total Cryostat 1&amp;2</b>	<b>898</b>
Cryostat 3&4 Detector Electronics	450
Cryostat 3&4 Argon Pumps	98
Cryostat 3&4 CF	342
<b>Total Cryostat 3&amp;4</b>	<b>890</b>
Central Utility Cavern - Detector Cryogenics	956
Central Utility Cavern - DAQ	36
Central Utility Cavern - CF	753
<b>Total Central Utility Cavern</b>	<b>1745</b>
Spray Chamber	165
Maintenance/Assembly Shops (2)	84
Drifts	152
<b>Total (other spaces)</b>	<b>401</b>
<b>Total non-CF</b>	<b>2088</b>
<b>Total CF</b>	<b>1846</b>
<b>Total</b>	<b>3934</b>
Aggregate Demand Factor	0.736
<b>Total × Aggregate Demand Factor</b>	<b>2894</b>

**Table 6.3: Surface Electrical Loads**

<b>Surface Electrical Load</b>	<b>kW</b>
Cryogen Building	5000
Control Room	250
Emergency/Standby Generator	50
<b>Total Surface Load</b>	<b>5300</b>

## 6.4.2 Standby and Emergency Power

Standby power is necessary for emergency evacuation of personnel and circulation of cryogens (to avoid rapid boil-off and loss of argon) when surface power is inoperable.

A 300-kW emergency/standby diesel generator will be provided in the Central Utility Cavern with 48 hours worth of diesel fuel to operate it. This duration aligns with the stored LN for controlling argon boil off; these figures satisfy requirements derived from historical power outages at the facility. Note that the facility is fed by the local utility provider in a loop infrastructure, and therefore power to the site has historically been very reliable – on the order of a few hours down per year. Within the facility, power outages due to maintenance or unforeseen events also occur at a very low rate. The following electrical loads are anticipated to be installed to the emergency/standby power system at the 4850L:

- Security
- IT System for communications
- Smoke control fans
- Mono rail
- Cryogenics system controls
- Lighting

## 6.4.3 Fire Alarm and Detection

The 4850L will have notification devices installed to alarm the occupants in case of a fire. Notification devices will consist of speakers and strobe lights. Manual pull stations will be provided within 200 ft of egress. Phones will be installed in the detector chambers and every 400 ft along the access drifts to communicate with the Command and Control Center at the surface.

An air-sampling and gas-detection system will be installed in the drifts and detector chambers for early detection of a fire condition. The air sampling system will be connected into the fire alarm system.

- 1 The fire alarm system will also interface with the oxygen deficiency hazard (ODH) system to  
2 activate the fire alarm system and initiate an alarm at the respective level fire alarm panel

3 at the what? seems like you want it to alarm at any level that could be affected

- 4 and at the Command and Control Center at the surface. Specific sounds and strobe colors will be  
5 identified with and used for specific types of alarm (fire, ODH, etc.).

#### **6 6.4.4 Lighting**

- 7 Suspended lights mounted at a height just below the lowest obstruction will be provided for all drifts  
8 and ramps. Mounting for the lights is to be coordinated with conduit and supports of other systems  
9 running overhead. An average illumination of approximately 24 lux (2.4 foot candles) at floor level  
10 will be maintained throughout the drifts. Lighting control in drifts will be accomplished via low-  
11 voltage occupancy sensors and power packs suitable for high-humidity environments. Emergency  
12 lights will be provided in all areas, with a 90-minute backup power supply. Note that all occupants  
13 are required by SURF policy to have cap lamps readily available for emergency use as well.

#### **14 6.4.5 Grounding**

- 15 The grounding system will be designed to enable protective devices

16 emergency devices? not sure what we're referring to here

- 17 to operate within a specified time during fault conditions, and to limit touch voltage under such  
18 conditions.

19 pls clarify prev sentence. I don't understand. To me grounding doesn't have to do with duration, it provides a safe path for current

- 20 The grounding system will be designed for a maximum resistance of 5 ohms, where possible, based  
21 on Mine Safety and Health Administration (MSHA) recommendations for ground resistance in  
22 mines.

23 and where 5 ohms isn't possible?

- 24 Ground beds, consisting of an array of ground rods, will be installed at each substation

25 what's a substation underground? This could use a picture

- 1 to provide low impedance to ground.
- 2 Electrical separation between the cryostat detectors and cavern utilities will be achieved by separating the metal components (rebar, structure support, etc.) from each other. Inductors will be installed between grounding systems to control noise between systems while also controlling touch potential for safety.

6 detector grounding reqs?

## 7 **6.5 Plumbing**

- plumbing
- 8 CF only provides plumbing for the DUNE detector and the infrastructure that services it, i.e., plumbing for the cooling systems and gas piping for nitrogen and argon delivery from the Cryogenics Compressor Building (on the surface) to the Central Utility Cavern. Beyond this,

11 SURF supplies the required...?

- 12 potable and industrial water, as well as a means to remove water inflows.

### 13 **6.5.1 Industrial Water**

- ind-h<sub>2</sub>o
- 14 An existing 4-inch industrial water riser will be used for construction and as a secondary fire

15 suppression

- 16 service. It is not feasible to run an uninterrupted main water supply line from grade level down to the lower levels due to the extremely high hydrostatic pressure that would occur in the system.
- 17 A series of pressure-reducing stations are located at regular intervals in intermediate levels and at
- 18 the 4850L in order to maintain the pressure within the capability of readily available piping.

### 20 **6.5.2 Potable Water**

- pot-h<sub>2</sub>o
- 21 Potable water is not required in large quantities for LBNF. The SURF experience has been that
  - 22 plumbing potable water through the shafts for low volumes is not effective, as the pressure reducing
  - 23 systems have the potential to introduce biological contaminants that result in the water no longer
  - 24 meeting drinking water standards, especially in low-flow situations. To address this, local filters
  - 25 and ultraviolet treatment is done at the 4850L to purify industrial water sufficiently to meet
  - 26 drinking water standards. This system has been used successfully for several years at SURF.

### 6.5.3 Chilled Water

- 1 The DUNE equipment will produce a significant amount of heat during operations that will be  
2 removed by LBNF-provided chillers. Three chillers at 50% each

3 50% WHAT?

- 4  
5 have been selected to provide N+1 redundancy to allow for maintenance. Heat from the chillers  
6 and various process loads will be rejected using a spray chamber located at the east end of the  
7 detector caverns immediately before exhausting see:iscf-und-vent into a new borehole providing a direct connection  
8 to the exhaust shaft to surface. See Section 6.3.

9 should the rest of this go under Ventilation?

- 10 The ventilation air is a mixture of air from the Yates and Ross Shafts at approximately 68 degrees  
11 F. This volume of air is such that the total heat rejected (2.9 MW or 822 Ton)

12 Ton can't be the right unit; needs a per unit time unit

- 13 will raise the air temperature

14 in the borehole or exhaust shaft?

- 15 to no more than 95 degrees F.

### 16 6.5.4 Fire Suppression

- 17 The source of water for fire suppression will be the existing 4-inch industrial water main at the  
18 Ross Shaft. The connection to this line will be at the 4100L, where a new sump with at least  
19 27,000 gallons capacity will be built using sump walls in an existing drift. This will provide 90  
20 minutes of capacity even if the supply were cut off.

21 cut off at what point? unclear

- 22 The fire protection system at the 4850L Campus will be gravity-fed. There will be a connection to  
23 an existing 6-in industrial water main in the west drift fed from the Yates Shaft, where a similar, but  
24 slightly larger (50,000 gallons), sump has been built by SURF. This provides a redundant supply  
25 from the surface. All new and/or enlarged excavations created for LBNF, with the exception of  
26 excavation-specific mucking ramps, will be provided with fire-suppression systems. In the detector  
27 caverns, pre-action type systems, which require two indications of fire before activating, will be  
28 provided.

## 1 6.5.5 Drainage

2 Drainage [17]

3 citation

4 from the drifts, mechanical electrical rooms (MERs), and from any areas where spillage is likely to  
5 occur, will be collected locally in sumps. Sumps will be located every 500 feet in any areas where  
6 drainage to the drifts is not practical. Sumps will be equipped with sump pumps in a staged  
7 configuration in which each pump discharges to the adjacent sump until water is discharged to the  
8 #6 Winze, where it flows to the primary facility pool, approximately 1,000 feet below the 4850L.  
9 From there, the existing SURF dewatering system pumps the water in stages to the surface where  
10 it is treated before being discharged into a nearby stream.

## 11 6.5.6 Sanitary Drainage

12 No sanitary drainage is included in the requirements for LBNF. Existing SURF facilities are  
13 planned to be used.

## 14 6.5.7 Nitrogen and Argon Gas Piping

15 Two 16-in and three 8-in mild steel pipes are provided by CF from the surface Cryogenics Com-  
16 pressor Building to the

17 Ross?

18 shaft, through the shaft, and across the 4850L to the Central Utility Cavern west entrance. The  
19 design and specifications of this piping are the responsibility of the Cryogenics Infrastructure  
20 Project team. The supply and installation within the Cryogenics Compressor Building and the  
21 central Utility Cavern is also the responsibility of the Cryogenics Infrastructure Project.

22 what part is CF responsible for? Should this be in the last chapter?

## 23 6.6 Cyberinfrastructure

24 The Structured Cable System design for the cyberinfrastructure will be based on uniform cable  
25 distribution with a star topology. New fiber connections will be extended to the 4850L from the  
26 Ross Dry Building, and will be dedicated to the use of LBNF/DUNE. The design provides one (1)

- 1 96-strand single-mode armored fiber optic cable from the DUNE Control and Command Center  
 2 at the surface. A second 96-strand single mode armored fiber optic cable has been identified as a  
 3 scope option and, if included, will be routed through the Yates shaft to provide redundancy for  
 4 data systems. Figure 6.3 shows the fiber distribution network for LBNF/DUNE.

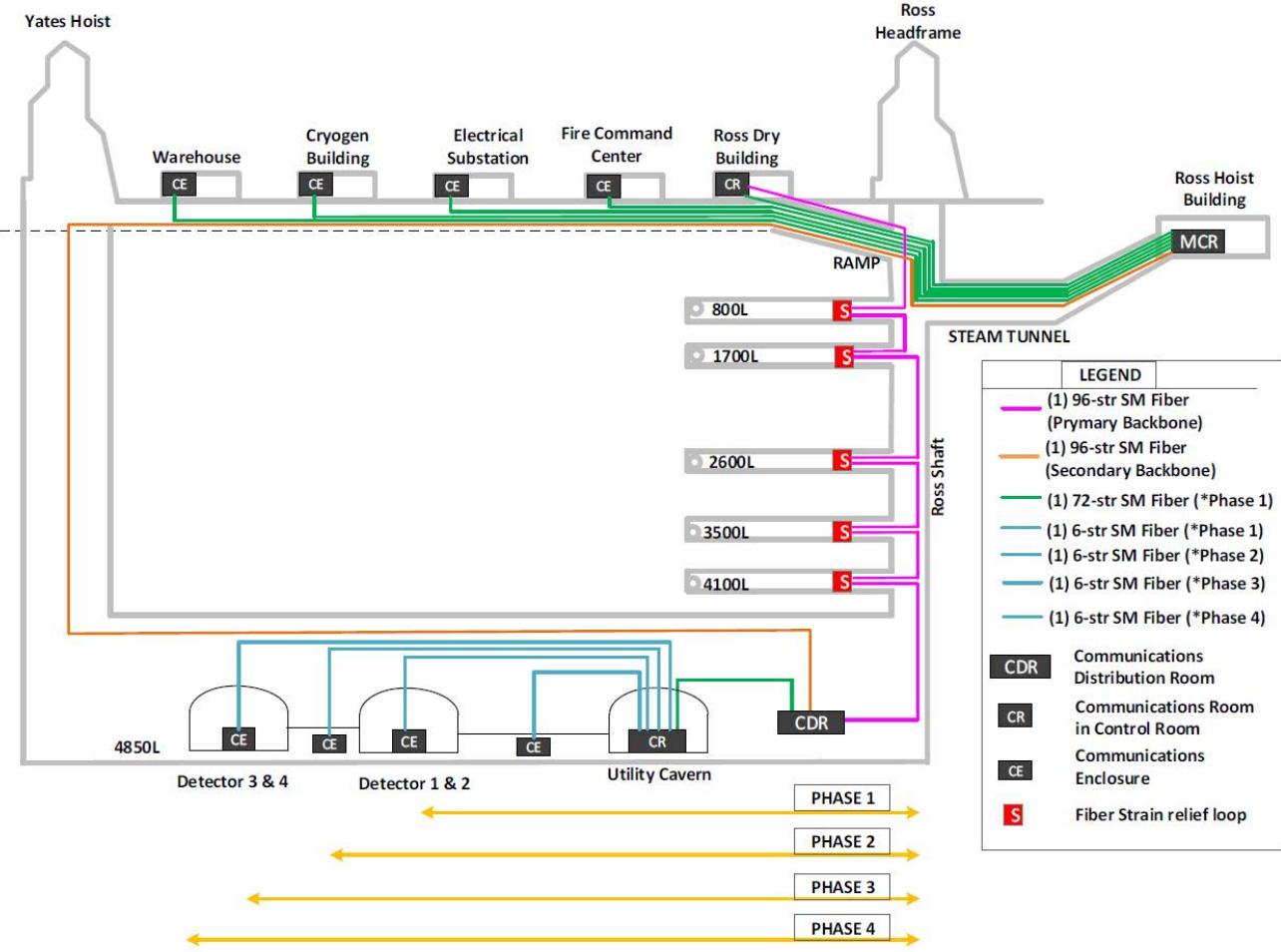


Figure 6.3: Fiber distribution system for LBNF/DUNE (Arup)

5 Voice communications are provided via two-way radios and phones distributed throughout the  
 6 underground spaces (in every room as well as every 500 ft in drifts). Two-way radios and cellular  
 7 phones utilize a leaky feeder system to ensure communications over long distance without line  
 8 of site. These leaky feeders are cables that act as antennas installed the length of all drifts and  
 9 shafts. The leaky feeder is planned as a scope option. Standard phones utilize Voice over Internet  
 10 Protocol (VoIP) to provide communication through the fiber optic data backbone.

11 The data system is designed to provide 10-Gigabit Ethernet in the backbone and 1-Gigabit Ether-  
 12 net to connected systems (computers). This system is intentionally left at a lesser level of design  
 13 due to the continuous progression and advancement of technology that will almost certainly result  
 14 in more advanced technologies than are currently available being utilized at the time of construc-  
 15 tion.

## 1 6.7 Excavated Material Management

- 2 Prior to the commencement of any excavation activities, it will be necessary to establish an  
 3 excavated-material management system and repository

4 Josh says: Need to determine whether this terminology is acceptable from Pepin

- 5 . The capacity of this system will be equivalent to what was in place during mining operations.  
 6 There are a number of components to the management system, including refurbishing the Ross  
 7 Shaft hoisting system and crushers, and constructing a new conveying system. As of this report,  
 8 two options have been identified for final repositories of the material.

- 9 The former Gilt Edge mine is located approximately seven miles from the SURF property and  
 10 would require truck haulage as a component of the transportation system. In this option, a new <sup>fig:waste\_rock-sys</sup>  
 11 conveyor is provided to transport rock downhill to Kirk Road, as seen in Figure 6.4. This is  
 12 considered the reference design as of the date of this report.

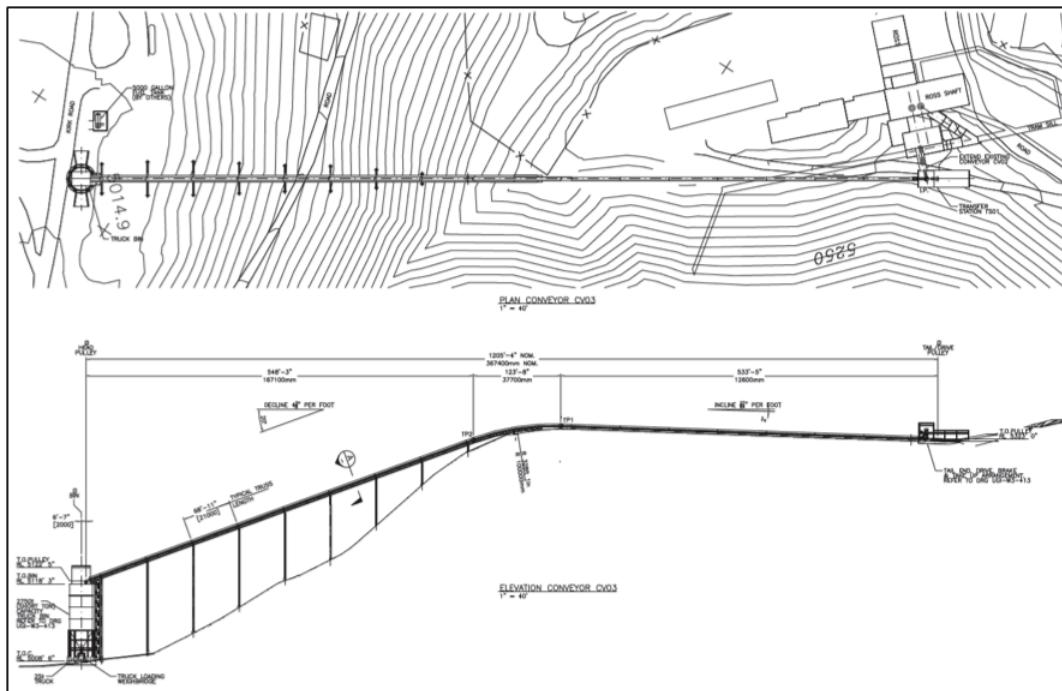


Figure 6.4: Waste-rock Handling System route (SRK, Courtesy SURF)

- 13 The alternative repository is the Homestake Open cut, located less than 1 mile from the SURF  
 14 property. In this option it is possible to transport material directly to the final location, avoiding  
 15 the need for over-the road transportation. The conveying system would be designed to follow a  
 16 route formerly used to transport material from the open cut to the former Homestake mills.

17 what constitutes the conveying system?

- 18 A final decision on which repository to use will be made prior to the CD-3a approval. Both options

- 1 have been evaluated in detail and are not significantly different in cost or installation schedule.
- 2 The systems utilize experience and equipment from the former Homestake Mining Company, where  
3 rock was removed to the surface using skips in both the Yates and Ross Shafts. At the headframe  
4 of each shaft, the material was crushed to a nominal 3/4 in, passed through ore bins, and was  
5 transported via underground rail to the mill system. All systems from the underground to the  
6 crushers will be rehabilitated from the original systems, though the material may not be required  
7 to be crushed as finely as it was during the mining period, and therefore some components of the  
8 system may not be re-used.

# <sup>1</sup> Chapter 7

## <sup>2</sup> SURF Site Preparation Activities

site-prep

### <sup>3</sup> 7.1 Overview

overview

<sup>4</sup> A number of activities at the SURF site that focus on maintenance or restoration of capabilities  
<sup>5</sup> have been identified by the LBNF and SDSTA team as required for risk mitigation and/or con-  
<sup>6</sup> struction preparation. These tasks are planned to be completed before or during the LBNF Project  
<sup>7</sup> and are included as part of the overall LBNF project cost and schedule due to their potential im-  
<sup>8</sup> pact on the construction and operation of LBNF and DUNE. They are, however, outside of the  
<sup>9</sup> CD-3a request since they are not viewed as construction.

### <sup>10</sup> 7.2 Ross Shaft Rehabilitation

rossrehab

<sup>11</sup> The SDSTA has been in the process of rehabilitating the Ross Shaft since 2013. This rehabilitation  
<sup>12</sup> includes removal of all existing steel structural elements, installation of ground support (rock bolts  
<sup>13</sup> and welded wire mesh), and installation of new structural steel. Beginning in 2016, the funding for  
<sup>14</sup> this project will be tied to the LBNF Project, but the actual implementation will not change. When  
<sup>15</sup> the rehabilitation completes in 2017, the *cage*, or personnel conveyance, will be replaced with a new  
<sup>16</sup> conveyance; this will restore the load capability of two decks, thereby improving personnel access.  
<sup>17</sup> Both of the *skips*, which are buckets used to remove excavated material from the underground,  
<sup>18</sup> will also be replaced with new ones to restore full functionality

<sup>19</sup> of the shaft?

<sup>20</sup> .

## 1   **7.3 Oro Hondo Fan Upgrade**

2 The primary ventilation fan for the entire underground facility was installed at the Oro Hondo  
3 Shaft in the mid-1980s to support mining efforts at various levels underground. This fan was  
4 designed for much larger air volumes than will be necessary for LBNF/DUNE construction or  
5 operation, and uses less than 25% of the 3000-HP motor's capacity. The variable-speed drive  
6 for this fan is obsolete, with little to no availability of parts. To reduce the likelihood and impact  
7 of failure, this fan will be evaluated for efficiency and either a new motor/drive combination or a  
8 completely new fan will be installed prior to LBNF construction.

## 9   **7.4 Refuge Chamber Additions and Upgrades**

10 SURF currently has small refuge chambers at two of the four dewatering pump locations in the  
11 Ross Shaft, and a large refuge chamber near the Ross Shaft at the 4850L. Refuge chambers are  
12 designed to provide food, water, breathable air, and sanitary facilities for individuals trapped  
13 underground. In preparation for the LBNF Project, two additional pump room refuge chambers  
14 will be procured and installed, and the 4850L chamber will be modified to accommodate the  
15 additional capacity made possible by the Ross Shaft rehabilitation. Underground occupancy is  
16 defined by the maximum number of individuals that can be transported to the surface in one hour.  
17 With the improvements to the shaft, that number will approximately double.

18 from what to what?

## 19   **7.5 Resupport of Drifts at the 4850L**

20 The drifts (tunnels) connecting the Yates and Ross Shafts at the 4850L were excavated for mining  
21 purposes with ground support (rock bolts) installed only as deemed necessary at that time

22 give approx year

23 . This ground support was submerged in water when the mine shut down, accelerating corrosion.  
24 The LBNF Project will provide supplies to re-support these drifts with full coverage in preparation  
25 for significantly increased traffic during construction and operation of LBNF and DUNE.

## **7.6 Water Inflow Control**

While the SURF facility is generally very dry compared to most underground facilities, the vast expanse of the underground space both vertically and horizontally provides the opportunity for many small water inflows to aggregate, resulting in a total inflow of over 700 gallons per minute integrated over the 350+ miles of drifts. The surface mining of the open cut aggravates this during large inflow events (rain or snow melt) by acting as a direct funnel to the upper levels of the facility. This water migrates to either pump rooms or the *pool*; at ~1,000 feet below the 4850L, the pool provides enough reserve capacity to prevent flooding of the 4850L even if the dewatering system were shut down for nearly a year. A system of walls and boreholes controls the flow of water, keeping it away from the occupied footprint. These controls were installed throughout the 125-year history of mining, however, and cannot all be accessed for evaluation. To prevent failure of an inaccessible control system, a project to capture and direct water from the upper levels to a known route is planned.

## **7.7 Adit Repairs**

A number of adits (tunnels that connect underground areas to the surface) will be rehabilitated to prevent their failure. Specifically, two adits connecting at the 300L and two connecting at the *tramway* level are included in the LBNF budget. These adits support power, fiber, sewer, and water utilities, any of which could halt construction if a failure occurred. Repairs are primarily focused on the first 60–100 feet of the tunnels, measured from the surface, with some repairs within the tunnels themselves.

the first 60-100 ft aren't within the tunnels? where are they with respect to the tunnels?

## **7.8 Ross Crusher Roof Reinforcement**

As part of previous design efforts, many of the existing structures at SURF were evaluated for compatibility with current codes and standards. The SDSTA has already repaired many of the substandard roofs throughout the facility, with the Ross Crusher building lagging due to lack of immediate use. In preparation for use of this building by the LBNF project, the roof will be reinforced to ensure reliable support of snow loads.

## **7.9 Hoist Motor Rebuilds**

All of the hoist motors at both the Yates and Ross Shafts were evaluated by consultants through the SDSTA and found to require rebuilds for reliable operation. The SDSTA started this process

- 1 by rebuilding the motors at the Yates shaft, which currently provides primary access to the un-  
2 derground spaces while the Ross Shaft is rehabilitated. After the shaft rehabilitation completes,  
3 but before excavation can commence, all of the motors at the Ross Shaft will be removed, cleaned,  
4 and re-insulated

5 how does this compare to a rebuild?

- 6 to reduce the risk of failure during the heavy construction utilization.

## 7 7.10 Parking Lot Repairs

- parking
- 8 The surface facilities at SURF are located in steep and rugged terrain in Lead, SD. The headframes  
9 and supporting buildings were constructed at the top of a hill, with cut-and-fill techniques used  
10 to provide flat and level areas for buildings, roads and parking lots beginning in the 1930s. One  
11 of these parking lots, adjacent to the SURF administration building and near the Yates Shaft,  
12 experienced subsidence in the 1990s while the mine was still operational. To temporarily manage  
13 this, a number of limestone blocks were placed in the area of concern. In recent years, following  
14 significantly higher-than-normal precipitation, this area has again exhibited signs of movement.  
15 To address this issue, a permanent retaining wall system has been designed by a local engineering  
16 firm contracted by the SDSTA. The LBNF Project has included budget to implement this design  
17 to ensure that access to the Yates shaft is not compromised.

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