6 Design Concepts and Infrastructure Development for Homestake Interim Lab and DUSEL

In this chapter we present a description of the Homestake site, plans to re-enter the facility to preserve the site for subsequent development into DUSEL. We go on to describe our conceptual plans for providing underground research space and surface support facilities for DUSEL's Initial Suite of Experiments and the Early Implementation Program.

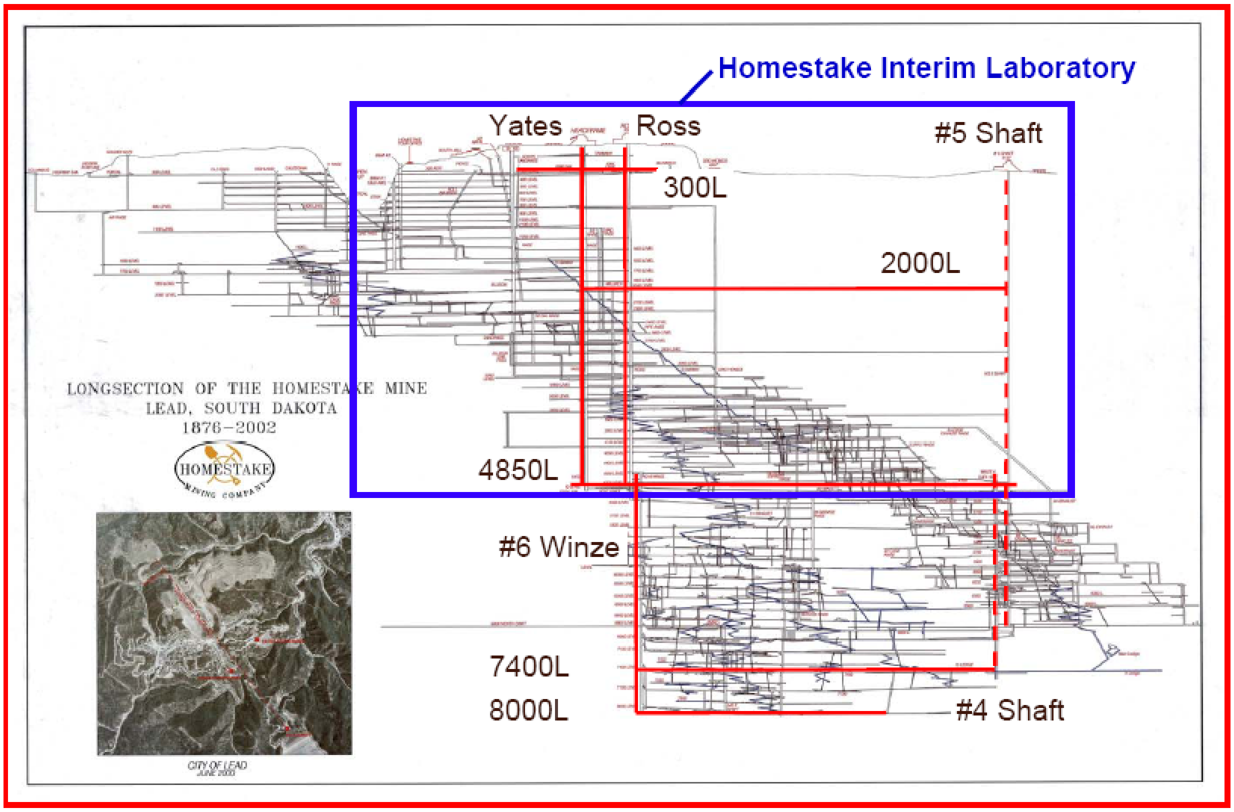

Figure 6.1 Homestake Mine Long-section: Homestake Interim Lab development and access to 4850 Level and DUSEL development and deeper levels access to 8000 Level. A high resolution version of the figure is located at http://neutrino.lbl.gov/homestake/S2_Supporting_Documents/ .

6.1 Overview of Existing Site Conditions and Infrastructure at Property Transfer

The Property Donation Agreement [Appendix A6] transfers 75.3 hectares (186 acres) of surface property with more than 20 existing buildings and structures to the South Dakota Science and Technology Authority (the Authority). The underground workings comprise approximately 324 hectares (800 acres) with more than 600 km (370 miles) of shafts and tunnels at approximately 60 levels extending to 2484 meters (8150 ft.) below the surface, and including more than 30 cubic kilometers (7.2 cubic miles) of rock mass. Figure 6.1 is a Long-section view that represents the underground workings of the mine projected onto a single plane of the drawing, and Figure 6.2 shows a schematic representation of the primary shafts and drifts that were in use for mining operations prior to closure. Figure 6.3 highlights the surface buildings near the Ross and Yates shafts that are planned for initial use and development for DUSEL. The property transfer also includes the core-sample archives and extensive operations, maintenance, and mine closure records from the former Homestake Mining Company (see Chapter 7 for a detailed description).

Following the property transfer, the Authority has begun hiring staff, purchasing equipment, restoring infrastructure, and coordinating subcontracts to manage the mining-to-labs conversion effort for development of the Homestake Interim Laboratory and preparation for DUSEL. The primary roles and responsibilities of the Authority staff for the conversion project are as follows:

- Oversee and insure safe operation of the Authority's Homestake Interim Laboratory property and infrastructure.
- Develop plans for facility and infrastructure rehabilitation and upgrades to implement the Program Advisory Committee recommendations for science and engineering research.
- Manage design and engineering for re-entry to mid-levels, rehabilitation of surface and underground infrastructure, and excavation for new underground laboratory development.
- Manage and supervise construction for re-entry, infrastructure rehabilitation, new excavation and development of surface and underground facilities to support Early Implementation Program experiments.
- Prepare for management transition to Homestake DUSEL facility and science operations.

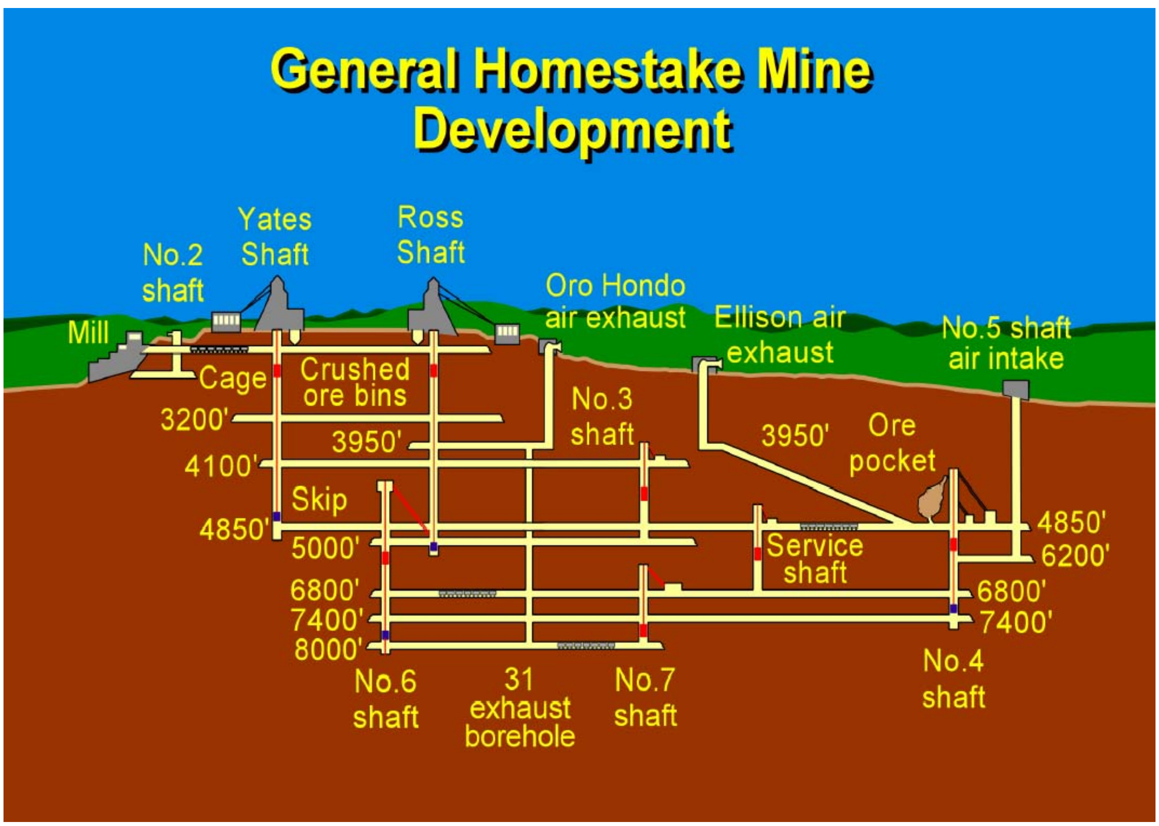

Figure 6.2 General Homestake Mine Development: A schematic representation of the primary shafts and drifts that were in use for mining operations prior to closure in 2003.

All access shafts and portals to the mine have been closed since July 2003 and sealed to restrict airflow in the mine. A preliminary Yates inspection was carried out on 10 June 2006 and recorded the good condition of the entire shaft and infrastructure. On 7 December 2006 the Ross shaft was inspected and similarly found to be in good condition. Sealing the mine to restrict airflow has reduced corrosion and other deterioration of mine infrastructure by controlling the cycling of humidity and temperature underground. However, closure halted removal of accumulated water. Water has been accumulating in the deep levels at an estimated rate of approximately 700 gallons per minute. The most recent monitoring point indicated that the water had risen to 5600 Level in November 2006, with a slightly slower rate of rise than predicted.

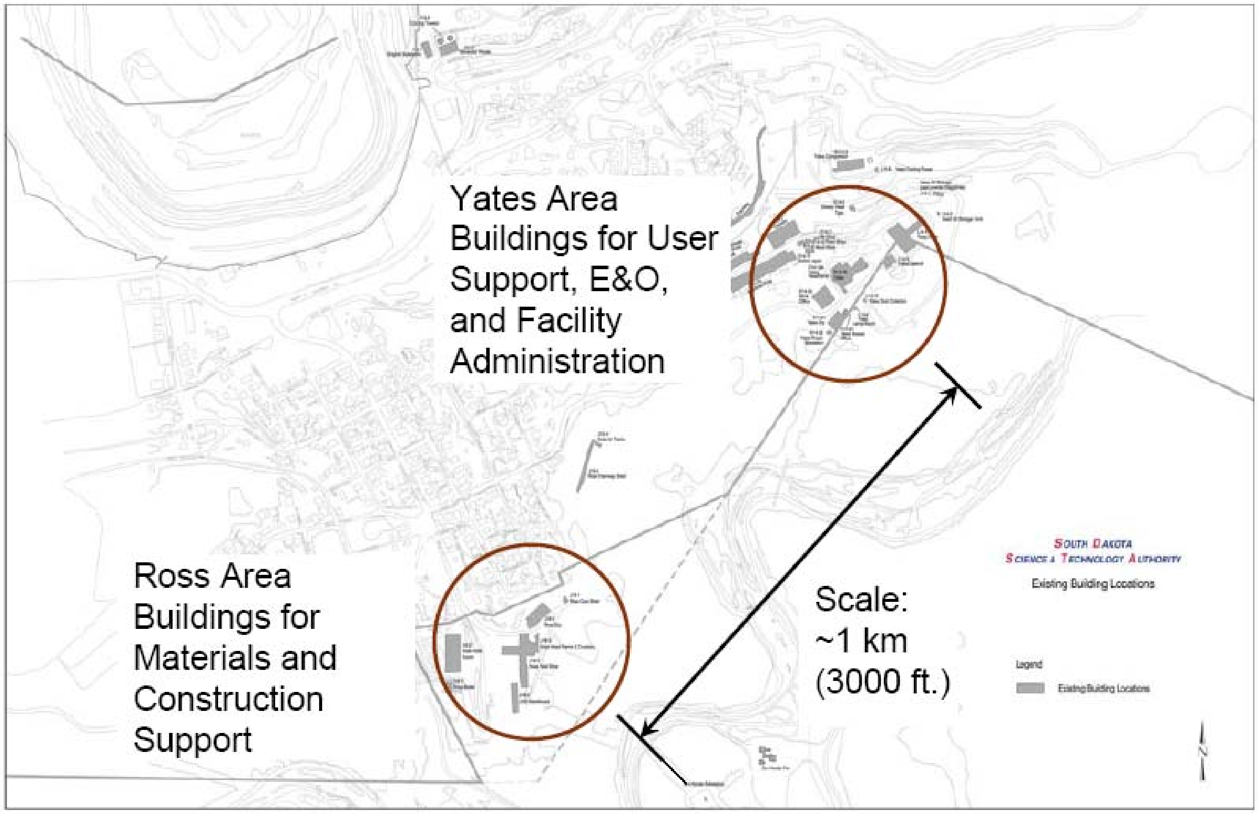

Figure 6.3 Homestake site surface plan and existing structures for laboratory programs.

6.2 South Dakota Science and Technology Authority's Mine Re-entry and Rehabilitation Plan

One can view the mine infrastructure as a two-level facility: the upper levels from surface to 4850 Level being served by one set of utilities, pumping systems, electrical power distribution, ventilation, conveyances, shafts and ramps, and the deeper levels from 4850 Level to 8000 Level by a second set. The sequence for re-entry and rehabilitation of the mine exploits the separation of infrastructure by providing initial access to 4850 Level and above, with rehabilitation and development which enables early occupancy for research activities in the Early Implementation Program. Access and occupancy at the 4850 Level will also serve as a base for dewatering and re-entry to the deeper levels.

Restoration of the #6 Winze and rehabilitation of ramps from 4850 Level to 8000 Level can be accomplished concurrently with initial science operations at the upper levels. The 7400 Level is selected as a preferred candidate for the primary deep campus for DUSEL because it meets many of the scientific requirements for depth, suitable rock properties for excavation of chambers for large detectors at reasonable cost, and the existing lower infrastructure provides a good platform for development at this level. The #6 Winze provides primary access to the deep campus, and a ramp system from 4850 Level provides both secondary egress and movement of material and equipment. Access to the deepest level of the mine at 8000 Level will also be maintained and may be further developed for experiments which require this depth. There is an existing Drill Room at 8000 Level, which will be available and suitable for bio- and geo-sciences research immediately upon re-entry to this level.

A detailed report, “Feasibility Evaluation of the Conversion of the Homestake Underground Mine to the Homestake Underground Laboratory,” [52 and Appendix A10] was prepared by Dynatec Corp., an independent mining company, and presented and reviewed in December 2004. This report demonstrates feasibility of the mining-to-labs conversion program and identifies specific activities that are needed for re-entry and rehabilitation of mine infrastructure in order to support underground research. It provides a preliminary basis for planning, cost estimates, and schedules, which have been further developed for this Conceptual Design Report and for the Authority’s program for both re-entry activities and on-going operations.

Pumping of water, from both naturally occurring inflow and processes for mining operations, is common in all underground mines and was practiced in Homestake. Water inflow at the Homestake site has been characterized; it is estimated that 2/3 of the total 700gpm inflow originates from upper levels (primarily from surface inflow) and the remaining third from deeper sources. The current water level is monitored with sensors stationed every 600 feet in the Ross and #6 shafts. Flooding and water accumulation in the deeper portions of the mine raises three main issues that are addressed in the re-entry plans:

- The first issue is the level of deterioration of mine infrastructure, i.e., conveyances, power, air conduits, and ground support. The near neutral pH of water in this mine retards corrosion of ground support compared to that seen in mines with strongly acidic water. Following dewatering, plans for re-entry include replacing all mechanical, electrical and conveyance infrastructure below the 4850 Level, and thorough inspection of ground support to determine what maintenance is required, and installation of bulkheads to isolate portions of the mine that will not be used for research activities.
- The second issue is delayed access to deep underground locations. With the current schedule for re-entry, accumulated water will restrict access to deeper levels during the Early Implementation Program. Access from the surface to the 4850 Level will continue to be open and the lower sections of the Ross and Yates shaft conveyances above the 4850 Level will remain dry. The Authority’s plan is to intercept and remove inflowing water above the 5000 Level and establish and maintain the water level at or below the 5300 Level. The Homestake mine model predicts accumulated water will not reach the 5000 Level until September 2007 [55]. Maintenance pumping will prevent water accumulation from rising above this level. The upper infrastructure, which has not been flooded, is expected to be in good condition, with some anticipated maintenance requirements. The hoists, motor generator sets, cables, pumps, ventilation and electrical equipment have been properly mothballed and are available for re-installation and commissioning.

- The third issue is that accumulation of water may jeopardize studies of biology and geo-microbiology. Water flow has been inward for the life of the mine. The enormous hydrostatic pressure of water in the deep rock and its low permeability prevents water from flowing from mine openings back into the rock. Studies that require unperturbed conditions must drill beyond a limited cone of disturbance created by the inflows. Similar drilling would have been required even if the pumping had continued unabated. The Homestake site can host such drilling efforts laterally and vertically from many levels and ramps, and we expect only small and manageable impact for these studies.

For re-entry to 4850 Level and above, the Authority will perform the following primary tasks, with personnel safety being an essential priority at every step:

- Perform detailed video camera inspections of the Yates, Ross and #5 shafts.
- Re-establish power to site services under the Authority utility contracts.
- Inspect and re-commission the Ross and Yates hoist systems to restore the conveyances.
- Re-commission mine ventilation systems with modifications, which will support the Homestake Interim Laboratory and DUSEL requirements to provide intake air through the Ross and Yates shafts, and exhaust through the #5 shaft and/or Oro Hondo shaft, for support of new excavation and construction.
- Inspect, repair or replace timbers in the Yates Shaft, which were identified for maintenance at mine closure.
- Inspect, repair or replace steel supports in the Ross Shaft, which were identified for maintenance at mine closure.
- Inspect all accessible drifts, ramps, and shafts at 4850 Level and above; evaluate conditions at the time of re-entry, and initiate maintenance as required for safe access and egress.
- Construct ventilation-isolation bulkheads at Ross and Yates shafts for drifts that are not intended for the Homestake Interim Laboratory and DUSEL access. Install or modify ventilation control doors to establish intake and exhaust air flow as required.
- Inspect and repair underground electrical power distribution systems, including re-installation of transformers and switchgear at several levels for the Homestake Interim Laboratory and DUSEL campuses, and enable temporary power supplies for entry to other levels for identification of monitoring station locations.
- Inspect and re-activate piping and pumping systems above 5300 Level. Accumulated water will be maintained at or below the 5300 Level while awaiting authorization to initiate dewatering for DUSEL. For dewatering below 5300 Level, the existing winch operation at the #6 Winze will be temporarily converted to a hoist. A series of portable pumping stations will be lowered into the #6 Winze and a floating barge used to maintain the lowest pump on the retreating water surface.
- Re-commission existing or install new water treatment facilities (on the surface) as required to achieve acceptable water quality for DENR Water Discharge Permits. Water from upper levels may not require treatment; however, accumulated water from the deep levels is likely to require cooling and additional treatment to mitigate total dissolved solids.

6.2.1 Re-entry Plan to Install Ross Shaft Pumping System

In February 2007, SDSTA approved the re-entry plan for installation and commissioning of the pumping system at the Ross Shaft, which is presented in Appendix A11 "Homestake Re-entry and Dewatering Program Plan." This plan comprises a phased sequence for safe re-entry to initiate dewatering which will hold the accumulated water below the 5000 level. It will enable construction access and development of the mid-level campus at 4850 level and above and access for future installation of pumping systems at the #6 Winze to dewater the entire facility to the 8000 level. The project phases for this effort include the following primary tasks:

(1) Rehabilitation and re-commissioning essential surface infrastructure for hoist operations at the Ross Shaft, installation of two new exhaust fans at the #5 Shaft for ventilation, re-commissioning electrical power distribution systems, and securing all necessary environmental permits for pumping and water discharge;

(2) Re-entry for inspection and rehabilitation shaft infrastructure and intersecting drifts, installation of ventilation bulkheads to isolate the fresh-air circuit at the Ross Shaft and selected drifts for future access and development, installation of new power supply cabling and refurbished transformers and switchgear, installation of refurbished pumps and piping at the four primary pumping stations along the Ross Shaft at 1250, 2450, 3650, and 4850 levels, installation of new fiber optic cable for communication and controls; and

(3) Operation and maintenance of the pumping system, ventilation, hoists, and Ross Shaft infrastructure to provide continuous dewatering to support development and operation of the interim laboratory, aiming to begin steady-state operation by the end of calendar year 2007.

6.3 Surface Buildings and Structures

The existing surface infrastructure at the Homestake Interim Laboratory was built primarily to support previous mining operations. Many of these buildings are significant assets for mining-to-labs conversion. Some facilities and their functions will continue to be needed to support underground access and activities for underground construction and lab operations. However, in the absence of ore processing and high-volume, production-scale mining, other buildings are available and suitable for conversion or remodeling to suit the needs of the lab, to be developed concurrently as research operations and user support become the primary activities at the site. Of the buildings and structures included in the property transfer, there are several prime candidates for continued use or development for the Homestake Interim Laboratory and DUSEL, including:

- Yates Shaft complex to be developed for facility administration, site services and user support:

  Mine Office and Administration Building
  Yates Safety and Dry Building
  Yates Headframe and Crusher Building
  Yates Hoist Room
  Machine Shop Building
  Main Warehouse
  Foundry Building
  Yates East Substation

- Ross Shaft complex with minimal remodeling for construction staging and maintenance:

  Ross Headframe and Crusher Building.
  Ross Hoist Room
  Ross Dry Building

Ross LHD Warehouse
Ross Pipe Shop
Ross Substation

- Other Buildings and Facilities with functional infrastructure:

Water Treatment Facilities
Oro Hondo Substation
Oro Hondo Fan
Kirk Fans
#5 Ventilation Shaft

Initial planning has focused on maintenance and preparation of surface facilities needed to support re-entry, rehabilitation, and new construction of underground lab modules. During the next project stage for Preliminary Design, design concepts will be developed to remodel space for site services and user support (e.g., administrative offices, classrooms, surface laboratories, and shops) and Education and Outreach (e.g., classrooms and conference rooms, visitor center, displays and demonstrations). Buildings in the Yates Complex which are being studied for these functions include the Mine Office and Administration Building, Yates Safety and Dry, Machine Shop, Warehouse, and Foundry. These five buildings alone offer nearly 9300 m^2 (100,000 ft^2) of floor space available for facility and lab operations in the Yates Complex.

The Authority is currently converting 5400 square feet on top floor of Yates Dry for safety, offices, meeting rooms, as illustrated in Figure 6.4.

Figure 6.4 Conversion of the Yates Dry for safety offices, meeting rooms and office space.

6.4 DUSEL Campus Development at Near-Surface, Mid-Levels and Deep Levels

Initial development to support early access to mid-levels for Early Implementation Program experiments and R&D will focus on the 4850 Level underground campuses for the Homestake Interim Laboratory: with primary access via the Yates and Ross shafts, as shown in Figures 6.2 and 6.3. Planning for infrastructure rehabilitation and alterations at re-entry includes considerations to enable phased development of lab modules and common facilities for eventual DUSEL programs at near-surface, mid-levels and deep-level campuses at the 7400 and 8000 Levels. According to preliminary plans, ventilation fans for the #5 Shaft will be converted to exhaust air, and the Yates and Ross shafts used for intake air, which facilitates access to other drifts and ramps throughout the mine (such as the long drift at the 2000 Level) for off-campus underground research including biosciences, geosciences, and geomechanics, which may require access to a variety of rock types and conditions, and physics experiments that may require a greater degree of isolation.

6.4.1 Near-Surface Campus at the 300 Level

Preliminary engineering for underground construction to initiate Early Implementation Program research activities will begin as soon as funding is available. Figure 6.5 shows a development concept at the 300 Level adjacent to the Ross Shaft where the existing Power Tunnel portal provides horizontal entry from Kirk Road. A new drift and portal (5m x 5m) will allow drive-in access to the 300 Level campus which will initially have a total of approximately 925 m^2 (10, 000ft^2) of floor space in these new rooms and access drifts. This concept also includes options for future development of additional near-surface space for DUSEL experiments and activities that are suitable at the 300 Level.

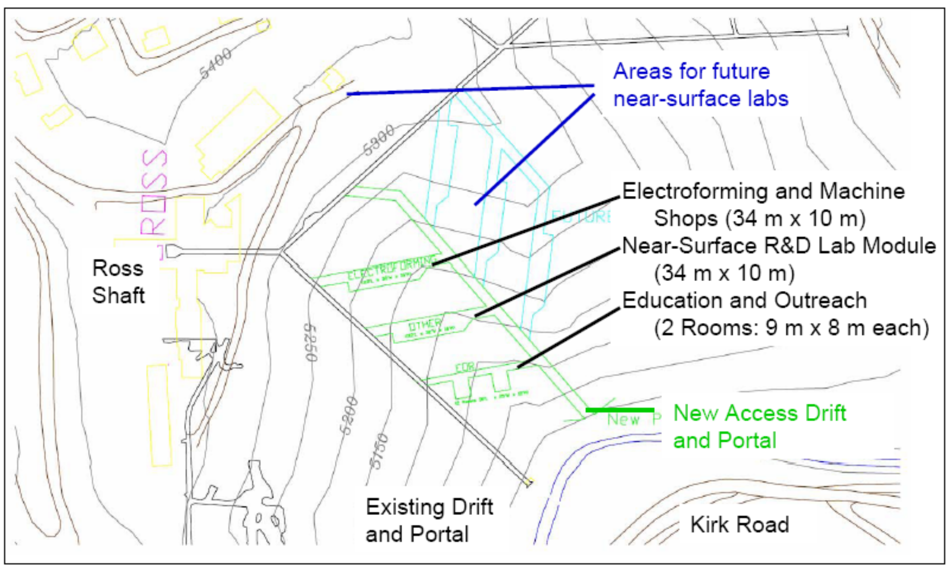

Figure 6.5 Development Plan for Near-Surface Facilities at 300 Level. Total excavated space for initial excavation at 300 Level provides more than 925m^2 (10,000 ft^2) for labs, shops, access drifts, and E&O.

Pending funding availability with an aggressive schedule for excavation and outfitting, beneficial occupancy of underground labs at the 300 Level may occur as early as 2010 to support Early Implementation Program and R&D experiments such as a near-surface Low-Background Counting Facility, Low-Background Materials Manufacturing and storage (i.e., Copper electroforming and machine shops), R&D facilities for several experiments which will be implemented later at deeper levels, and classroom/display space for E&O. Access and construction at 300 Level may be done concurrently with the mid-levels re-entry and infrastructure rehabilitation program.

6.4.2 Mid-Level Campus at 4850 Level

Development of the 4850 Level as a primary campus for DUSEL has several attractive features which are well matched to scientific goals. At this level, the overburden provides approximately 4100 mwe, which meets or exceeds the overburden depth needed for a wide range of experiments, as discussed in Chapter 4. Initial assessments of rock mass undertaken by Pariseau, Golder, NIOSH, and RESPEC [40-45] indicate that, for geotechnical and engineering purposes, both the Yates and Poorman rock are conducive to the construction of large excavations using appropriate state-of-the-industry ground support techniques in moderate stress regimes. The base of the Yates shaft terminates within the Yates Member at 4850 Level for convenient, direct access from the surface for lab personnel and materials.

By exploiting the combined operation of conveyances at both Yates and Ross Shafts, phased excavation activities at 4850 Level may be done with access by construction crews via the Ross Shaft concurrently with access for on-going lab operations staff via the Yates Shaft. Existing mine infrastructure provides supply air through both shafts, which permits temporary construction barriers to isolate construction from clean areas for research activities. The conversion plan includes Yates Shaft upgrades to enhance accessibility with an automated personnel lift for 24 hour/7 day access, a large cage (approximately 4m x 4m) for lab materials and equipment, and defined space for services and utilities, including ducting for low-radon air from the surface, as shown in Figure 6.6. Waste rock removal and mobilization of construction materials and equipment will utilize the existing conveyances in the Ross Shaft, which terminates at 5000 Level. As discussed above, early access to 4850 Level by the Authority will enable pumping to keep accumulated water from rising above 5300 Level, which will reduce the time and cost for re-entry and infrastructure rehabilitation at 4850 Level. Site investigation and geotechnical studies for development of lab modules at 4850 Level may begin as early as 2008.

6.4.3 Existing Cage Dimensions and Capacities

Yates Cage Hoist (shown in Figure 6.7)

- Maximum Cage dimensions: 1.4 x 3.7 x 2.2m high (side-by-side)
  (4’ 8” x 12’ 1.5” x 7’ 2” high)
- Maximum cage payload: 5,450 kg (12,000 lb), nominal
  5,900 kg (13,000 lb), allowable at half-speed.

Ross Cage Hoist

- Maximum Cage dimensions: 1.3 x 3.8 x 2.2m high (double deck)
  (4’ 4-5/8” x 12’ 5” x 7’ 2” high)
- Maximum cage payload: 5,450 kg (12,000 lb, nominal
  6,100 kg (13,400 lb), allowable at half-speed.

#6 Winze Cage Hoist

- Maximum Cage dimensions: 1.3 x 3.7 x 2.2m high (double deck)
  (4’ 4” x 12’ 1-1/2” x 2.2m high)

- Maximum cage payload: 5,450 kg (12,000 lb), nominal
  6,400 kg (14,000 lb), allowable at half-speed.

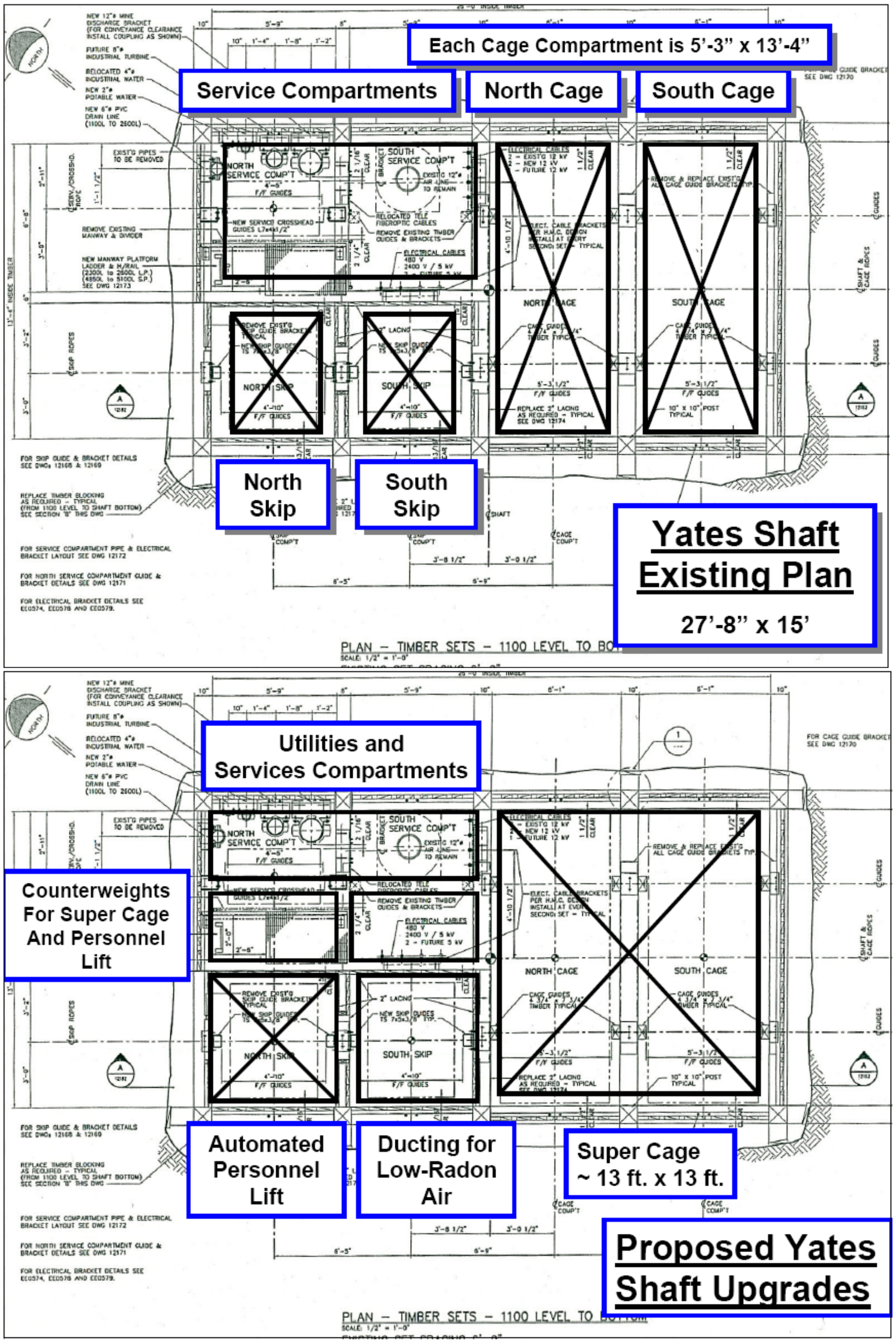

Figure 6.6 Existing (top) and proposed (bottom) layouts for the Yates Shaft and conveyances. Smaller cages and skips will be replace by a large Super Cage for material and equipment, and ore skips will be replaced by an automated lift for personnel.

Ramp System to Deep Levels:

A series of ramps connecting levels between the 4850 and 8000 Levels provide secondary egress and also a back-up transport path for mobile equipment and construction materials which may not fit in the #6 Winze cage hoist. Primary staging for materials and equipment will be done at the 4850 Level Ross Shops for construction and installation activities at the 7400 Level campus, and space will also be made available for staging at the 7400 Level during excavation and laboratory construction.

Waste Rock Hoist Capacities and nominal daily capacity with 3-shift (22 hours) operation:

Yates Ore Hoist:	182 metric tons/hour (200 tons/hour)	4,000 metric tons/day (4,400 tons/day)
Ross Ore Hoist:	137 metric tons/hour (150 tons/hour)	3,000 metric tons/day (3,300 tons/day)
#6 Winze Ore Hoist:	173 metric tons/hour (190 tons/hour)	3,800 metric tons/day (4,180 tons/day)

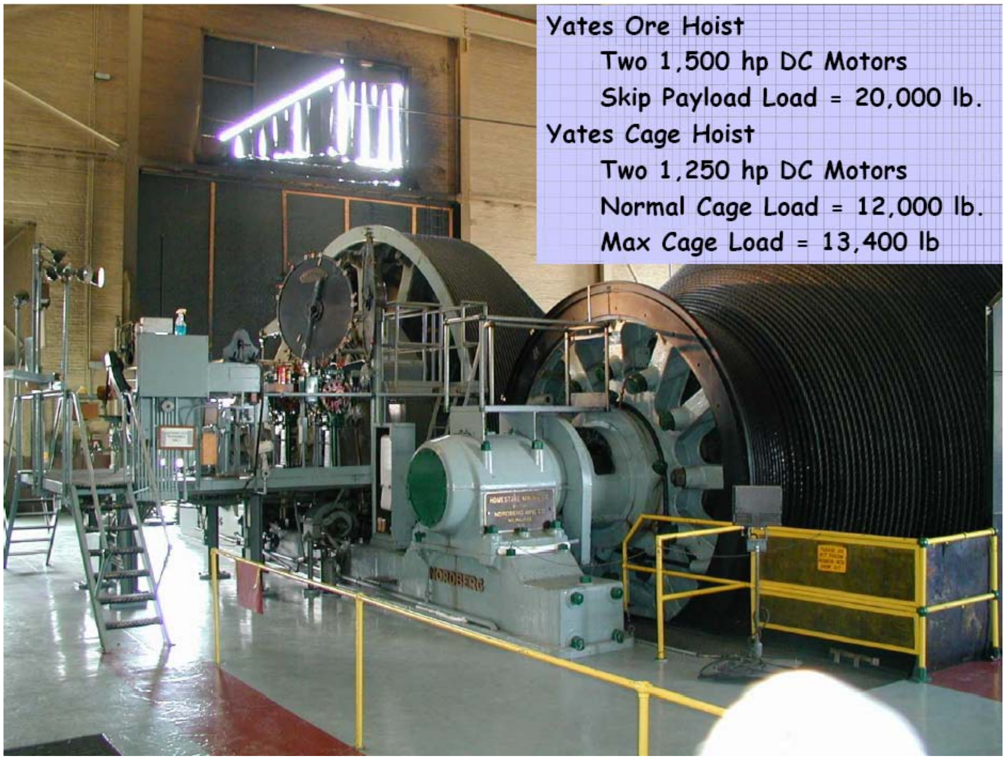

Figure 6.7 Photograph of the Yates Cage Hoist and controls, located in the Yates Headframe.

6.2.1.1 Hoist Upgrade Options to Increase Size and Weight Capacities

Feasibility studies and cost estimates were done by the Homestake Mining Company in 1997 and 2001 to evaluate upgrades to the hoists and conveyance systems at the Yates shaft and #6 Winze. The study in 1997 considered relatively modest alterations to the Yates production hoists to increase the capacities to handle loads between 15 to 18 tons, and to increase the capacities of the service hoists to 10 tons. In addition to some structural enhancements, alterations included several new components such as hoist ropes, brake systems, clutches and clutch linings, and improved hydraulics for the existing two ore skips and two cages.

The study in 2001 considered major alterations to the Yates shaft to install a "super-cage" which could handle shipping containers up to 9' x 9' x 20' size and 25 ton load capacity, and also to install a smaller hoist and personnel lift. The nominal super-cage size was 13' x 22'. This configuration would also require major changes to the Yates shaft and headframe, hoists, and the drifts at the 4850 level.

For this conceptual design, we have proposed relatively modest and cost-effective upgrades to the Yates shaft and hoist systems. As described above in Sections 6.4.2 and 6.4.3, we plan to install a single super-cage (~13' x 13') to replace the two existing cages, and a smaller automated

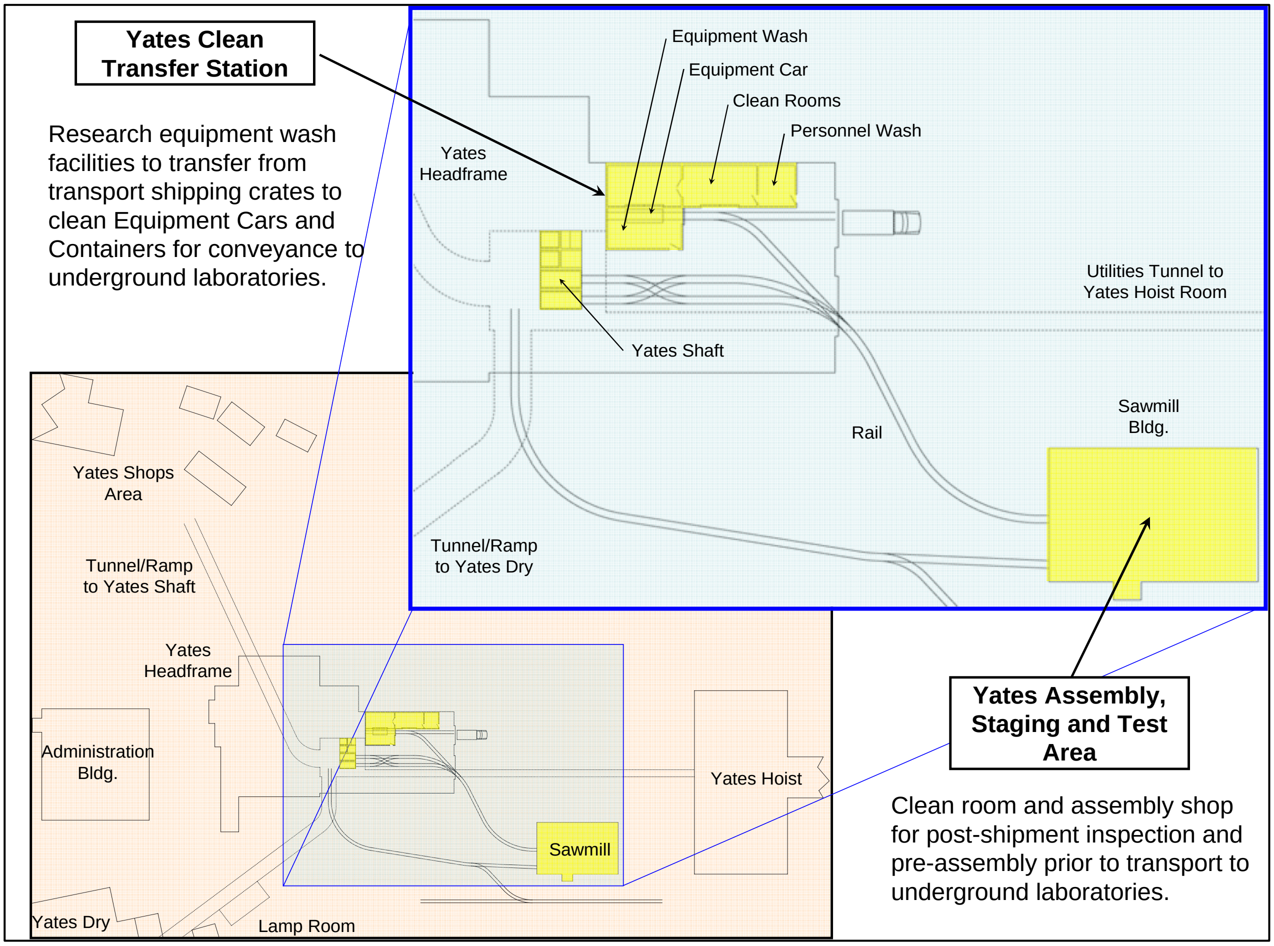

Figure 6.8 Proposed surface facilities to prepare materials and equipment for conveyance to underground laboratories, including the Yates Clean Transfer Station within the existing Yates Headframe building, and alterations at the Sawmill Building for the Yates Assembly, Staging, and Test Area.

lift for personnel. Shipping containers and other large equipment which exceeds the super-cage size capacity may be slung under the cage, hanging vertically. This configuration was done routinely for mine operations to transport bundles of rail and pipe up to 30 feet in length. This will require minimal alterations to the Yates shaft infrastructure and will significantly enhance capabilities for larger-size loads of material and equipment and dedicated access for personnel. Options to increase the load capacity are also being considered, and upgrades will be matched with identified requirements and budgetary constraints.

Other temporary configurations are possible which could accommodate additional weight capacities and/or sizes, depending on the combined requirements. For example, we currently have the option to replace the cage with a crosshead and guide assembly in order to handle oversize loads which exceed the cage nominal size constraints. In addition, without the weight of the cage itself, the weight capacity for the hoist system using a crosshead assembly is increased by approximately 4 tons. Similarly, other scenarios are feasible to develop economical, cost-effective design configurations which may handle special or specific requirements.

A key component of our design concept for the Yates super-cage is the planned development of surface infrastructure at the Yates Headframe building and at the nearby Sawmill building for inspection, cleaning, pre-assembly, testing, and re-packaging components as they are received from shipment. Development of the Sawmill building into a staging area with a clean assembly shop and construction of a Clean Transfer Station in the Yates Headframe building are also included in the construction plans, and shown in Figure 6.8. We anticipate that a standard practice for movement of materials and equipment from the surface to underground will necessarily include a careful inspection of all parts to insure that any damage which might have occurred during shipment can be identified and repaired prior to taking those parts underground.

Whenever possible, components and subsystems will be cleaned, pre-assembled and tested on the surface to minimize the work required to assemble and commission the systems underground. This is similar to procedures that are typically done at other underground research facilities such as SNOLab. We plan to develop and make available to users standard transport containers which match the size capacities and constraints for conveyance of parts from the surface to underground laboratories. The customized containers will have appropriate provisions to handle the atmospheric pressure differential between the surface and underground and also to maintain cleanliness, for example, using a “double-bagged” design, as needed. Standard practice for effective underground construction and commissioning will likely require surface inspection and preparation following receipt of shipments and before parts and sub-assemblies are taken underground – for engineering, safety and security considerations.

A further consideration regarding project scope in the context of overall systems design for accessibility and material transport is scheduling and availability of the hoist and conveyance systems. With Homestake being a dedicated facility for science, all decisions regarding priorities for access and services will be under the control of DUSEL management. At other underground research facilities, such as SNOLab, scheduling for both personnel and material transport must be coordinated with concurrent mining operations, generally with secondary priority to production requirements.

6.4.4 Phased Development for 4850 Level Campus

Figure 6.9 shows the existing workings and major geological features at 4850 Level. The encircled area near the Ross and Yates Shafts will be developed for the mid-level campus, and illustrates the approximate contact region between the rock of the Yates Member (Yf) and the Poorman Formation (Pf). Initial plans for excavation of new lab modules will be done within the triangle. Excavation for future modules and purpose-built chambers for large detectors is feasible outside the triangle to the east and west, with good proximity to existing drifts and shafts for access, waste rock removal, services and utilities, and ventilation. Figure 6.10 shows with more detail several of the existing rooms that are available for development and outfitting at re-entry to 4850 Level. Direct access to this area also provides immediate opportunity to begin coring and site investigations. This will provide data for studies to evaluate rock properties at specific locations prior to detailed design and excavation for lab modules.

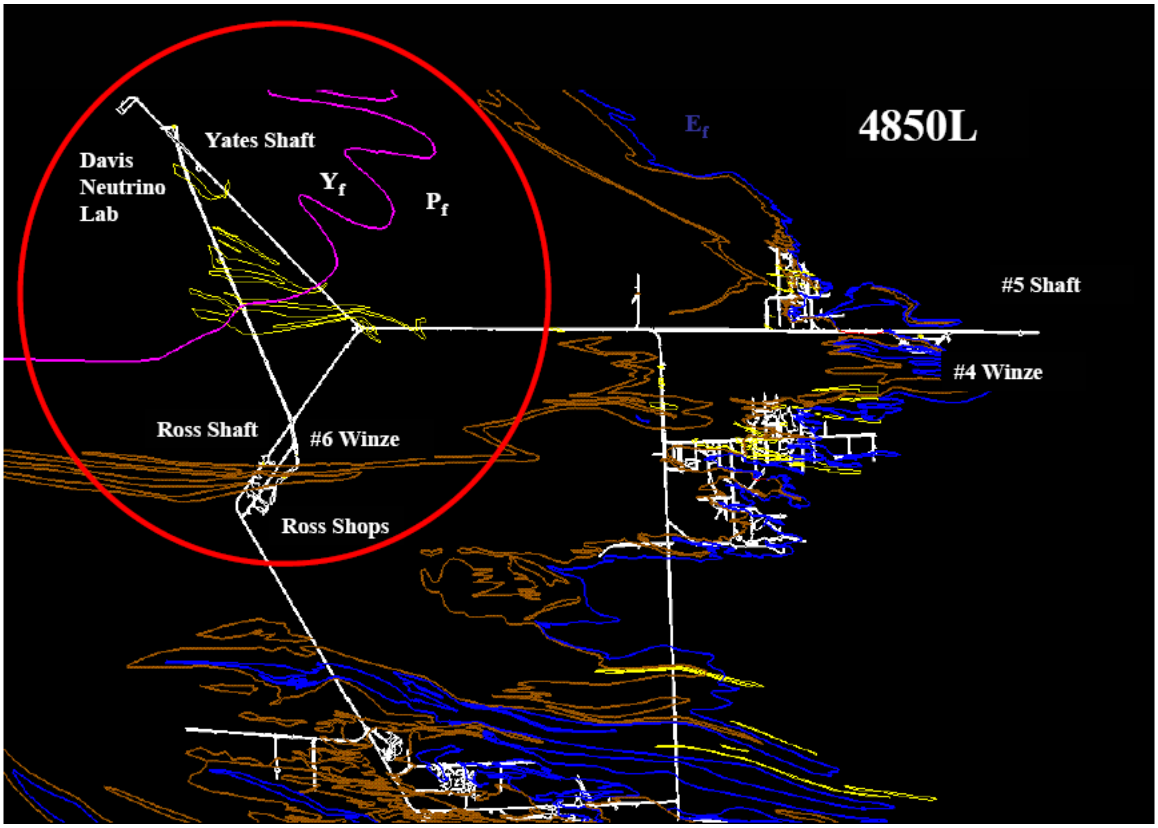

Figure 6.9 Homestake Mine 4850 Level workings and geological features. Encircled area near Yates and Ross Shafts will be developed for the DUSEL Mid-Level Campus. Preferentially, large excavations will be done within the competent rock of the Yates Member (Yf).

The proposed development plan for the mid-level campus is shown in Figure 6.11, which demonstrates a phased sequence of excavation for new lab modules, common facilities and services, and construction maintenance shops. This plan provides more than 6,000 m^2 (65,000 ft^2) footprint at 4850 Level.

The first stage of excavation, which may start as early as 2008, will enlarge the existing Ross Shops to be used for construction materials and equipment maintenance. Because this space is adjacent to the #6 Winze and accessible to the ramp systems to deeper levels, it will also be used to support construction of labs at 7400 Level for the deep campus. Excavation in Stage #1 includes expansion of the existing Davis Neutrino Chamber to increase the height of the room. It will be developed for a Water Shield Facility, initially planned for the LUX and CLEAN experiments as described in Chapter 4 for the Early Implementation Program. In the area immediately adjacent to the Davis Neutrino Chamber, two new rooms will be excavated: a laboratory which may be outfitted for R&D and early implementation of the Majorana Experiment (20m x 6m x 5m high) and a smaller Control Room (9m x 6m x 5m high) which may be shared by both the LUX, CLEAN and Majorana experiments. Excavation in Stage #1 also develops a large laboratory (32m x 9m x 5m high) to be used as a base of operations for Geosciences and Biosciences research in both Early Implementation Program and DUSEL. For this first construction stage at 4850 Level, outfitting may be completed by mid-2009 to begin installation of research instrumentation.

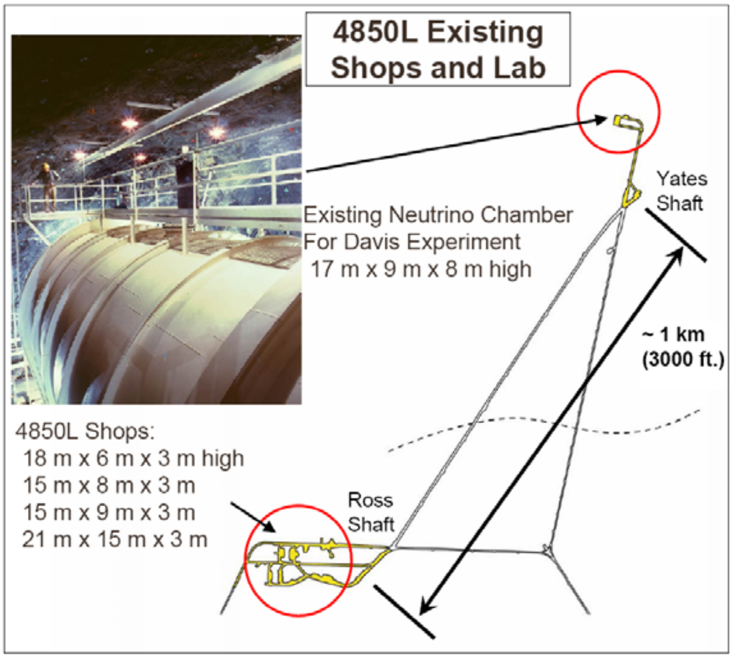

Figure 6.10 Existing chambers near Yates and Ross Shafts, available for development and outfitting at re-entry to 4850 Level. Existing drifts provide direct access for coring and site investigation to initiate detailed design for excavation of additional lab modules.

The second excavation stage at 4850 Level is scheduled to begin directly on completion of stage #1, ideally to maintain continuity for construction crews and equipment. Continuity of the construction and excavation work will avoid incurring significant, additional costs for mobilization and de-mobilization if there is a gap in the construction schedule. In developing the excavation sequence and schedules, we have aimed to match the construction scale and sequence with several drivers:

(1) anticipated maturity of scientific programs to specific requirements and their likely schedule for readiness of research instrumentation;

(2) project management objectives to maintain uniform staffing levels for both sub-project design teams and construction crews;

(3) develop reasonable cost profiles to be negotiated with the funding agencies for the duration of the project;

(4) scaled to optimize workloads for construction crews and equipment to enable concurrent operations in alternate areas for the sequence of activities to drill and blast, remove waste rock, and install ground support; and

(5) balanced design scale to minimize costs and risks for excavation and outfitting with shared infrastructure among multiple experiments rather than isolated chambers for each experiment.

Item (5) is a significant cost driver identified by our preliminary estimates, which indicate that laboratory infrastructure and outfitting are likely to be a major cost element for underground experiments. By developing reasonable sized lab modules that may host more than one experiment, laboratory infrastructure costs may be shared among multiple experiments.

Excavation stage #2 will develop new space along the Yates-Ross drift to be used for common facilities and services, and two general-purpose lab modules within the Yates-Ross triangle. The large Common Room (~50m x 15m x 5m high) is located along the main access drift and will be outfitted for utilities and services to support the mid-level campus (electrical power transformers and switchgear, air handling equipment for ventilation and filters, communications and monitoring systems, compressed air, purified water, and emergency response equipment and refuge station).

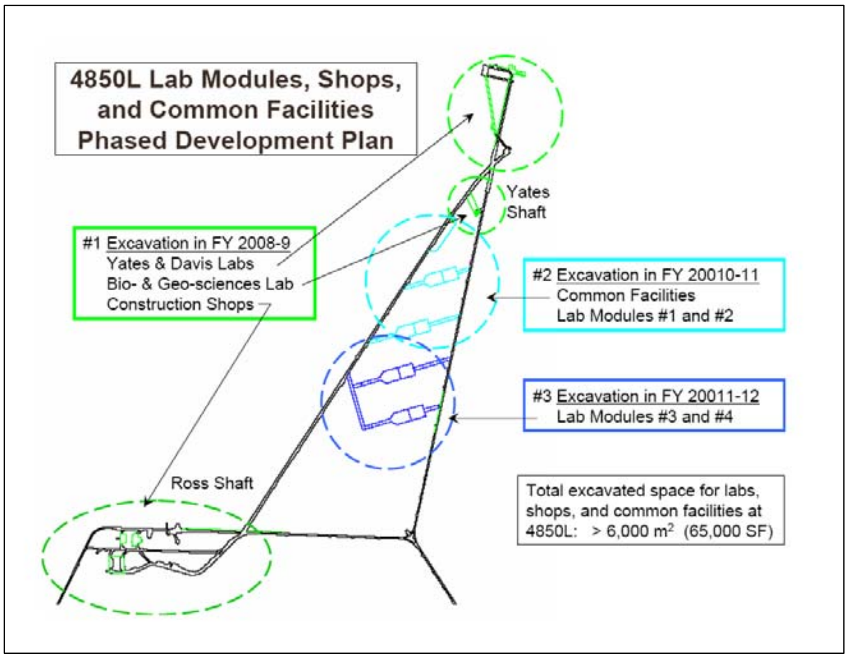

Figure 6.11 Development Sequence at 4850 Level provides construction access via Ross Shaft isolated from on-going lab operations with staff access via Yates Shaft. Each of four large lab modules (~50 x 20 x 15m high) provides shared outfitting and common services for multiple experiments.

The Common Room will support user services and wash facilities for an initial transition from the mine environment to a clean, laboratory environment. Each of the Lab Modules (~50m x 20m x 15m high) within the Yates-Ross triangle will have a secondary transition to purpose-built clean rooms that meet the requirements of specific experiments. Each lab module will be outfitted for specific experimental configurations, and a nominal module design is presented below to serve as a basis for preliminary project planning and estimates. Stage #2 construction may start in FY11, pending availability of construction funds. Duration for excavation will be approximately one year, plus up to one year for outfitting to prepare for beneficial occupancy to begin installation of research instrumentation.

The third excavation stage at 4850 Level may begin in FY11 or FY12, pending experimental needs and funding. The current plan for development of the 4850 Level campus includes a budget for excavation of the two additional lab modules in this stage, but excludes costs for outfitting and research instrumentation in these modules. This approach is most cost effective to exploit continuity for construction by eliminating an additional mobilization and de-mobilization cycle, and also enables flexibility to tailor the outfitting to match experimental requirements which may be identified as DUSEL research programs mature during the next few years.

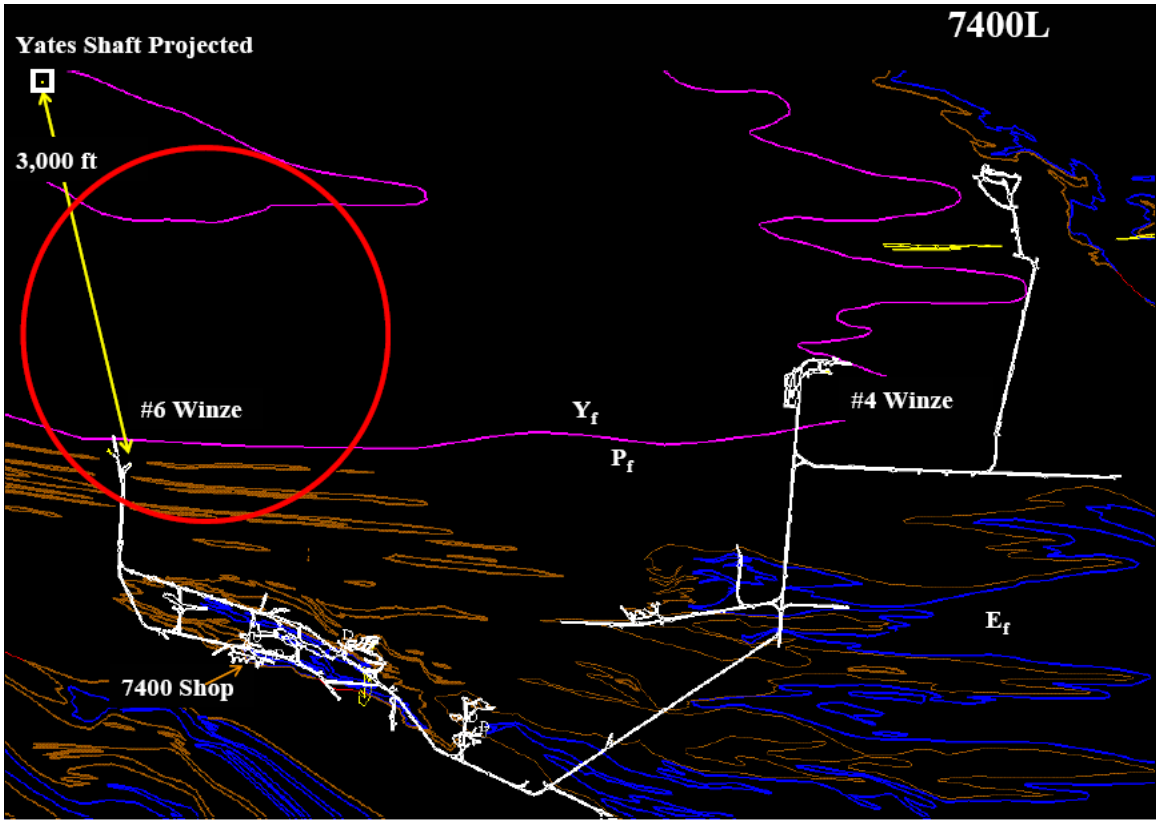

Figure 6.12 Homestake Mine 7400 Level workings and geological features. Encircled area near #6 Winze will be developed for the DUSEL Deep-Level Campus. Preferentially, large excavations will be done in the more competent rock of the Yates Member (Y_f).

6.4.5 Deep-Level Campus at 7400 Level

The #6 Winze provides primary access to the levels below 4850 Level. A ramp system between 4850 Level and 8000 Level provides secondary egress from the deeper levels, and also provides access for materials and mobile equipment from the construction staging areas at 4850 Level. Figure 6.12 shows the existing workings at 7400 Level and the encircled area near the #6 Winze in the Yates Member (Y_f) is the preferred site for excavation of lab modules and large detector chambers. The existing 7400 Shop (~42 x 9 x 5m high) may be used for construction materials, staging, and equipment storage. Intake air is directed through the #6 Winze, and air controls doors will direct the exhaust air to the #4 shaft.

Plans for development of the deep-level campus, shown in Figure 6.13, follow a similar, standardized approach with the ladder-type layout for lab modules as used at 4850 Level. This configuration enables phased construction concurrently with adjacent lab operations, primary and secondary egress paths, excellent options for routing ventilation and utilities, and allows cost-effective, optimal scheduling for construction activities. The plan includes initial excavation of a Common Room for facilities and user services near the user entrance from #6 Winze, and a construction materials and equipment room on the opposite leg.

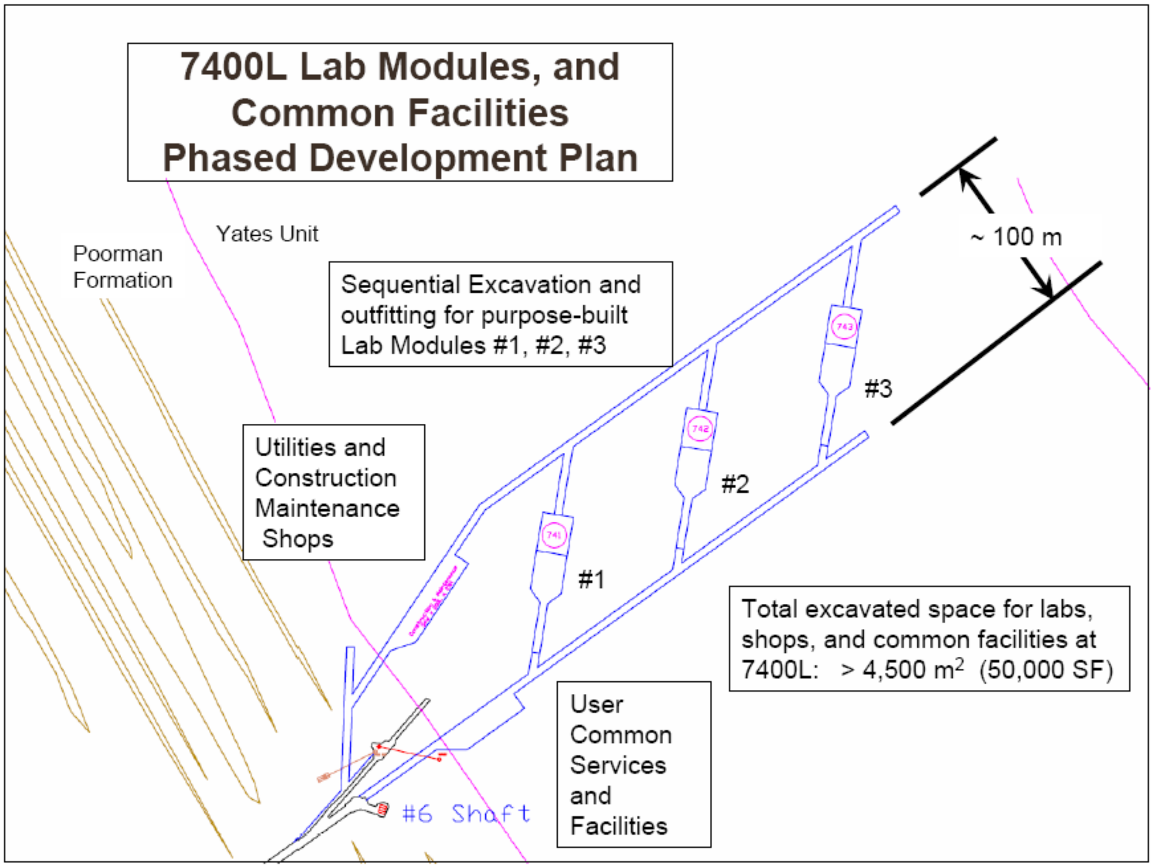

Figure 6.13 Homestake Mine 7400 Level Concept for DUSEL Deep-Level Campus, planned for sequential development of Common Space and Construction Areas, and three purpose-built lab modules each with shared outfitting and services for multiple experiments.

Excavation of the three proposed lab modules will be done in sequence for early experiments to begin in Lab Modules #1 while construction is continued for Lab Modules #2 and #3. With this configuration, the total excavated footprint at the 7400 Level campus is more than 4,500 m^2 (50,000 ft^2). The planned budget for construction at 7400 Level includes excavation of all three Lab Modules, outfitting for the Common Room and Lab Module #1 at the 7400 Level, but excludes outfitting of Modules #2 and #3. As at the 4850 Level, this approach is most cost effective to exploit continuity for construction by eliminating an additional mobilization and de-mobilization cycle, and enables flexibility to tailor outfitting to match experimental requirements which may be identified as DUSEL research programs mature during the next few years.

6.5 Primary Levels in Homestake of Interest to Research

Although the most intensive activity will be associated with the upper and lower campuses and will focus on the 7400, 4850, and 300 Levels, other levels will require some amount of continued access. Some of the levels will be maintained for operational purposes and some will be maintained to provide access to important areas of the underground for experimental

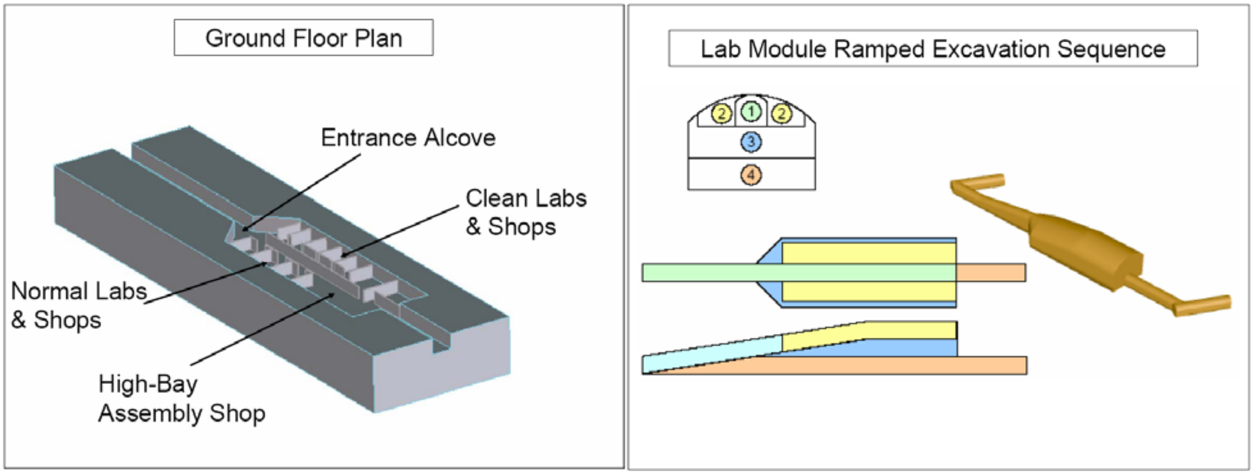

Figure 6.14 Nominal layout and Ground Floor Plan (left) for typical Lab Module. Ramped excavation sequence (right): (1) access drift and heading top cut, (2) slash top bench, (3) middle bench, (4) bottom bench and exit drift. Floor plan outfitting will be purpose-built for specific experimental requirements.

purposes. Table 6.1 lists those levels deemed to be most important, but the selection of these levels for continued maintenance does not necessarily preclude access to other levels and areas in the underground. In addition the ramp system provides for exceptional access to many of the geologically varied environments in the Homestake facility.

6.6 Lab Module Concepts, Common Facilities and Services

A concept for a standardized lab module configuration is presented in Figures 6.14 and 6.15. This nominal configuration is used as a basis for planning, analysis, and estimating to develop the conceptual design for Homestake DUSEL. As specific information for individual experimental requirements becomes available, this concept for excavation and outfitting will evolve with additional detailed engineering and design. The nominal design has a footprint of approximately 50 x 20 m and the maximum ceiling height is 15 m over half the length of the room. With construction of a partial mezzanine floor, a portion of the module may utilize the full

Table 6.1 Levels in the Homestake Facility of Interest for Research

Level	Priority (1 is highest)	Justification/Comments
300L	1	Experiments are currently planned for this level; potential walk-in access for experiments and education and outreach
800L	2	Offers access to the north; will be useful for underground mapping educational purposes; older part of underground and may be important for geomicrobiology
1100L	3	May offer access to sump for water collection; only a limited amount of the level would have to be maintained
2000L	2	Provides very wide access; will be useful for underground mapping educational purposes; will be important for geosciences; and may be important for geomicrobiology

2600L	2	Connects the two main areas of mineralization at depth; important for geoscience—study of mineralization; good connector throughout this depth of the underground
3800L	3	May be redundant to 2600L but offers access to the #5 shaft and may be useful for both geoscience and maintenance of the shaft; may be important to provide depth access (provides access between the 2600L and 4100L)
4100L	2	Connects the two main areas of mineralization at depth; important for geoscience—study of mineralization; good connector throughout this depth of the underground
4850L	1	Primary level for laboratory module development
5900L	2	Offers access to the #4 winze and to wide areas of the underground; midway between 4850L and 6800L
6800L	1	Connection to the #5 shaft; important to maintain monitoring of underground facilities
7400L	1	Primary level for laboratory module development
7700L	4	May be a useful level to drift under the 7400L experimental area for a cryogen dump and other utilities; use is speculative at this time
8000L	1	Required for access for deep drilling for geomicrobiology; is the location of the skip pocket for rock from the 7400L; required for pumping of water from the deepest levels

15 m ceiling height for a high bay assembly shop with overhead crane capability for material handling. Including the build-out with a mezzanine and entrance alcove, total usable floor space is approximately 1,600 m^2 (17,600 ft^2). For several proposed experiments with similar infrastructure requirements, it will be cost-effective to develop lab modules to have shared services to the extent feasible, and purpose-built rooms for detectors and other functions that may be unique to an experiment.

The shared services within modules may include functions such as clean rooms and wash facilities, electronics and mechanical shops, communications and control room, meeting room and offices, storage, emergency response equipment and refuge, electrical and mechanical utilities (including purified water systems and reduced-radon air), emergency exhaust or containment/drainage systems for hazardous materials. Many of these functions add significant cost to lab and experiment outfitting and may be used only intermittently during installation and normal operations. Early planning to co-locate experiments with similar requirements to enable shared services will be beneficial for both cost and schedule management.

Accessibility is another important design issue associated with planning and development of lab modules. Upgrades to the conveyances at the Yates Shaft will increase clearance capacity to handle equipment containers, construction materials, and lifting fixtures up to ~4m x 4m in cross-section. The cage may be rigged to handle vertically longer lengths of containers, such as lengths of piping structural components, with the primary limitation being maneuvering the vertical lengths from the shaft into horizontal drifts. The nominal cross-section in the main Yates-Ross drift is approximately 4 x 4m (13 x 13ft.), with some tight regions to be expected. Rehabilitation of existing access drifts and excavation for any new drifts will maintain a minimum stay-clear area of 3 x 4m (10 x 13ft.), with expanded widths at passing zones and at sharp turns and junctions for adequate swing length around corners.

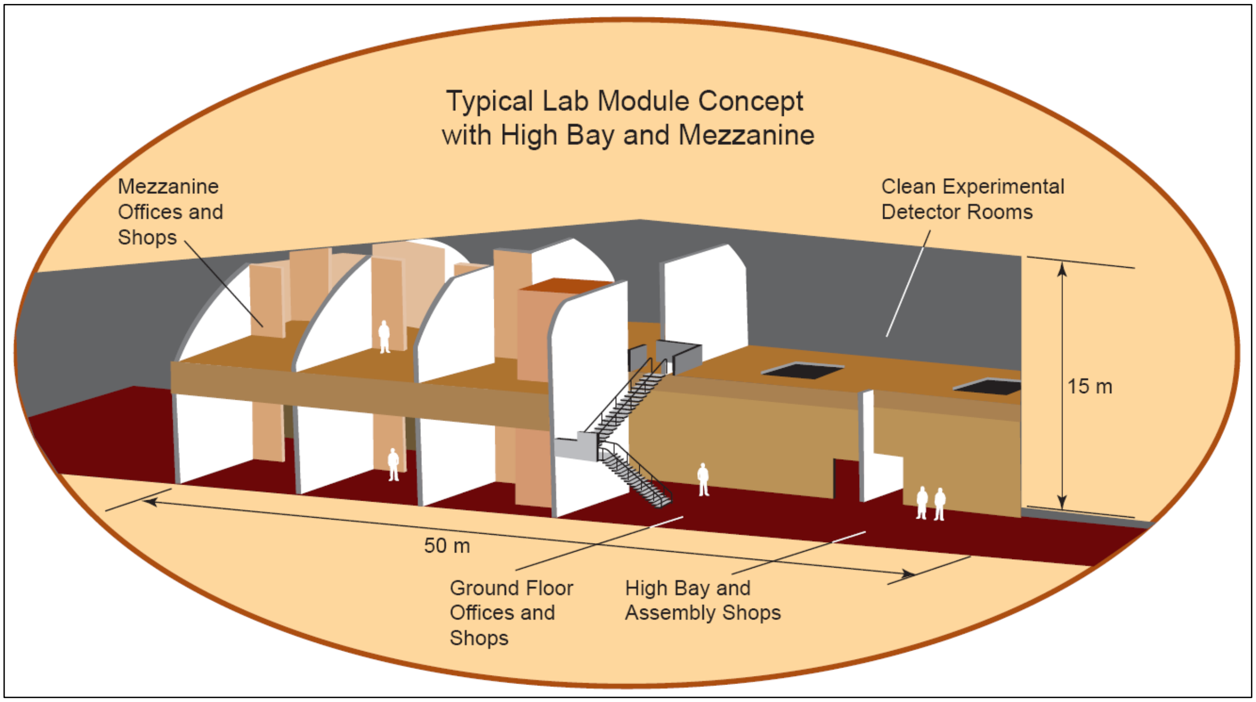

Figure 6.15 Cut-away view of chamber opening for Lab Module concept with high bay and mezzanine for multiple experiments.

The nominal design for new, primary access drifts for lab modules is 5m x 5m in cross-section in order to provide space along the walls and ceiling for mechanical and electrical utility distribution and drainage. Figure 6.16 shows a concept to define clearances and utilities in new drifts, including space reserved for ventilation ducting for specific experiments that may require reduced-radon air supply, isolated exhaust for fume hoods or boiloff gas from normal operations, and emergency exhaust to contain and isolate potentially toxic gases for personnel safety.

For most standard construction materials for laboratory outfitting, normal material-handling equipment may be used to transport supplies from shafts to each lab module, comparable to construction material handling in a typical surface building. For specific research instrumentation and materials which may require special handling to maintain cleanliness or to prevent damage to sensitive components, we will develop standard transport containers which can be loaded and sealed at the surface under clean-room conditions, and moved underground using engineered lifting fixtures and handling features. It is important that all containers and equipment moved from surface to underground must insure that atmospheric pressure changes with elevation do not cause any damage, leakage, or hazardous material spills. We expect that standard shipping containers for the trucking industry, for example, would not be acceptable for material handling and transport into the mine. Shipments will normally require inspection for damage upon receipt at the site. Often, pre-assembly and testing of some components will be done at the surface to facilitate trouble-shooting and maintenance prior to underground installation.

6.7 Geotechnical Studies: Stability Analyses to Support Site Selection

Large openings have been excavated at many locations within the mine and have demonstrated excellent stability for several decades, including rooms at the 4850, 6800, 7400, and 8000 Levels in a variety of rock types. In addition, recent geotechnical analyses and feasibility studies have been done to evaluate potential sites and prepare preliminary plans for large excavations for installation of experiments. Modeling behavior of the host rock for laboratories has shown that large rooms can be constructed and remain stable at 4850 Level, 7400 Level, and 8000 Level when proper detectors in various ground support is installed.

Tesarik *et al.* (2002) [42] modeled a cylindrical room. Their calculations showed that room shape can be adjusted to improve room stability. Rooms with an arched crown and height to width ratio of 1.5:1 will be stable at 4850 Level with cross sections of 50m x 50m, and at 8000 Level with cross sections of 18m x 18m. Golder Associates (2004) [45] showed that a 50 m domed cavern with height to width ratio of 2:1 is controllable at 7400 Level using currently available ground support technology.

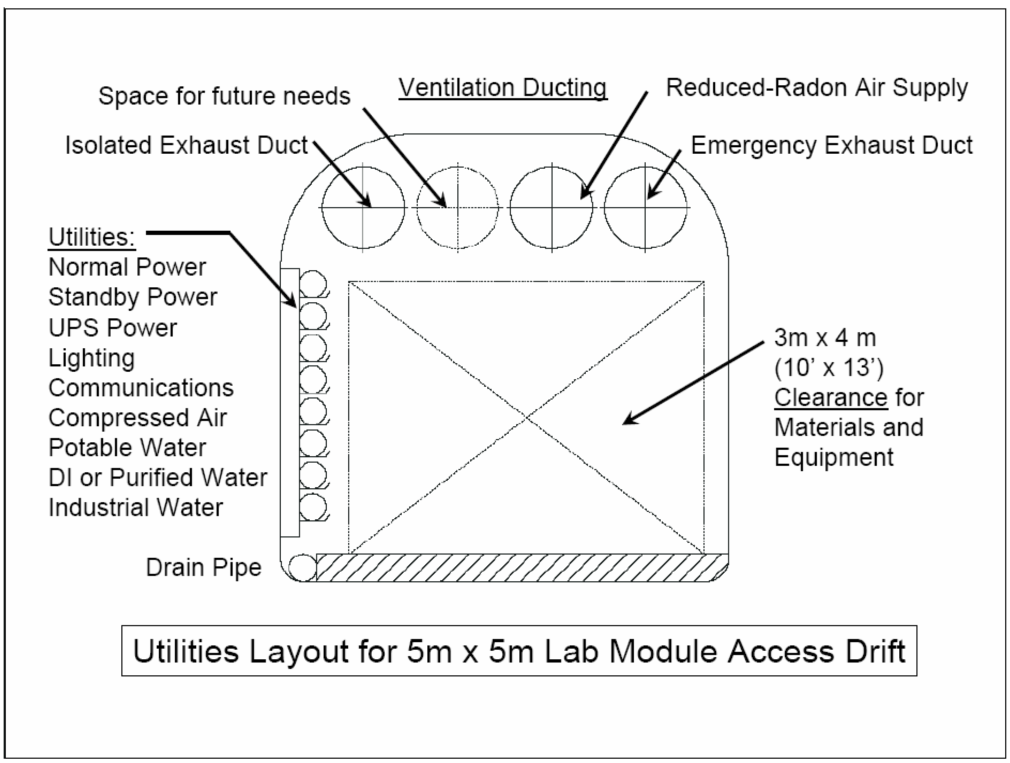

Figure 6.16 Nominal Lab Module access drift layout, with defined clearance for materials and equipment and reserved space for utilities and ventilation ducting.

Table 6.2 Preliminary recommendations for rock support for lab module excavations (~50 x 20 x 15m high) at mid-level and deep-level campuses. (Golder, 2006) [44]

FORMATION	LEVEL	LOCATION	BOLTING	SHOTCRETE
Poorman Formation	4850L	Roof	5 m long bolts @ 2 m c/c	90 mm fibre reinforced shotcrete
		Side Walls	8 m long bolts @ 1.75 m c/c	100 mm unreinforced shotcrete
	7400L/8000L	Roof	5 m long bolts @ 1.75 m c/c	100 mm fibre reinforced shotcrete
		Side Walls	8 m long bolts @ 1.5 m c/c	90 mm fibre reinforced shotcrete
Yates Unit	4850L	Roof	5 m long spot bolts	none
		Side Walls	4 m long bolts @ 2.5 m c/c	none
	7400L/8000L	Roof	5 m long bolts @ 2.5 m c/c	none
		Side Walls	4 m long bolts @ 2.25 m c/c	50 mm unreinforced shotcrete

Based upon rock mass conditions reported by Tesarik *et al.* (2002) [42], Golder Associates (2006) [44 and Appendix A12] performed the most comprehensive study to date. They examined stability of the proposed Lab Module layout geometries for Homestake DUSEL, which consist of (1) a parallel pattern for the rooms with 60 m center to center spacing, and (2) rooms of similar size and spacing but arranged in echelon. They considered depths at 4850 Level, 7400 Level, and 8000 Level as well as varying orientation of the rooms with respect to the major horizontal stress. A realistic sequence for room construction was considered wherein a 5 x 5m top heading is excavated followed by side slashing, excavation of a middle bench, and finally excavation of the bottom bench.

Subject to further confirmation of site-specific rock properties, this model demonstrates viability for rooms with 20 m span and 15 m height. Due to assumptions made in the failure criteria, relative paucity of data on the rock mechanics, and relatively small difference in compressive stress between values perpendicular and parallel to the schistosity, isotropic behavior was assumed for the purposes of the model. They conclude that Lab Module construction in the Yates Member will not have problems at 4850 Level with plasticity or micro-cracking, and have only limited, manageable zones at 7400 Level and 8000 Level on sidewalls, with these types of disturbances being limited to 2.5m or less. Excavation in the less competent rock in the Poorman Formation is expected to experience a plastic zone considerably larger at 7400 and 8000 Levels with the sidewall plastic zone extending up to 6 or 7 m into the rock. They determined that the 60 m center to center spacing for the lab modules is acceptable and is independent of layout pattern. Table 6.2 shows their preliminary recommendations for rock support systems for the nominal lab module configuration planned for the mid-level and deep level campuses.

6.8 DUSEL Excavation and Ground Control Guidelines and Standards

For production mining at Homestake, a mature set of guidelines was established for drilling and blasting operations and for ground control in new excavations and reconditioning with considerations for various rock conditions including stress conditions and geometry of openings, duration of required accessibility, proximity of other openings, personnel exposure, and potential for violent ground failure. These guidelines and associated mining technologies which were derived from analytic studies and also confirmed by many decades of experience will provide an excellent basis to develop requirements and standards for excavation and ground control of new openings for DUSEL underground laboratories.

However, we recognize that excavation and underground construction standards for laboratory applications will be significantly more stringent than those that may be acceptable for mining operations. Site investigation and geotechnical analyses prior to detailed design and excavation are critical to insure that both personnel safety and equipment protection is maintained with long term stability of all underground facilities. Traditional excavation and ground control methods for production mining operations will require greater care and coordination for quality assurance and construction management. Detailed engineering, excavation process specifications and controls will address issues and concerns that are not typically present for production mining. For example, in addition to standard rock support, long-term stability of large openings may require specific rockburst control measures such as ground preconditioning using destress blasting. The Golder report includes a program for site investigation and geotechnical analyses to determine specific rock properties and site conditions to be used for detailed design and engineering for excavation of the lab modules, with the following recommended tasks:

1. Conduct an underground face/mapping program at proposed locations of large excavations to measure all parameters required for Bieniawski's Rock Mass Rating, NGI Tunneling Quality Index, definition of joint fabric and joint orientations.
2. Establish a drilling program for rock mass characterization, hydrogeological characterization, selection of samples for a laboratory testing program, and in-situ stress measurements.

Proximity of new excavations to concurrent lab operations will generate additional requirements and controls to prevent damage to research instrumentation and loss of research data quality. Recent experience at SNOLAB with new excavation being done close to the on-going SNO experiment confirm that monitoring and control techniques can be effective to minimize detrimental effects. SNOLAB excavated drifts as close as 110m from the center of the SNO experiment and major cavity excavations as close as 155m. During this excavation the SNO experiment continued operation and data collection. The experiment consists of evacuated glass PMTs (9438 PMTs) and high pressure, helium-filled proportional tubes suspended in water. Data collection and operation of SNO continued throughout the entire excavation of the SNOLAB extension. During major blast operations, the detector recorded momentary increase in noise and electrical pickup, but no loss of detectors was observed. The SNO experiment monitors the surround water volume with a hydrophone sensor. This sensor recorded the coincidence of the increase of PMT and electronics noise signals and NCD signals (resistive coupling dropout and MUX noise) with the blasts. The duration of the increase of signals was a few seconds. In the case of the "break out" blast where the new SNOLAB drift connected to the existing SNO access drift, operators were on-hand to power-down the detector if necessary, but even this blast at ~ 110m from the center of the SNO experiment did not warrant such protective actions.

During the next project phase, DUSEL design standards for excavation and ground control will be prepared for the Preliminary Design, to be incorporated with construction subcontracts, construction management and oversight to insure compliance. Site investigations to further evaluate proposed locations for lab modules and other large openings will be initiated immediately after direct access to the potential sites becomes possible during the re-entry. A preliminary analysis of fall of ground during Homestake operations is included in Appendix A13.

6.9 Facility Electrical Systems: Power, Controls, and Communications

Primary power distribution on site is fed at 69 kV from the Kirk Switch Station. This station is supplied from the general power grid owned by Black Hills Power and Light. The Kirk Station feeds power through two independent 69 kV overhead lines to the East Substation and Ross Substation, shown schematically in Figure 6.17. The Ross substation provides underground power via the Ross Shaft, and the East Substation supplies power via the Yates Shaft, both tied to a substation at the #6 Winze on the 7700 Level. One of the first tasks for the mining-to-labs conversion will be to re-establish power for the surface site and underground services, which were shut off at mine closure. The existing surface electrical substations and distribution network have been maintained and are fully operable, and portions of the surface distribution system have stayed in service for the ongoing Homestake Mining Company work for environmental remediation. We expect that full power can be restored to the site within a few days.

The power capacity requirements of the converted facility will be significantly less than what was used for previous mining operations. The existing infrastructure provides an excellent base and equipment inventory with multiple options for implementation with future laboratory facilities, including power lines, transformers and switchgear. Existing emergency generator sets are also available to provide backup power for both life-safety and support systems in the event of a grid power failure. Capacity of the distribution system is more than sufficient for future operation of the fully developed facility and all anticipated loads during construction.

6.9.1 Utilization of Existing Mine Power Distribution

For initial re-entry, dewatering and later construction, the required electrical power will be drawn from the existing power distribution at the two main substations (East and Ross substations) and distributed to various level substations located underground. The underground electrical equipment removed prior to mine closure will need to be re-installed and the distribution systems reconditioned or replaced to be operational. All of the cable and electrical equipment at deeper levels that has been submerged will need to be replaced. Whenever possible, equipment may be reconditioned for temporary use, then kept in service until the permanent system is completed. On the surface, the Yates hoists, Ross hoists, ventilation fans, and selected air compressors will be reconnected and operate as previously. The #6 Winze Hoists will operate off the existing power system only until the new power distribution system is completed. The new, primary underground power supply system will be taken off the 12.4 kV bus at the East Substation.

The facility has a large inventory of miscellaneous electrical cables, switchgear and other electrical equipment that will be assessed and used wherever possible.

6.9.2 Redundant Power Supply Systems and Underground Distribution

New power to underground laboratory facilities will be supplied via two fully redundant distribution systems. Two 3c# 500 MCM cables will provide power to 4850 Level through the Yates Shaft from existing 12kV feeder circuit breakers at the East Substation. Power distribution to deeper levels will connect at 4850 Level to the #6 winze and continue to the 7400 Level and 8000 Level. These power feeders will loop in and out to the level substations at 2600 Level, 4850 Level, 6800 Level, 7400 Level and will loop in only and terminate at the substation on 8000 Level. The primary voltage of 12.4 kV will be stepped down to 4.16/2, 4 kV, 480/277 V and 120V levels to satisfy all requirements for pumps, fans, and other equipment at various voltage levels. Also, a redundant 12 kV overhead line, which is under-slung via the East Substation overhead line, will be installed for backup power to either substation.

As a redundant supply and backup to the main feeders at the Yates Shaft, two cables of equal size and capacity will also be installed through the Ross Shaft and to the #6 Winze, and will connect to all the same level substations as the primary feeder. At either shaft, the power feeder cables will have sufficient capacity to supply the entire underground facility power demand. For normal operation and construction activities, we expect that the underground loads will not exceed the allowable capacity of one shaft feeder system, which provides a redundant supply to accommodate maintenance activities or temporary outages at either location.

Existing substations will be configured as follows in order to utilize existing equipment and maximize efficiency, with full redundancy as needed:

- A 20 MVA transformer, existing in the East Substation will be installed into the Ross 69kV Substation to provide redundancy of the underground 12kV distribution system, and feed the underground dewatering pumps main transformer.
- A 5 MVA 12/4.16kV transformer existing in the Yates Compressor Substation will be installed in the existing Ross 69 kV Substation, to feed the Upper Ross Underground Pumps at 4160 volts.
- A redundant overhead 12kV line will be installed under slung the existing East Substation Overhead 69kV line, providing redundancy of primary power and providing means to supply power in times of maintenance of equipment, and/or events.

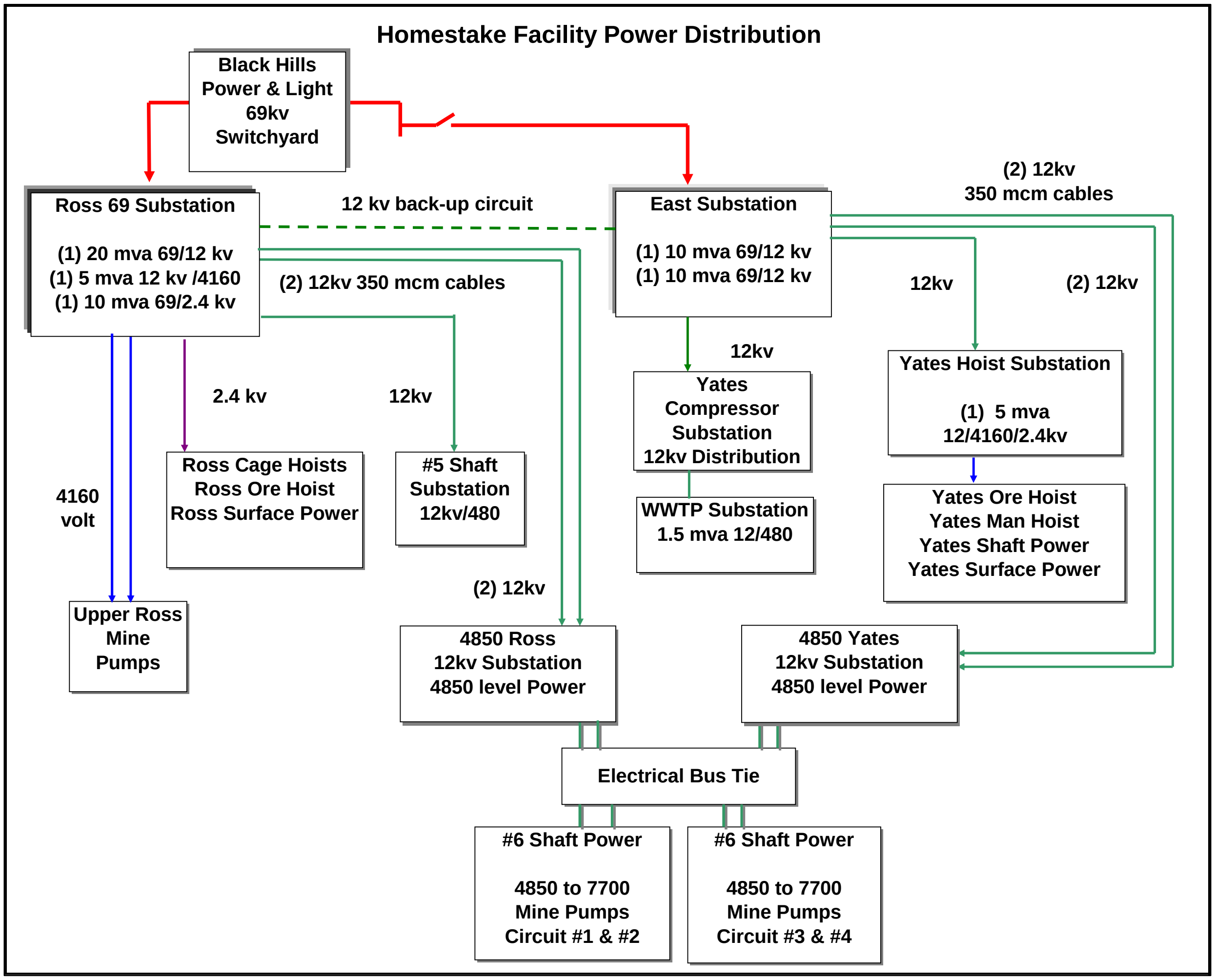

Figure 6.17 Schematic of the two facility substations and primary electrical power distribution network for Homestake DUSEL.

The East Substation status will be reconfigured as follows:

- Two Existing 69/12.4kV 10MVA transformer will remain and feed 12kV power to Yates Hoists, Surface areas, and two underground feeder 12 kV cables.

The Ross Substation status after changes:

- One 20 MVA 69/12kV transformer feeding power to Underground 12kV feeders.
- One 10 MVA 69/2.4kV transformer feeding power to Ross Hoists.
- One 5 MVA 12/4.16kV transformer feeding power to Upper Ross Underground pumps.

6.9.3 Typical Standards for Electrical Installation

- Power cable used at all voltage levels will be armored type MC. In underground shafts, special shaft cable type SWA or Vertiteck and Verlock will be installed.
- All permanent substations will be enclosed, ventilated and pressurized with filtered air.

- Cabling will be installed in cable trays and wiring and protection will be in accordance with NEC to meet the requirements of authorities having jurisdiction over electrical installations in underground facilities.
- All electrical switchgear will meet ANSI standards and be installed on a concrete pad. Transformers used will be of a dry type, 80C degrees rise, insulation class H and be of completely enclosed and ventilated construction.
- Substation floors will be sloped for drainage.
- The new distribution system will be installed with ground fault monitoring and ground fault trip where required. The existing system will be inspected and upgraded where required.
- The system power factor will be maintained at a value above 0.9 at all times with use of capacitor banks.

6.9.4 Power Allowances for Major Loads

Existing infrastructure will support a total connected load, not including the stand-by units, of more than 20,000 kW, of which up to 10,000 kW is the nominal allowance for the load connected underground. A rough estimate of the distribution and maximum allowance for major loads is shown in Table 6.3. The allowance should significantly exceed the actual loads (to be determined as requirements and designs mature for the facility and experimental systems).

Table 6.3. Allowed and expected nominal values of major loads.

Item	**Allowance kW**	**Nominal Load kW**
Ventilation and Chiller systems	7,000	3,500
Pumping and Water Management systems	3,000	1,500
Hoists	3,000	1,500
Lighting and misc. underground utility power	1,000	500
Surface Buildings	1,000	500
Underground laboratories and experimental systems	1,000	500
Auxiliary power during new construction and excavation	4,000	2,000

In a total loss of normal and redundant power supplies, all loads considered vital for life safety and emergency systems would be supplied from diesel generator sets. Two existing generators will be used: a 500kW generator will supply the # 5 shaft ventilation fan on the surface, and a 1500kW generator will feed the Yates Auxiliary Cage Hoist and underground loads such as the Auxiliary Cage Hoist at the #6 Winze and selected essential loads at the 4850 and 7400 Levels. Emergency power underground will be supplied at 12.4 kV with a 3c# 2AWG cable installed in the Yates shaft to the 4850 Level, continuing via the #6 Winze to the 7400 Level.

Automatic transfer switches (ATS) will be installed at each location with essential loads. Each ATS will be connected to the extended central control system (Intellulation IFIX) for automatic start-stop of the diesel generators and for control of automatic power switching between normal and stand-by power supply configurations. Uninterruptible back-up power may be installed by users for specific experimental requirements.

6.9.5 Communications and Controls

All the existing systems including Intellulation IFIX, leaky feeder radio, hardwired PA, telephones, and fiber optics cabling will be extended to the project areas and laboratories to enable safe automatic/remote controls, communication, monitoring and safe manual overrides. One element of the proposed R&D Plan is to evaluate existing technologies and commercially available systems, and to develop criteria and specifications for installation and potential integration or commonality of new equipment for underground communications, health and safety monitoring, control systems for experiments and remote operations, and data acquisition. We expect that facility management systems for monitoring and controls will be maintained separate and distinct from both health and safety and other experiment control systems.

6.9.6 Lighting

The lighting system will utilize fluorescent fixtures, high or low bay high-intensity discharge lighting, and also battery-powered fixtures. The lighting fixtures will be enclosed to match the area classification and all will be powered from normal power distribution. In the event of normal power interruptions, the battery-powered units at area exits and other key locations will engage and only a selection of the remaining area lighting fixtures will transfer to the stand-by diesel power and be thus turned on with a short time delay of approximately 15 seconds. During emergencies, the normal standard area lighting illumination will be somewhat evenly reduced to a level for people to either safely move through the area or just move out of the affected area.

6.10 Pumping Systems and DUSEL Water Management Plan

The DUSEL water management plan includes rehabilitating and re-commissioning the pumping systems used for mining operations prior to closure, as shown schematically in Figure 6.18. A sequence of settling sumps and pumping stations along the Ross Shaft will be put back into service following re-entry to 4850 Level, to capture the inflow, holding the accumulated water level below 5300 Level until funding and authorization is available to proceed with dewatering.

Other water management plans to reduce surface water inflow into the mine include potential opportunities to divert surface water and storm runoff away from the Open Cut. Currently, water collected in the Open Cut reports to the 1100 Level within the mine, and drains toward the Ross Shaft for pumping. Similarly, it may be feasible to reduce surface inflow at the #5 Shaft to reduce pumping requirements within the facility. During the next project phase for preparation of a Preliminary Design, a comprehensive DUSEL Water Management Plan will be developed. The initial effort for the Homestake Interim Laboratory will prepare detailed plans for dewatering and mining-to-labs conversion, to be coordinated with planning for all other DUSEL project activities and facility operation.

6.11 Facility Ventilation System Plans and Air Volume

The mine in its current closed state has had the main entries sealed. In order to re-establish ventilation, the seals on the Yates, Ross, Oro Hondo, and #5 Shafts will be removed to allow the ventilation system to be re-activated. Figure 6.19 shows a schematic of the ventilation system and air-flow circuits for mining operations prior to closure. Initially, one of the exhaust fans at the Oro Hondo Shaft will be energized to draw fresh intake air through the Yates and Ross shafts and allow personnel to safely re-enter the mine. When safe access to the mine is established, ventilation bulkheads will be installed at selected drift levels along each shaft to isolate unused portions of the existing mine workings from the fresh air circuit. The bulkheads will provide a ventilation barrier, but will include appropriate drainage paths and personnel access doors. We anticipate that up to 50 bulkheads are needed along the Yates Shaft and 40 along the Ross Shaft. Ventilation control for access to deeper levels below 4850 Level will also include installation of bulkheads at selected levels along the #6 Winze and the ramp system to 8000 Level.

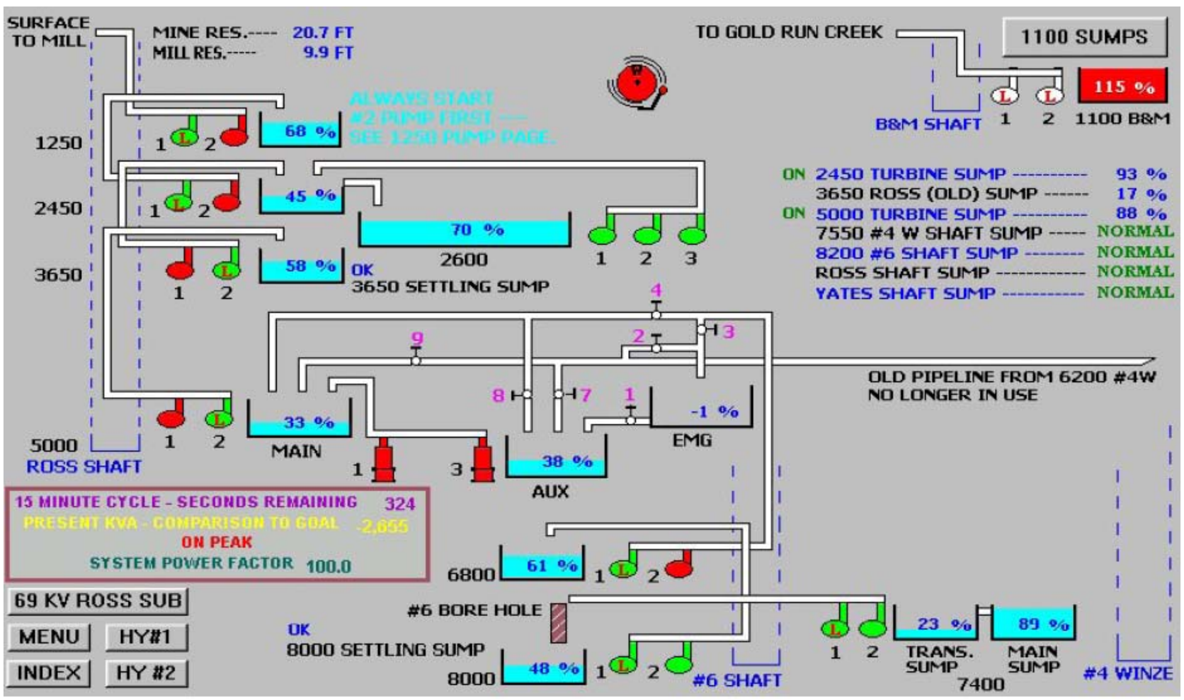

Figure 6.18 Homestake pumping systems schematic for mining operations prior to closure in 2001, showing primary pumping column with sumps along the Ross Shaft and deep level pumping along #6 Winze.

Several different scenarios for alterations and upgrades have been considered to determine appropriate, cost-effective ventilation in a variety of operating conditions. A final configuration will be developed during the next project phase as experiment and laboratory requirements become well-defined, and phased development of underground space and infrastructure is established. Currently, the design basis for our preliminary project planning is to maintain the Yates and Ross shafts for intake air during all phases of development. The path for exhaust air will be shifted from the Oro Hondo shaft to the #5 Shaft during the course of infrastructure development at 4850 Level, dewatering, and development at 7400 Level and deeper. We anticipate that the existing variable-speed exhaust fan currently located at the Oro Hondo Shaft will be moved to the #5 Shaft to be used for primary ventilation of both mid-levels and deep-levels. The existing back-up exhaust fan at Oro Hondo may remain in service for intermittent operation as needed during maintenance or other outages of the primary fan. The primary variable-speed fan has a 3,000 HP synchronous motor and approximately 520,000 cfm air volume capacity. It may be operated at reduced speed for energy cost savings to be matched to actual air volume requirements of the facility, which are expected to be less than 2/3 of the fan capacity at final operating conditions of the underground laboratories.

6.11.1 Preliminary Ventilation System Feasibility Study

The Dynatec Feasibility Study for mining-to-labs conversion, see [52] and Appendix A10, includes a preliminary study and analysis of ventilation requirements for one of the initial concepts to support lab development at the 7400 Level. It evaluated three operating scenarios: (1) Initial re-entry, dewatering, and operations to support initial excavation and construction of a laboratory at the 7400 Level, (2) Normal laboratory operations, and (3) Additional excavation and construction activities at 7400 Level concurrent with lab operations.

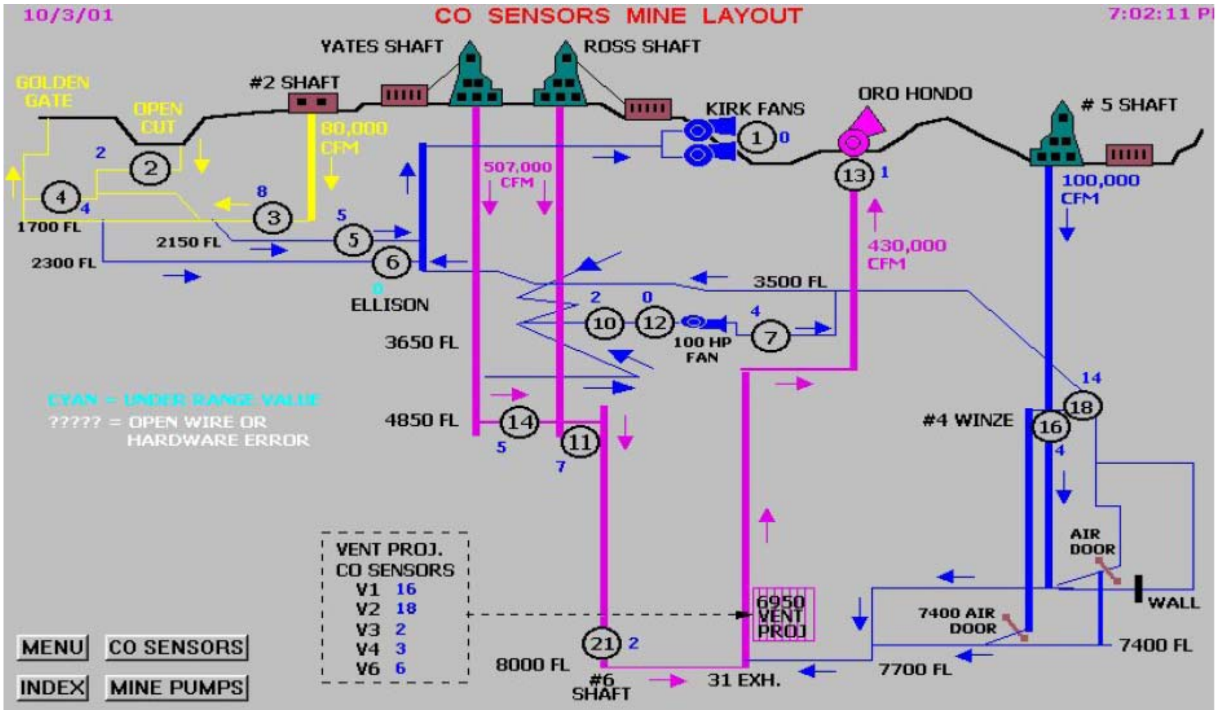

Figure 6.19 Homestake primary ventilation system schematic showing air-flow circuits for mining operations prior to closure in 2001. A proposed configuration for DUSEL will move the primary exhaust fan from Oro Hondo to #5 Shaft and retain the existing back-up fan at Oro Hondo shaft.

Details from the Dynatec ventilation system [56] feasibility study are summarized in Appendix A17, including concepts that address the following primary engineering issues and requirements:

- Avoid cross-contamination by separating the exhaust streams from operational science and engineering laboratories, and from that of any expansion (i.e. rock excavation) for new facilities.

- Limit exposure of laboratory staff to potentially toxic atmospheres resulting from a system failure during DUSEL operations (experimental tank rupture, etc.) by providing defined escape routes to the surface in fresh air.
- Limit DUSEL excavation contractors' exposure to potentially toxic atmospheres resulting from blasting, excavation, and emergency events (e.g., underground fires) by providing defined escape routes to the surface in fresh air.

Although specific air volume requirements are not yet available for each DUSEL experimental system and other construction and operational activities, the study describes nominal ventilation system configurations derived from established mining engineering knowledge and experience. We recognize that further analysis is required as design requirements mature and the sequence is defined for development of underground space at the 4850 and 7400 Levels, and potentially other levels. The analyses presented in Appendix A14 confirm that sufficient ventilation capacity is feasible using existing mine infrastructure, and some additional new equipment may be installed for cost-effective operation of underground research facilities.

6.11.2 DUSEL Air Management Plan

In the next project phase, follow-on studies will evaluate specific issues associated with underground laboratories and experiments to prepare a comprehensive DUSEL Air Management Plan. Further analyses must establish the volume and purity of air for the proposed Initial Suite of Experiments and cleanroom environments, and will be integrated with requirements for concurrent excavation in other parts of the facility. Planning will consider removal of heat from all sources for air temperature control, control of particulates and humidity, and delivery of radon-reduced air to radiation-sensitive experiments and labs. Exhaust air control will incorporate options to split and isolate flow paths for potential discharges of hazardous or toxic gases, cryogen boil-off gases, fumes and smoke, and other contaminants. Intake and exhaust systems will include air control for both normal operations and credible accident conditions for spills, fire, or other scenarios, and will define personnel evacuation paths with sufficient air quality for health and safety. Early definition of the DUSEL Air Management Plan will provide a basis for development and selection of both experimental systems and facility infrastructure.

An initial ventilation plan is being prepared for the re-entry program described in Section 6.2, which specifies initial installation of two exhaust fans at the #5 shaft. This will provide approximately 120,000 cfm air flow capacity not only for the initial re-entry and pumping installation, but also for excavation, construction, and operation of initial laboratory modules at the 4850 level for the Early Implementation Program. This configuration will provide for fresh air through both the Ross and Yates Shafts, with up to 80% of the air directed through the Yates Shaft to support various scenarios for concurrent excavation and laboratory operations. The ventilation plan includes discussion of controls which will minimize the risk of fire due to spontaneous combustion at levels where fire risks have been identified, and also to control the air flow of fire by-products for safe egress if a fire does occur. The initial ventilation plan is also consistent with current concepts for continued development at 4850 level for DUSEL, re-entry to deep levels, dewatering, development and operation of laboratory modules at the 7400 level. A draft-version of the ventilation plan is included in Appendix A15.