DOE/MC/29109-3634
(DE94004053)

Road Transportable Analytical Laboratory System
Phase I

Topical Report

S. M. Finger
V. F. Keith
R. O. Spertzel
J. C. De Avila
M. O'Donnell
R. L. Vann

September 1993

Work Performed Under Contract No.: DE-AC21-92MC29109

For

U.S. Department of Energy
Office of Environmental Management
Office of Technology Development
Washington, DC

U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Engineering Computer Optecnomics, Inc. (ECO)
Annapolis, Maryland

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September 1993

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ABSTRACT

The U.S. Department of Energy (DOE) facilities around the country have, over the years, become contaminated with radionuclides and a range of organic and inorganic wastes. Many of the DOE sites encompass large land areas and were originally sited in relatively unpopulated regions of the country to minimize risk to surrounding populations. In addition, many times wastes were stored underground at the sites in 55-gallon drums, wood boxes or other containers until final disposal methods could be determined. Over the years, these containers have deteriorated, releasing contaminants into the surrounding environment. This contamination has spread, in some cases polluting extensive areas.

Remediation of these sites requires extensive sampling to determine the extent of the contamination, to monitor clean-up and remediation progress, and for post-closure monitoring of facilities. The DOE would benefit greatly if it had reliable, road transportable, fully independent laboratory systems that could perform on-site the full range of analyses required. Such systems would accelerate clean-up and remediation efforts by providing critical analytical data more rapidly, and save money by eliminating handling, shipping and manpower costs associated with sample shipments.

The goal of the Road Transportable Analytical Laboratory (RTAL) Project is the development and demonstration of a system to meet the unique needs of the DOE for rapid, accurate analysis of a wide variety of hazardous and radioactive contaminants in soil, groundwater, and surface waters. This laboratory system has been designed to provide the field and laboratory analytical equipment necessary to detect and quantify radionuclides, organics, heavy metals and other inorganics, and explosive materials. The laboratory system consists of a set of individual laboratory modules deployable independently or as an interconnected group to meet each DOE site's specific needs.

After evaluating the needs of the DOE field activities and investigating alternative system designs, the modules to be included as part of the RTAL are:

- Radioanalytical Laboratory
- Organic Chemical Analysis Laboratory
- Inorganic Chemical Analysis Laboratory
- Aquatic Biomonitoring Laboratory
- Field Analytical Laboratory
- Robotics Base Station
- Decontamination/Sample Screening Module
- Operations Control Center
- Protected Living Quarters

Each module provides full protection for operators and equipment against radioactive particulates and conventional environmental contaminants. This is especially important in

areas where radioactive particulates from environmental matrices, e.g. soils, are aerosolized by wind or volatile chemicals are present. These contaminants can adversely affect sensitive chemical and radiochemical analyses as well as potentially being harmful to personnel.

The goal of the integrated laboratory system is a sample throughput of 20 samples per day, providing a full range of analyses on each sample within 16 hours (after sample preparation) with high accuracy and high quality assurance. Projected annual operating costs for the sample analysis laboratories (Radioanalytical, Organic Analysis and Inorganic Analysis Labs, and Sample Screening Module) providing this sample analysis throughput are $3,344K. This includes operating personnel, depreciation, consumables, and a 30% contingency factor. Based on a total of 4,800 samples per year (20 samples per day for 240 operating days per year), the cost per sample for a full set of radioactive, and organic and inorganic chemical analytes is projected to be $697. A full set of analyses (except for anion analysis) performed at a commercial laboratory was priced at $4,015. Assuming a 20% volume discount, the annual cost for analyzing 4,800 samples would be $15,418K. Thus, each RTAL system will save the DOE $12,074K per year. If RTAL systems were used at the eight largest DOE facilities (at Hanford, Savannah River, Fernald, Oak Ridge, Idaho, Rocky Flats, Los Alamos, and the Nevada Test Site), the annual savings would be $96,589,000. The DOE's internal study of sample analysis needs projects 130,000 environmental samples requiring analysis in FY 1994, clearly supporting the need for the RTAL system.

The time savings provided by the RTAL are equally impressive. The RTAL will provide a 1 day sample turnaround time. The central commercial laboratory discussed above has a standard 45 day turnaround time. This can be reduced to 14 days, but for a 100% premium.

Thus, the RTAL will provide the DOE with very significant savings in terms of both cost and time. This will accelerate and improve the efficiency of clean-up and remediation operations throughout the DOE complex. At the same time, the system will provide full protection for operating personnel and sensitive analytical equipment against the environmental extremes and hazards encountered at DOE sites.

ADMINISTRATIVE INFORMATION

The Road Transportable Analytical Laboratory (RTAL) System Project was conducted by Engineering Computer Optecnomics (ECO), Inc. for the Morgantown Energy Technology Center (METC) of the U.S. Department of Energy under Contract No. DE-AC21-92MC29109. The METC Contracting Officer's Representative (COR) is Mr. Jagdish L. Malhotra. The METC Contracting Specialist is Mr. Ronald Roth. The ECO Principal Investigator is Dr. Stanley M.

Finger, Director of Environmental Programs. The ECO Project Director is Mr. Virgil F. Keith, President.

OBJECTIVE

The goal of this effort is the development and demonstration of a Road Transportable Analytical Laboratory (RTAL) system to meet the unique needs of the Department of Energy (DOE) for rapid, accurate analysis of a wide variety of hazardous and radioactive contaminants in soil, groundwater, and surface waters. This laboratory system has been designed to provide the field and laboratory analytical equipment necessary to detect and quantify radionuclides, organics, heavy metals and other inorganics, and explosive materials. The laboratory system will consist of a set of individual laboratory modules deployable independently or as an interconnected group to meet each DOE site's specific needs. Modules originally considered for inclusion in the system were:

- Radiochemistry Laboratory
- Chemical Analysis Laboratory
- Biomonitoring Laboratory
- Field Analytical Instrument Laboratory
- Robotic Sampler/Monitor Base Station
- Decontamination Trailer
- Operations Control Center
- Protected Living Quarters

However, after evaluating the needs of the DOE field activities and investigating alternative system designs (topics covered in this report), the modules to be included as part of the RTAL are as follows:

- Radioanalytical Laboratory
- Organic Chemical Analysis Laboratory
- Inorganic Chemical Analysis Laboratory
- Aquatic Biomonitoring Laboratory
- Field Analytical Laboratory
- Robotics Base Station
- Decontamination/Sample Screening Module
- Operations Control Center
- Protected Living Quarters

The current arrangement provides for 9 modules (compared to the original 8 module system originally conceived) primarily because all the sample preparation and analytical equipment required for both the organic and inorganic chemical analyses could not be contained in one module without significantly impacting operational efficiency. It would have been too crowded for analytical personnel to perform their functions without interfering with each other. In addition, several of the modules have been reorganized to better accomplish their missions. The rationale for the recommended system arrangement will be fully discussed in this report.

Each module provides full protection for operators and equipment against radioactive particulates and conventional environmental contaminants. This is especially important in areas where radioactive particulates from environmental matrices, e.g. soils, are aerosolized by wind or volatile chemicals are present. These contaminants can adversely affect sensitive chemical and radiochemical analyses as well as potentially being harmful to personnel.

The use of a road transportable, fully independent, highly reliable laboratory system will save the DOE significant time and money (documented in this report) by eliminating costly, paper-intensive, and time-consuming shipment of samples to central laboratories. The goal of the integrated laboratory system is to provide a full range of analyses within 16 hours (after sample preparation) with high accuracy and high quality assurance. At the same time, the system will provide full protection for operating personnel and sensitive analytical equipment against the environmental extremes and hazards encountered at DOE sites.

BACKGROUND

The DOE facilities around the country have, over the years, become contaminated with radionuclides and a range of organic and inorganic wastes. The major types of contamination found at the various sites have been summarized in the "Environmental Restoration and Management Five Year Plan" and, except for radionuclides (at most locations) and high explosives (at a few locations), are representative of the types of wastes found at many industrial facilities.

The DOE faces additional unique challenges in cleaning up this contamination. Many of the DOE sites encompass large land areas and were originally sited in relatively unpopulated regions of the country to minimize risk to surrounding populations. In addition, many times wastes were stored underground at the sites in 55-gallon drums, wood boxes or other containers until final disposal methods could be determined. Over the years, these containers have deteriorated, releasing contaminants into the surrounding environment. This contamination has spread, in some cases polluting extensive areas.

Remediation of these sites requires extensive sampling to determine the extent of the contamination, to monitor cleanup and remediation progress, and for post-closure monitoring of facilities. The U.S. Environmental Protection Agency (EPA) has found that shipping samples to a central laboratory for analysis is a slow and expensive process. The EPA is emphasizing the use of field instrumentation and transportable laboratories to provide critical analytical data (which form the basis for remediation decisions) faster and at lower cost. The use of field systems can cut several weeks to months off the turnaround time for analytical information.

The DOE's problems in getting samples analyzed is further compounded by the almost universal presence of radionuclides in the samples. The DOE's samples require wipe tests for surface contamination before shipment and after receipt, specialized transportation containers and procedures (depending on the level of radioactivity present in the sample), and a substantial amount of additional paperwork. It can be very difficult and time-consuming to ship samples off-site from DOE facilities because of requirements established to ensure against inadvertent release of radioactive materials. The occasional improper shipment of radioactive materials from DOE facilities has also led to periodic curtailment of all shipments to ensure that proper shipping procedures are followed. Such curtailments can cause havoc to projects where accurate sample analytical data is critical to decision-making and also because environmental samples degrade over time.

Thus, the DOE would benefit greatly if it had reliable road transportable, fully independent laboratory systems that could perform on-site the full range of analyses required. Such systems could accelerate clean-up and remediation efforts by providing critical analytical data more rapidly, and save money by eliminating handling, transportation and manpower costs associated with sample shipments.

The current effort addresses the unique requirements of the DOE for a Road Transportable Analytical Laboratory system capable of analyzing for a wide variety of hazardous and radioactive contaminants in soil, groundwater, and surface waters. This effort is based on the earlier laboratories and operations control centers developed by Engineering Computer Optecnomics (ECO), Inc. for the U.S. Environmental Protection Agency, and the U.S. Departments of Defense and State. These include counter-terrorist systems for use in areas contaminated with chemical or biological warfare agents. The advances achieved in the development of these earlier systems have been incorporated into the development of the RTAL.

The RTAL has been designed to provide for the efficient and effective operation of the field and laboratory analytical equipment necessary to detect and quantify radionuclides, organics, heavy metals and other inorganics, and explosive materials. The integrated RTAL system will be able to provide a full range of accurate analyses on-site. At the same time, the RTAL system will provide full protection for the operating personnel and the sensitive analytical equipment against the environmental extremes and the hazards encountered at DOE sites.

APPROACH

The development of the Road Transportable Analytical Laboratory system is being conducted in two phases. Phase I, encompassing work at Maturity Level 4, Major Sub-systems, is for the development and optimization of the RTAL system design to most effectively meet the needs of the DOE. This phase incorporates development of detailed performance requirements (based on documented data and meetings with potential DOE users of the RTAL system), development and evaluation of alternative system configurations, and optimization of the final design.

Phase II of this project represents a transition to Maturity Level 5, Full-Scale Demonstration. A full-scale, fully operational prototype RTAL system will be constructed. This system will be tested at an appropriate DOE site or sites to demonstrate the performance of the system and to quantify the cost and time savings it provides.

Upon completion of Phase II, ECO, Inc. will enter into commercial production of the Road Transportable Analytical Laboratory system, providing full warranties and guarantees for the product. The RTAL system will be integrated into ECO's existing line of TERMM™ and Superfund TERMM™ modular transportable analytical laboratory and operational control systems.

RTAL PERFORMANCE REQUIREMENTS

The DOE's Office of Environmental Restoration and Waste Management is conducting a study of projected analytical needs across the DOE Complex. The study concentrates on the DOE's nine largest facilities in terms of analytical requirements and extrapolates these data to the entire Complex The preliminary results of this study (as of September 1992) were obtained and reviewed. The final version of the study is expected to be published later during FY 1993 but was not available for this report.

The study projects that, across the DOE Complex, some 1.2 million sample analyses were performed on 60,000 samples during FY 1991. This demand is projected to grow to 3.3 million analyses on 130,000 samples in FY 1994. The study indicates a slow drop in demand after FY 1994, but this may be an artifact due to the relative scarcity of remediation project definition in the out-years.

Most of the samples that will be taken and analyzed are for operable unit characterization and for low level/mixed waste disposal. The types of analyses that will have to be performed are:

- Volatile Organics by GC/MS
- Semi-Volatile Organics by GC/MS
- Pesticides/PCB's by GC
- Toxicity Characteristic Leach Procedure (TCLP)
- Metals by ICP-AES
- Metals by AA

- Anions
- Gross Alpha or Beta
- Gamma Spectroscopy
- Nuclide-Specific Analysis

The DOE study also investigated the radioactivity of the samples to be collected. The study defines four levels of sample radioactivity:

R1 -	radiation low enough for bench-top analysis	<10 mR/h, <10 nCi/g alpha
R2 -	sample handling must be performed in a hood	10-200 mR/h, <10 nCi/g alpha
R3 -	sample handling must be performed in a hot cell	>200 mR/h
R4 -	sample handling must be performed in a glove box	<200 mR/h, >10 nCi/g alpha

The vast majority (84%) of the samples projected to be collected are expected to fall into the R1 category, suitable for bench-top handling. Samples falling into the R2 category (handling in a hood) represent 14% of the total. Samples in the R3 an R4 categories (handling in a glove box or hot cell) represent a combined total of only 2% of the samples to be collected. These results clearly indicate that the RTAL system design should emphasize handling of samples on benches and in hoods. Providing the hot cells, glove boxes, and associated handling equipment necessary to perform the complete range of analyses on the 2% of the samples in the R3 and R4 categories greatly increase the cost of the RTAL modules. The RTAL's mission is to provide rapid response with high quality assurance and control for a limited number of samples. The remaining samples, not requiring rapid analysis, would be processed through central laboratories. For this reason, it was determined that the sample screening area of the Decontamination/Sample Screening Module would be designed to safely screen for all sample categories, R1 through R4, but that the other laboratory modules would be designed for R1 and R2 samples only.

The report, "Analytical Laboratory Study Report for Pit 9 Remediation Activities," prepared for EG&G Idaho by Dames & Moore in July 1992 projects analytical requirements for the remediation of this waste pit at the Idaho National Engineering Laboratory (INEL). Analyses required include:

- Volatile Organics
- Semi-Volatile Organics
- Polychlorinated Biphenyls (PCB's)
- Metals (including mercury)
- TCLP
- Gross Alpha/Beta
- Gross Gamma

- $Pu^{239,240}$
- Am^{241}
- $U^{234,235,238}$
- Th^{234}
- Co^{60}
- Cs^{137}/Ba^{137}
- $Sr^{89,90}/Y^{90}$

The report concludes that a transportable analytical laboratory able to process 20 samples per day would significantly accelerate the Pit 9 remediation. Remediation efforts at Pit 9 are scheduled to last for three years.

In addition to Pit 9, the INEL also has remediation efforts underway or planned for other sites at the facility. For example, the INEL Test Area North (TAN) has groundwater contamination problems that would also benefit from the availability of an RTAL system.

To meet the environmental analytical goals cited above while retaining the flexibility to meet the requirements of the individual DOE sites, the RTAL was conceived as a series of individual modules that could be deployed as an integrated group or individually. Each module has the following features, as required, to ensure the independent operation of the system:

- Shock and vibration protected for road transport
- No Department of Transportation restrictions
- Filtration of incoming and exiting air through HEPA filters
- Integral electrical generation system providing filtered power
- Uninterruptible power supply
- Heating, ventilation and air conditioning (HVAC) system capable of handling wide range of outside temperatures and humidities
- Controlled air flow from "clean" to "dirty" areas
- Insulation in walls, floor and roof
- Integral fuel tanks
- Integral tanks for water and wastewater
- Water Purification Equipment
- Rugged, redundant design for maximum availability
- Hardened equipment for maximum reliability
- Designed for long life
- Designed for minimum acquisition and maintenance costs
- Designed for ease of repair and maintenance
- Designed for ease of exterior decontamination
- Innocuous appearance to minimize public apprehension during transport and deployment

Each module has two large double doors to facilitate movement of equipment into or out of the system. A standard 3 foot wide doorway for personnel entry and exit is incorporated into one of the larger doors.

The continuous supply of electricity is critical to the reliability of the tests being performed. The loss of power would shut down the critical analytical equipment, and support and control systems, critical for maintaining controlled experimental conditions. For this reason, an automatic switching circuit is provided. This circuit is used when operating off an external power source. If the external power source fails, this circuit automatically starts the laboratory's electrical generator and switches all systems to this independent source of power, thus ensuring maintenance of experimental conditions.

Each module is housed in a standard 48 foot long by 8½ foot wide trailer to facilitate transport to the test sites. These units have no Department of Transportation restrictions on road transport. Wider trailers are considered "wide loads" and must have vehicular escorts, can not travel all roads, and most states have fees for wide loads traversing their roads. These restrictions limit the adaptability of extra-wide systems to meet the changing requirements across the DOE complex and adds significantly to their operating costs.

The use of a truck, with a dedicated engine, instead of a trailer for the laboratories was also considered. The use of a separate vehicle to move trailer-mounted modules results in higher system reliability and lower cost compared to the use of truck-mounted laboratories with a dedicated prime mover. Experience has shown that truck engines which are operated sporadically have much higher than normal breakdown frequencies. For example, the state of Maryland's truck-mounted air pollution laboratory underwent three engine overhauls within 8,000 miles of driving due to the fact that it was moved so infrequently. In addition, use of a separate prime mover saves the acquisition cost of the truck. Vehicles to move the trailers can be rented readily anywhere in the country. Thus, since deployed modules will normally be at a single site for several months to several years, the economics strongly favor setting up the modules on separate trailers rather than using a dedicated prime mover.

ALTERNATIVE SYSTEM DESIGNS

A multi-modular system is required to provide the extensive instrumentation and support equipment necessary to accommodate the wide variety of analytes listed above. Accordingly, the Road Transportable Analytical Laboratory will consist of a set of individual laboratory modules, deployable independently or as an interconnected group to meet each DOE site's specific needs. The RTAL's throughput design goal is 20 samples per day for each type of analysis with a sample turnaround time of 16 hours (after sample preparation). The RTAL design developed maximizes flexibility to meet each site's particular needs while being able to accommodate even the most demanding situations.

Alternative designs were developed for the overall system and for each module to optimize the design. The design and layout of the RTAL and each of its modules was based on a top-down approach. These were based on the system performance requirements and goals discussed above. These then became the basis for determining the function required of each module, i.e. each module design was developed to directly support the objectives of the overall system. The interior layout of each module was determined by its function and the equipment it must carry. The alternative system and module designs developed were carefully evaluated to determine the system which most effectively meets the needs of the DOE.

Overall System

The original concept for the RTAL Project was based on arranging the modules in a circle around an interconnecting carousel. Enclosed walkways would emanate from the interconnecting carousel to each module, as shown in Figure 1. This arrangement provides relatively easy access to each module. However alternative arrangements were also evaluated after studying the DOE's needs and visiting DOE sites.

One arrangement, in particular, offers significant advantages over the arrangement originally proposed. This arrangement of the modular laboratories, shown in Figure 2, closely follows the steps the samples and operating personnel will take. The module closest to the contaminated area is the Decontamination/Sample Screening Module. This module is divided into two halves. The decontamination side is used to decontaminate personnel in protective gear who have been collecting samples or performing other duties in contaminated areas. The other side of the module is for screening of collected samples. Personnel, in appropriate protective gear, bring the samples to the sample pass-through (located on the side of the module closest to the contaminated area). The samples are passed directly into the hot cell inside the Sample Screening side of the module. The samples are screened for radiation level to determine handling requirements during subsequent testing. They are also subdivided for the analyses to follow.

The next modules behind the Decontamination/Sample Screening Module are the Robotics Base Station and the Field Analytical Laboratory. These modules provide robotically operated and hand-carryable instrumentation for field determination of radioactive and chemical contamination levels. These modules would be needed for initial mapping of large areas. The robotic systems, in particular, would include automated geographic positioning equipment to fix the location of each measurement. All data is transmitted to the computer in the Robotic Base Station for computerized mapping. The data provided by the robotic and field analytical systems would not meet the same high quality assurance/quality control standards as the samples analyzed in

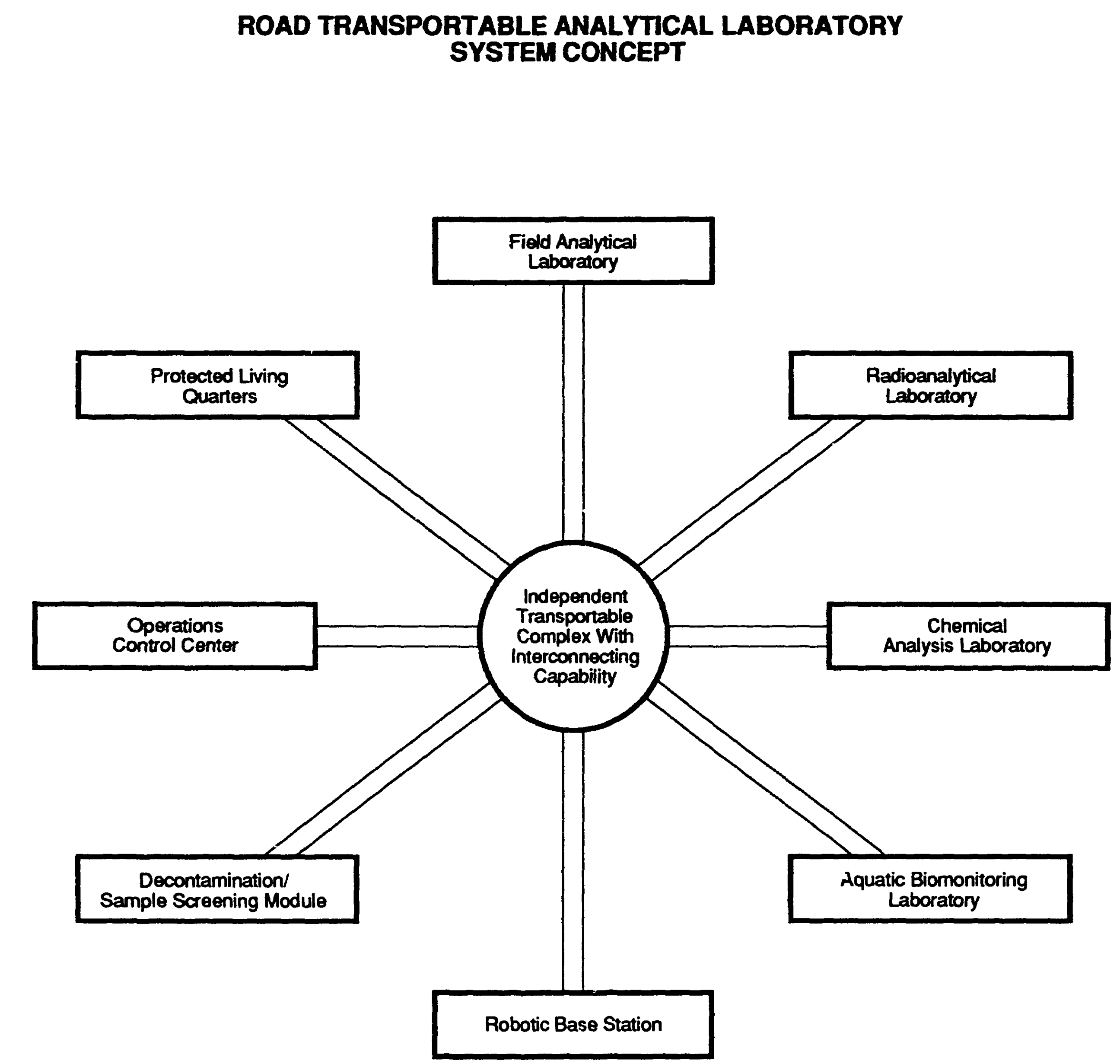

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Figure 1. Road Transportable Analytical Laboratory System Concept

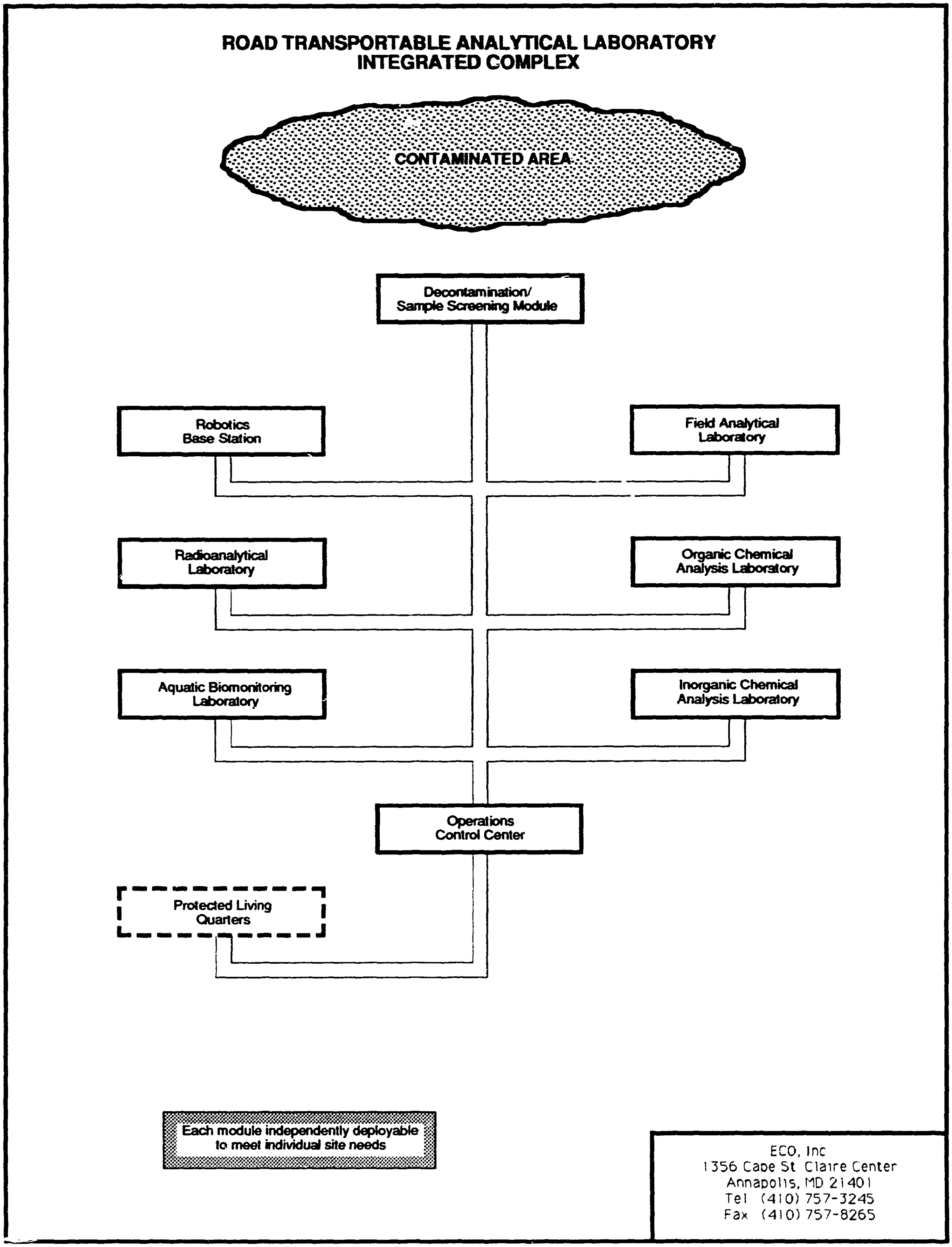


Figure 2. Road Transportable Analytical Laboratory Integrated Complex

the RTAL modules. However, the data are very useful in determining the location of "hot spots," i.e. areas where personnel require protective ensembles.

The next set of modules are the four laboratories which are the heart of the RTAL System. These are the Radioanalytical Laboratory, the Organic Chemical Analysis Laboratory, the Inorganic Chemical Analysis Laboratory, and the Aquatic Biomonitoring Laboratory. The subdivided samples from the Decontamination/Sample Screening Module are analyzed for specific analytes in the first three laboratories. The Aquatic Biomonitoring Laboratory is used for broad screening of hazardous contamination (radiological or chemical) using fish and amphibians as test organisms. Aquatic biomonitoring tests are used to detect the presence of even trace levels of contamination, i.e. below standard detection levels for specific analytes. It is also used to determine the absence of contaminants, providing the only means of determining whether an environmental matrix is "clean."

The next module is the Operations Control Center, which serves as the coordinating "brains" for all RTAL operations. The Operations Control Center also provides a final frisking station for all personnel leaving the laboratory area. Even though great care will be taken to ensure that all personnel handling samples remain uncontaminated, it is felt that a final check is important to ensure that there is no inadvertent contamination as a result of operations conducted within the RTAL area. If contamination is detected, a decontamination shower is located adjacent to the frisking station.

This RTAL System configuration clearly divides the overall area into three contamination zones. The first zone is the contaminated area where radioactive and chemical contaminants are expected. The second zone is the laboratory modules where contaminated samples are handled in hoods, on bench tops, and in the analytical equipment. Although these areas are designed to prevent contaminant release, there is always a small risk of inadvertent release. The third zone is the contaminant-free zone beyond the frisking station in the Operations Control Center. Personnel and samples exiting the contaminated zone must go through the Decontamination/Sample Screening Module. This ensures that the only contamination entering the second zone is contained within the samples. All personnel exiting the second zone must go through the Operations Control Center frisking station to ensure they are contaminant-free. This arrangement minimizes contaminant risks for all personnel, both within and outside the RTAL area, and is in compliance with the principle of As Low As Reasonably Achievable (ALARA).

The final module is the Protected Living Quarters. This module is located beyond the Operations Control Center and is used when personnel are needed on-site for around-the-clock operations. The need for such demanding efforts are not expected to occur very often and, therefore, this module is shown in dashed lines. However, in critical situations, the Protected

Living Quarters would be very effective in supporting needed personnel in a safe environment very near the area of operations.

Interconnecting covered walkways are provided to connect all the modules so operating personnel can easily walk among the modules, as needed. The walkways come in interlocking sections which allow great flexibility in siting the individual modules within the complex. The walkways contain a conduit for the communications wires running between the modules. These wires provide telephone and computer connections among the modules and to the outside.

Communications among the modules will be by hard-wired telephone. Communications beyond the RTAL area of operations will be by cellular telephone and, if necessary, satellite communications. STU-III encryption devices for secure communications can also be added, if needed.

The RTAL computers are interconnected in a Local Area Network (LAN). Appropriate software is included so that all computer systems within the RTAL complex, including the computers controlling the analytical equipment, can be monitored and controlled from the Operations Control Center or any of the other modules. This greatly enhances the efficiency of the operation and minimizes personnel requirements for operating the complex and performing the analyses.

A third alternative RTAL complex configuration, shown in Figure 3, that was investigated is the use of a separate module for electrical generation. This module would be capable of generating sufficient electricity to meet the needs of all the modules. The generating capacity would be divided among two generators to improve the reliability of the system. Thus, even if one generator was inoperable, the other one could be used to maintain the most critical operations. This configuration shown in Figure 3 eliminates the need for electrical generating equipment in each module, providing more room in the other modules for other uses (an important consideration). It also minimizes shock and vibration mounting requirements in the laboratory modules. However, the use of a central electrical generation module would limit the deployment flexibility of the RTAL since this module would have to be deployed whenever an independent source of power was needed. Deployment flexibility is a cornerstone of the RTAL design. Thus, it was decided that each module should retain its own electrical generating system. Intermediate alternatives, in which some of the modules have their own electrical generating system so they could be deployed independently while retaining the use of a central electrical generation module when the entire modular RTAL complex is deployed, were also investigated. However, these alternatives would increase the cost of the RTAL system without significantly improving deployment flexibility.

Based on these analyses, the RTAL System configuration shown in Figure 2 was determined to be the one best able to meet the needs of the DOE. The alternative configurations studied for

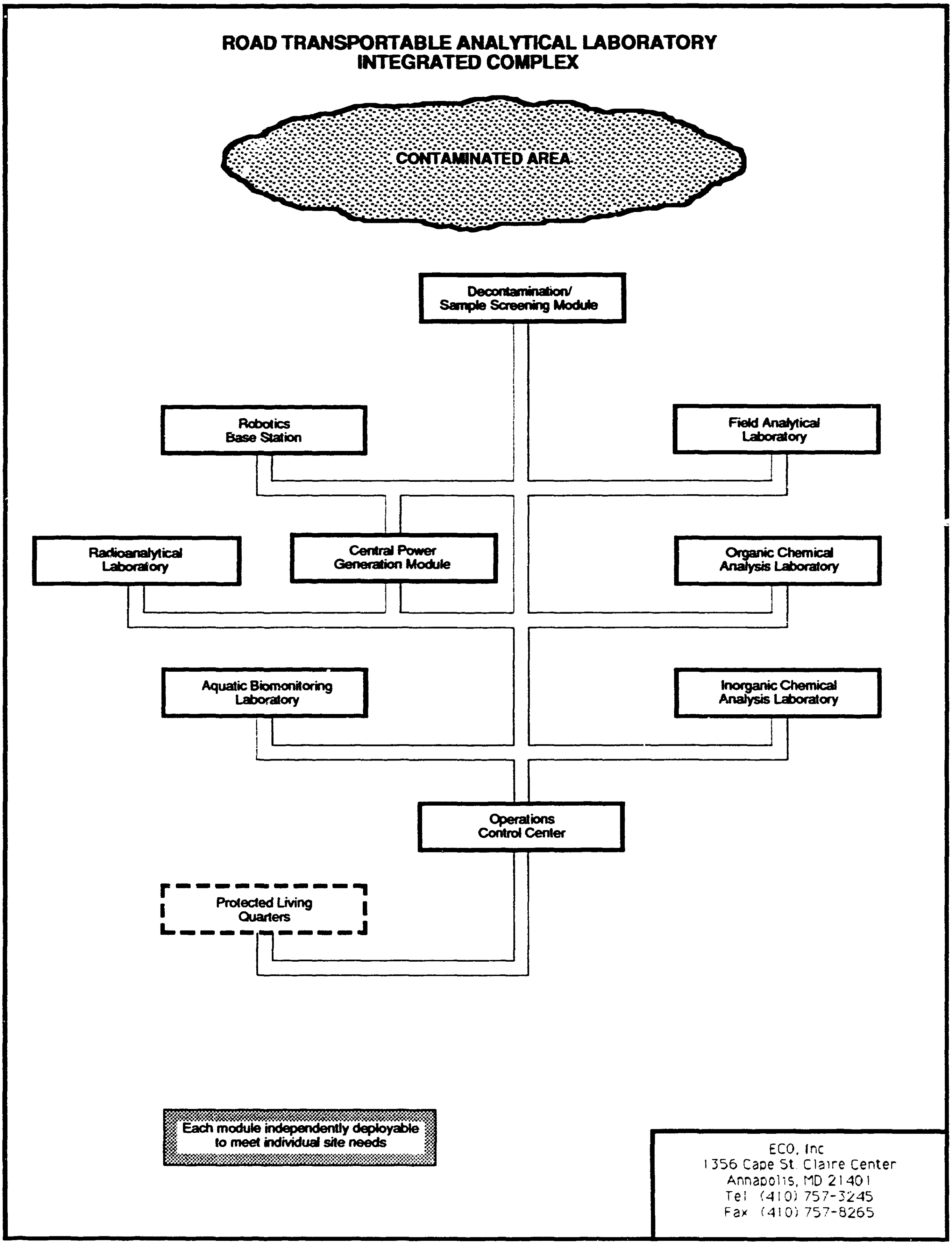


Figure 3. Road Transportable Analytical Laboratory Integrated Complex - Alternative Design

each of the RTAL modules are discussed in the following sections of this report.

Decontamination/Sample Screening Module

The Decontamination/Sample Screening Module provides for (1) decontamination of personnel leaving the contaminated zone and (2) initial screening and subdividing of samples prior to the radioanalytical and chemical analyses conducted in the other modules. This module is actually divided into two separate halves, representing its two functions. The design which was determined to work best is shown in Figures 4a-c. Figure 4a shows the interior layout of this module. Figures 4b and 4c show the exterior views.

The decontamination side of the module has an entrance door on the side of the module facing the contaminated zone. Personnel who have been working in contaminated areas enter the decontamination shower through this door. They can be frisked for contamination to determine if they are "clean" or if they require decontamination. Alternatively, a decontamination shower could be required of all personnel who have been working in contaminated areas. This option is left up to the managers of the operation. The decontamination shower provides a high pressure multi-nozzle spray to remove any contamination from overgarments. The decontamination shower wash water drain through double walled piping into a separate waste water tank. The use of a separate tank segregates radioactively contaminated water from other waste waters to minimize subsequent treatment and the volume of radioactive waste. After showering, the worker is frisked to ensure there is no remaining contamination. Initial and final frisking is performed using automated portable alpha/beta and gamma monitors, and alpha/beta and gamma foot monitors. After final frisking, the decontaminated person then changes into street clothes in one of the two dressing rooms provided. A separate personnel shower compartment (normal pressure) is also provided for the comfort and convenience of the personnel. Lockers are also provided for stowage of protective equipment and for the use of decontaminating personnel. The decontaminated personnel exit the module through a door on the "clean" side of the module.

The sample screening side of the module provides the necessary facilities and equipment for screening collected samples and for subdividing them for further analyses. Sample collectors bring the samples to a pass-through on the "dirty" side of the module, i.e. the side facing the contaminated zone. They insert the samples into the pass-through which leads directly into the hot cell. The hot cell is designed to handle all environmental samples, R1 through R4. However, it is not designed to protect against neutron emitters since these emanate only from potentially fissionable material and should not be encountered in environmental matrices. The presence of any

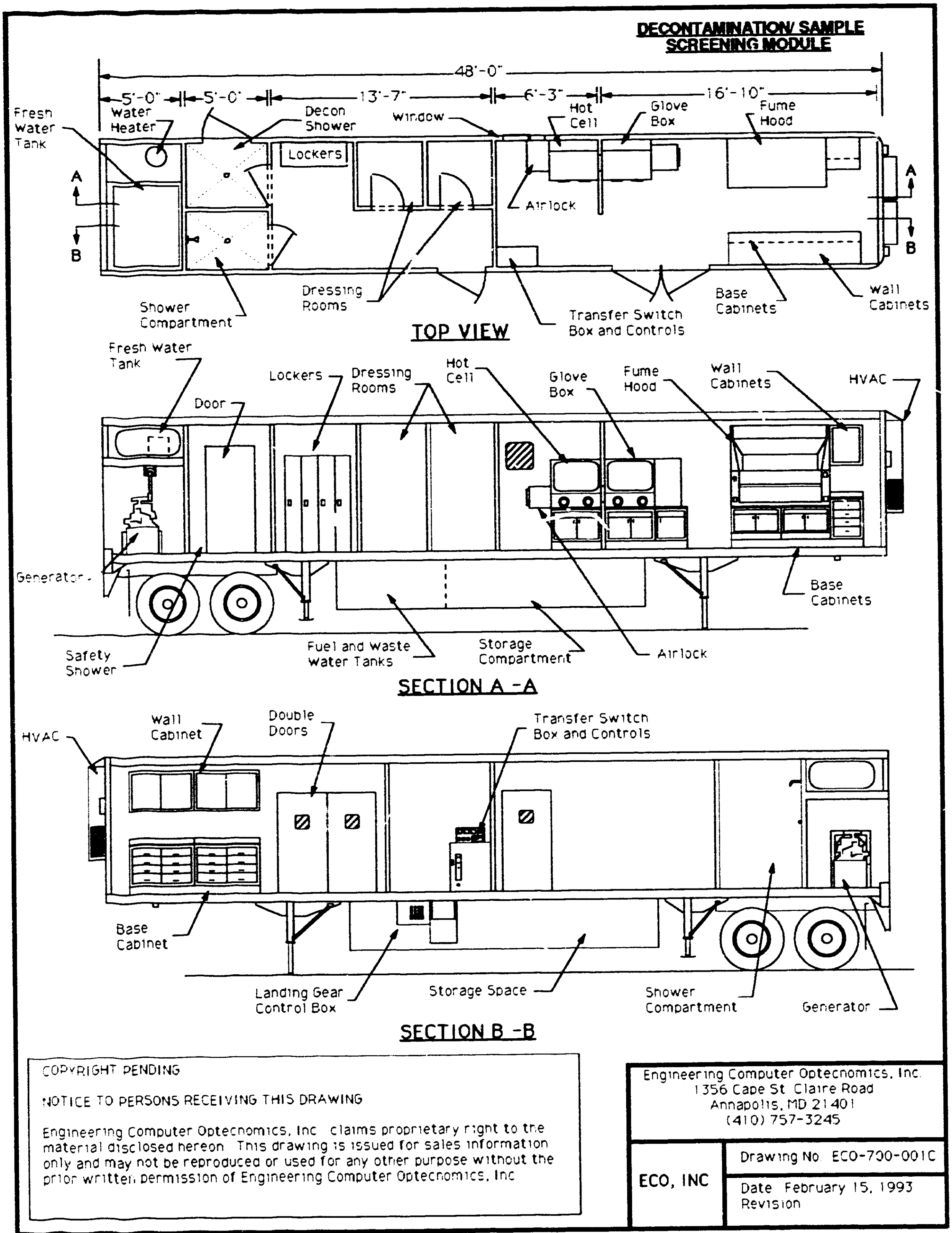
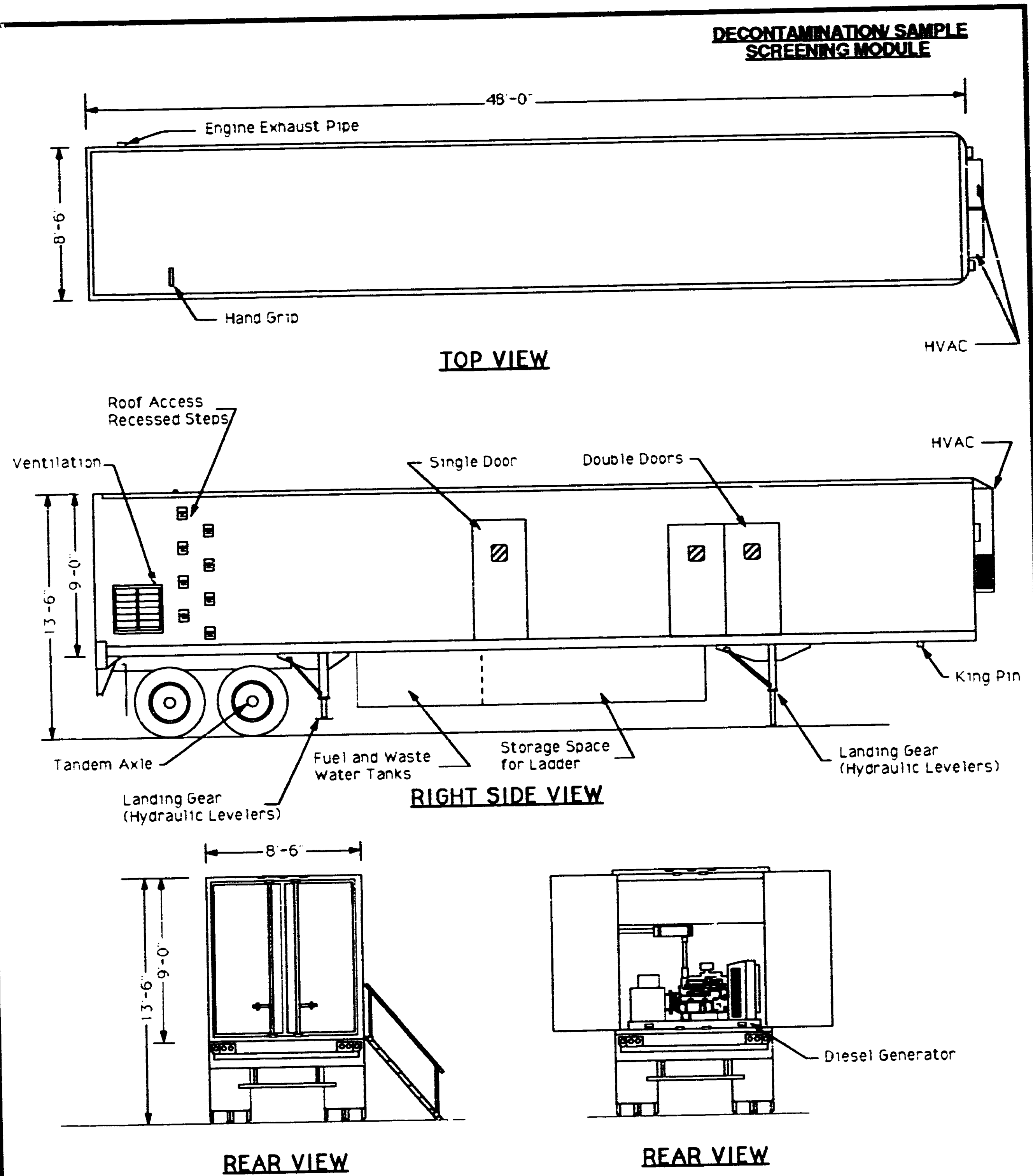


Figure 4a. Decontamination/Sample Screening Module - Interior Views



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	Date. March 29, 1993 Revision.

Figure 4b. Decontamination/Sample Screening Module - Exterior View

DECONTAMINATION/ SAMPLE SCREENING MODULE

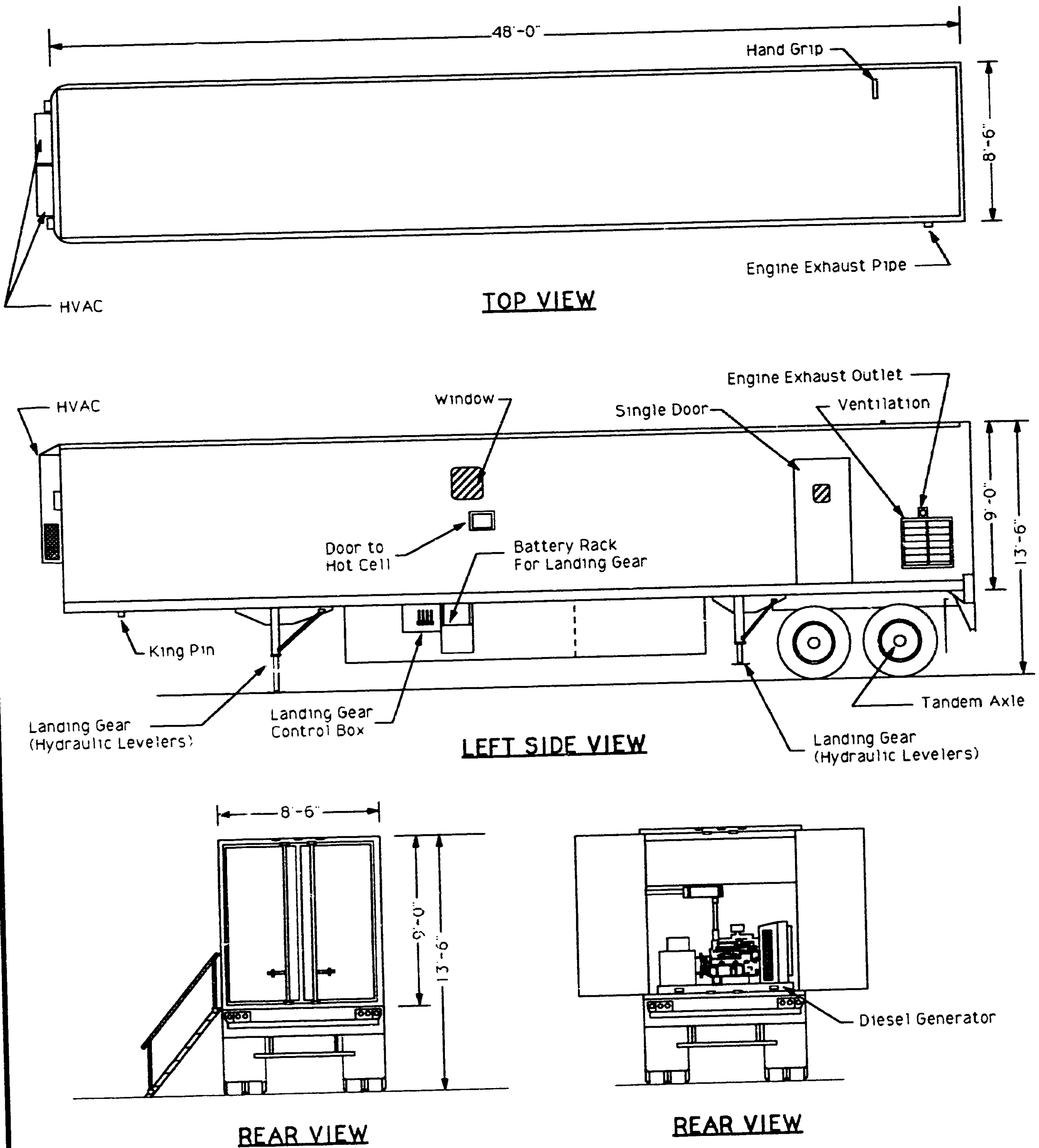

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Figure 4c. Decontamination/Sample Screening Module - Exterior Views

neutron-emitters should be determined during the initial mapping of the area using robotic monitors. Adding neutron protection to the hot cell would double its price and is not warranted in the case of environmental analyses. The hot cell is located in a separate room within the module. The interior of the hot cell represents a triple-containment area. In addition to the physical barriers around the sample, the air flow will be maintained to ensure that all air leakage is from outside the Sample Screening Room into the room, and from the room into the hot cell. All exiting air from the hot cell and the rest of the module will be filtered through HEPA filters.

The sample screening operator determines each sample's radiation level category, R1 through R4 (as defined above), while it is in the hot cell. The anticipated 2% of the samples in categories R3 and R4 would be sent to a central laboratory equipped to handle these more radioactive samples. After initial screening in the hot cell using an alpha/beta monitor and a gamma monitor, the category R1 and R2 samples are passed through an interconnecting chamber into a glove box located in the adjacent room. The samples are subdivided in the glove box or moved directly into the hood, also located in this room, for subdivision. The availability of the glove box, while not strictly required, provides extra operator protection during initial sample handling while not increasing the cost of this module significantly. After subdivision, the samples are stored in protected cabinets until they are moved to the other laboratories for further analysis.

This configuration provides excellent safety for operating personnel while efficiently providing for performance of this module's decontamination and sample screening functions. In addition to its decontamination and sample screening capabilities, the module has an integral electrical generator, HVAC system, fuel tank, wastewater holding tanks (segregated tanks for radioactive and non-radioactive wastewaters), potable water tank, hydraulic leveling legs for use on uneven terrain, and enclosed storage space under the module.

Figure 5 shows the same basic design, but this configuration assumes the presence of a central electrical generator, as shown in Figure 2. Thus, there would be no need for an integral electrical generator within the Decontamination/Sample Screening Module, as shown in Figure 5. However, as discussed earlier, the use of a central electrical generator had significant drawbacks in terms of logistics and overall system reliability. Therefore, the design shown in Figure 5 was not chosen.

Figure 6 provides an alternative design for the Decontamination/Sample Screening Module. In this configuration, the samples are passed into the hot cell as discussed above. However, there is no provision for a glove box in the adjacent room. While strictly speaking, the glove box may not be required, it was felt that its use would provide an extra margin of safety for operating personnel in this module without a significant cost increase. This configuration also provides an

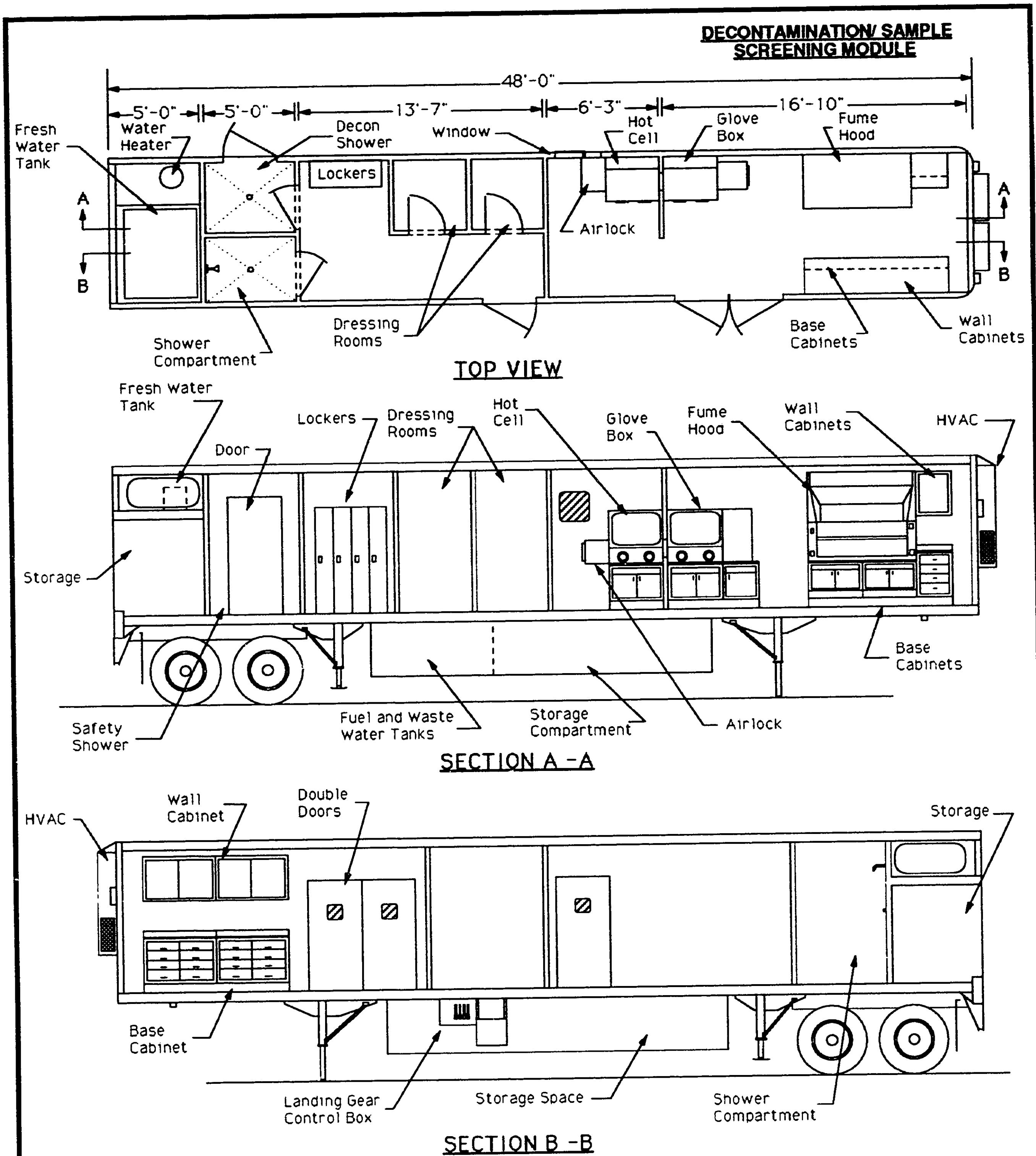

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Figure 5. Decontamination/Sample Screening Module - Alternative Design 1

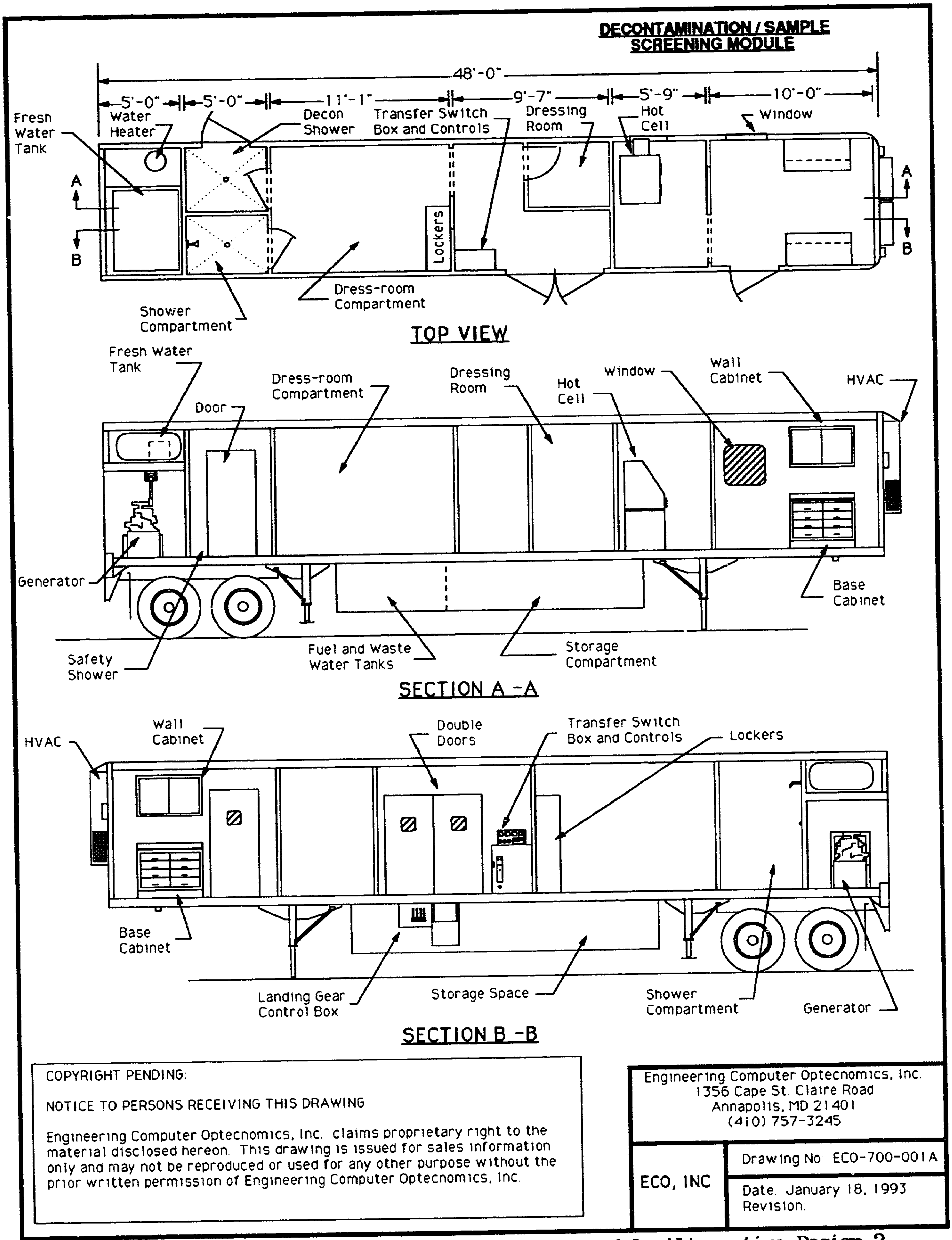

Figure 6. Decontamination/Sample Screening Module Alternative Design 2

alternative arrangement of the decontamination area which, while workable, was not considered as efficient as the preferred design, shown in Figure 4a.

Radioanalytical Laboratory

The Radioanalytical Laboratory is designed for the qualitative and quantitative analysis of radionuclides in the samples. The design for this laboratory, as well as the other modules, was based on a top-down approach. Table 1 lists the analytes of concern based on the DOE reports cited earlier. For each analyte it then lists the standard analytical procedures (sample preparation and analysis) to be used. Based on the requirements of the analytical procedure the major equipment required were determined and are also listed in the table. All procedures assume a quality assurance/quality control (QA/QC) level of III (using the terminology from the INEL report). This provides full validation of all data via a series of standards, replicates and other QA/QC tests.

The design that was determined to be best suited to the needs of the DOE is shown in Figures 7a-c. Figure 7a shows the interior layout of the laboratory and Figures 7b and 7c show the exterior views. The Radioanalytical Laboratory is divided into two rooms - a Sample Preparation Room and a Sample Analysis Room. The main entrance into the module leads into the Sample Preparation Room. This room contains three hoods and bench-top work area to facilitate the often time-consuming preparation of samples for subsequent instrumental analysis. This room also contains the compressed gas tanks required for the analyses. A second door opens onto the tank area to facilitate the input and removal of tanks. A small hydraulically operated crane is provided to facilitate tank movement. The Sample Preparation Room also contains a safety shower and emergency eye wash station.

After preparation, the samples are brought into the Sample Analysis Room where it is analyzed using the equipment listed in Table 1. These include Alpha Spectrometer, Gamma Spectrometer, Alpha/Beta Monitor, Liquid Scintillation Counter, Germanium Detector, Multi-channel Analyzer, and supporting computers. The equipment to be used makes maximum use of computer control and automatic sequential sample feeding to maximize operator efficiency. This allows the instrumentation to operate overnight to analyze samples without operator attention, increasing throughput at essentially no additional cost (except for consumable materials).

The Radioanalytical Laboratory module has an integral electrical generator, HVAC system, fuel tank, wastewater holding tank, potable water tank, hydraulic leveling legs for use on uneven terrain, and enclosed storage space under the module.

Alternative designs which were considered but found to be less advantageous are shown in Figures 8 and 9. Figure 8 shows

Table 1

RADIOCHEMISTRY LABORATORY

PARAMETER	SAMPLE SIZE	EPA METHOD	QA/QC LEVEL	MAJOR EQUIPMENT
Gross Alpha & Gross Beta Radioactivity	100g	900.0	III	Gas-flow proportional counting systems or Scintillation detector systems Stainless steel planchets Drying oven Analytical balance Drying lamps Electric hot plates
Gamma Emitting Radionuclides	100 g	901.1	III	Large volume (>50 cm3) Ge (li) detectors or 4" x 4" NaI (Tl) detectors Gamma-ray spectrometers Data processing equipment
Radioactive Strontium	100g	905	III	Low background beta counting system Centrifuge Drying oven Hot water baths Electric hot plates Analytical balance pH meter Dessicators Stainless steel planchets Drying lamps

Table 1

RADIOCHEMISTRY LABORATORY (CONT'D)

PARAMETER	SAMPLE SIZE	EPA METHOD	QA/QC LEVEL	MAJOR EQUIPMENT
Actinide elements	100g	907	III	Alpha particle counters Stainless steel planchets Filtering apparatus Alpha sensitive phosphors Centrifuge Silica columns Reagent storage Vacuum source <u>Other Major Equipments</u> Fume hoops Microwave digestors

RADIOANALYTICAL LABORATORY

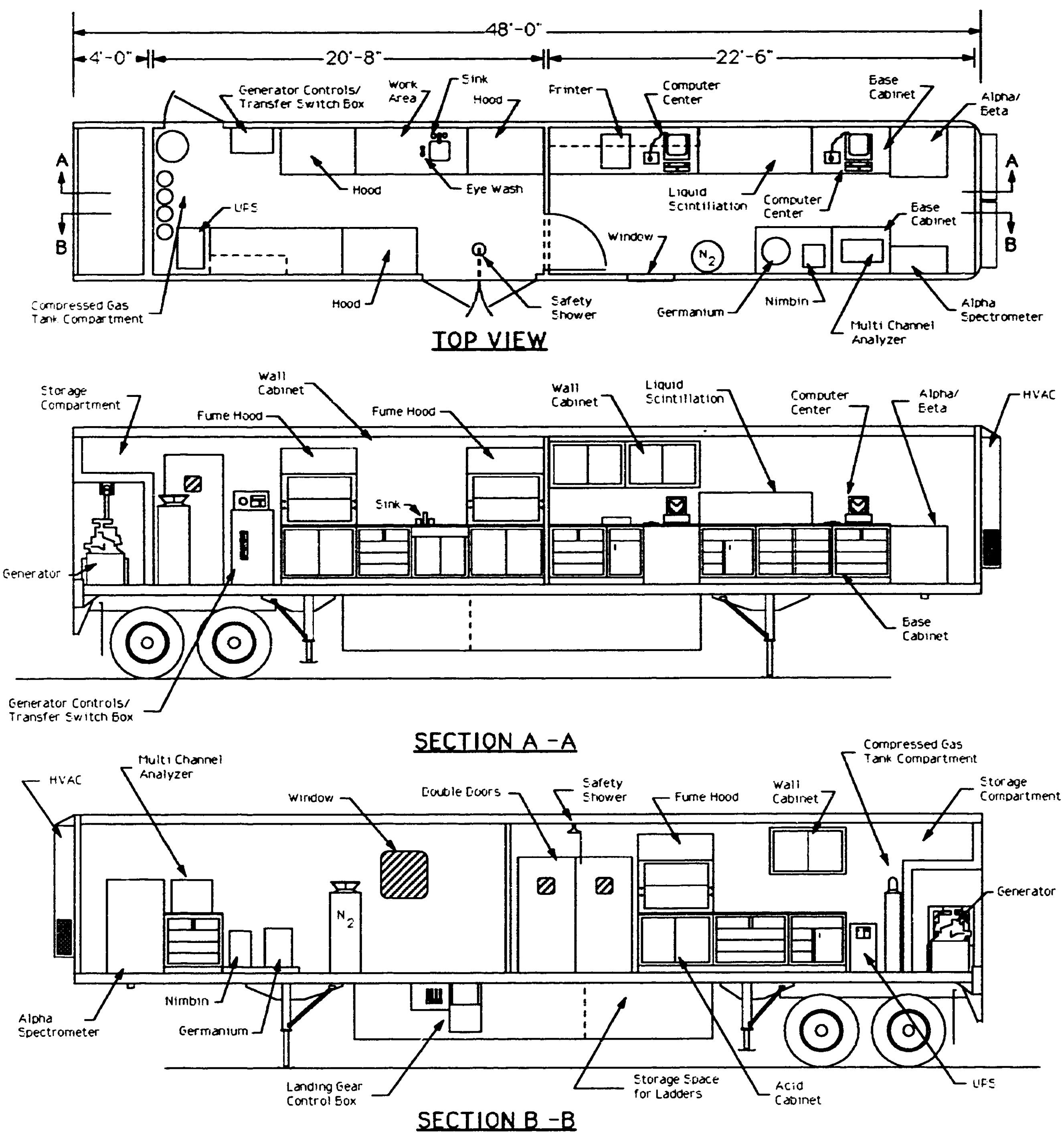

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Figure 7a. Radioanalytical Laboratory - Interior View

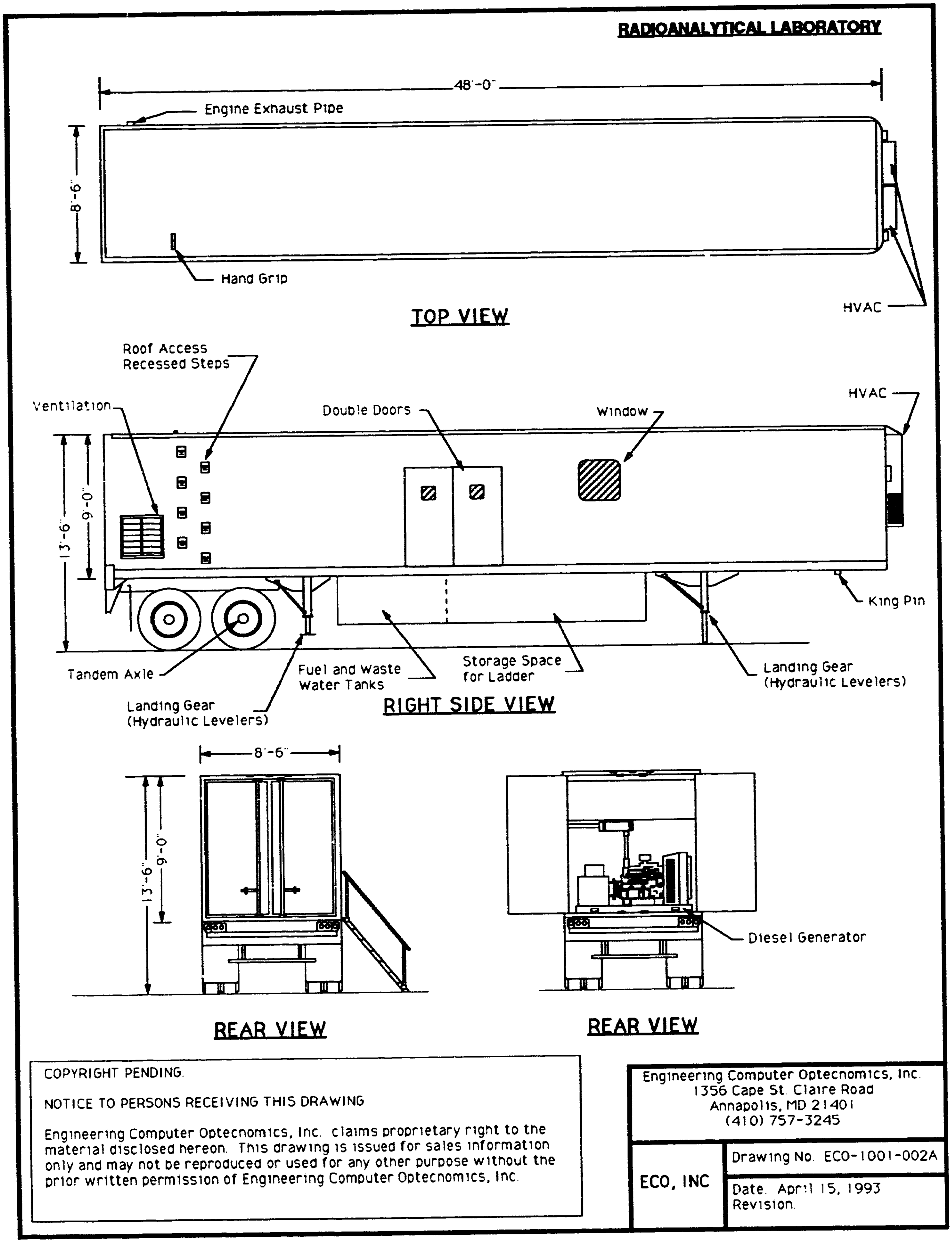

Figure 7b. Radioanalytical Laboratory - Exterior Views

RADIOANALYTICAL LABORATORY

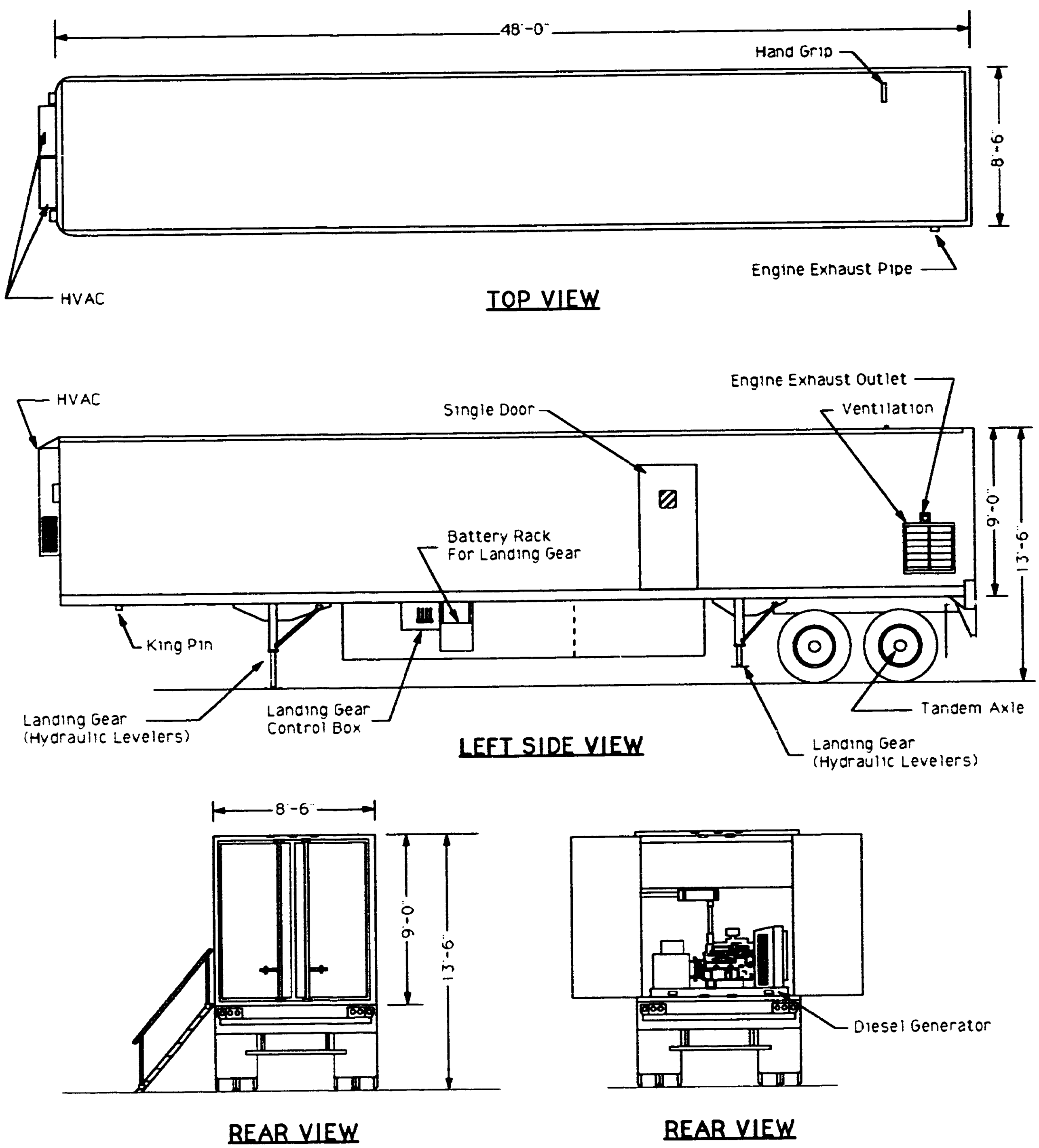

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Figure 7c. Radioanalytical Laboratory - Exterior Views

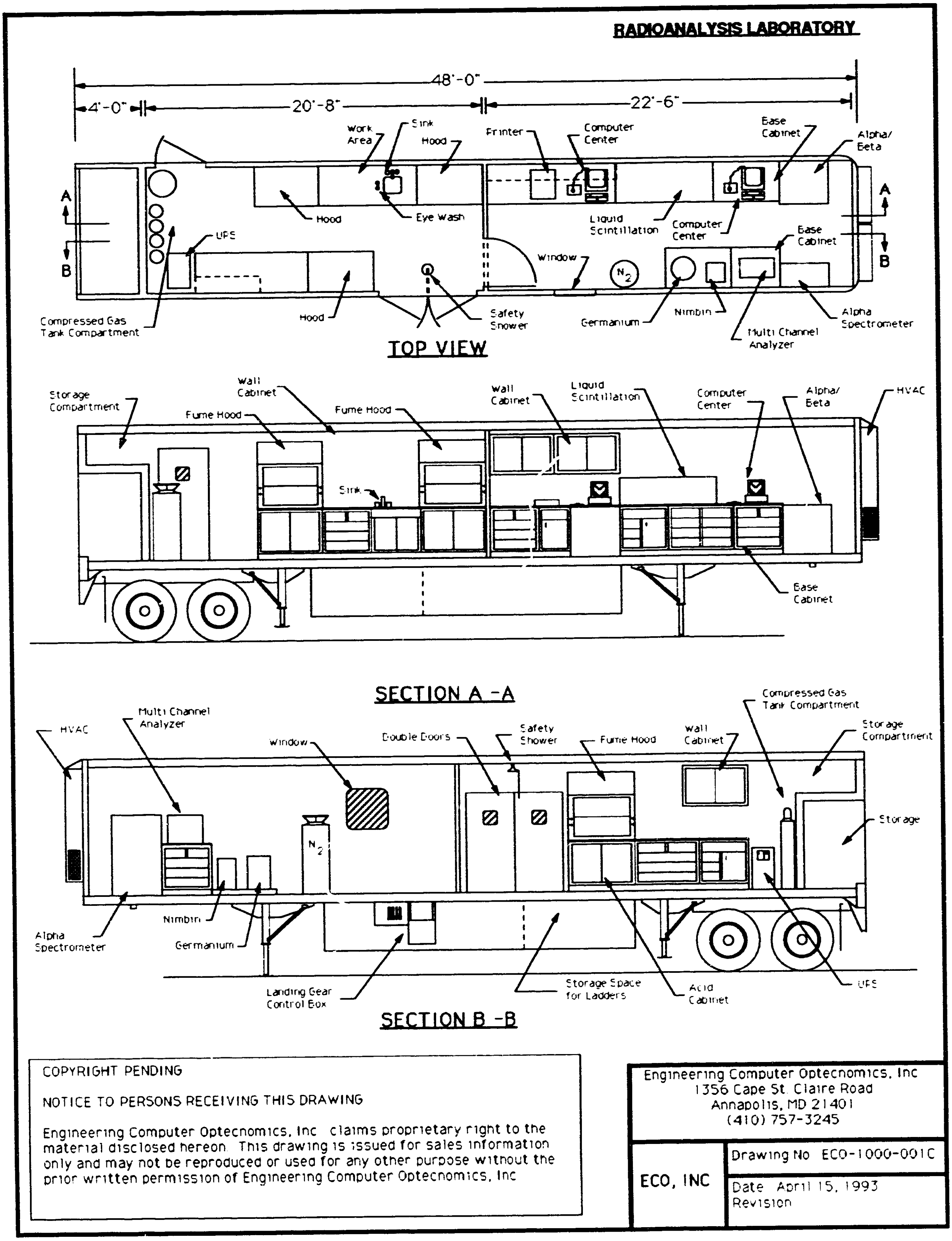

Figure 8. Radioanalytical Laboratory - Alternative Design 1

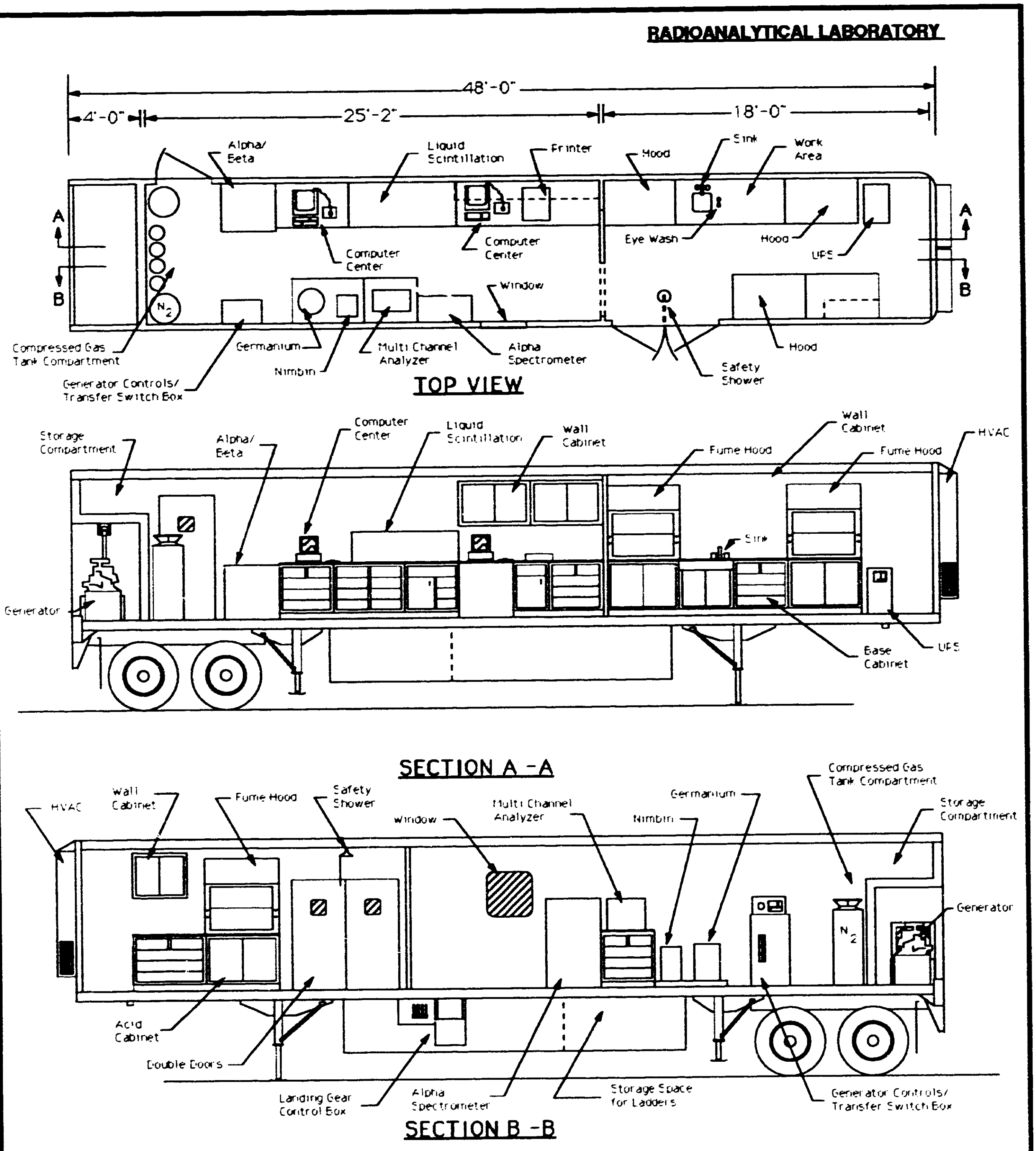

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Figure 9. Radioanalytical Laboratory - Alternative Design 2

the same basic arrangement as the recommended arrangement (Figures 7a-c) except that the onboard electrical generator is eliminated. Power would be provided by a central electrical generator. As discussed earlier, this arrangement was determined to have significant drawbacks in terms of overall system reliability and logistical support. Figure 9 reverses the location of the rooms within the module. As a result, the compressed gas tanks and the door adjacent to them are located in the Sample Analysis Room. This has potential negative consequences in terms of temperature gradients when door by the gas tanks is open and the outside temperature is either very hot or very cold. Other than that, this would be an acceptable configuration.

Organic Chemical Analysis Laboratory

The Organic Chemical Analysis Laboratory is designed for the qualitative and quantitative analysis of organic contaminants, including explosive compounds, in the samples. The design for this laboratory, as well as the other modules, was based on a top-down approach. Table 2 lists the organic analytes of concern based on the DOE reports cited earlier. For each analyte it then lists the standard analytical procedures (sample preparation and analysis) to be used. Based on the requirements of the analytical procedure the major equipment required were determined and are also listed in the table. All procedures assume a quality assurance/quality control (QA/QC) level of III (using the terminology from the INEL report). This provides full validation of all data via a series of standards, replicates and other QA/QC tests.

The design that was determined to be best suited to the needs of the DOE is shown in Figures 10a-c. Figure 10a shows the interior layout of the laboratory and Figures 10b and 10c show the exterior views. The Organic Chemical Analysis Laboratory is divided into three rooms - a Sample Preparation Room and two Sample Analysis Rooms. The main entrance into the module leads into the Sample Preparation Room. This room contains Toxicity Characteristic Leachate Procedure (TCLP) sample preparation apparatus (including Zero Headspace Extractor), two hoods, drying oven, and bench-top work area to facilitate the often time-consuming preparation of samples for subsequent instrumental analysis. This room also contains the compressed gas tanks required for the analyses. A second door opens onto the tank area to facilitate the input and removal of tanks. A small hydraulically operated crane is provided to facilitate tank movement. The Sample Preparation Room also contains a safety shower and emergency eye wash station.

After preparation, the samples are brought into the Sample Analysis Rooms where they are analyzed using the equipment listed in Table 2. The larger Sample Analysis Room contains a Gas Chromatograph/Mass Spectrometer (GC/MS), a Gas Chromatograph (GC)

Table 2

ORGANIC LABORATORY

PARAMETER	SAMPLE SIZE	EPA METHOD	QA/QC LEVEL	MAJOR EQUIPMENT
VOA	40ML (Liquid) 10g (Solid)	Sample Prep & Analysis 8240A	III	• GC/MS, packed column • Purge & trap device • Mass spec requirement: 35-260 AMU every 3 seconds or less • Data system • Recirc chiller • Carrier gases: H_2 or He • Analytical balance • Screening: head space sampler (method 38/0) with GC (PID & HECD detectors) or extraction with hexadecane & analysis on GC with FID and/or ECD
SEMI-VOA	1L (Liquid) 50g (Solid)	Sample Prep 3520A (Liquids)	III	• Continuous liquid-liquid extractors • Kuderna-danish concentrators • Water bath • Recirc chillers • Solvent storage
		3550A (Solids)	III	• Ultrasonic extractors • Sound enclosures • Vacuum pump • Kuderna danish extractors • Water bath • Analytical balance • Solvent storage
		or Supercritical Fluid Extraction		• Supercritical fluid extraction • Carbon dioxide source
		3640 (sample cleanup)	III	• Gel permeation chromatography system HPLC with GPC column UV detector Recorder

Table 2

ORGANIC LABORATORY (CONT'D)

PARAMETER	SAMPLE SIZE	EPA METHOD	QA/QC LEVEL	MAJOR EQUIPMENT
SEMI-VOA		Analysis 8270A	III	• GC/MS, fused silca capillary column • MS requirements: 35-500 AMU every 1 second or less • Data system • Carrier gas: H_2 or He
PCB's	1L (Liquid) 50g (Solid)	Sample prep 3520A (Liquids)	III	• Continuous liquid-liquid extractors • Kuderna-danish concentrators • Water bath • Recirc chillers • Solvent storage
		3550A (Solids)	III	• Ultrasonic extractors • Sound enclosures • Vacuum pump • Kuderna-danish extractors • Water bath • Analytical balance • Solvent storage
		or Supercritical fluid exraction		• Supercritical fluid extractor • Carbon dioxide source
		3640	III	• Gel permeation chromatography system HPLC with GPC column UV detector Recorder
		Analysis 8080A	III	• CG with ECD/HECD detector • Data system • Analytical balances

Table 2

ORGANIC LABORATORY (CONT'D)

PARAMETER	SAMPLE SIZE	EPA METHOD	QA/QC LEVEL	MAJOR EQUIPMENT
TCLP*		1311	III	• End over end agitation • Extractors • Filtration devices • Vacuum or N_2 source • Analytical balance
• VOA	40ml (Liquid) 120g (solid)			
• SEMI VOA	1L (Liquid) 120g (solid)			

* TCLP requirements are the same for both VOA's and SEMI-VOA's

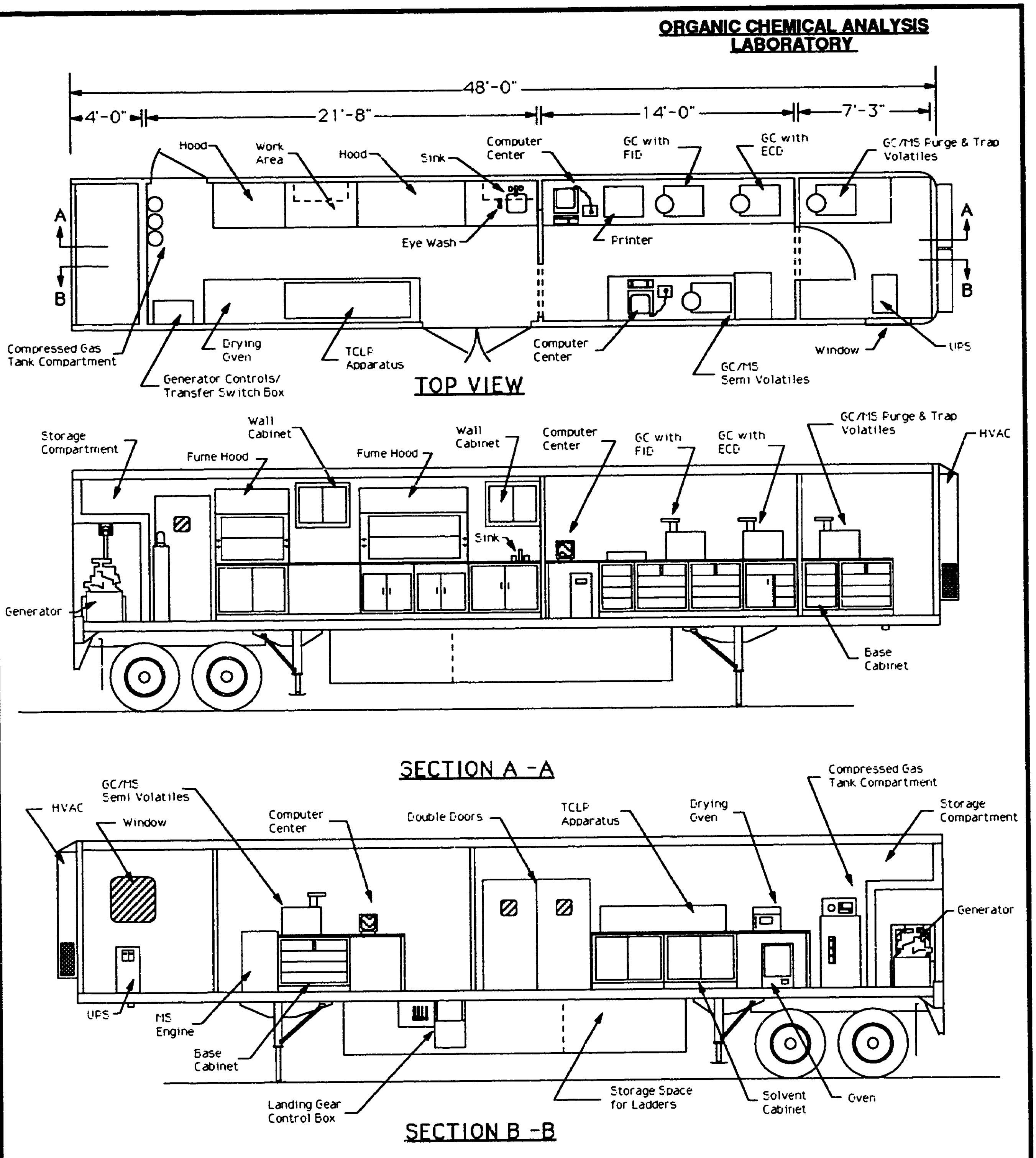

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Figure 10a. Organic Chemical Analysis Laboratory - Interior Views

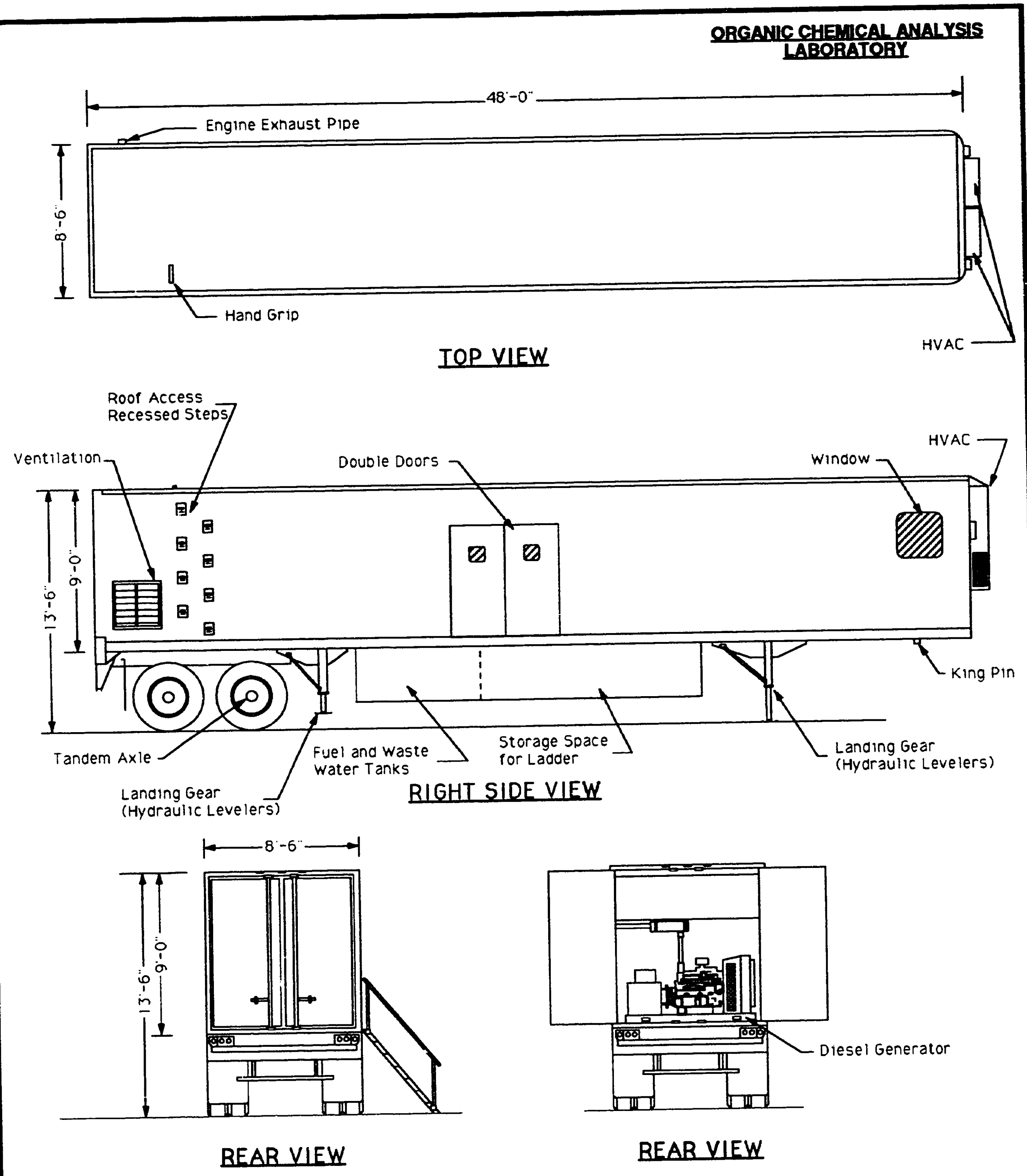

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Figure 10b. Organic Chemical Analysis Laboratory - Exterior Views

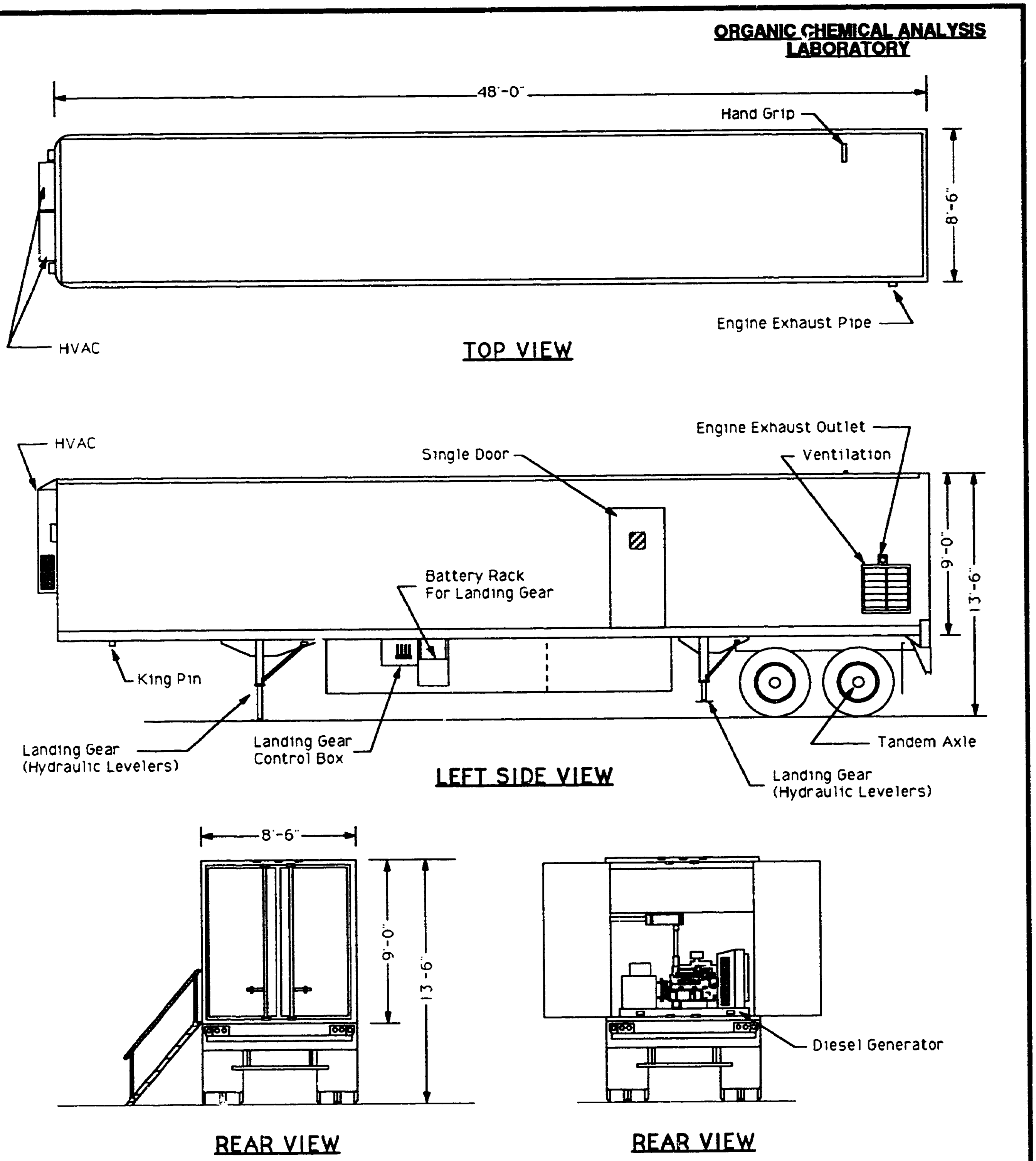

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Figure 10c. Organic Chemical Analysis Laboratory - Exterior Views

with Flame Ionization Detector (FID), a Gas Chromatograph with Electrical Conductivity Detector (ECD) and supporting computers. A separate Sample Analysis Room contains the Purge and Trap GC/MS used volatile analyses. This instrument is segregated to minimize potential interferences with the other instruments due to volatilized contaminants. The equipment to be used makes maximum use of computer control and automatic sequential sample feeding to maximize operator efficiency. This allows the instrumentation to operate overnight to analyze samples without operator attention, increasing throughput at essentially no additional cost (except for consumable materials).

The Organic Chemical Analysis Laboratory module has an integral electrical generator, HVAC system, fuel tank, wastewater holding tank, potable water tank, hydraulic leveling legs for use on uneven terrain, and enclosed storage space under the module.

The main alternative design considered was the originally proposed concept of a combined Inorganic and Organic Chemical Analysis Laboratory, shown in Figures 11a-c. The main advantage of this configuration is the use of one less module. However, the consequent space limitation precludes having all the instrumentation needed for the required analyses. Specifically, the two GC's and one of the GC/MS's would have to be deleted. Also, the Sample Preparation Room would have to be significantly downsized, lowering operator efficiency and limiting sample throughput. Also, the separation of the chemical analyses into individual Organic and Inorganic Chemical Analysis Laboratories allows for segregation of the hoods in each laboratory, i.e. the hood in the Organic Chemical Analysis Module would be used for organic chemicals only and the hood in the Inorganic Chemical Analysis Laboratory would be used for inorganic chemicals only. This segregation of the hoods for use with organic and inorganic chemicals is in keeping with standard laboratory safety practice. For these reasons, the combined laboratory design was determined to be inadequate to meet the DOE's needs.

Figure 12 shows the same basic arrangement as the recommended arrangement (Figures 10a-c) except that the onboard electrical generator is eliminated. Power would be provided by a central electrical generator. As discussed earlier, this arrangement was determined to have significant drawbacks in terms of overall system reliability and logistical support.

Inorganic Chemical Analysis Laboratory

The Inorganic Chemical Analysis Laboratory is designed for the qualitative and quantitative analysis of inorganic contaminants in the samples. The design for this laboratory, as well as the other modules, was based on a top-down approach. Table 3 lists the inorganic analytes of concern based on the DOE reports cited earlier. For each analyte it then lists the standard analytical procedures (sample preparation and analysis) to be used. Based on the requirements of the analytical

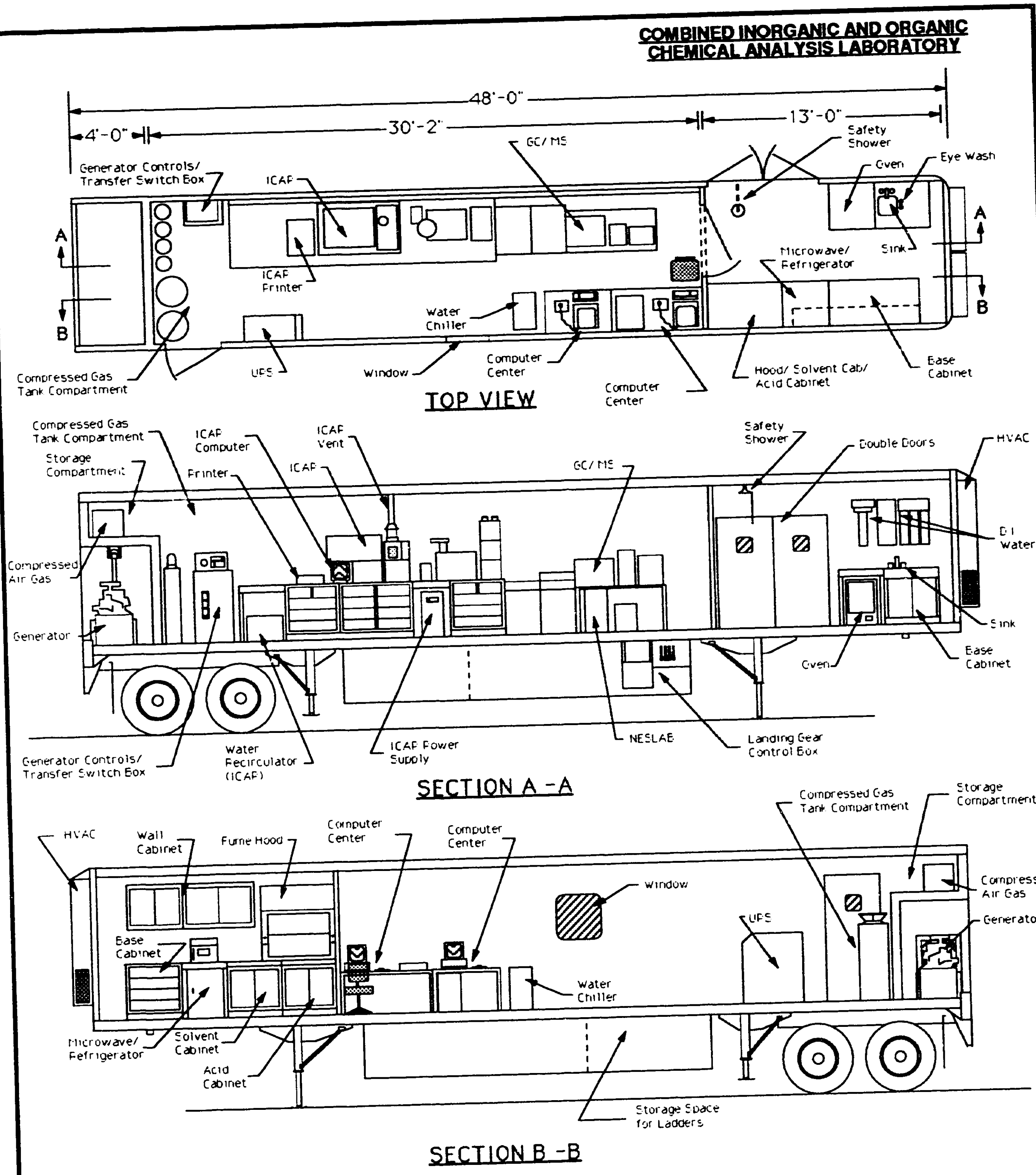

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Figure 11a. Combined Inorganic and Organic Chemical Analysis Laboratory - Interior Views

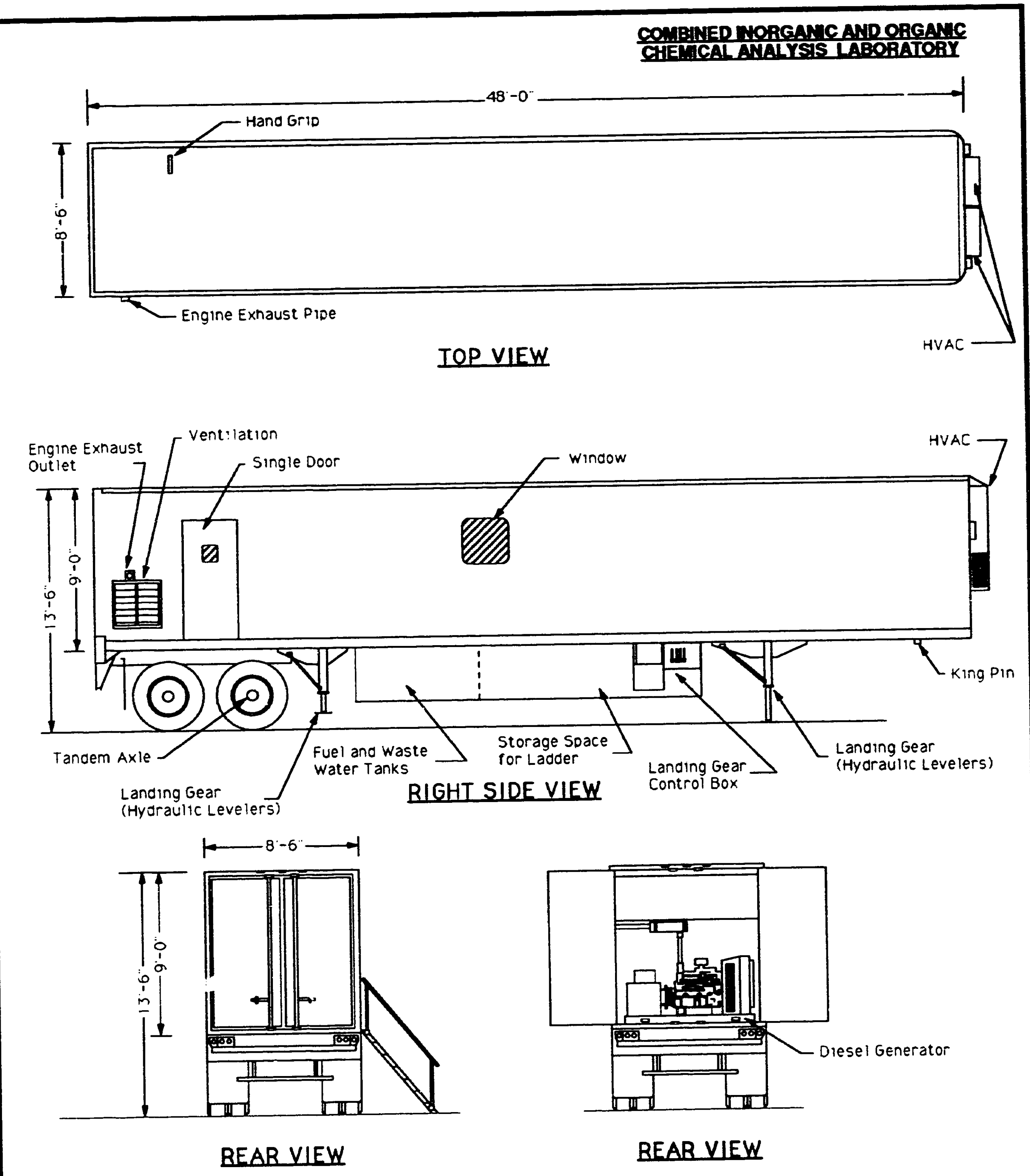

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Figure 11b. Combined Inorganic and Organic Chemical Analysis Laboratory - Exterior Views

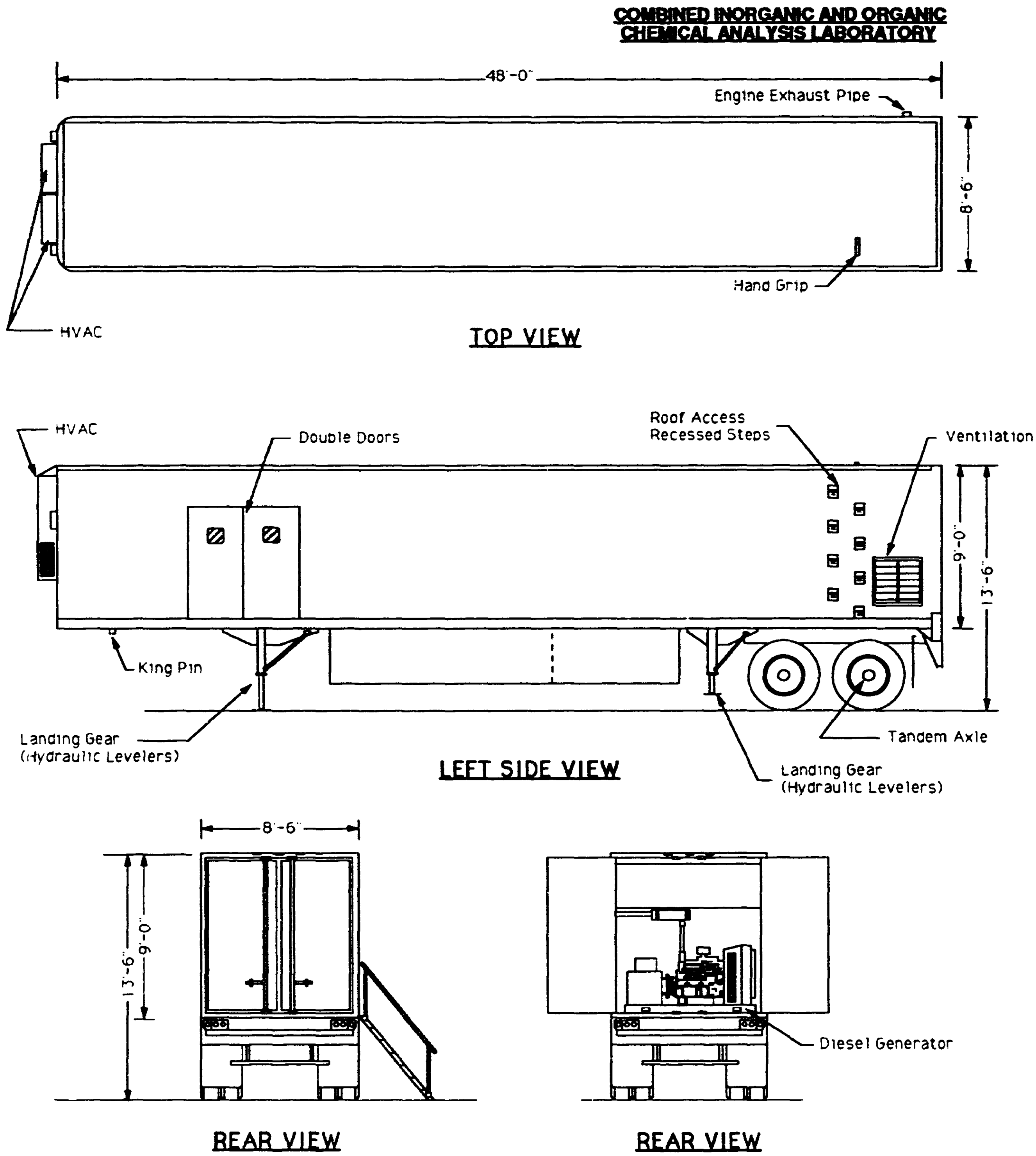

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Figure 11c. Combined Inorganic and Organic Chemical Analysis Laboratory - Exterior Views

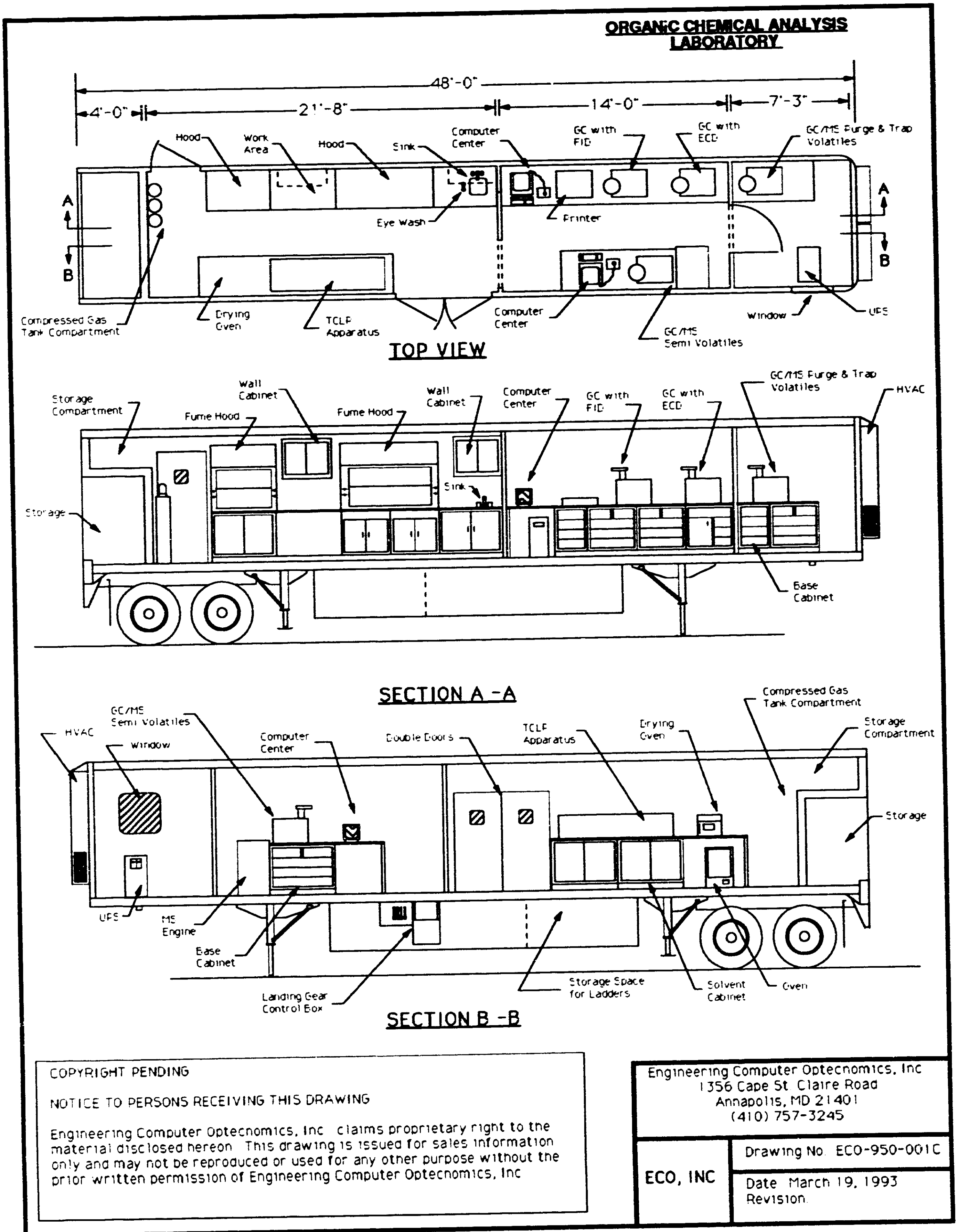

Figure 12. Organic Chemical Analysis Laboratory - Alternative Design

Table 3

INORGANIC LABORATORY

PARAMETER	SAMPLE SIZE	EPA METHOD	QA/QC LEVEL	MAJOR EQUIPMENT
Metals	100ml (Liquid) 10g (solid)	Sample prep 3010A (aqueous)	III	• No major equipment for standard method • Possible automated systems including microwave digestion to speed through-put
		3050A (sludges, soils & sediments)	III	• Analytical balance • Possible automated systems including microwave digestion to speed through-put
		Analysis 7470A/7471A	III	• Cold trap atomic absorption spectrophotometer
		6010A		• Inductively Coupled Argon Plasma emission spectrometer
Anions		300	III	• Ion chromatography system • Data system • Eluent storage
TCLP	100ml (Liquid) 120g (solid)	1311	III	• End over end agitation • Extractors • Filtration • Vacuum or N_2 source • Analytical balance

procedure the major equipment required were determined and are also listed in the table. All procedures assume a quality assurance/quality control (QA/QC) level of III (using the terminology from the INEL report). This provides full validation of all data via a series of standards, replicates and other QA/QC tests.

The design that was determined to be best suited to the needs of the DOE is shown in Figures 13a-c. Figure 13a shows the interior layout of the laboratory and Figures 13b and 13c show the exterior views. The Inorganic Chemical Analysis Laboratory is divided into two rooms - a Sample Preparation Room and a Sample Analysis Rooms. The main entrance into the module leads into the Sample Preparation Room. This room contains two hoods and bench-top work area to facilitate preparation of samples for subsequent instrumental analysis. This room also contains the compressed gas tanks required for the analyses. A second door opens onto the tank area to facilitate the input and removal of tanks. A small hydraulically operated crane is provided to facilitate tank movement. The Sample Preparation Room also contains a safety shower and emergency eye wash station.

After preparation, the samples are brought into the Sample Analysis Room where they are analyzed using the equipment listed in Table 3. The Sample Analysis Room contains an Inductively Coupled Plasma Spectrometer, Atomic Absorption (AA) Mercury Analyzer, an Ion Chromatograph for anion analysis, and supporting computers. All the heavy metals but mercury are detectable by Inductively Coupled Plasma Spectroscopy. Mercury analysis requires the use of an Atomic Absorption Spectrometer. The preferred analytical method for the other metals is ICP. The equipment to be used makes maximum use of computer control and automatic sequential sample feeding to maximize operator efficiency. This allows the instrumentation to operate overnight to analyze samples without operator attention, increasing throughput at essentially no additional cost (except for consumable materials).

The Inorganic Chemical Analysis Laboratory module has an integral electrical generator, HVAC system, fuel tank, wastewater holding tank, potable water tank, hydraulic leveling legs for use on uneven terrain, and enclosed storage space under the module.

The main alternative design considered was the originally proposed concept of a combined Inorganic and Organic Chemical Analysis Laboratory, shown earlier in Figures 11a-c. The main advantage of this configuration is the use of one less module. However, the consequent space limitation precludes having all the instrumentation needed for the required analyses. Specifically, the Atomic Absorption Mercury Analyzer and Ion Chromatograph would have to be deleted. Also, the Sample Preparation Room would have to be significantly downsized, lowering operator efficiency and limiting sample throughput. Also, as noted above, the separation of the chemical analyses into two individual laboratory modules has inherent safety advantages in terms of segregating the types of chemicals to be used in the hoods. For

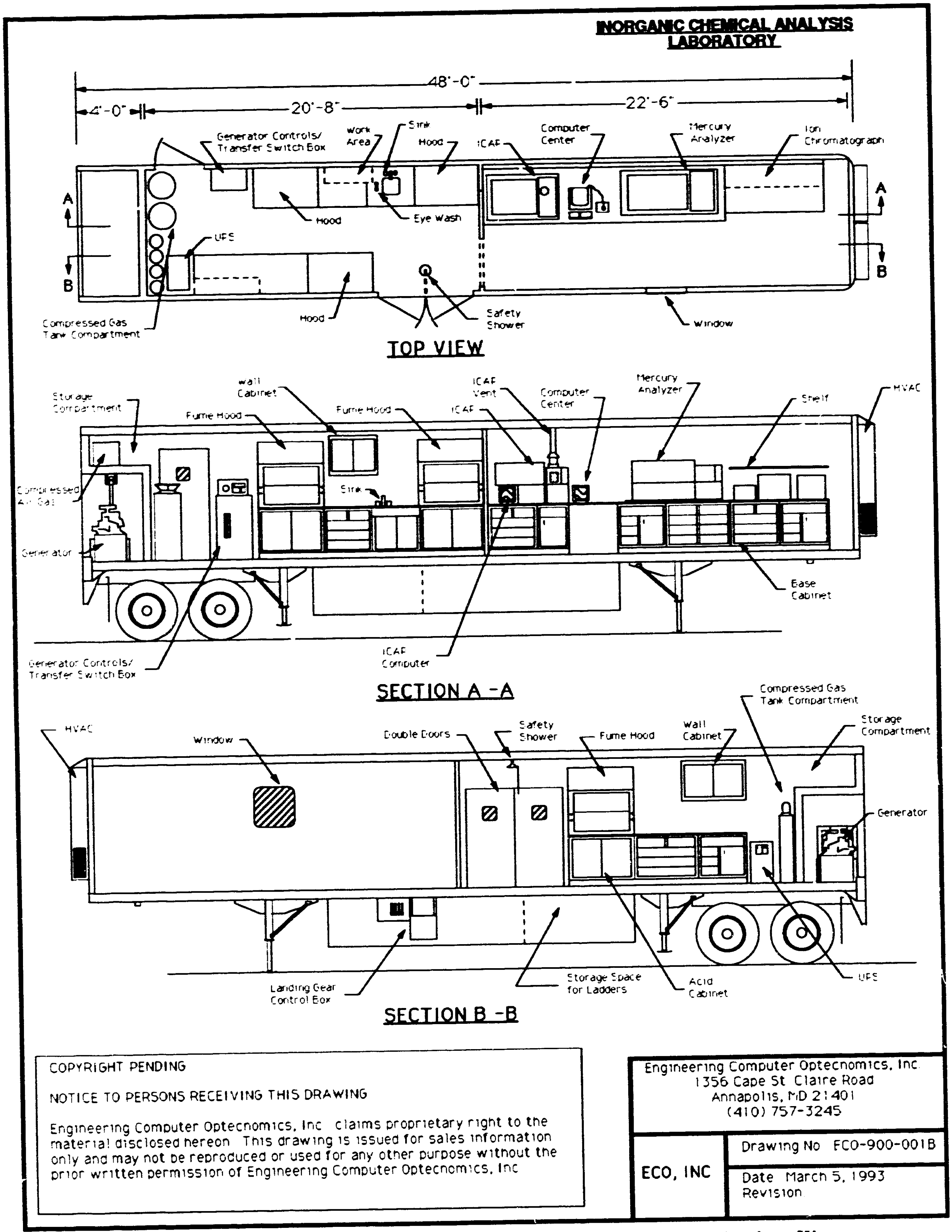

Figure 13a. Inorganic Chemical Analysis Laboratory - Interior Views

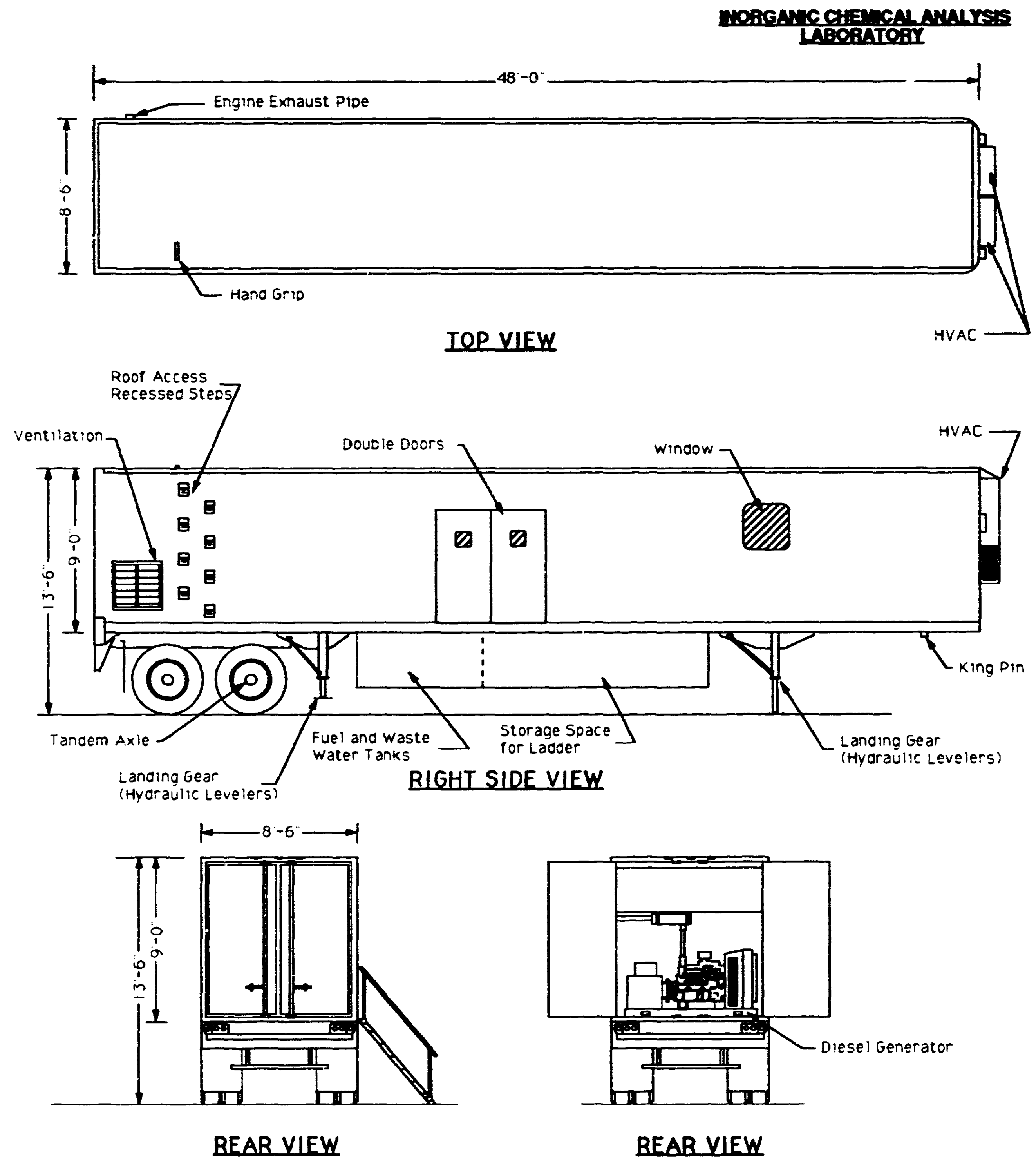

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Figure 13b. Inorganic Chemical Analysis Laboratory - Exterior Views

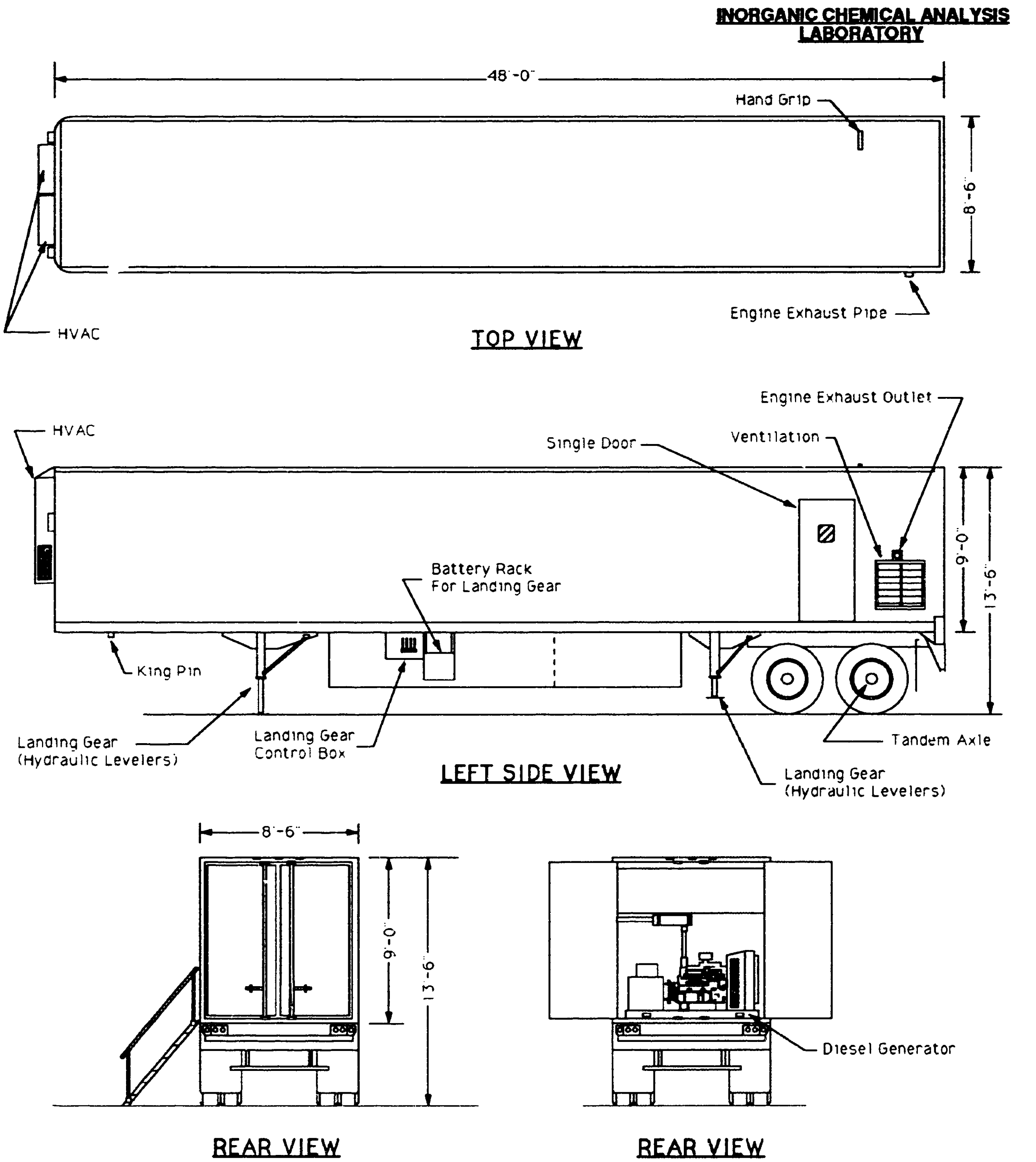

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Figure 13c. Inorganic Chemical Analysis Laboratory - Exterior Views these reasons, the combined laboratory design was determined to be inadequate to meet the DOE's needs.

Figure 14 shows the same basic arrangement as the preferred arrangement (Figures 13a-c) except that the onboard electrical generator is eliminated. Power would be provided by a central electrical generator. As discussed earlier, this arrangement was determined to have significant drawbacks in terms of overall system reliability and logistical support.

Aquatic Biomonitoring Laboratory

Integrated biological assessments of environmental hazard are conducted within the Aquatic Biomonitoring Laboratory. Integrated biological assessment addresses a variety of human health and ecological endpoints. These techniques employ non-mammalian *in vivo* bioassays, *in vitro* bacterial mutagenicity assays and analytical chemistry procedures in an integrated biological assessment to address the question "How clean is clean?" These techniques are the focus of an extensive in-house and extramural research program by the U.S. Army.

To assess the potential cancer hazard posed by a groundwater, effluent or surface water, a carcinogenicity bioassay using two species of small fish has been developed. These vertebrate animals share many anatomical, biochemical and genetic characteristics with mammalian animals. Basic and applied research projects continue to explore the similarities and dissimilarities these new species have with the more classical rodent models. The opportunity to perform an on-site, several thousand animal, chronic bioassay on the complex mixture of interest remains a compelling advantage of this new bioassay.

Developmental toxicity of test waters is assessed using an amphibian embryo assay. The Frog Embryo Teratogenicity Assay Xenopus (FETAX) has been refined by U.S. Army researchers. This method allows one to determine the developmental hazard of test waters by exposing frog embryos to varying concentrations of the material of concern. The FETAX assay is performed using an approved protocol and published atlas of abnormalities. The FETAX assay allows both human hazard assessment and ecological impact conclusions to be drawn from the same data set.

Near real-time biomonitoring of treated waters for rapidly developing acutely toxic conditions is accomplished using a computerized fish ventilatory monitor. Ventilatory and movement parameters from a series of small bluegills contained in individual chambers through which pass the water of interest are examined for deviations from normal values. Abnormal responses of these animals to water flowing through the exposure chambers indicates the possible presence of toxins in the water. This system can be programmed to alert a treatment plant operator or begin sampling of the water for subsequent chemical analysis.

Salmonella mutagenicity assays, acute aquatic organism toxicity tests and routine chemical analysis are also

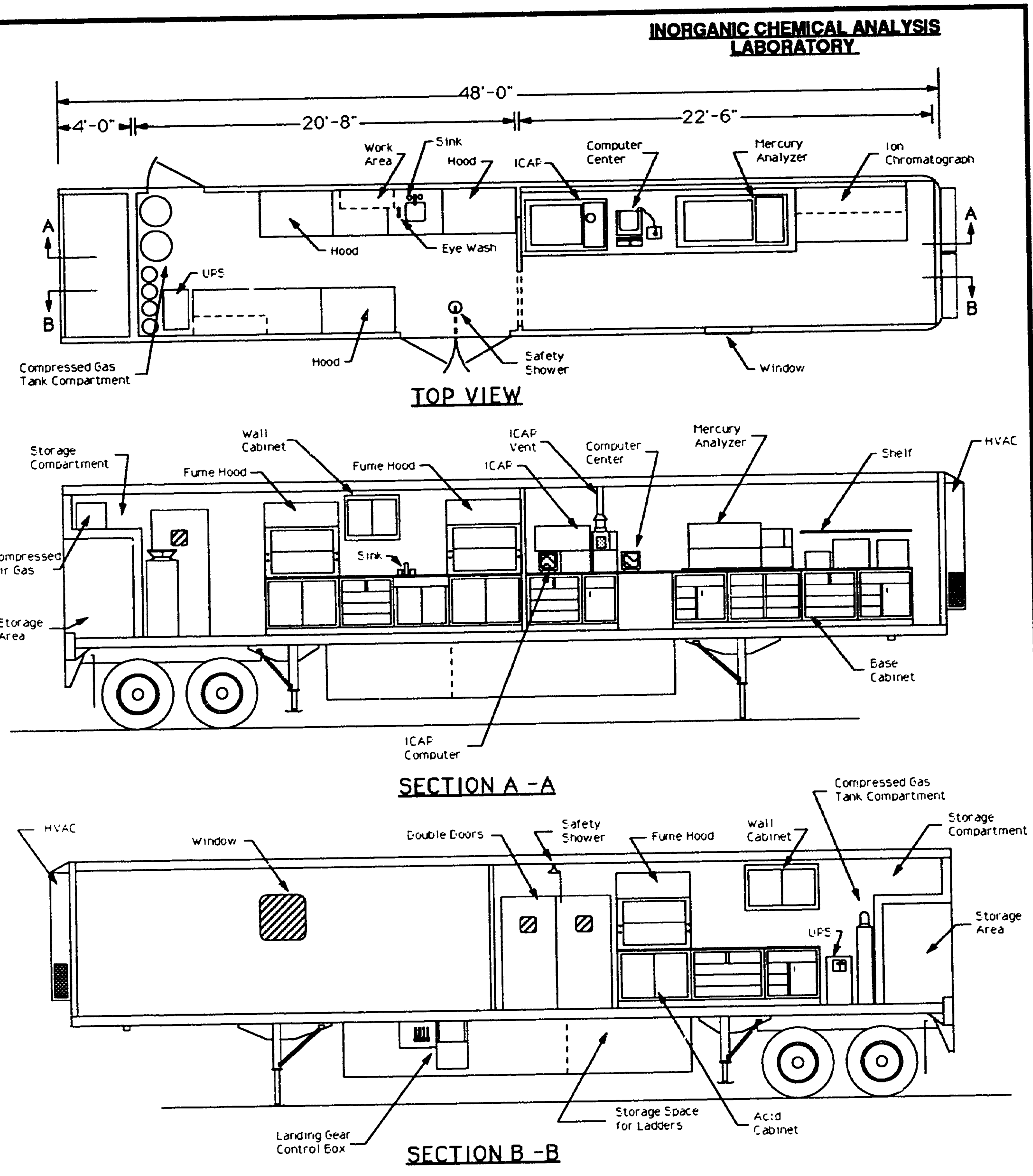

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Figure 14. Inorganic Chemical Analysis Laboratory - Alternative Design

simultaneously conducted on the water of interest, affording a powerful integrated biological assessment measure of hazard. This measure can be used to prioritize sites for remediation, compare pre-treatment water with post-treatment water yielding insights into remediation efficacy, and provide long-term monitoring data for tracking trends in the potential hazards associated with contaminated environmental sites.

The Aquatic Biomonitoring Laboratory is designed to provide a controlled environment for performing the tests described above on-site. The laboratory is divided into three work rooms; the design determined to best meet the DOE's needs is shown in Figures 15a-c. Two of the spaces contain the equipment for the aquatic experiments; the third space is for computers and operational controls.

The entry door leads to the Control Room. This space contains the equipment necessary to support the experiments - computers to record all data, and operational controls for all systems within the laboratory. A doorway from the Control Room leads to the Main Diluter Room. This room contains two banks of test animal tanks arranged along the walls. These banks are fed from two wall-hung diluters, one for each set of tanks. This room also contains the diluter used to feed the set of tanks in the Ventilatory Monitor Room.

The Ventilatory Monitor Room is entered through a doorway from the Main Diluter Room. In addition to another set of test tanks, this room also contains equipment to aerate, filter and control the temperature of the entering test waters. It also contains an autosampler connected to the test water feed lines.

Filtered air is fed into the laboratory in the Control Room. It then flows through the Main Diluter Room and, finally, into the Ventilatory Monitor Room. The air from the Ventilatory Monitor Room is filtered to remove volatile or particulate contaminants and either discharged or recycled. This maintains a safe breathing atmosphere within the laboratory and prevents cross-contamination by airborne contaminants. This air flow pattern also helps in maintaining very fine temperature control since the entering air has ample time to mix and equilibrate with air already in the laboratory before it enters the diluter rooms.

The laboratory has external connections to accept three water sources as feeds to the diluters. Two of these sources are normally test waters. For example, they could be groundwater without any treatment and groundwater which has been treated to remove contamination. In this way, parallel experiments can be conducted to determine the effectiveness of alternative remediation treatments in reducing hazard at minimum cost. The third water source would normally be "clean" water used for diluting the test waters. In this way, parallel tests can be conducted using different concentrations of test waters in the animal holding tanks. Each of these water sources is piped to each of the three diluter boards. The diluter boards control the dilution and feed rate of the test waters to each of the animal test tanks.

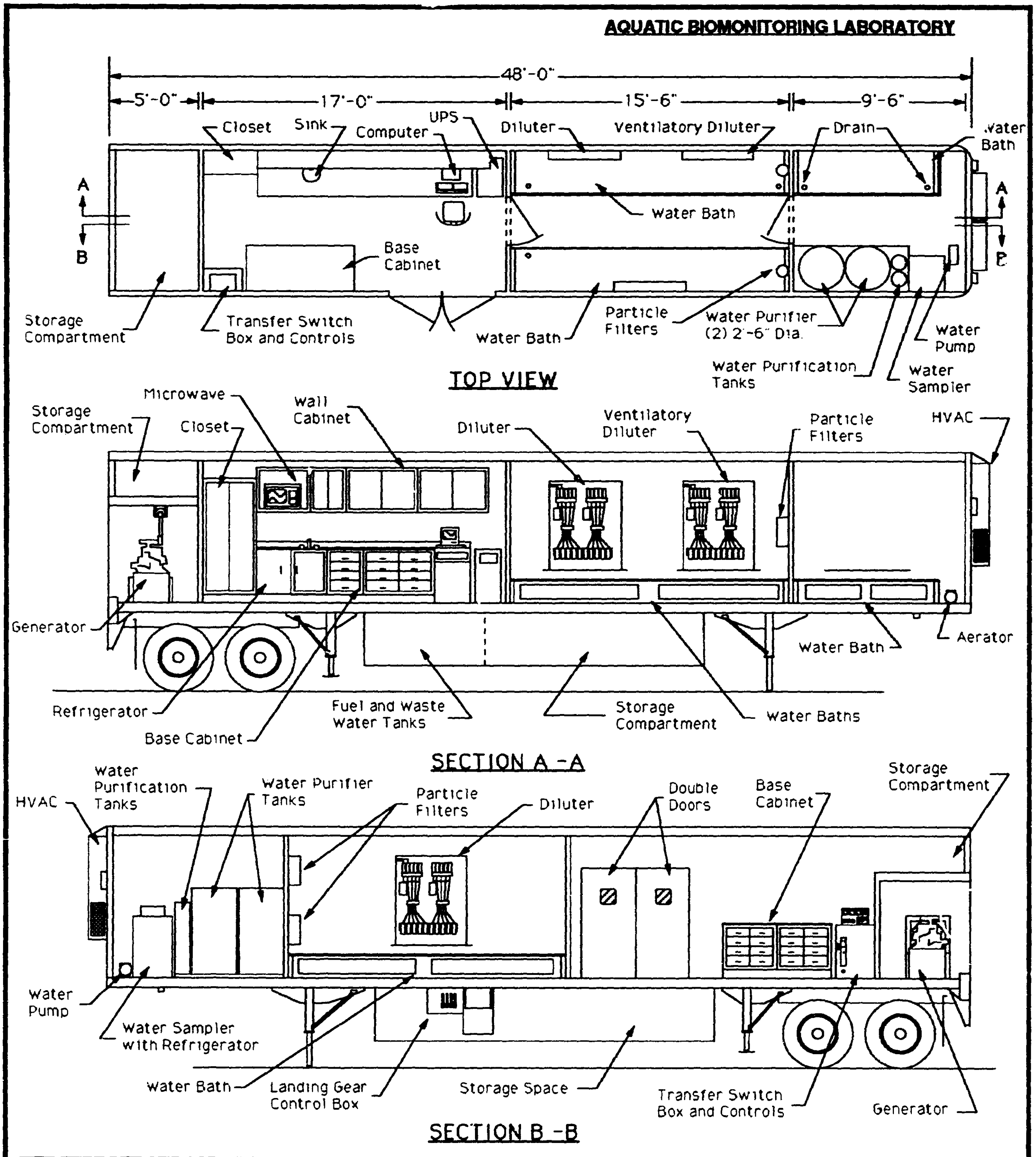

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Figure 15a. Aquatic Biomonitoring Laboratory - Interior Views

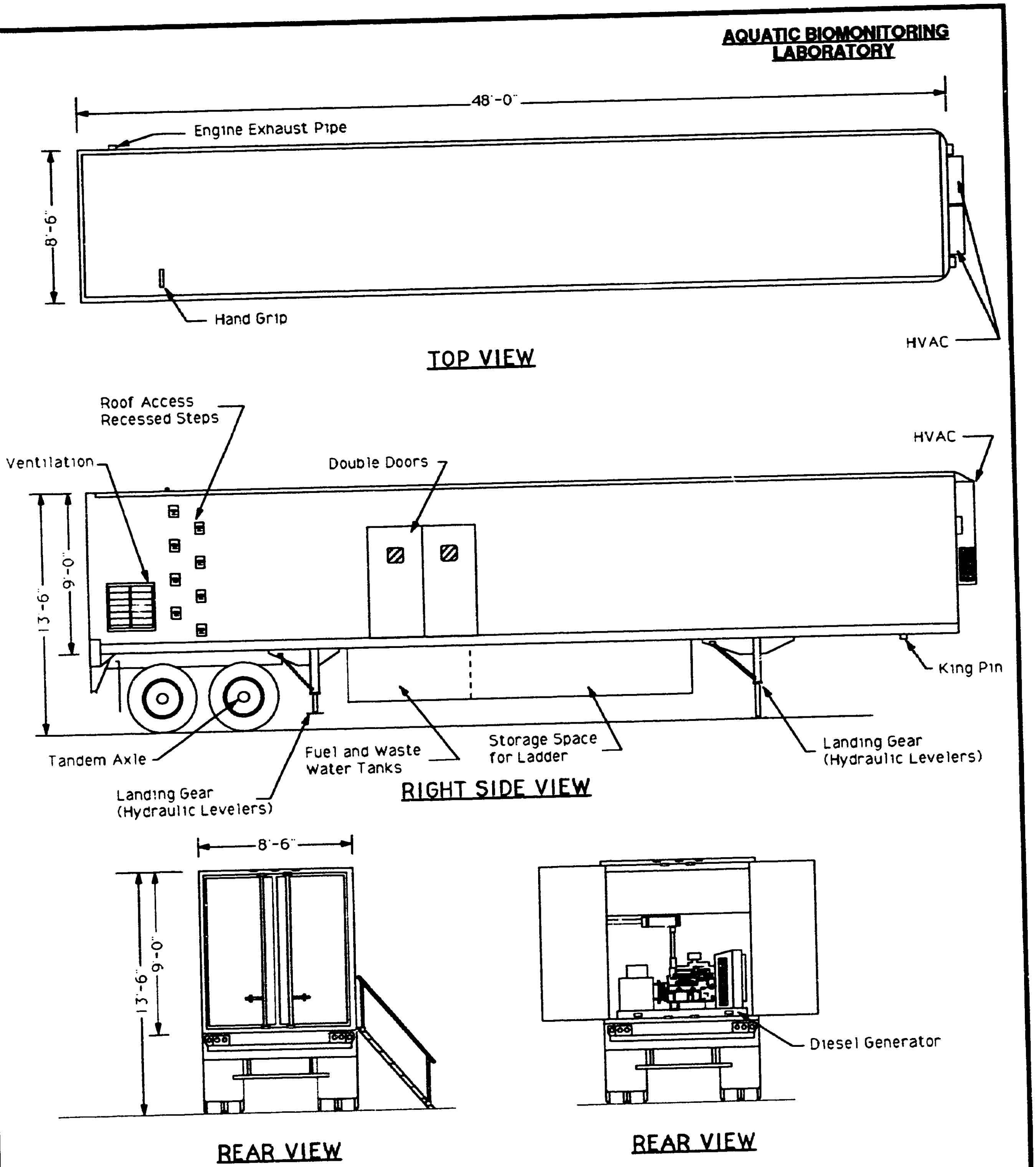

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Figure 15b. Aquatic Biomonitoring Laboratory - Exterior Views

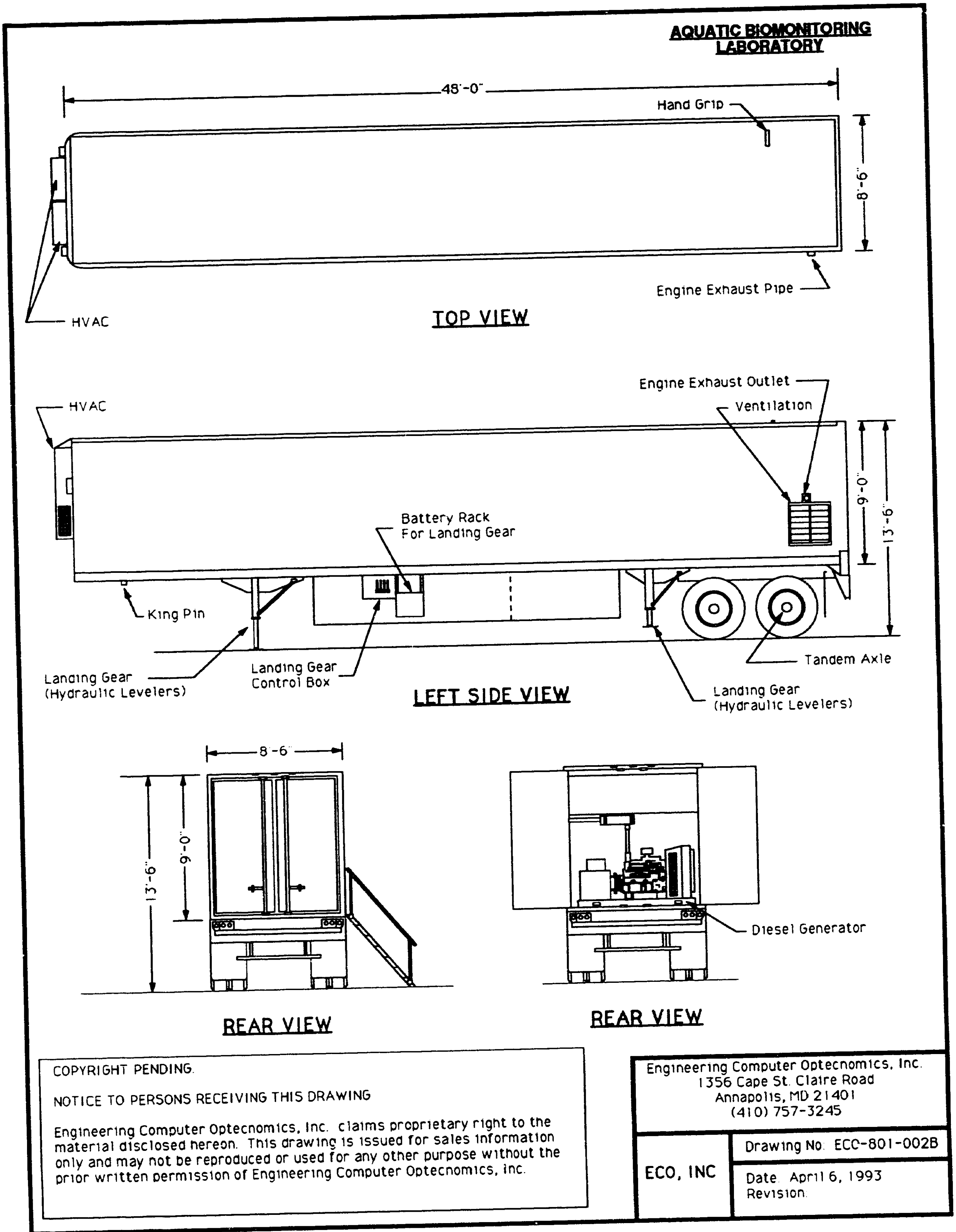

Figure 15c. Aquatic Biomonitoring Laboratory - Exterior Views

All control valves are located within the laboratory. The entering waters are temperature equilibrated through large tanks located in the Ventilatory Monitor Room. Dilution water is also cleaned through particulate and carbon filters and is aerated.

The Aquatic Biomonitoring Laboratory module has an integral electrical generator, HVAC system, fuel tank, wastewater holding tank, potable water tank, hydraulic leveling legs for use on uneven terrain, and enclosed storage space under the module.

The laboratory's HVAC system consists of a set of two parallel heat pumps to maintain the interior temperature within ±2°C over a wide range of outside temperatures. The use of two heat pumps provides a number of special advantages. First, in moderate temperatures, only one heat pump is required. The use of a single smaller heat pump prevents frequent on-off cycling which shortens the life of the system and can contribute to vibration problems. In more extreme outside temperature conditions, both heat pumps operate in parallel, providing fine temperature control.

Minimizing vibration was a special concern in the design and construction of the Aquatic Biomonitoring Laboratory. One of the test parameters measured in the laboratory is the activity of fish in specialized test chambers. Altered fish activity, i.e. less frequent or slower movement of the test organisms, is an indicator of contamination in the test water. This parameter is a very sensitive, rapid indicator of sub-lethal levels of contamination. However, accurate measurement of organism activity requires an exceedingly low level of background vibration. For this reason, the heat pumps are sized to minimize cycling, which would contribute to vibration. In addition, all the mechanical equipment (electrical generator, pumps, etc.) are carefully vibration mounted.

Figure 16 shows the same basic arrangement as the recommended arrangement (Figures 15a-c) except that the onboard electrical generator is eliminated. Power would be provided by a central electrical generator. As discussed earlier, this arrangement was determined to have significant drawbacks in terms of overall system reliability and logistical support.

Figure 17 shows another alternative configuration which was considered but determined to be less effective than the preferred design. In this alternative configuration, the Ventilatory Monitor Room is enlarged and the Control Room is made smaller. This design would work but it was determined that it would not be as efficient as the recommended option (Figures 15a-c).

Operations Control Center

As shown in Figure 2, the interconnecting walkways from the laboratory modules converge to the Operations Control Center. The recommended design for this module is shown in Figures 18a-c. The entrance to the Operations Control Center contains a frisking

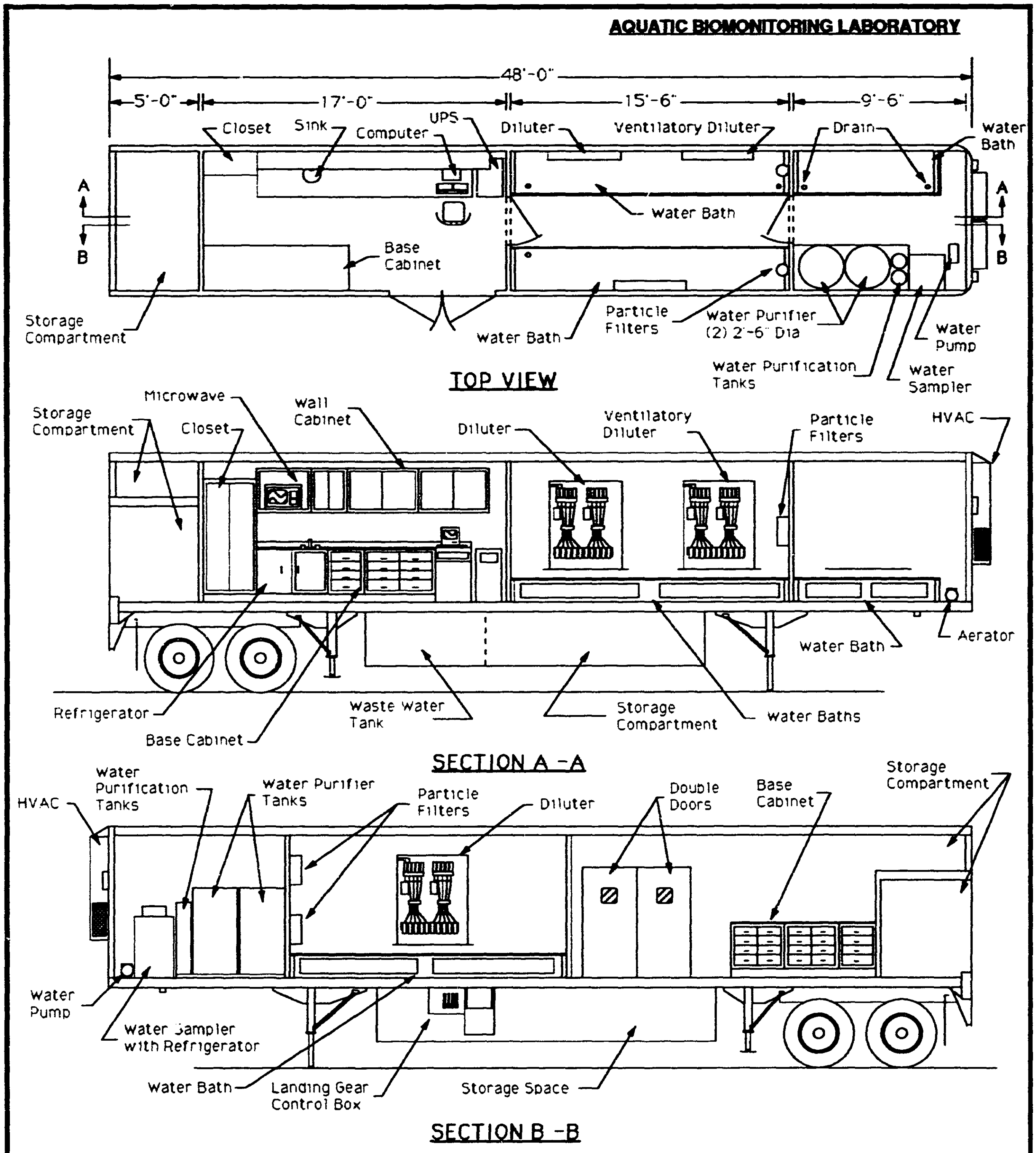

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Figure 16. Aquatic Biomonitoring Laboratory - Alternative Design 1

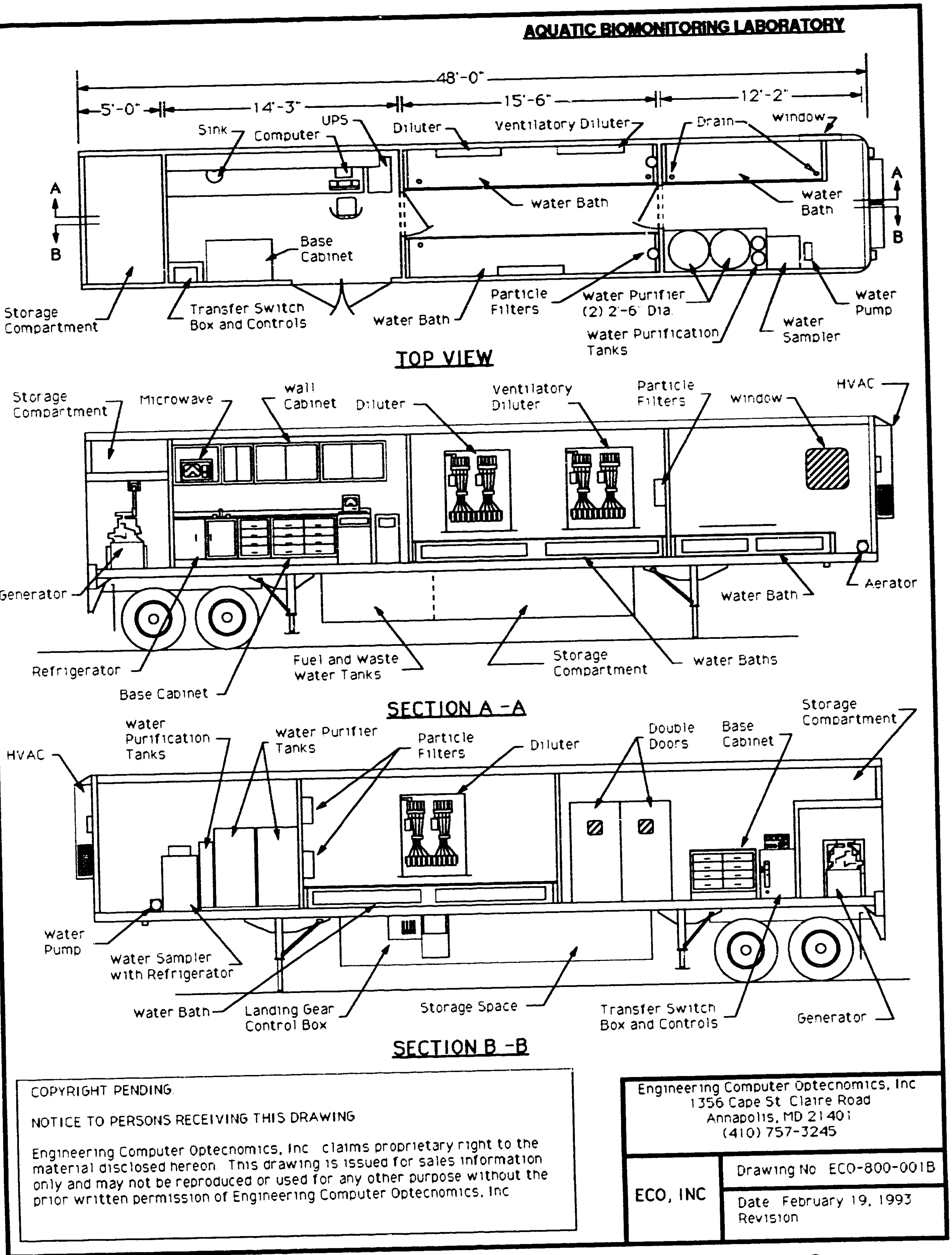

Figure 17. Aquatic Biomonitoring Laboratory - Alternative Design 2

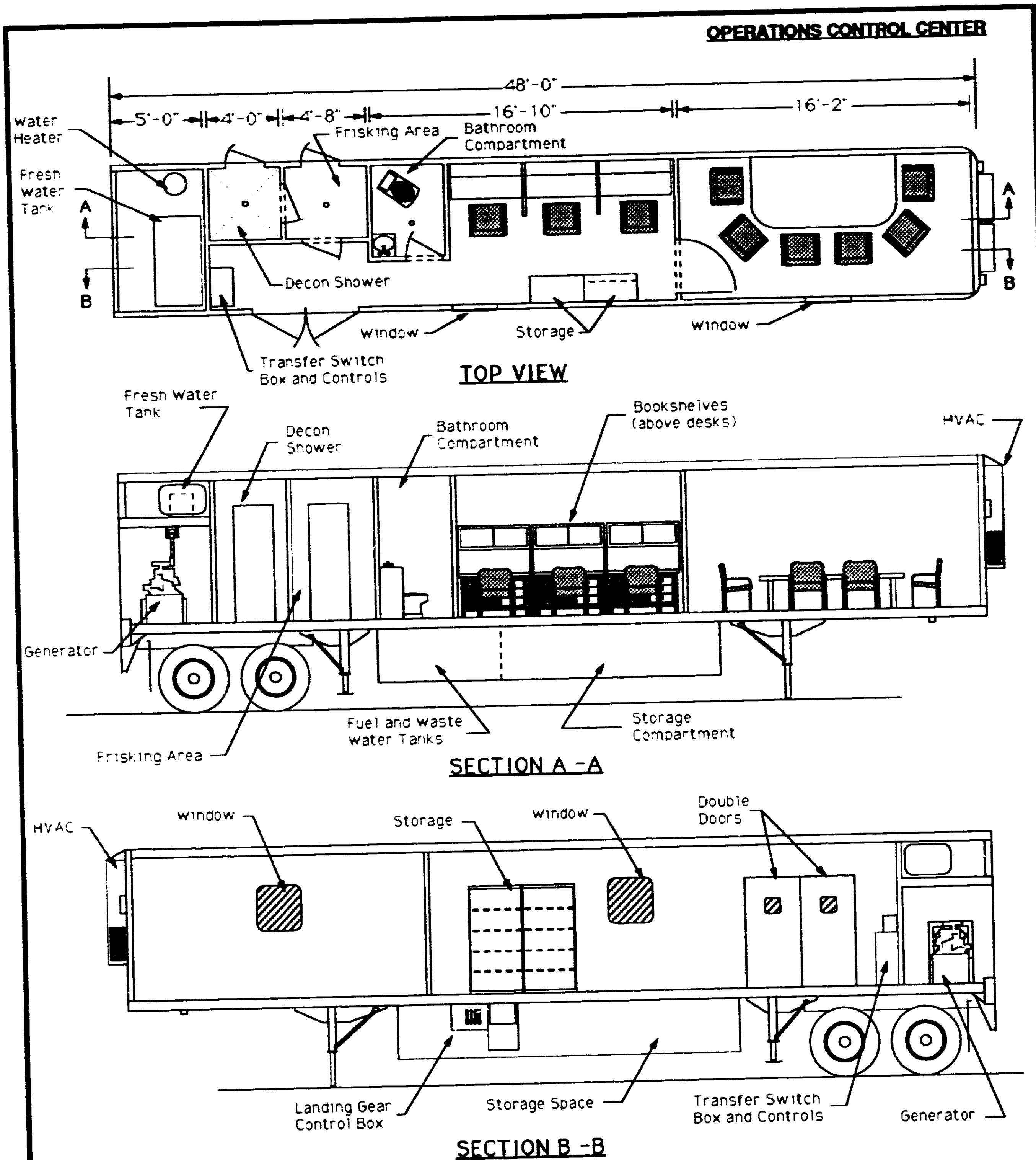

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Figure 18a. Operations Control Center - Interior Views

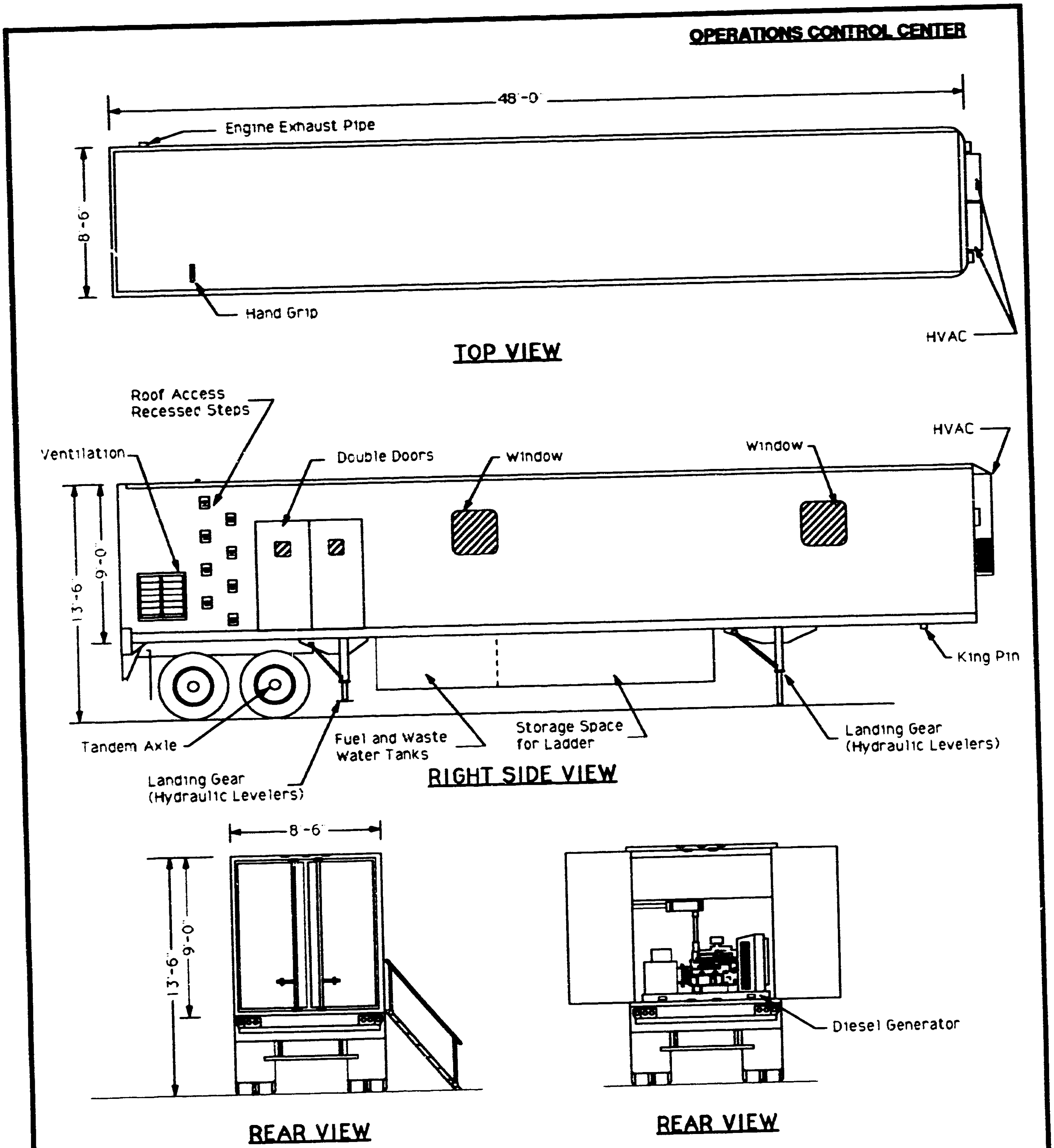

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Figure 18b. Operations Control Center - Exterior Views

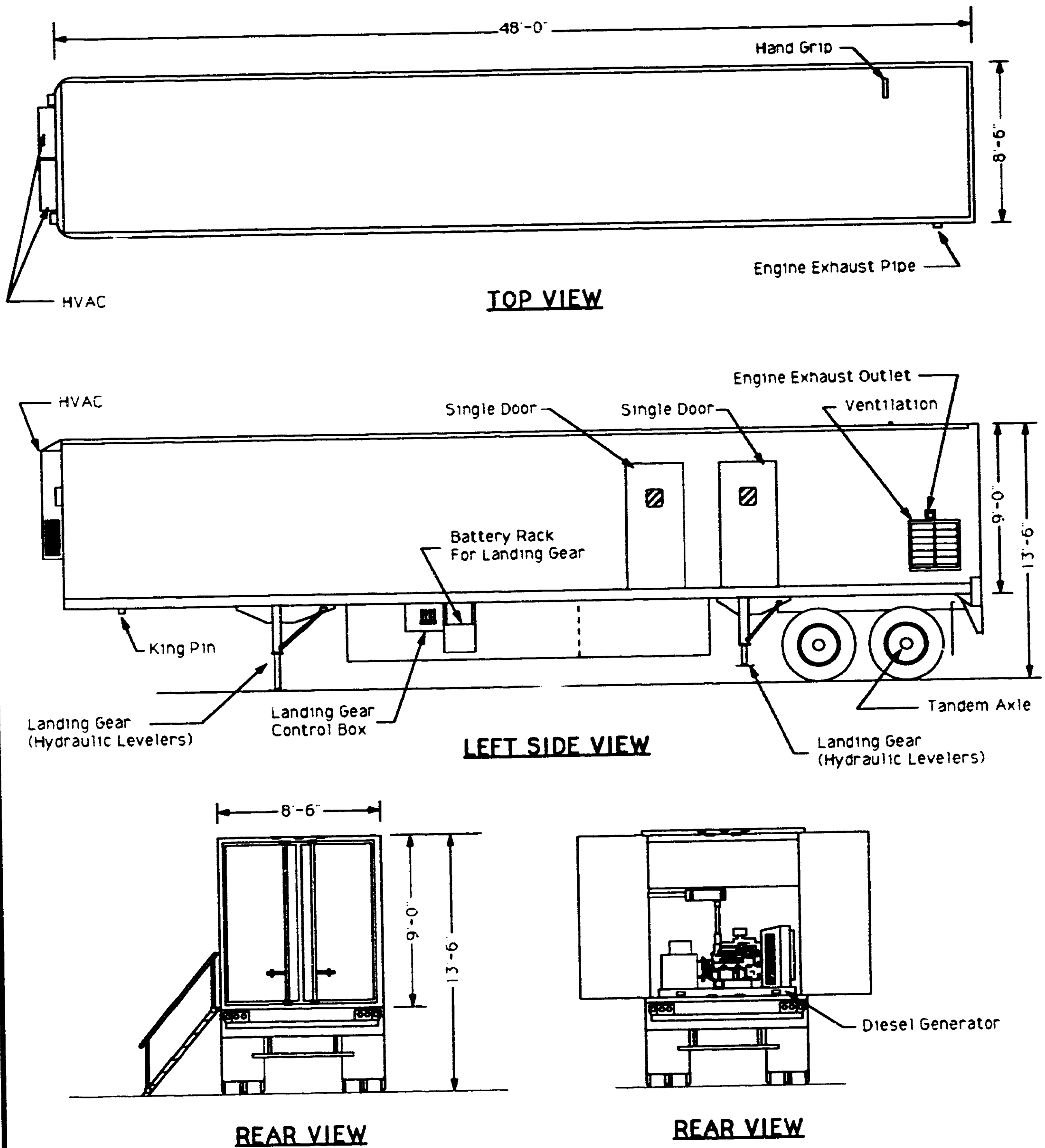

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Figure 18c. Operations Control Center - Exterior Views

station to ensure that all entering personnel are free of contamination, as shown in Figure 18a. If contamination is found, a decontamination shower is located adjacent to the frisking station with a direct entry door. The decontamination shower can also be entered directly from the outside for situations where contamination is known to have occurred. All personnel leaving the grouping of laboratory modules must go through the Operations Control Center. An additional set of doors to the "clean" side of the complex (away from the laboratory modules) is provided on the opposite side of the Operations Control Center. Thus, the final frisking station and decontamination shower in the Operations Control Center provide insurance against radioactively contaminated personnel inadvertently leaving the compound.

The Operations Control Center also contains three work stations for the system operators and a small meeting room with a conference table. Since many of the analyses can be automated and the modules' computers will be interconnected by a Local Area Network (LAN), the operators can work in the Operations Control Center and still maintain oversight and control over the operations in the other modules. The Operations Control Center will also contain a restroom for the convenience of the operators, an important consideration when the RTAL is stationed far from support buildings.

The Operations Control Center module has an integral electrical generator, HVAC system, fuel tank, wastewater holding tank, potable water tank, hydraulic leveling legs for use on uneven terrain, and enclosed storage space under the module.

Figure 19 shows an alternative configuration for the Operations Control Center. This design does not include the decontamination shower but does allow for frisking in the entrance area to the module. Instead of the shower, a storage compartment is provided. In other respects this design is similar to the recommended configuration. The decontamination shower is considered an important feature of the RTAL since it increases personnel protection, especially in emergency situations where someone has become contaminated with radioactive material. While decontamination showers are provided in the RTAL near the contaminated area, it was felt that an additional shower at the other end of the complex would be very desirable.

A second alternative design for the Operations Control Center is shown in Figure 20. This configuration provides increased storage area at the expense of one of the entrance doors. It also eliminates the onboard electrical generator, relying on a central generating system instead. While this configuration provides more storage area (an important consideration when deliveries of supplies are difficult) it was determined that this was less important than having the extra decontamination shower and frisking area.

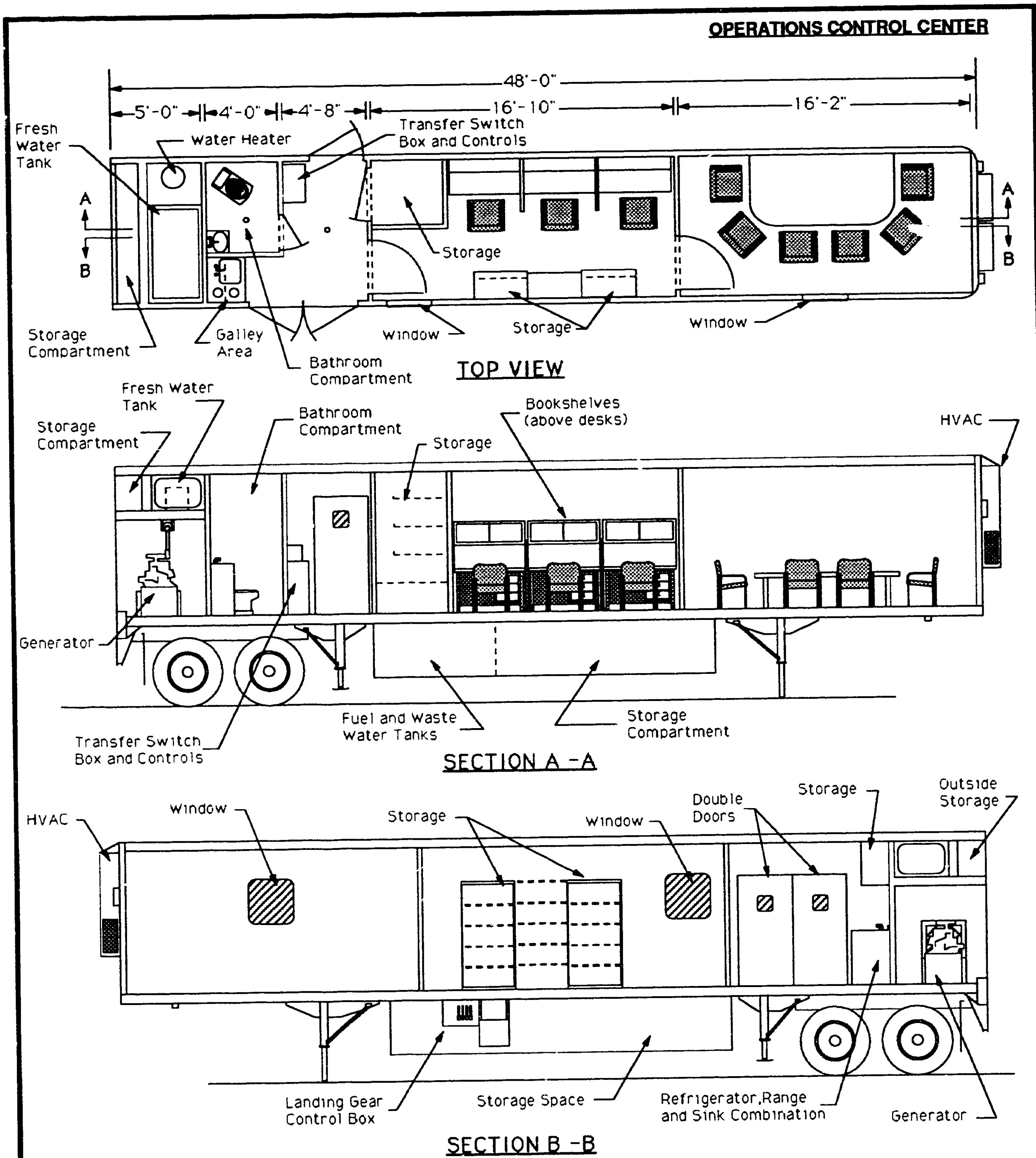

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Figure 19. Operations Control Center - Alternative Design 1

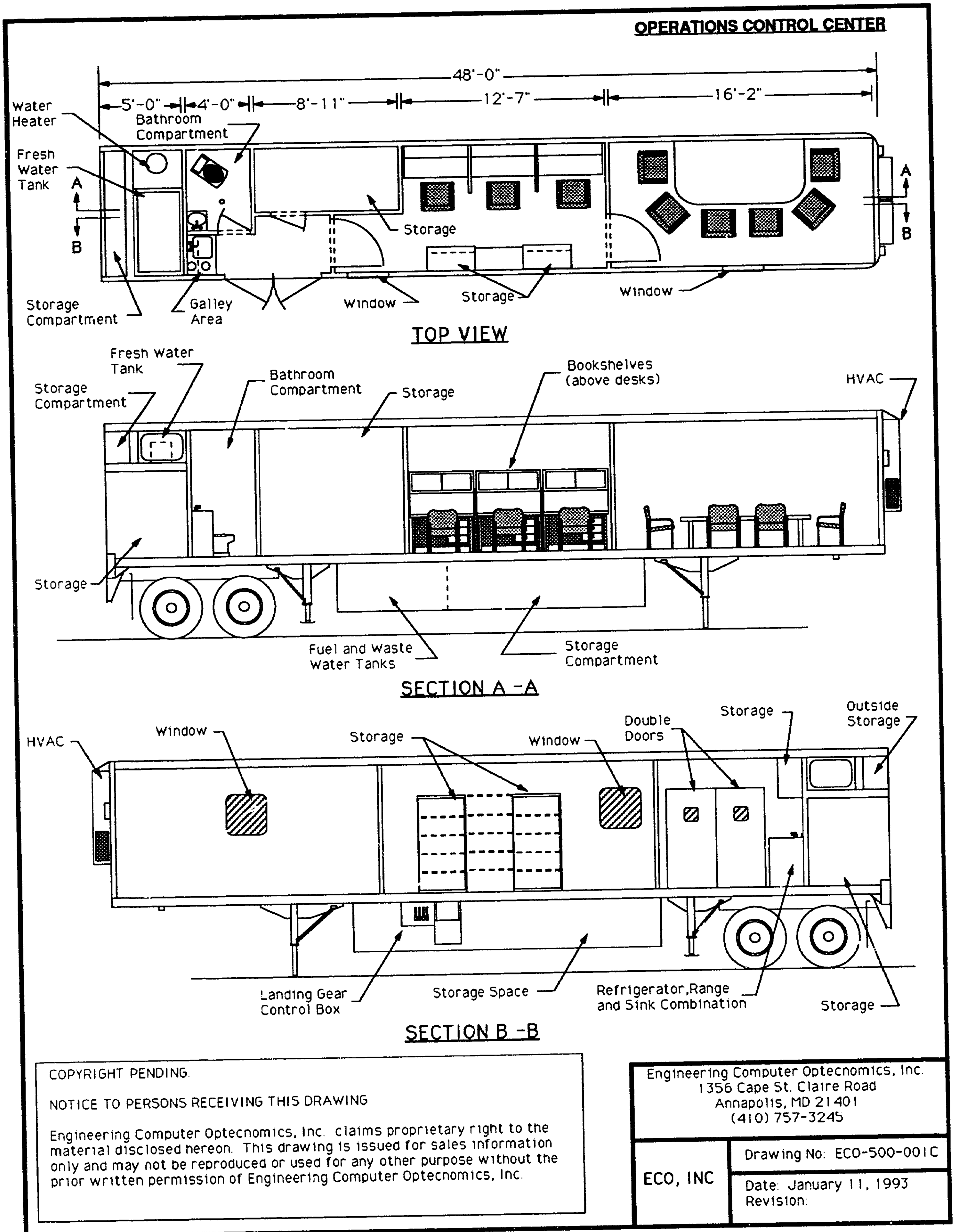

Figure 20. Operations Control Center - Alternative Design 2

Robotic Base Station

The Robotic Base Station is designed to support remotely controlled field operations at DOE facilities. These operations include field mapping for radioactive and chemical contamination, and remotely operated construction operations, e.g. digging to expose and remove buried contaminated materials.

The design that was determined to be best suited to the needs of the DOE is shown in Figures 21a-c. Figure 21a shows the interior layout of the module and Figures 21b and 21c show the exterior views. The Robotic Base Station is divided into a Control Room and a Robot Vehicle Storage Area. The main entrance into the module leads into the Control Room. This room contains bench-top work area for preparation of remotely operated monitoring instruments, including monitors for radioactive contaminants, volatile organics, and heavy metals; geographical positioning instrumentation to signal the exact location of the robotic equipment as it is mapping a contaminated area; and remotely operated television equipment for close-up views of the area under study. This room also contains large windows on both sides of the module providing wide area views to facilitate robotic operations. A second door opens into a personnel decontamination shower. Exterior wash-down equipment is provided to decontaminate the robotic equipment after it returns from a contaminated area. Thus, this module is designed for individual deployment, e.g. for initial area mapping, as well as deployment as part of the integrated RTAL complex. After decontamination, personnel and equipment must be frisked to be sure there is no residual contamination. A dressing room is provided adjacent to the personnel decontamination shower. A door from the shower leads directly into the dressing room and a second door leads from the dressing room into the main Control Room.

The Robot Vehicle Storage Area is located in the back of the module. Space is provided for two mobile robotic all-terrain vehicles. The monitoring and positioning instrumentation are mounted on these units; the specific monitors to be mounted depend on the type of operation to be performed. The robotic vehicles are driven out of the Vehicle Storage Area by ramps extending from the back of the Storage Area to the ground. The module's electrical generation system is also located in the Vehicle Storage Area.

Large robotically operated construction equipment, e.g. cranes and bulldozers, can also be operated from within this module's Control Room. However, these robotic systems would not be an integral part of the RTAL. They would be brought to the site on an as needed basis.

The Robotic Base Station module has an integral electrical generator, HVAC system, fuel tank, wastewater holding tank, potable water tank, hydraulic leveling legs for use on uneven terrain, and enclosed storage space under the module.

The main alternative design considered is shown in Figure 22. The main advantage of this configuration is the presence of

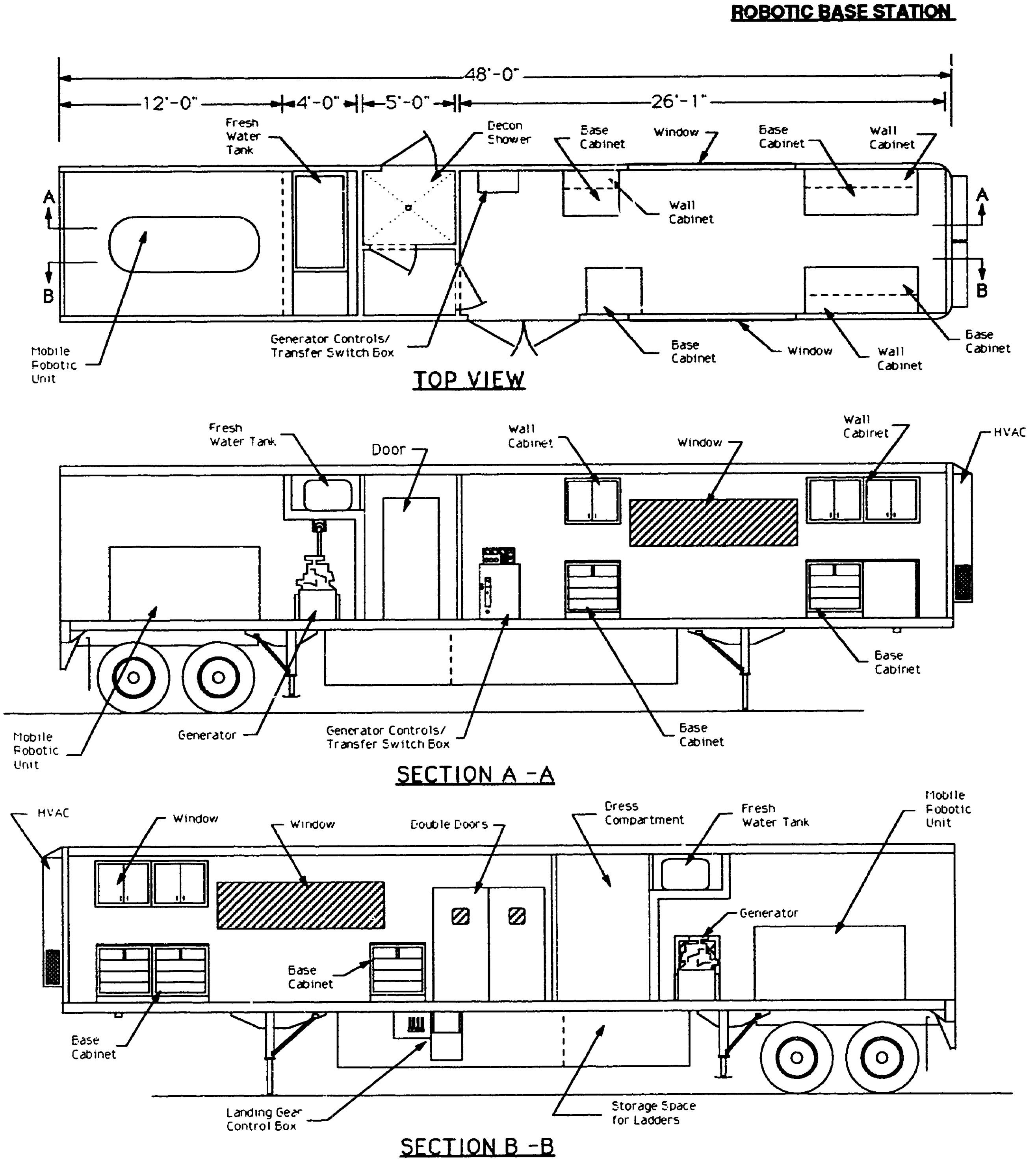

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Figure 21a. Robotic Base Station - Interior Views

ROBOTIC BASE STATION

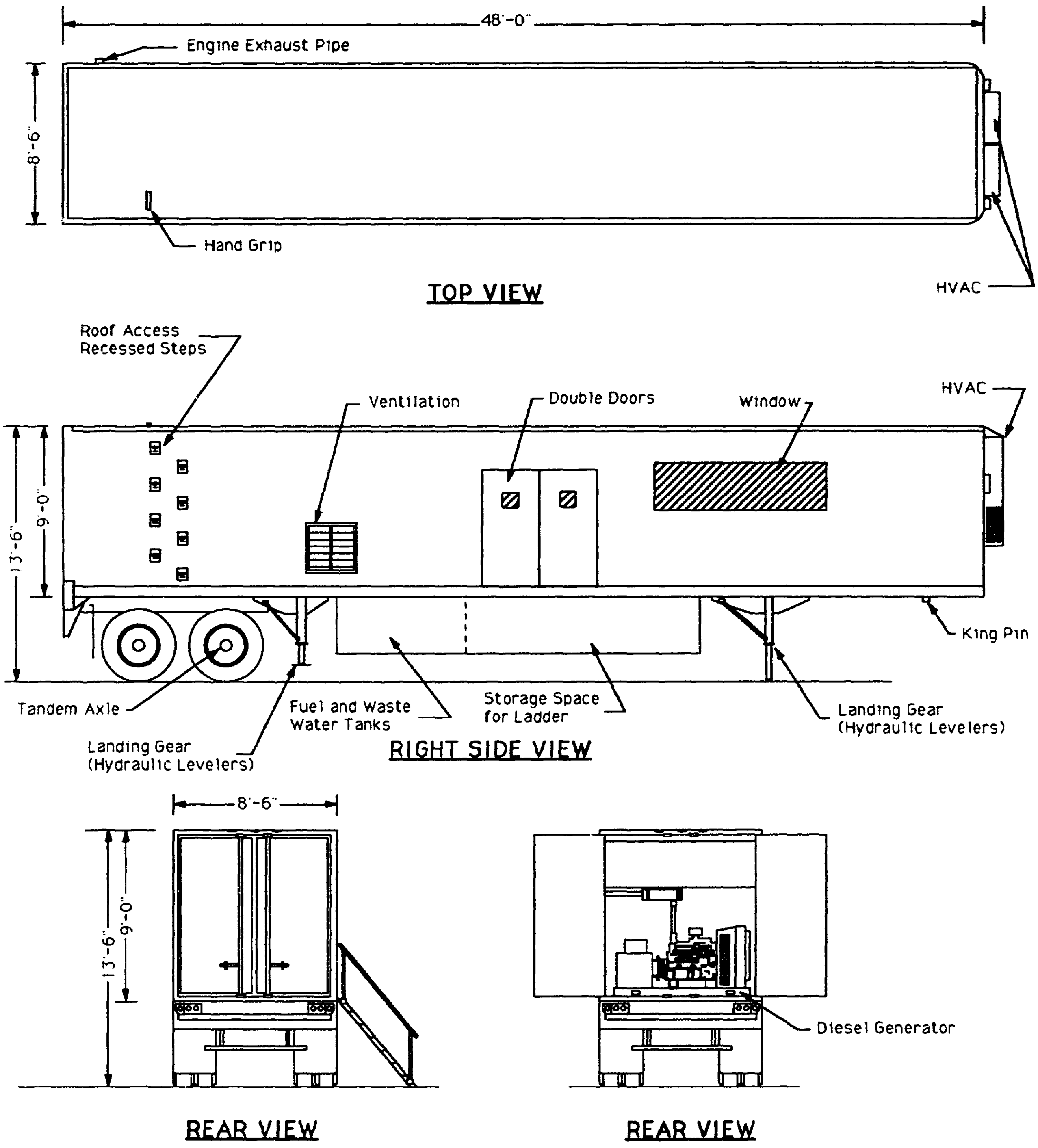

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Figure 21b. Robotic Base Station - Exterior Views

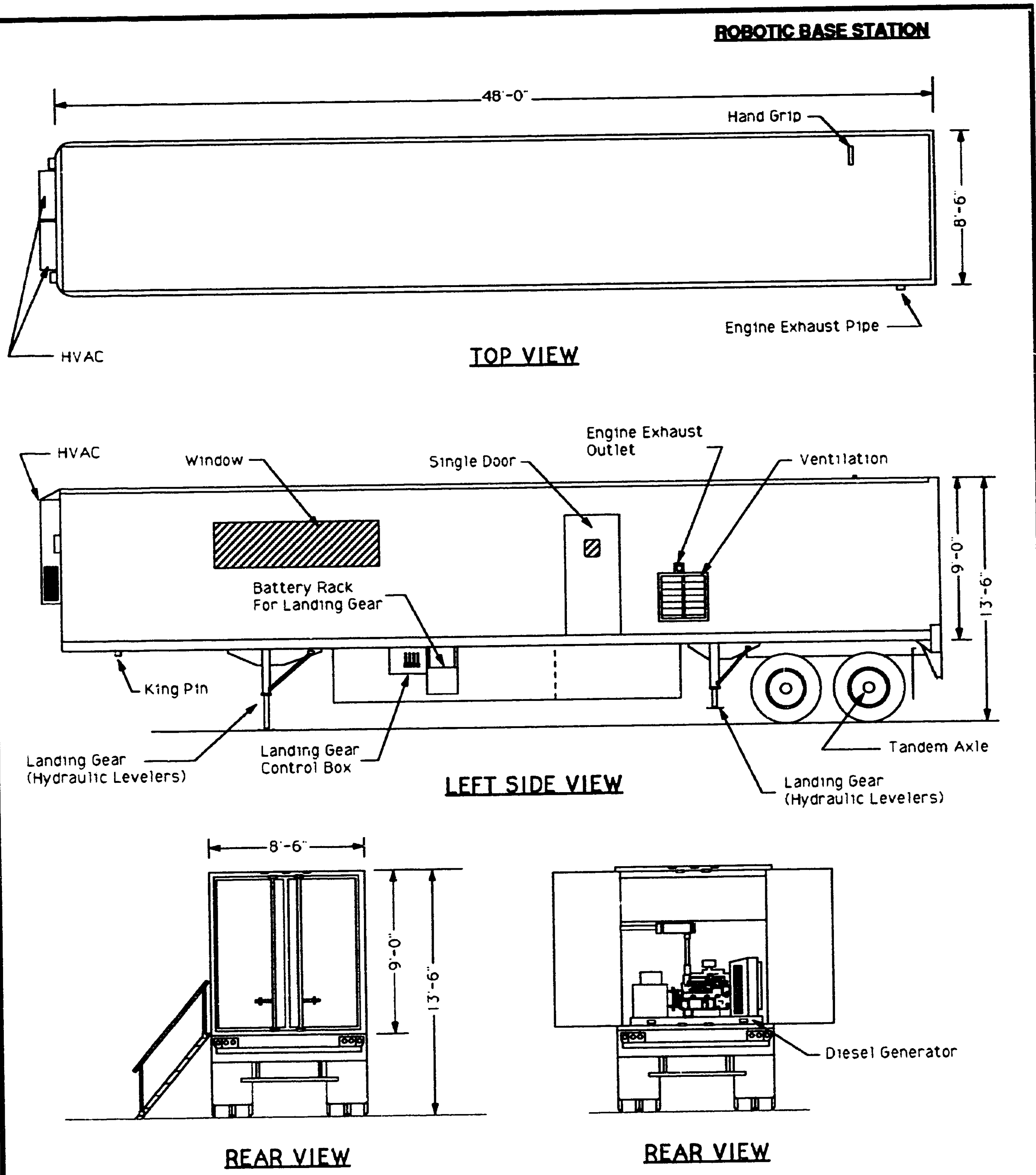

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Figure 21c. Robotic Base Station - Exterior Views

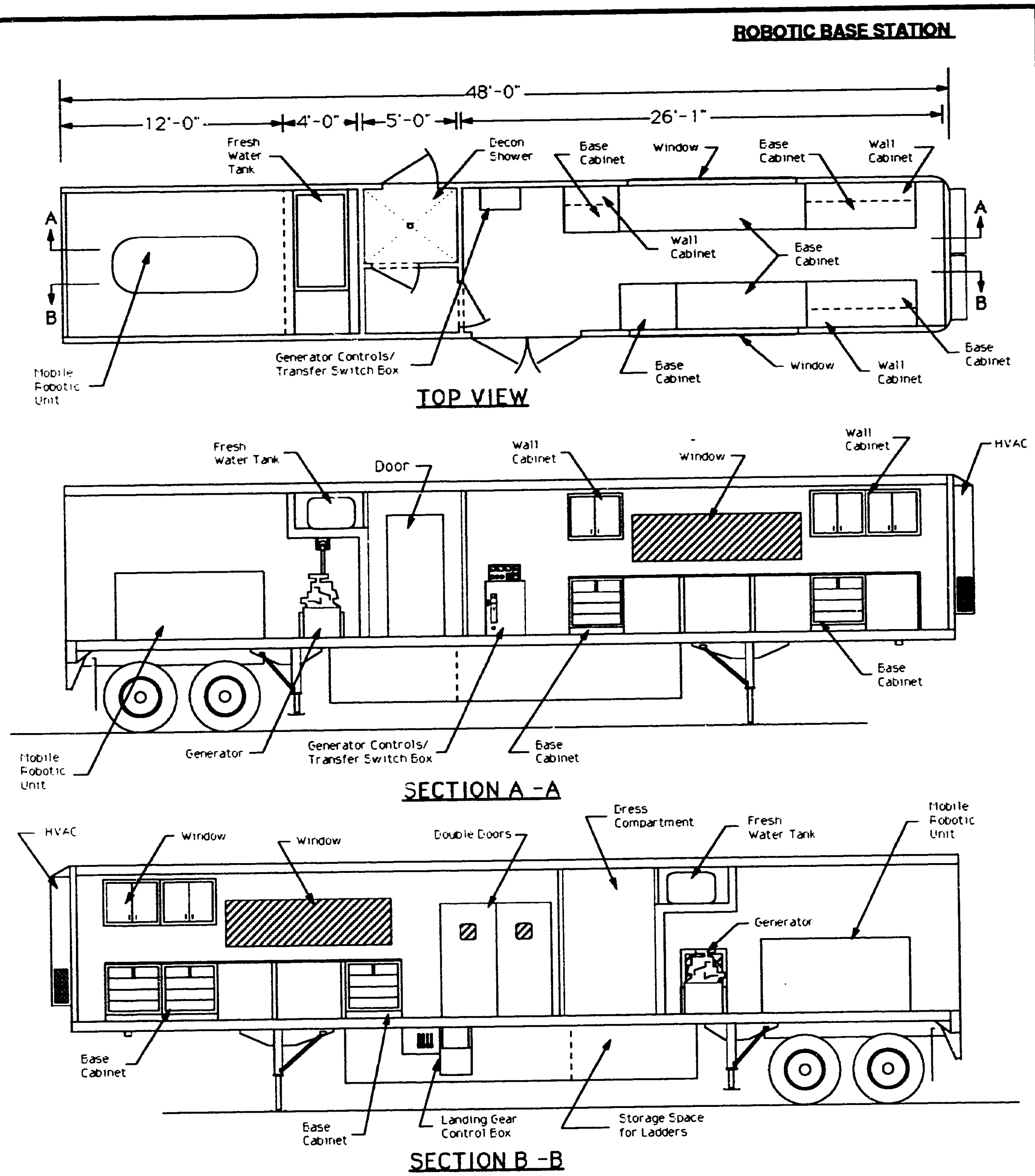

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Figure 22. Robotic Base Station - Alternative Design 1

additional benches in the Control Room. However, these additional benches would hinder access to the large windows provided for viewing the robotic operations. Although the robotic units are outfitted with television equipment, a direct view of their operation is very helpful in efficiently performing the necessary operations. Thus, it was felt that this design would not be as effective as the recommended configuration.

Figure 23 shows the same basic arrangement as the recommended configuration (Figures 21a-c) except that the onboard electrical generator is eliminated. Power would be provided by a central electrical generator. As discussed earlier, this arrangement was determined to have significant drawbacks in terms of overall system reliability and logistical support.

Field Analytical Laboratory

The Field Analytical Laboratory is designed to perform several critical functions:

- Maintenance, Calibration and Storage of Portable Radiation Sensors
- Maintenance, Calibration and Storage of Portable Chemical Contamination Sensors
- Maintenance and Calibration of the Modules' Contamination Monitors and Frisking Equipment

These operations are space intensive, requiring bench-tops, storage cabinets, and open-areas to efficiently perform the required functions. The Field Analytical Laboratory was designed to meet these needs.

The design that was determined to be best suited to the needs of the DOE is shown in Figures 24a-c. Figure 24a shows the interior layout of the module and Figures 24b and 24c show the exterior views. The Field Analytical Laboratory is divided into three rooms - a Radiation Equipment Room, a Chemical Equipment Room, and a Storage Room. The main entrance into the module leads into the Radiation Equipment Room. This room contains bench-top work area for maintenance and calibration of the portable sensors for radiation detection used within the RTAL area of operations. Specific health physics equipment carried in the Field Analytical Laboratory include a stationary Scintillation Counter for alpha and beta counting, a stationary gamma counter, and portable alpha/beta and gamma monitoring instruments. The Chemical Equipment Room, located adjacent to the Radiation Equipment Room, provides similar facilities needed for portable chemical sensors, e.g. portable gas chromatograph for volatile organic contaminants and portable X-ray fluorescence monitor for heavy metals. The Equipment Storage Room is located at the back of the module. It provides ample storage area for the portable field equipment. The storage cabinets are designed for the stored equipment to be quickly and securely tied down

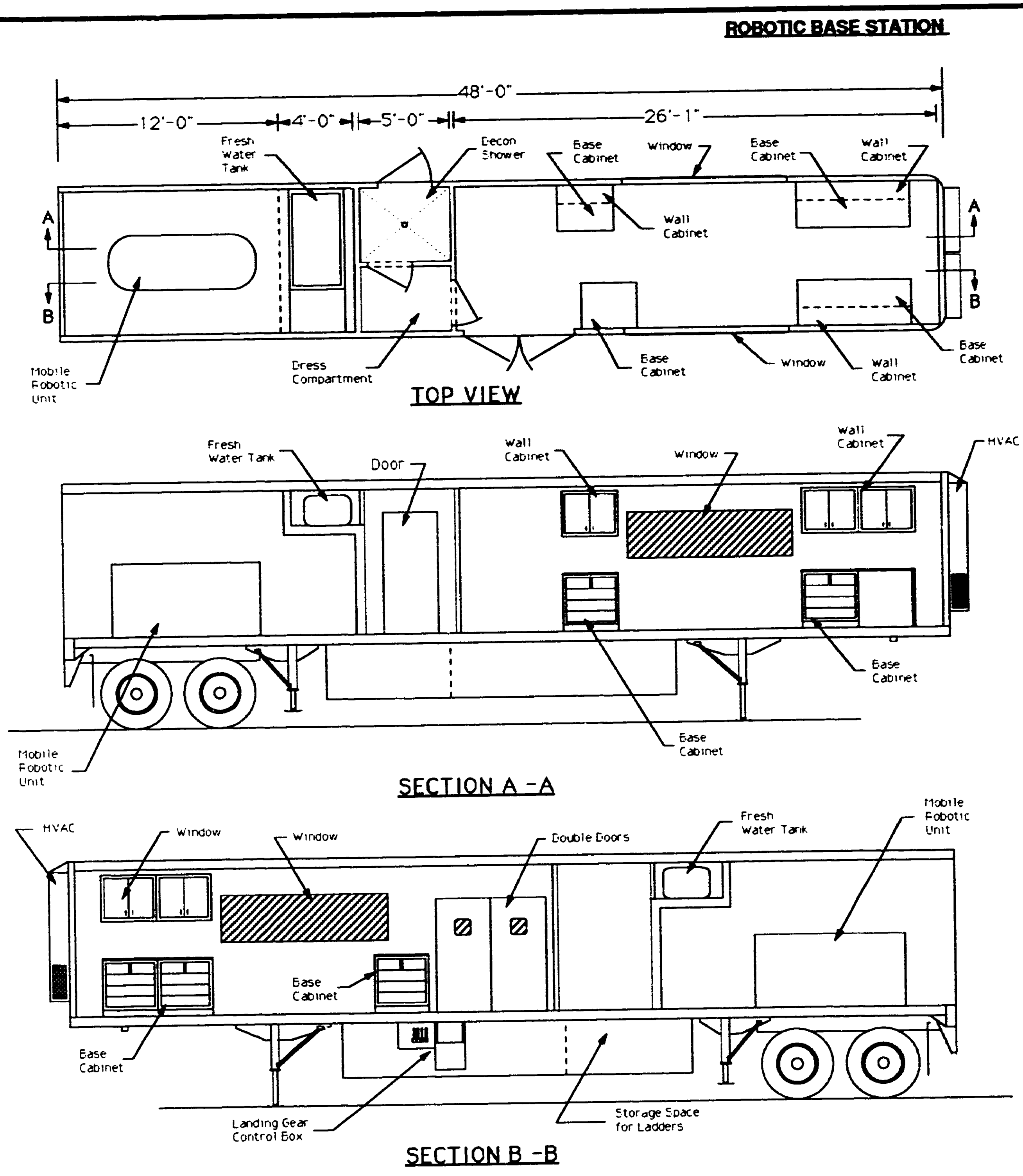

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Figure 23. Robotic Base Station - Alternative Design 2

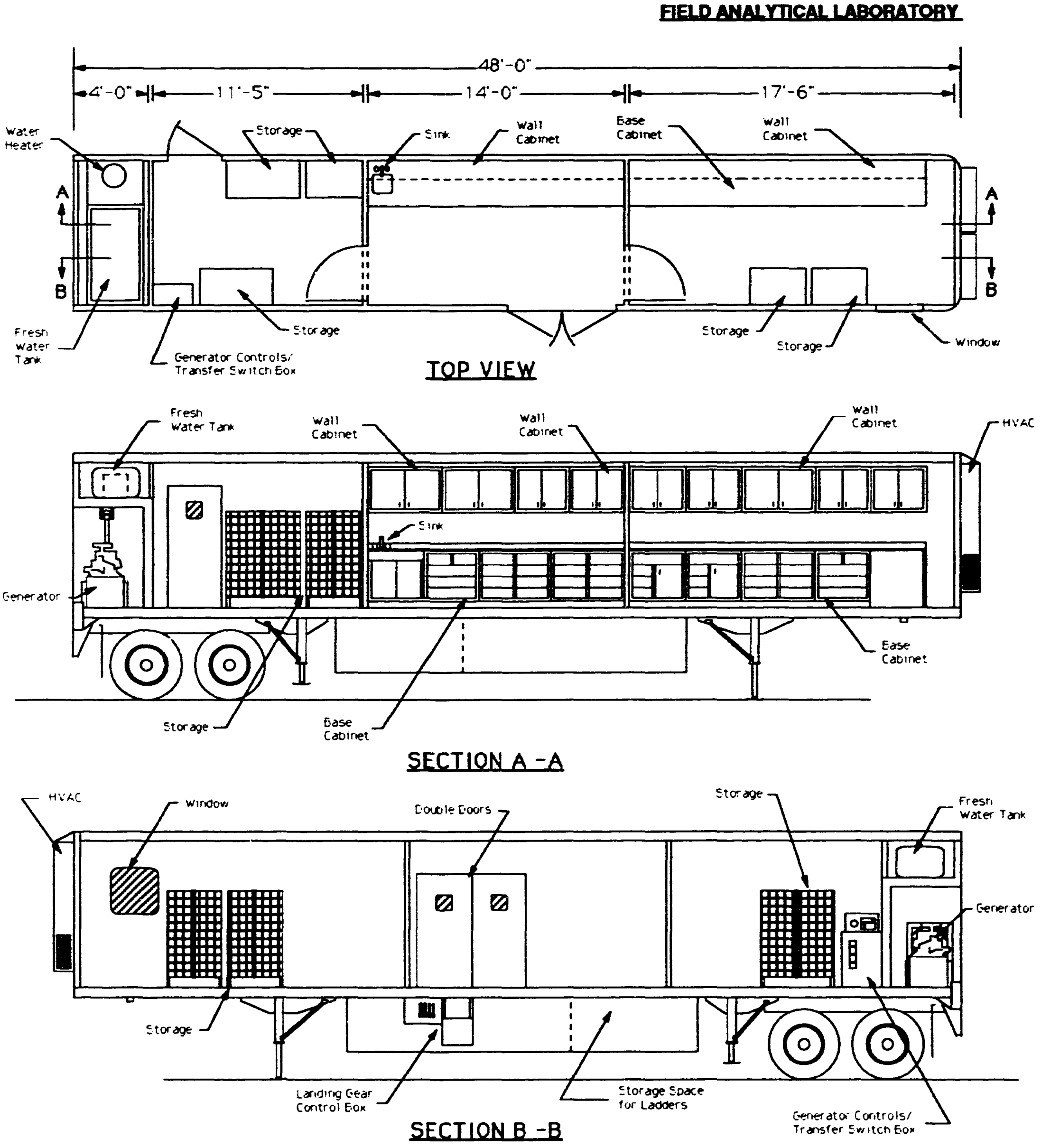

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Figure 24a. Field Analytical Laboratory - Interior Views

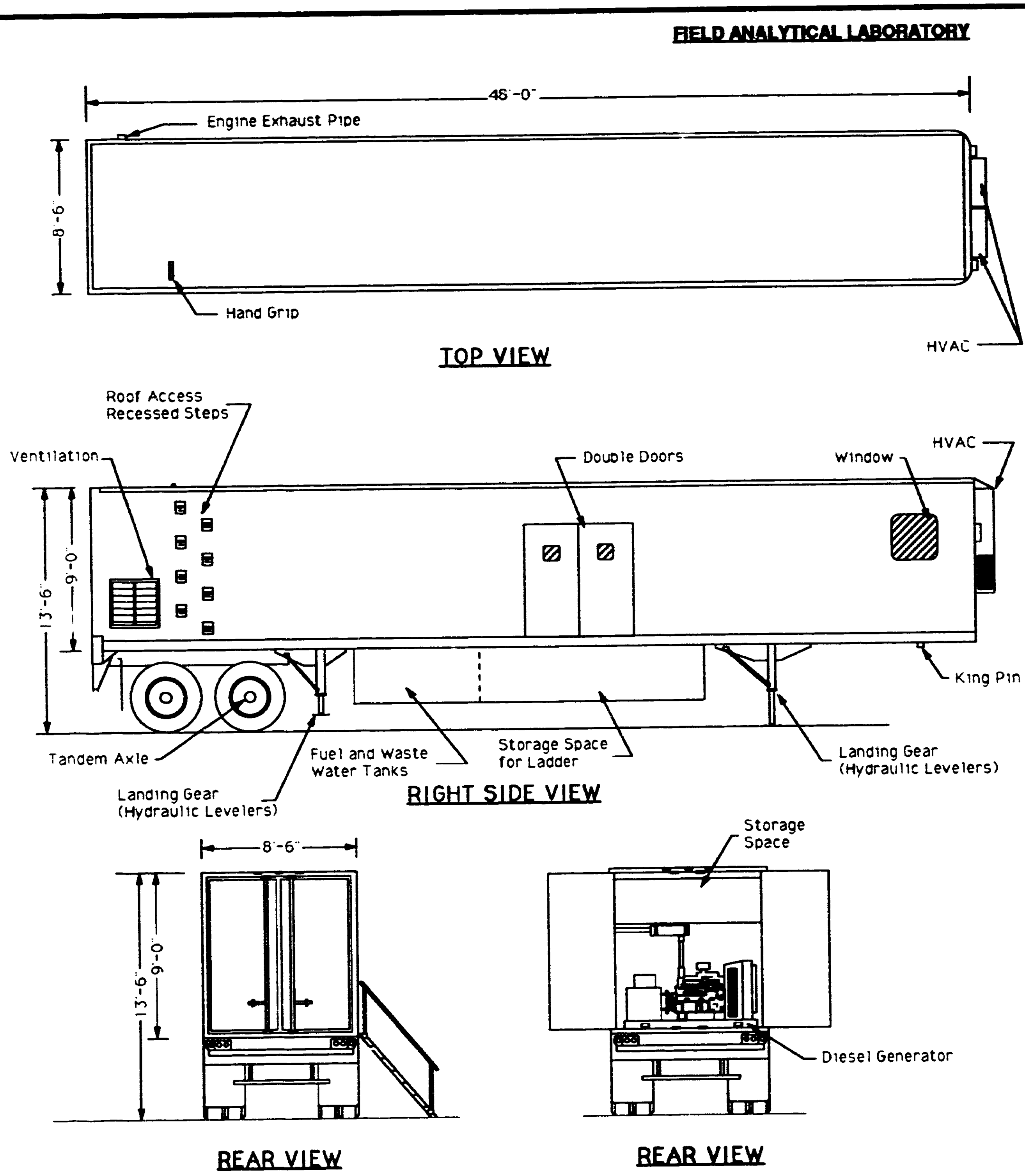

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Figure 24b. Field Analytical Laboratory - Exterior Views

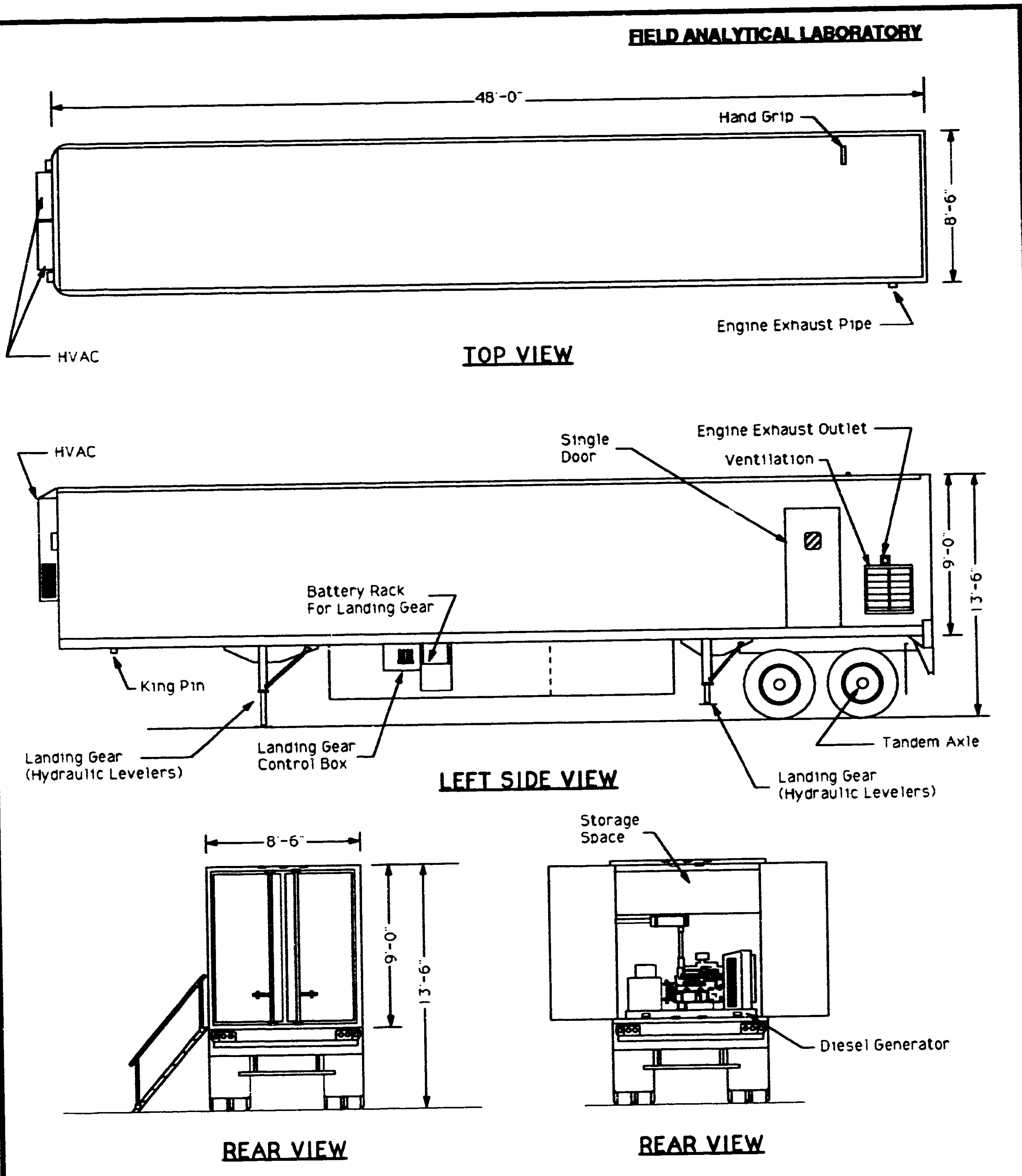

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Figure 24c. Field Analytical Laboratory – Exterior Views

during transport. A second door from the outside leads into this room to facilitate access to the stored equipment.

The Field Analytical Laboratory module has an integral electrical generator, HVAC system, fuel tank, wastewater holding tank, potable water tank, hydraulic leveling legs for use on uneven terrain, and enclosed storage space under the module.

The main alternative design considered is shown in Figure 25. The main difference in this configuration is the combining of the Radiation and Chemical Equipment Rooms into one large area. While there would be some synergism in that some maintenance tools and equipment (primarily electronic equipment) would be used for both the radiation and chemical portable sensors, it was determined that working on these two types of equipment would be more efficiently performed in separate rooms.

Figure 26 shows the same basic arrangement as the recommended configuration (Figures 24a-c) except that the onboard electrical generator is eliminated. Power would be provided by a central electrical generator. As discussed earlier, this arrangement was determined to have significant drawbacks in terms of overall system reliability and logistical support.

Protected Living Quarters

The final module, located behind the Operations Control Center is the Protected Living Quarters. This module provides support for personnel who must be at the site for extended periods. After visiting DOE sites and talking with personnel both at field activities and at headquarters, it became evident that the need for a Protected Living Quarters Module would be quite infrequent. Since it would not be included in most applications, it was shown with dashed lines in Figure 2. The RTAL system is being designed so that it can be included, however, it is recognized that in most cases it will not be needed.

The recommended design for the Protected Living Quarters module is shown in Figures 27a-c. Figure 27a shows the interior layout of the module and Figures 27b and 27c show the exterior views. The Protected Living Quarters is divided into a conference room, a kitchen area, a locker room, and bathroom and shower compartments. The main entrance into the module leads into the conference room. The kitchen area is entered through the conference room and is located at the front of the module. The locker room has a separate entrance from the outside and a door connecting it to the conference room. The bathroom and shower compartments are at the back of the module and are entered from the locker room.

The Protected Living Quarters module has an integral electrical generator, HVAC system, fuel tank, wastewater holding tank, potable water tank, hydraulic leveling legs for use on uneven terrain, and enclosed storage space under the module.

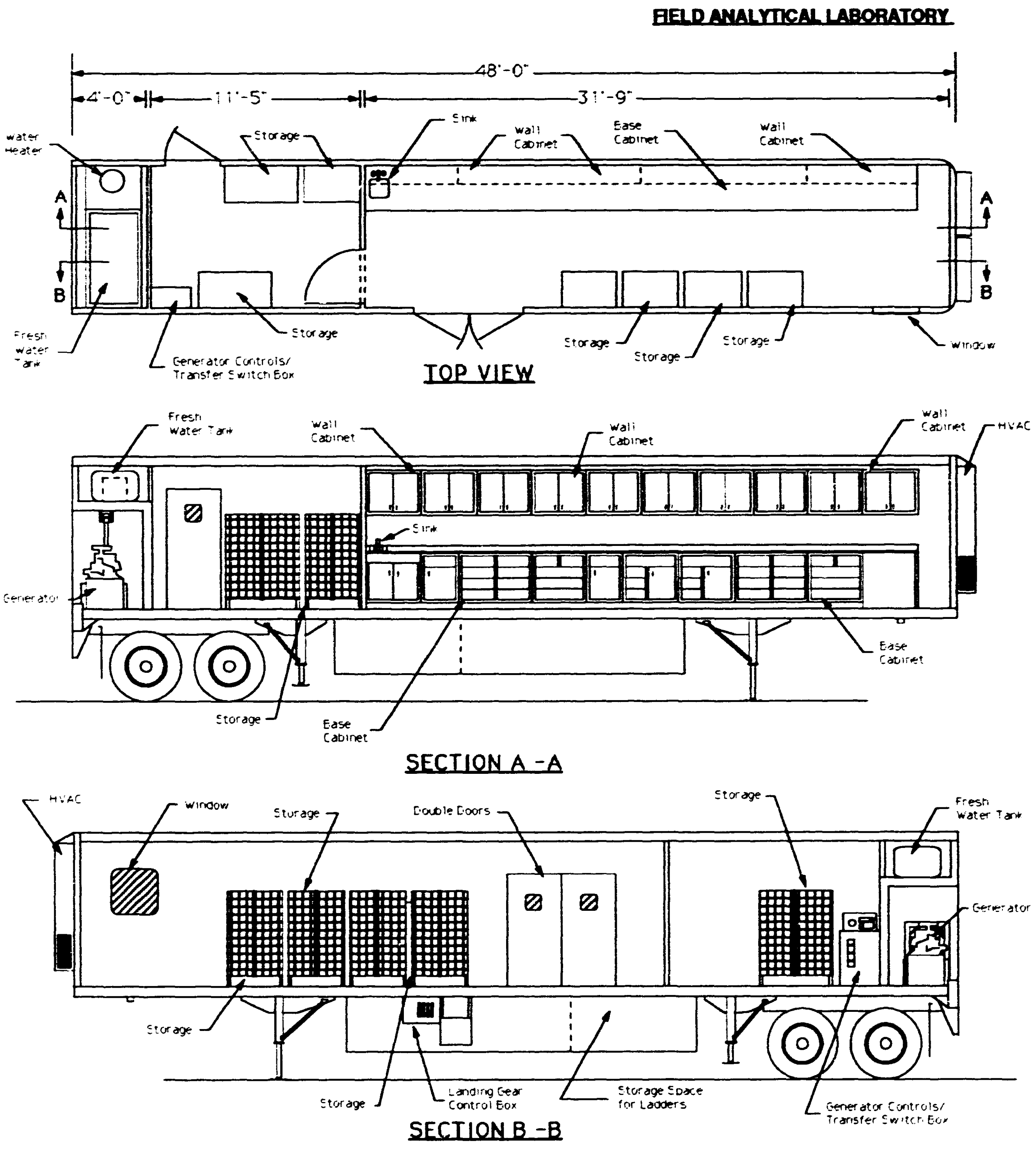

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Figure 25. Field Analytical Laboratory - Alternative Design 1

FIELD ANALYTICAL LABORATORY

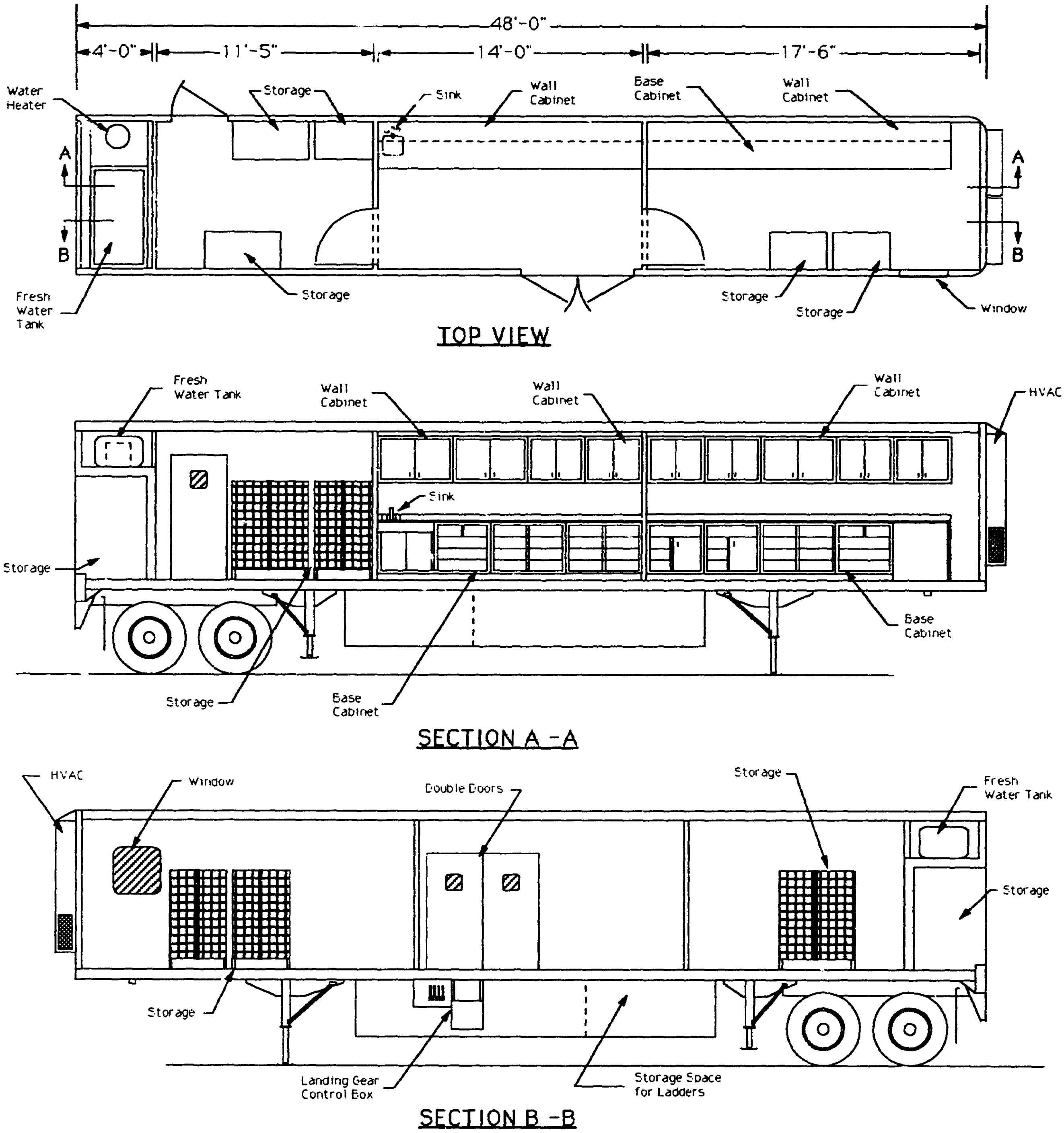

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Figure 26. Field Analytical Laboratory - Alternative Design 2

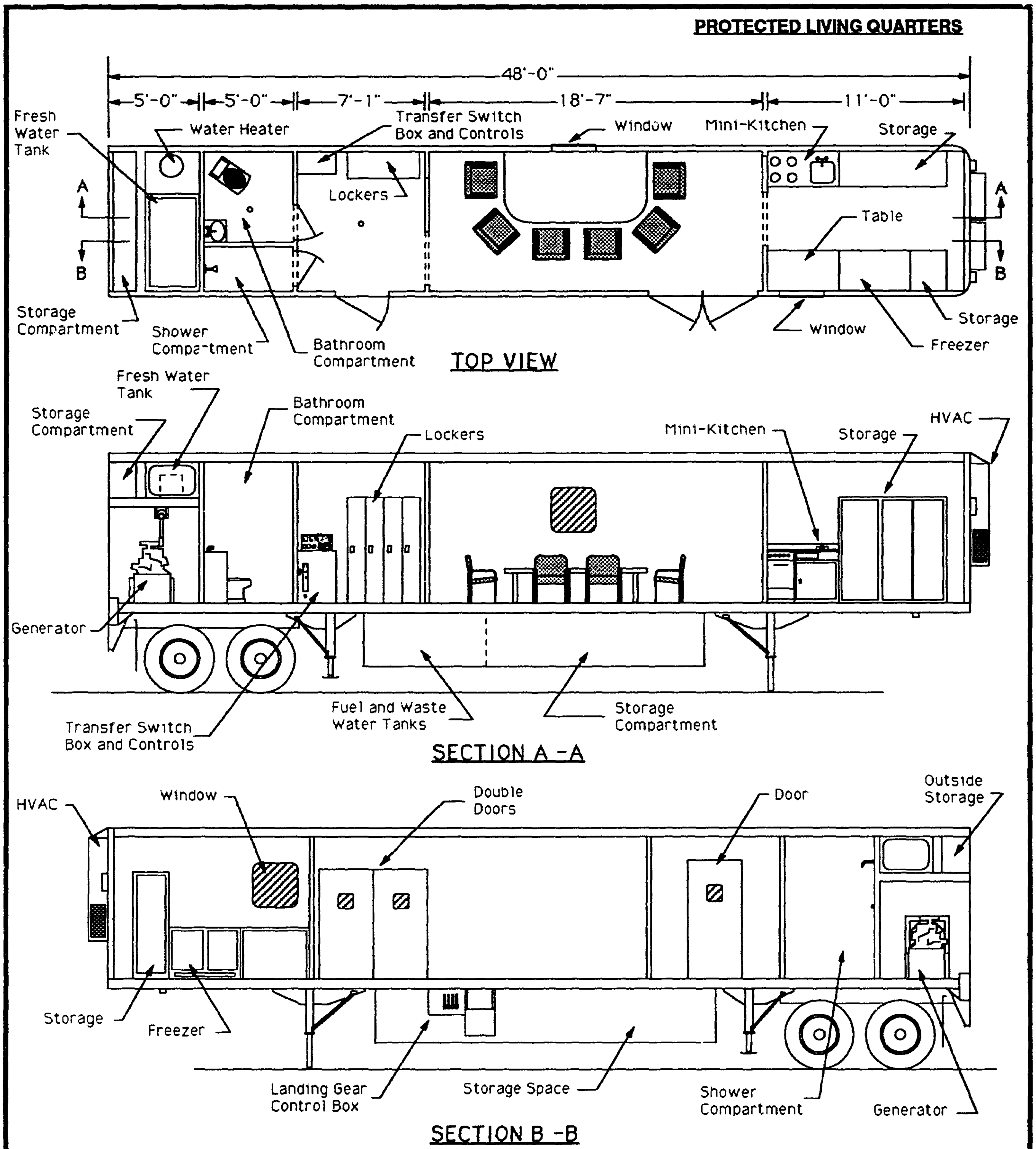

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Figure 27a. Protected Living Quarters - Interior Views

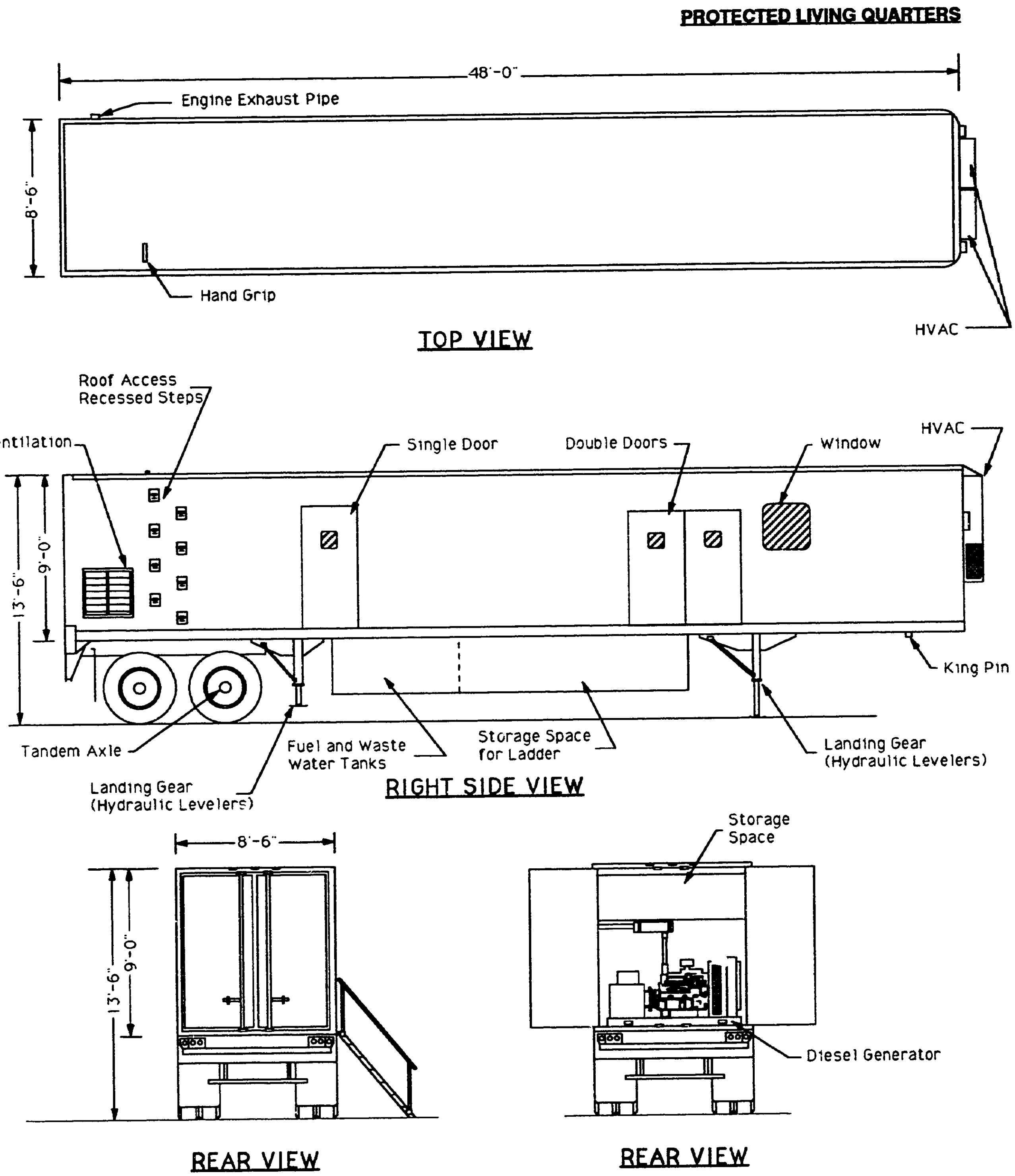

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Figure 27b. Protected Living Quarters - Exterior Views

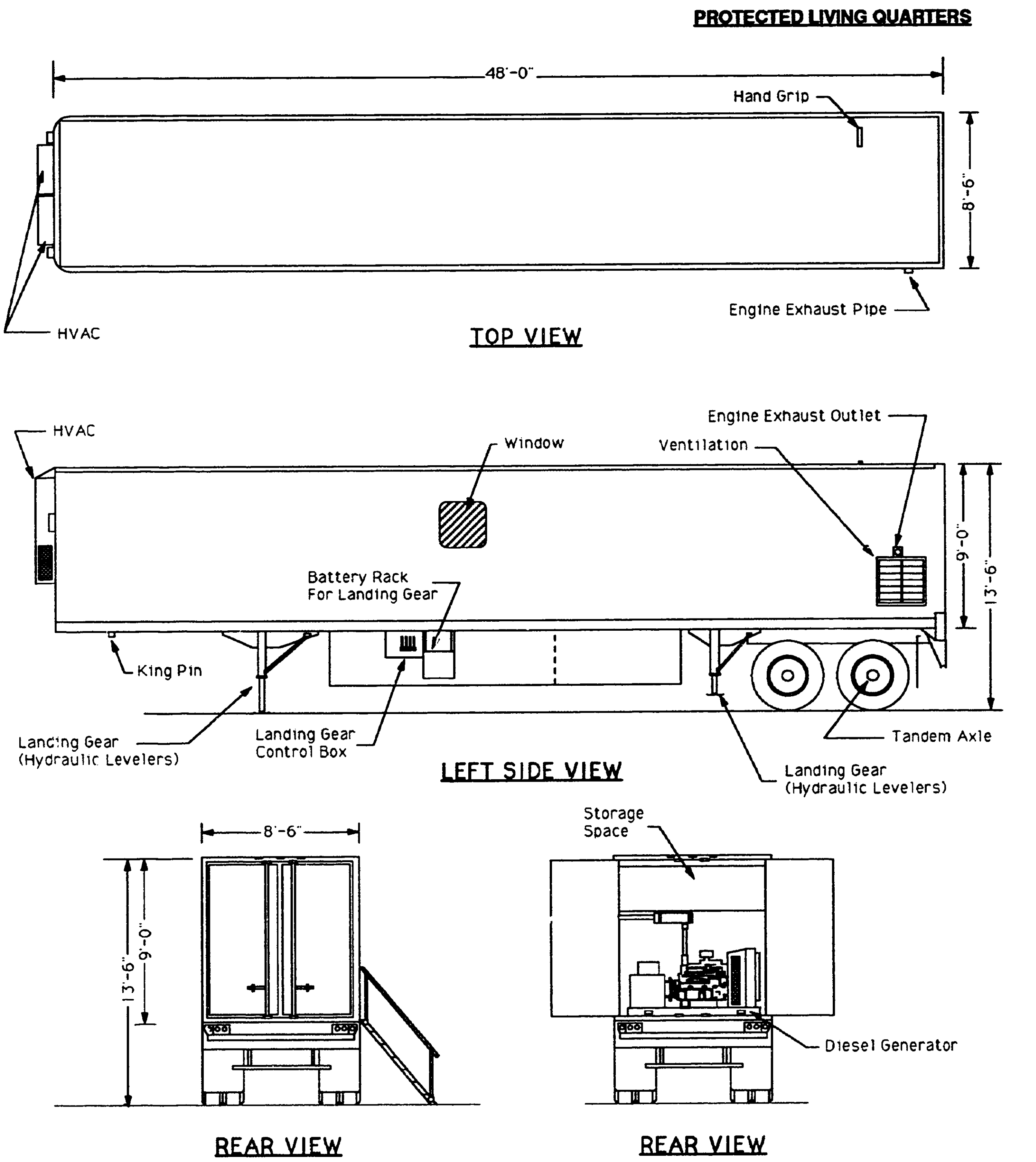

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Figure 27c. Protected Living Quarters - Exterior Views

The main alternative to the recommended configuration is shown in Figure 28. This design provides an area for three bunks (vertically mounted adjacent to the wall) at the expense of half the conference room. While the addition of the bunks would be advantageous for personnel working around the clock, it was felt that such a situation would occur so infrequently it would not be cost-effective to include the bunks. It was felt that the larger conference area would be used more frequently and would better enhance the effectiveness of the overall operation.

Figure 29 shows the same basic arrangement as the recommended configuration (Figures 27a-c) except that the conference area and kitchen area are reversed, and that the onboard electrical generator is eliminated. The room reversal was determined to be a less efficient design since the main entrance would lead into a rest area (the kitchen) rather than a work area (the conference room). This would be disruptive to personnel as well as presenting a less professional appearance to visitors. In this configuration, power would be provided by a central electrical generator. As discussed earlier, this arrangement was determined to have significant drawbacks in terms of overall system reliability and logistical support.

Central Power Generation Module

The RTAL complex design based on electrical power being provided by a central generating system was discussed earlier and shown in Figure 3. Figures 30a-c show the Central Power Generation module that would be required for this RTAL option. The electrical generation system would consist of two 400 kVA diesel-driven electrical generators. The use of two generators as opposed to a single 800 kVA generator provides greater system reliability. If one generator fails or is off-line for maintenance, critical RTAL operations can still be performed with the half-capacity electricity remaining.

The use of a Central Power Generation module eliminates the need for electrical generating equipment in each module, providing more room in the other modules for other uses (an important consideration). It also minimizes shock and vibration mounting requirements in the laboratory modules. However, the use of a central electrical generation module would limit the deployment flexibility of the RTAL since this module would have to be deployed whenever an independent source of power was needed. This would severely limit the flexibility of deployment which is a cornerstone of the RTAL design. Thus, it was decided that it would be better for each module to retain its own electrical generating system.

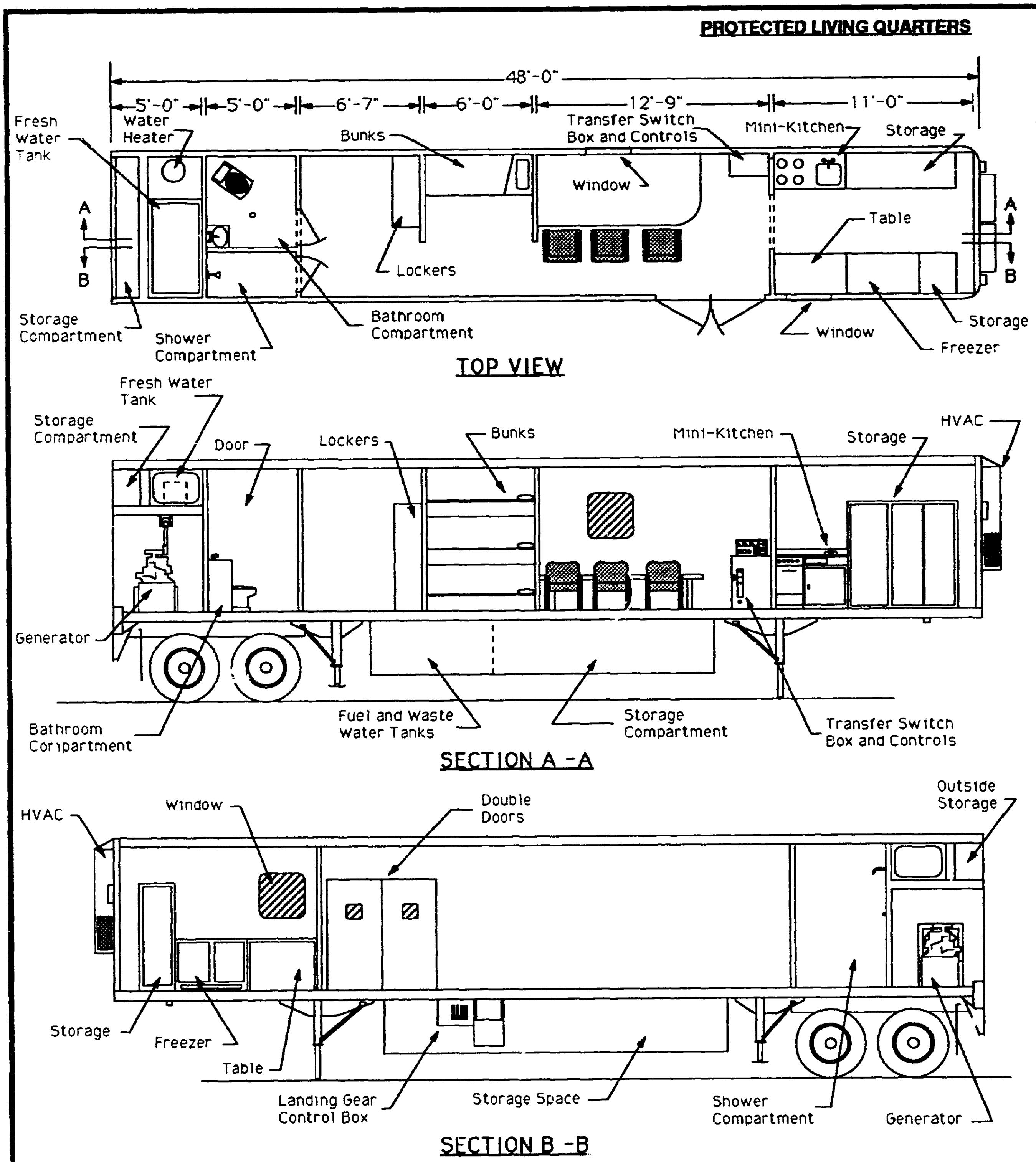

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Figure 28. Protected Living Quarters - Alternative Design 1

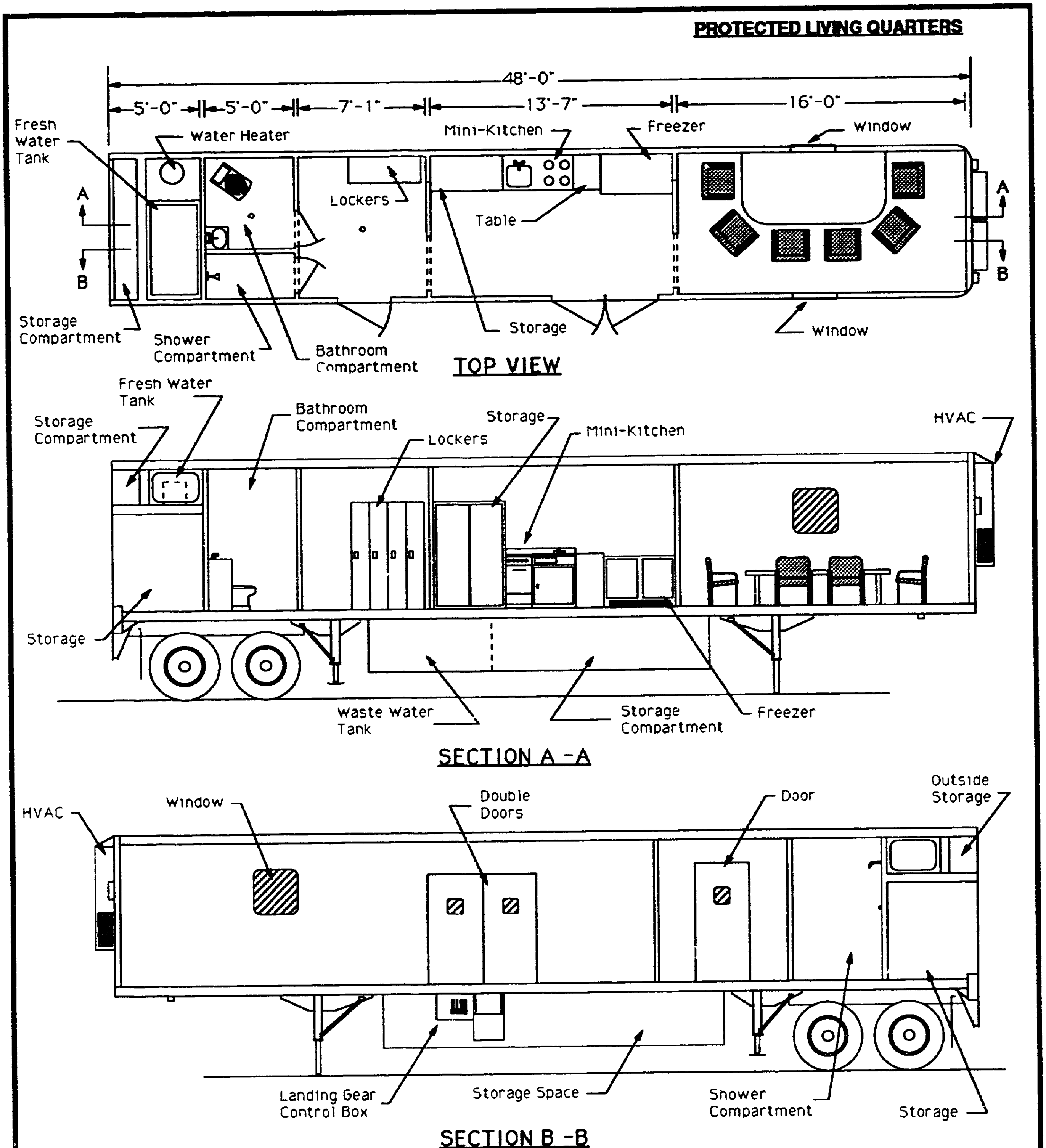

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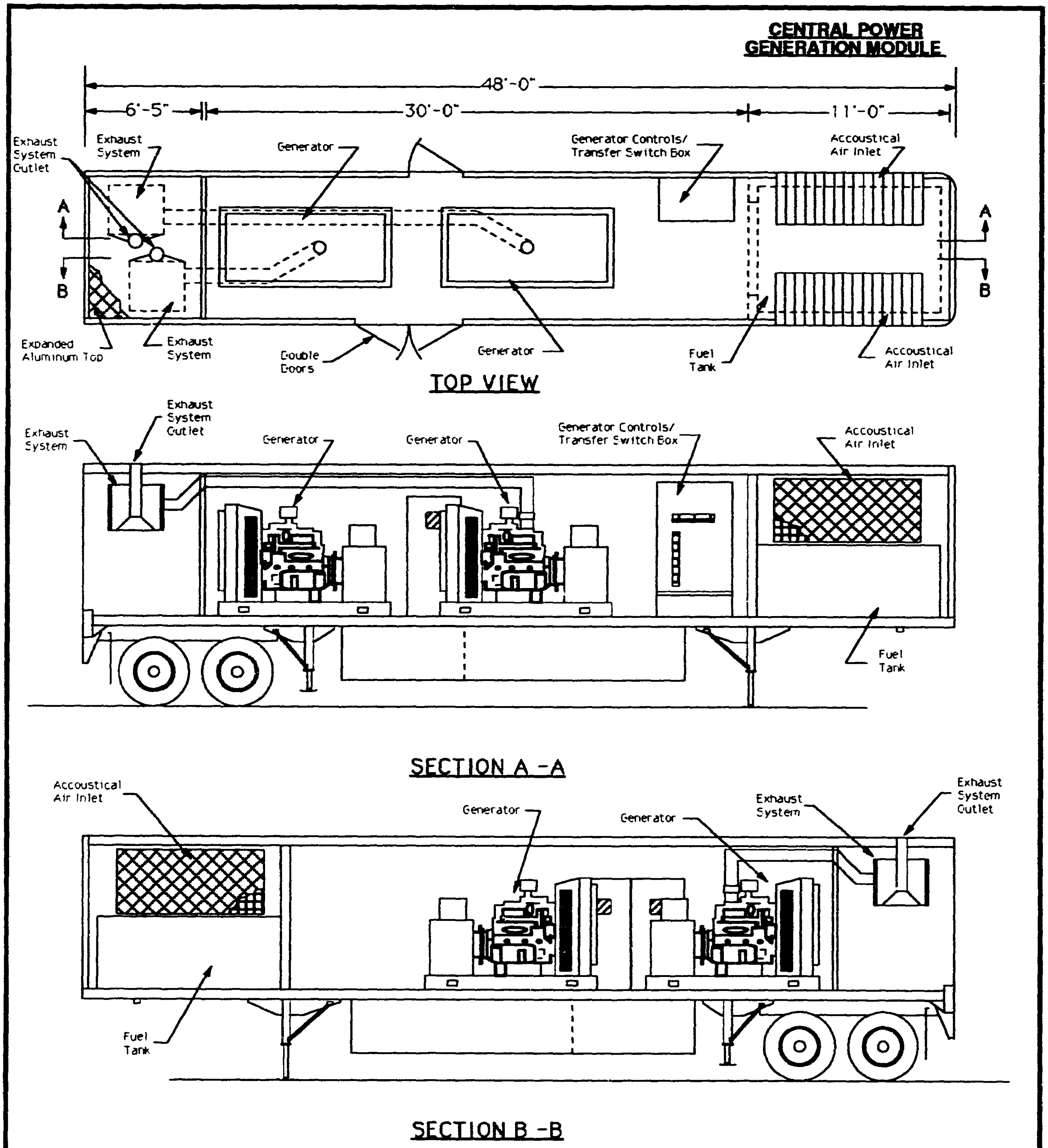
Figure 29. Protected Living Quarters - Alternative Design 2



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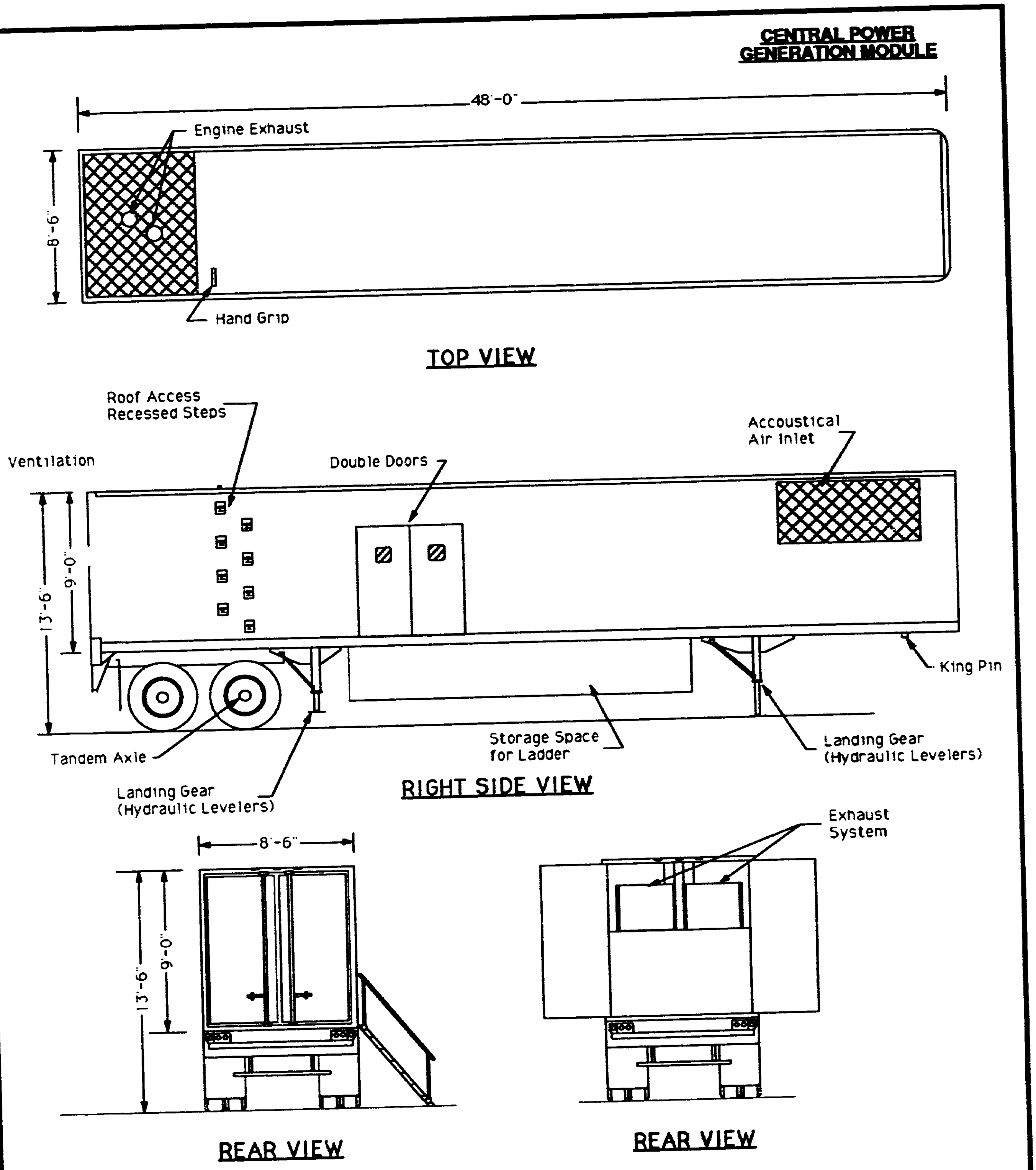
	Date: June 2, 1993 Revision.

Figure 30a. Central Power Generation Module - Interior Views



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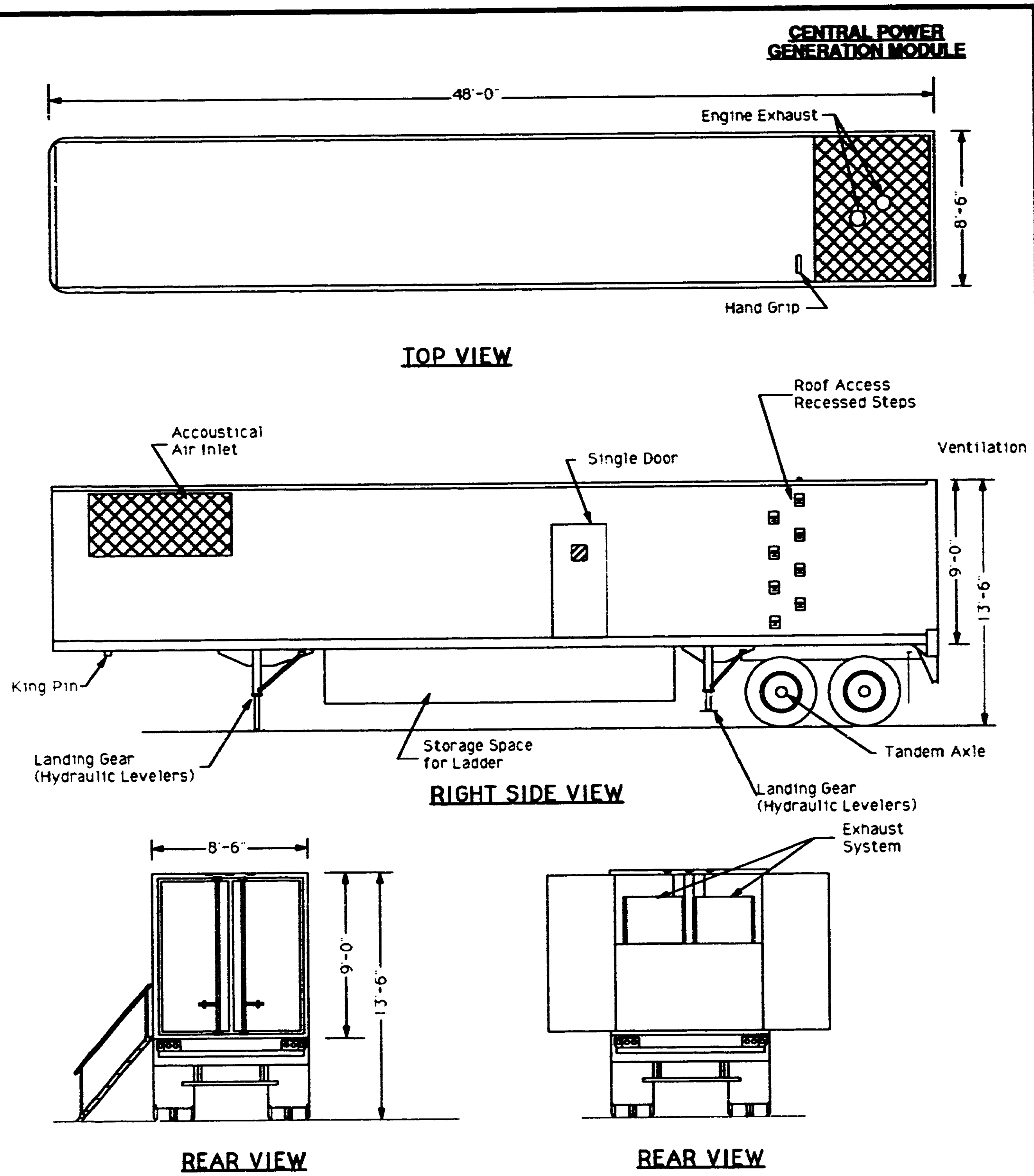
	Date: June 8, 1993 Revision.

Figure 30b. Central Power Generation Module - Exterior Views



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	Date: June 15, 1993 Revision.

Figure 30c. Central Power Generation Module - Exterior Views

NQA-1 ANALYSIS

A quality assurance analysis was performed to ensure that the alternative designs developed complied with appropriate and relevant DOE and other governmental regulations and requirements. This analysis also included requirements from appropriate industry requirement-setting organizations, e.g. the American Society for Testing and Materials (ASTM).

The NQA-1 analysis was performed in a top-down procedure. The process started with the overall goals for the full RTAL complex. Based on these criteria, specific complex-wide requirements for performance, design, construction, and materials were developed. Then, each module was studied. Specific requirements for performance, design, construction, and materials were developed based on the functions required of each module. Then, each sub-system within each of the modules was studied to develop the appropriate requirements. In this way, the design of each component of the RTAL directly supports the goals of the overall system and the many interrelated requirements are met.

The NQA-1 Analysis made extensive use of DOE Order 6430.1A of April 6, 1989, "United States Department of Energy General Design Criteria," and documents referenced in that manual. This design criteria manual provides guidance on a wide range of construction and material requirements.

The NQA-1 analysis was performed in a very thorough and complete manner. It is provided in Appendix A of this report. The alternative designs presented were reviewed to ensure compliance with the requirements of the NQA-1 analysis. Each of the designs presented meets the requirements expressed in Appendix A. This rigorous analysis is considered an important step in helping to guarantee that the RTAL system will meet the needs of the DOE and perform as expected.

RECOMMENDED RTAL DESIGN

The design of the overall RTAL system and each of its modules was developed in an iterative fashion. The three designs for the overall system and for each module which best met the needs of the DOE were discussed earlier in the report. These designs were also analyzed against the specific performance, design, construction, and material requirements of the NQA-1 analysis. Each of the design configurations presented earlier comply with the NQA-1 analysis requirements. There were many additional designs which were evaluated and discarded because they did not meet critical requirements or had serious drawbacks. Thus, the alternative design analyses presented earlier represent the results of an iterative optimization process.

As a summary, the recommended system and individual module designs are repeated on the following pages in Figures 2, 4a, 7a, 10a, 13a, 15a, 18a, 21a, 24a, and 27a. This recommended RTAL system meets the DOE's needs for on-site environmental sample

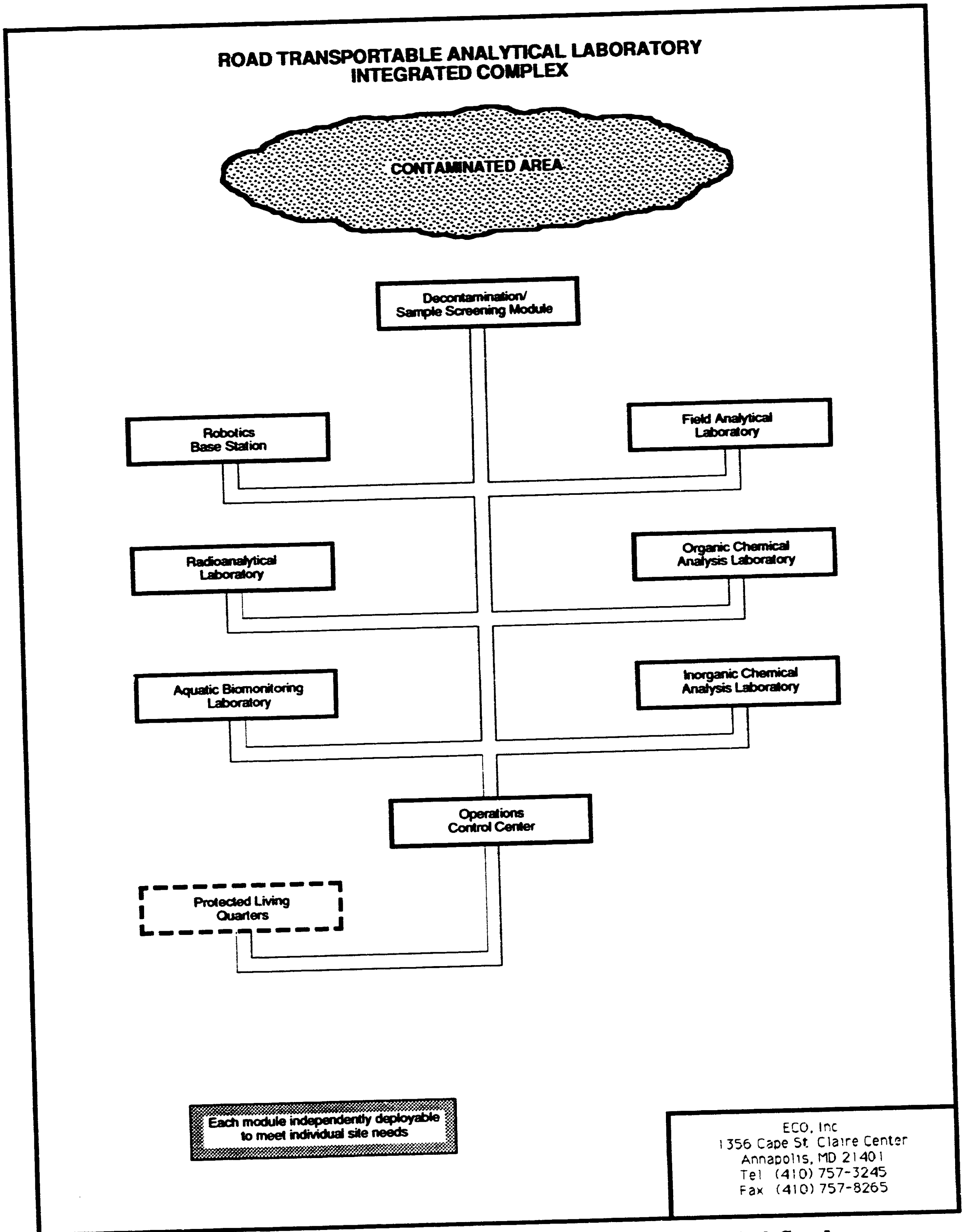
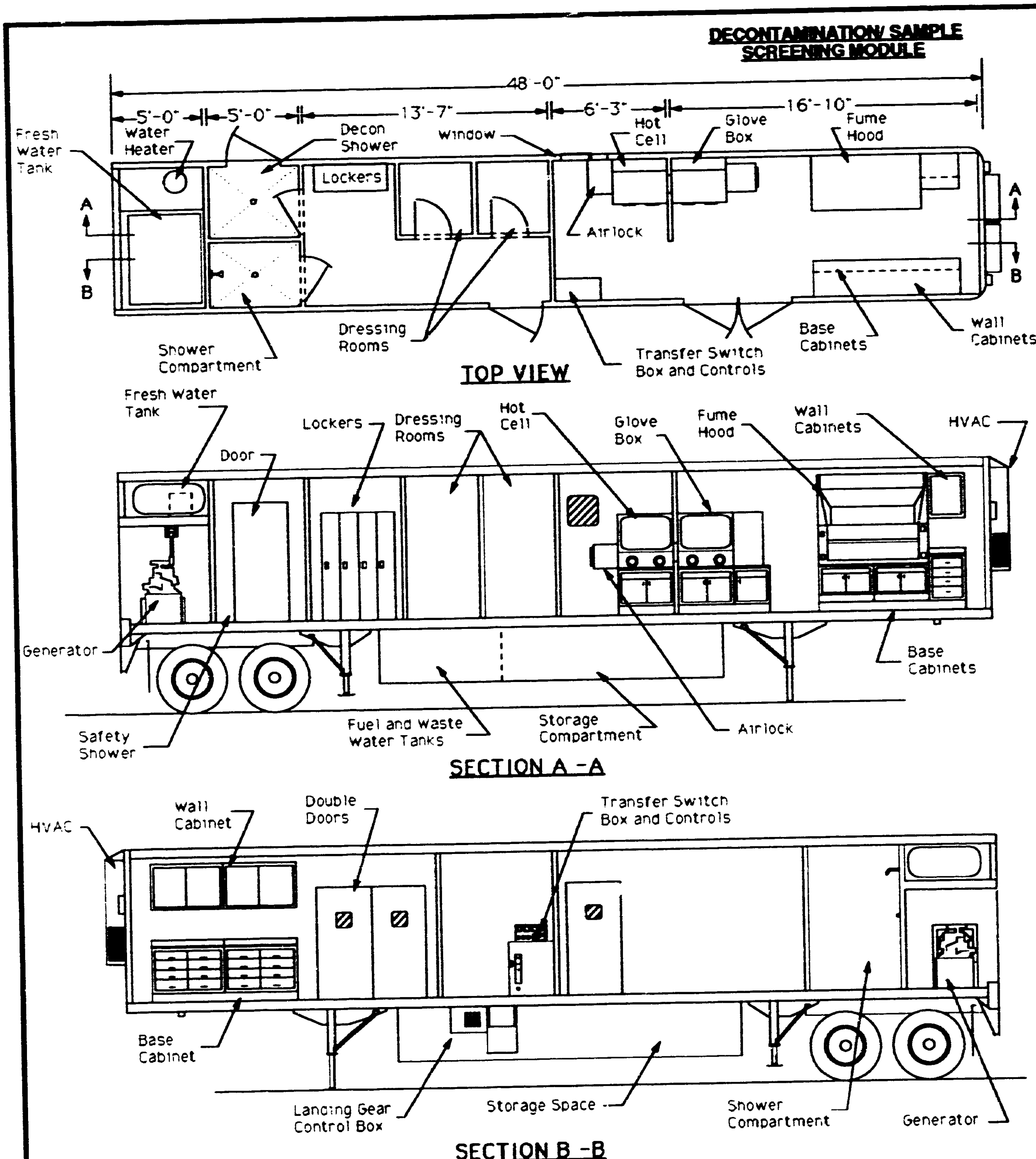


Figure 2. Road Transportable Analytical Laboratory Integrated Complex



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ECO, INC	Drawing No. ECO-700-001C
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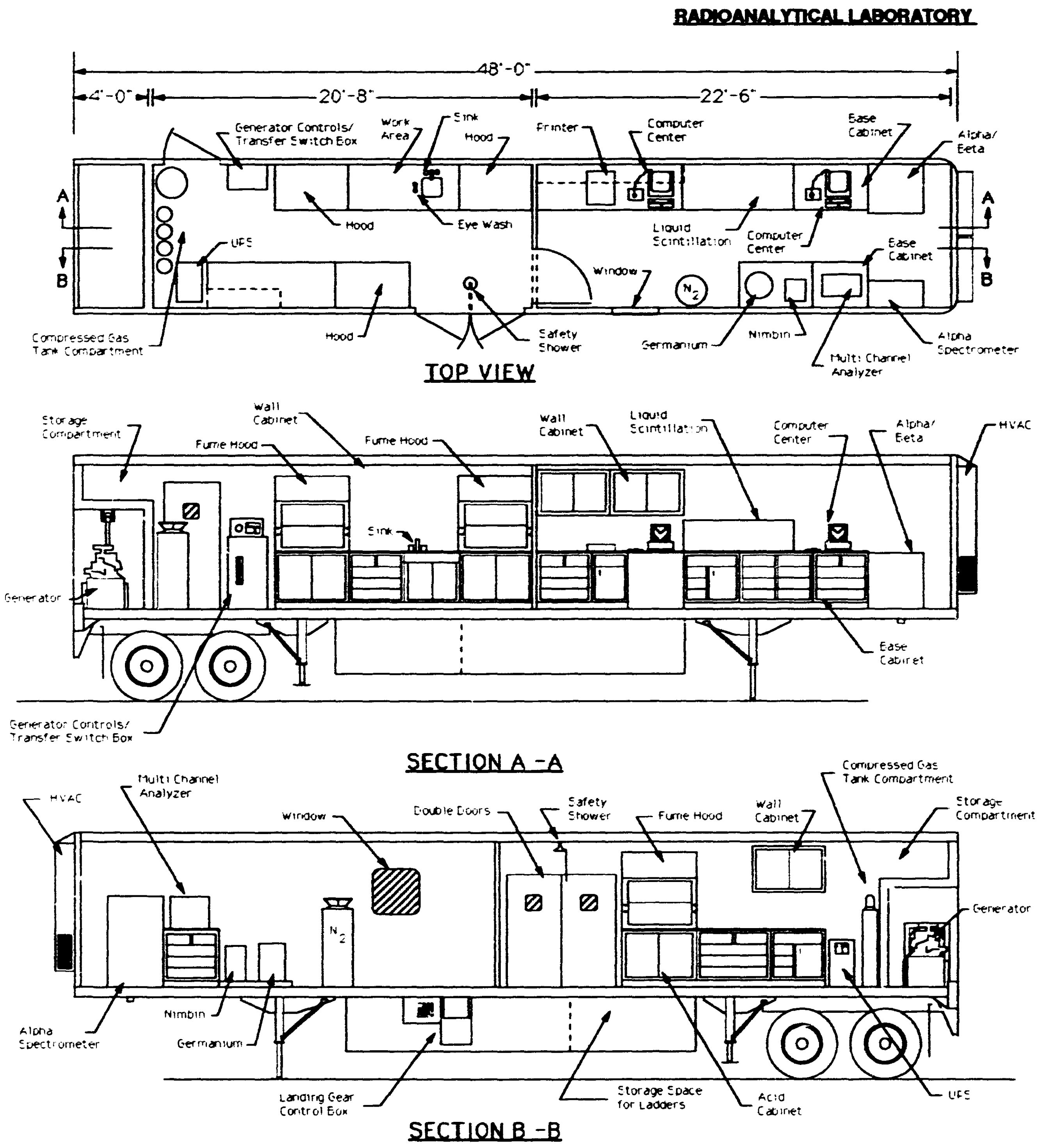
Figure 4a. Decontamination/Sample Screening Module - Interior Views



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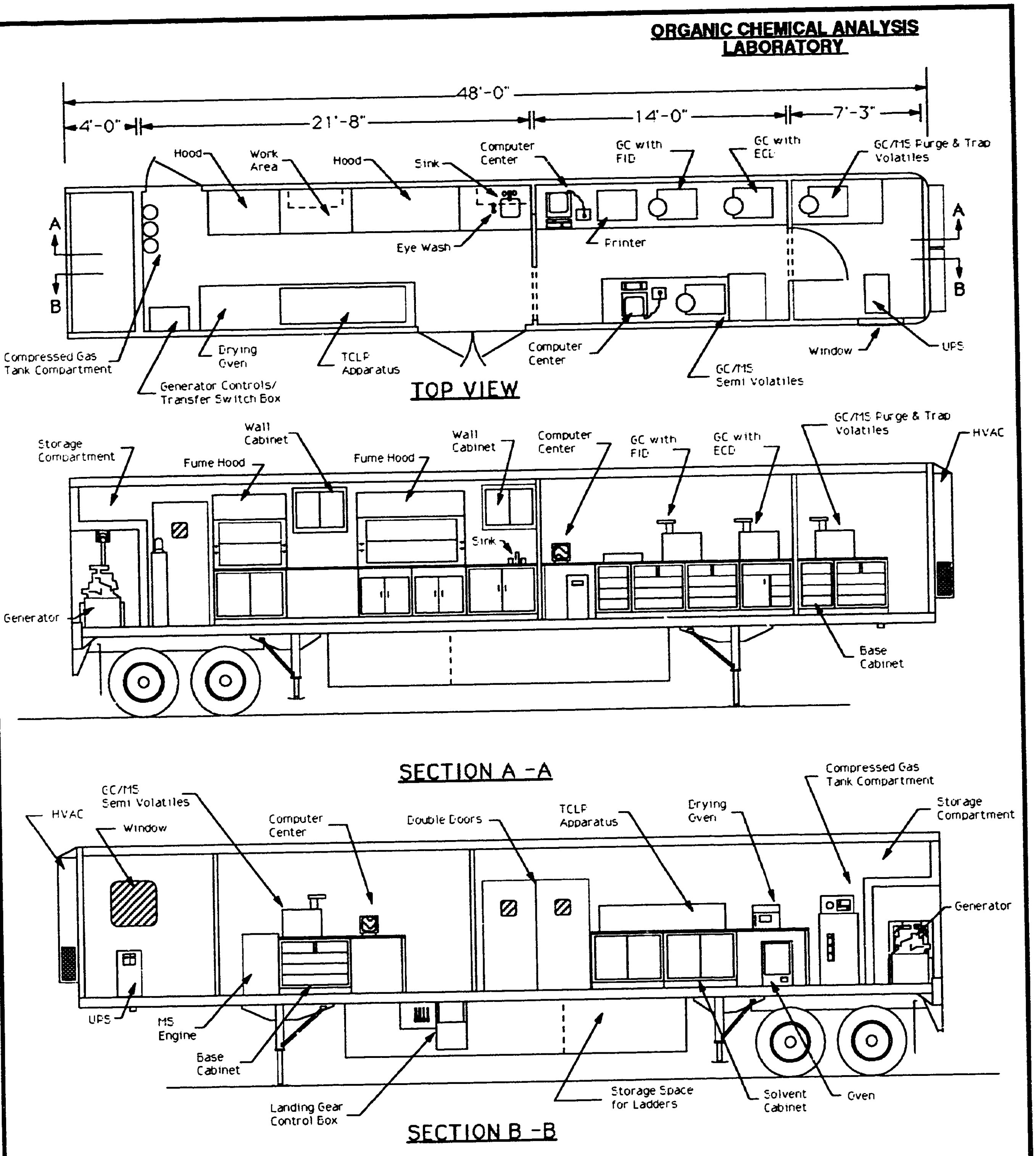
	Date. April 15, 1993 Revision.

Figure 7a. Radioanalytical Laboratory - Interior Views



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	Date: March 5, 1993 Revision.

Figure 10a. Organic Chemical Analysis Laboratory - Interior Views

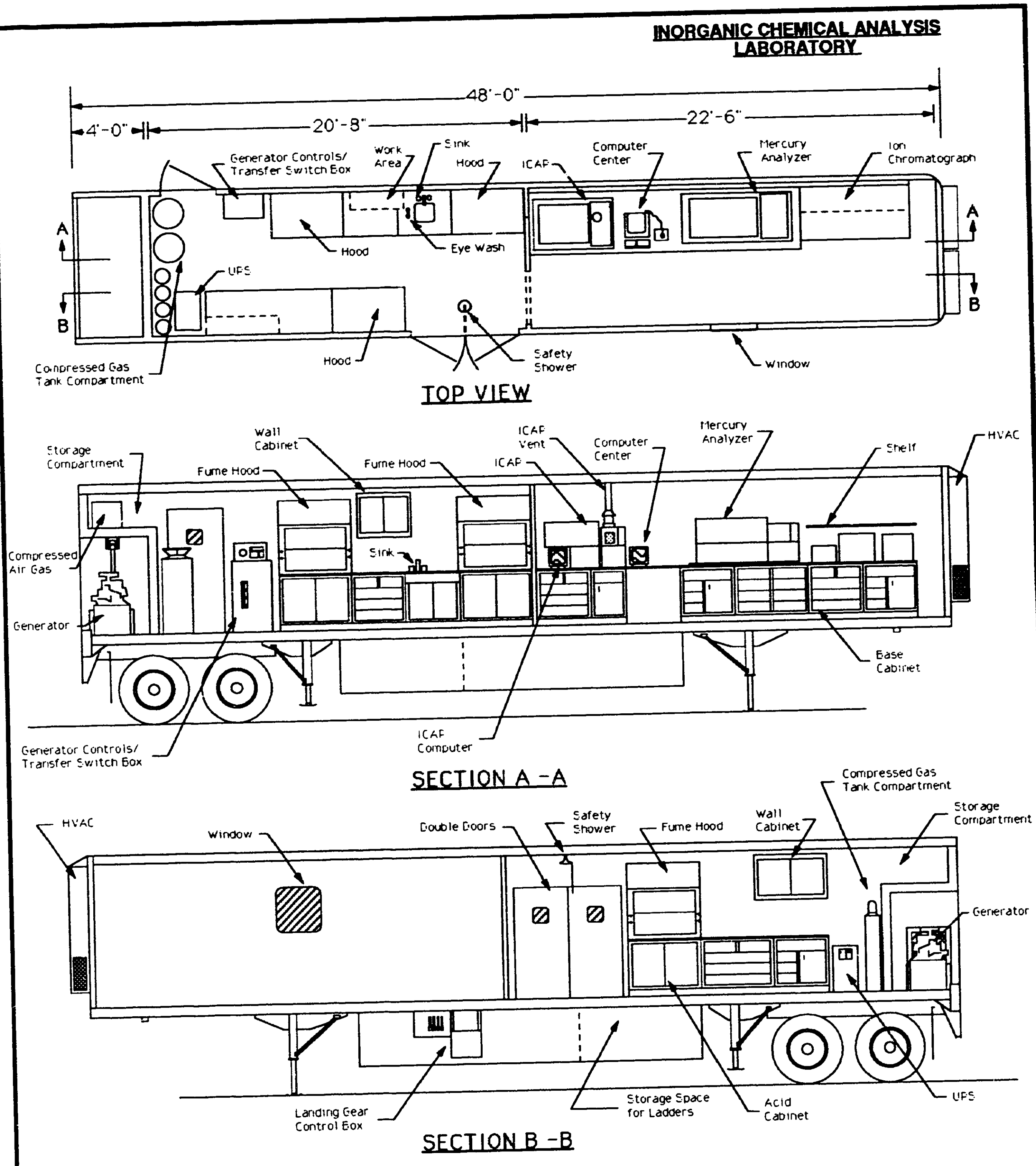

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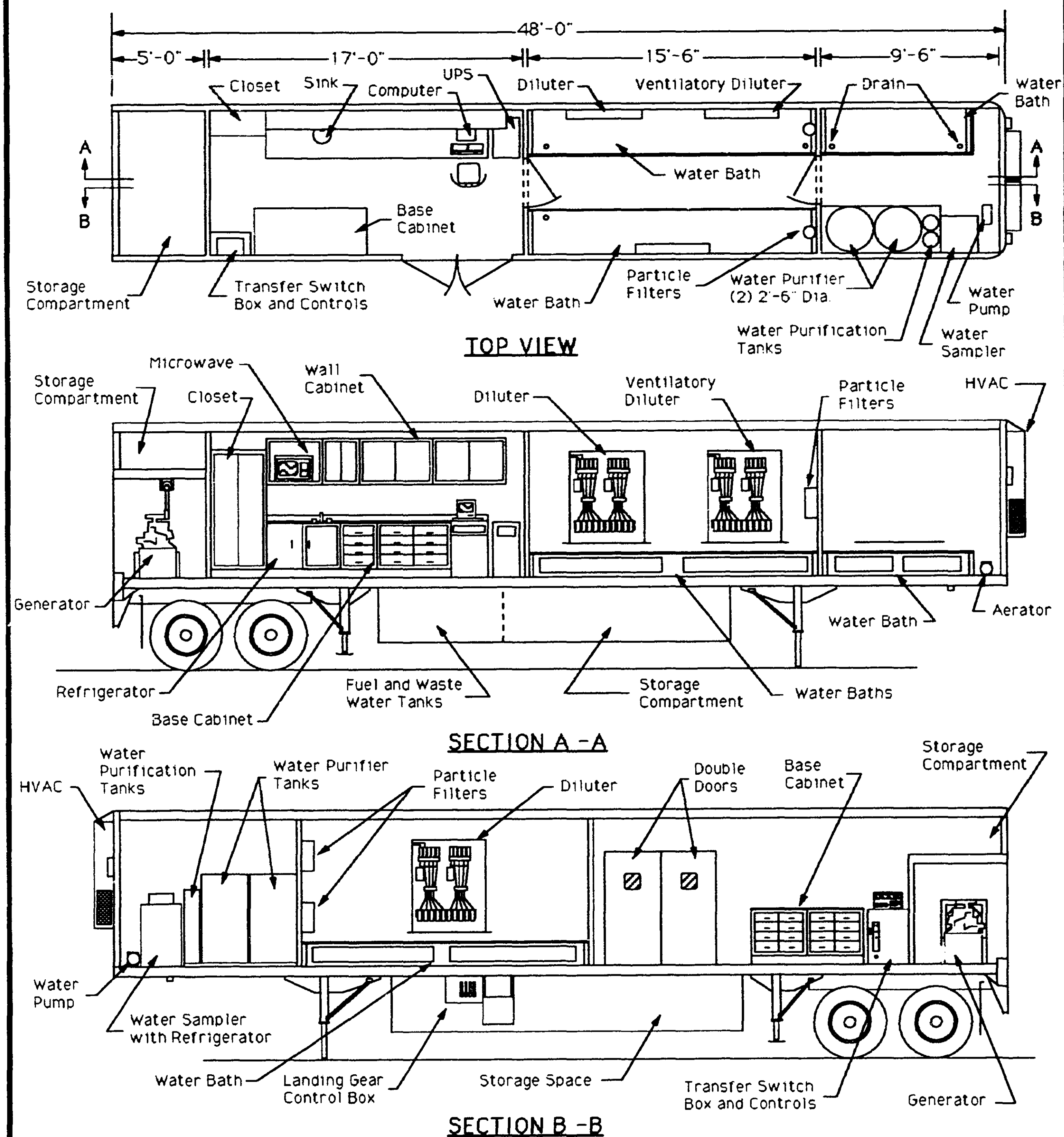
Figure 13a. Inorganic Chemical Analysis Laboratory - Interior Views

AQUATIC BIOMONITORING LABORATORY



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ECO, INC	Drawing No. ECO-800-001A
	Date: February 17, 1993 Revision.

Figure 15a. Aquatic Biomonitoring Laboratory - Interior Views

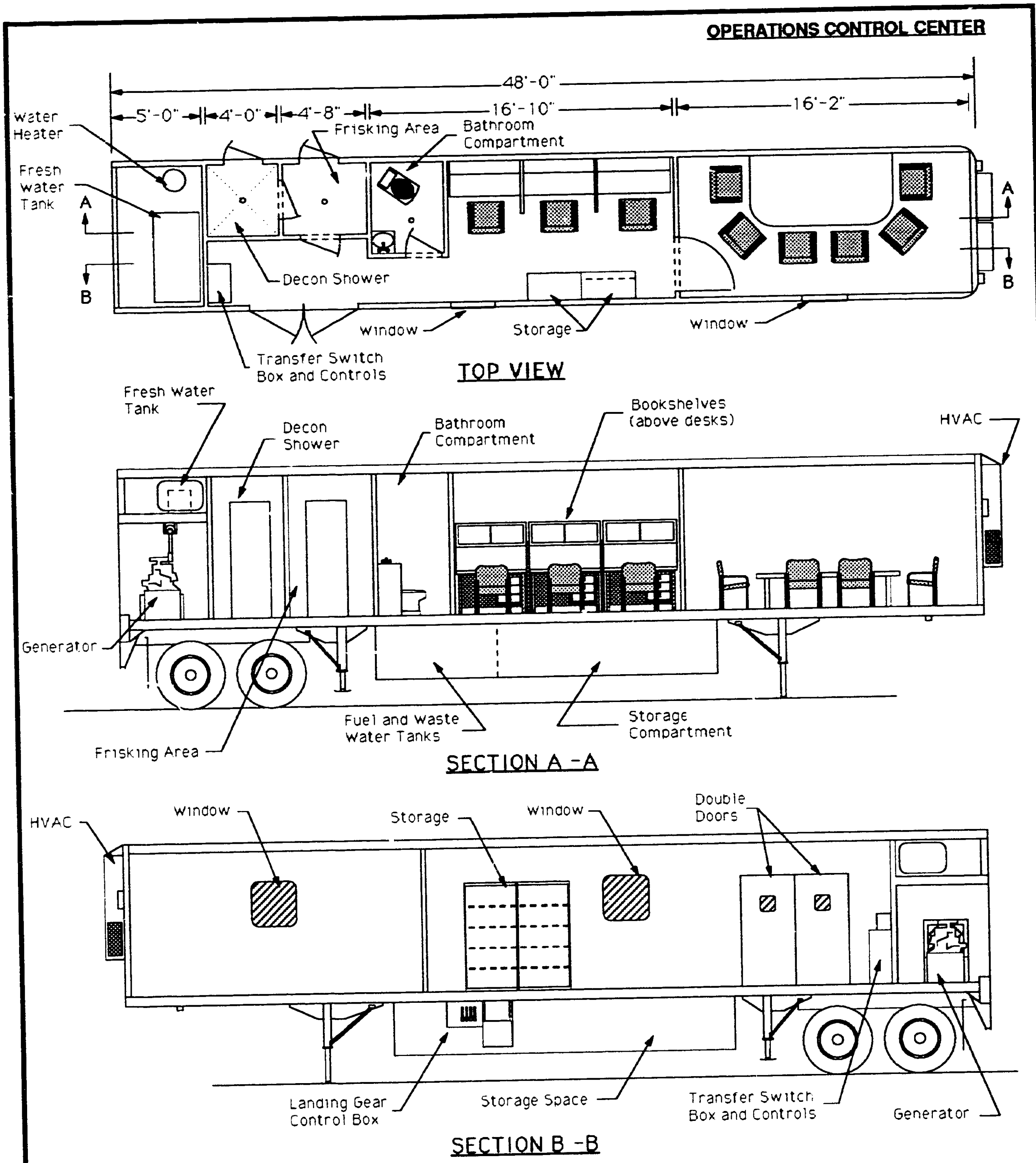

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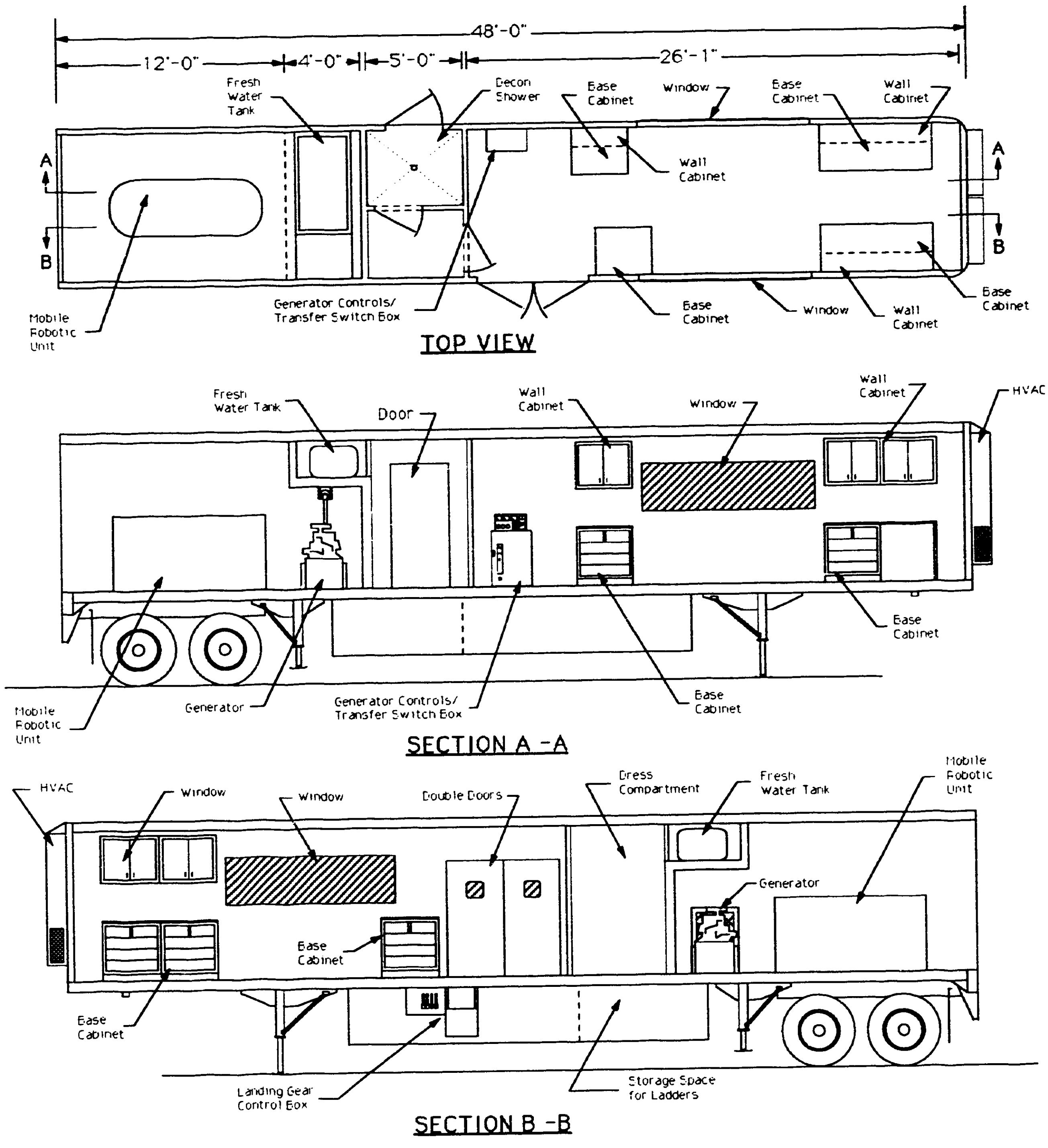
Figure 18a. Operations Control Center - Interior Views

ROBOTIC BASE STATION



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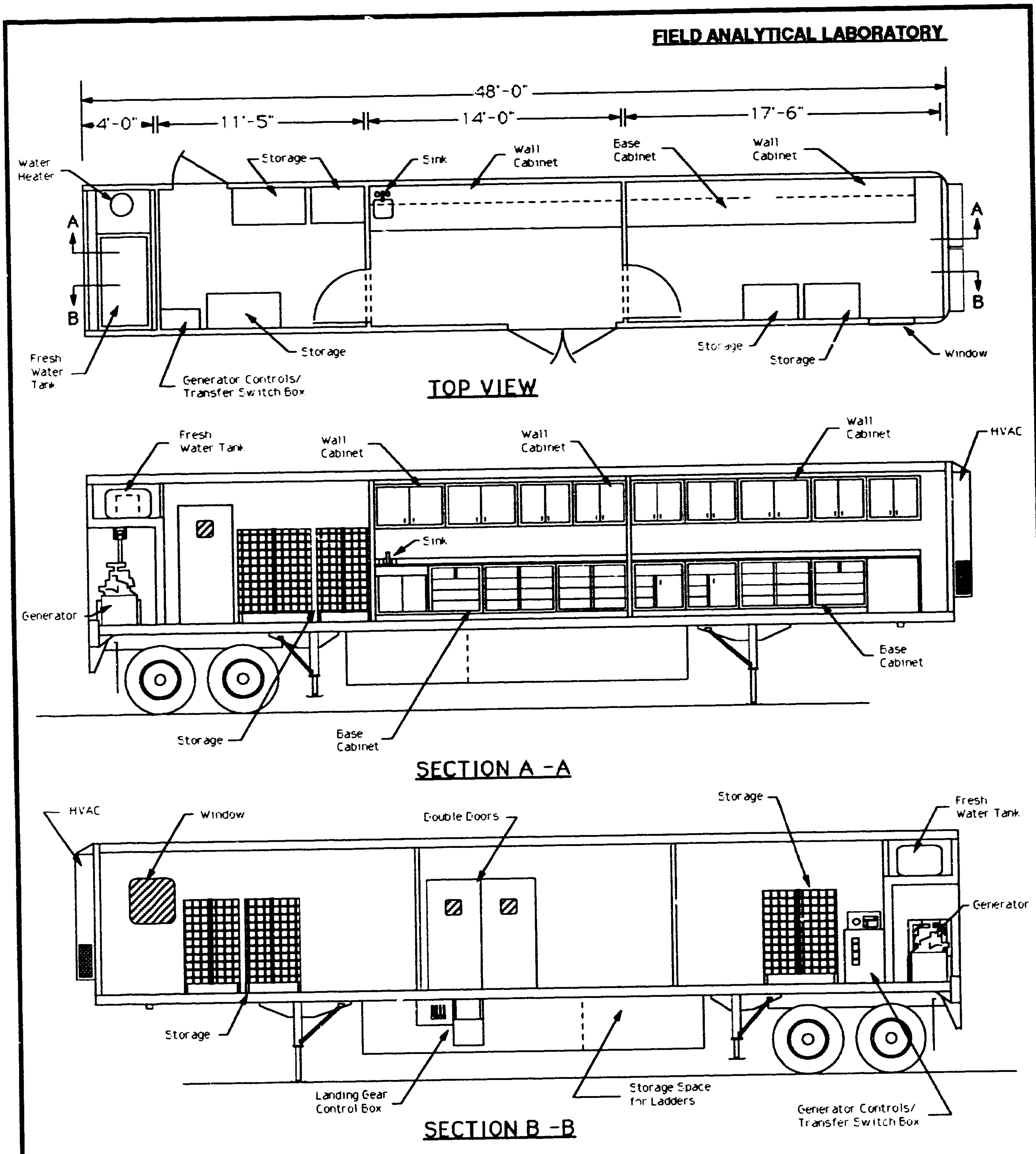
ECO, INC

Drawing No: ECO-990-001A

Date: April 12, 1993
Revision.

Figure 21a. Robotic Base Station - Interior Views



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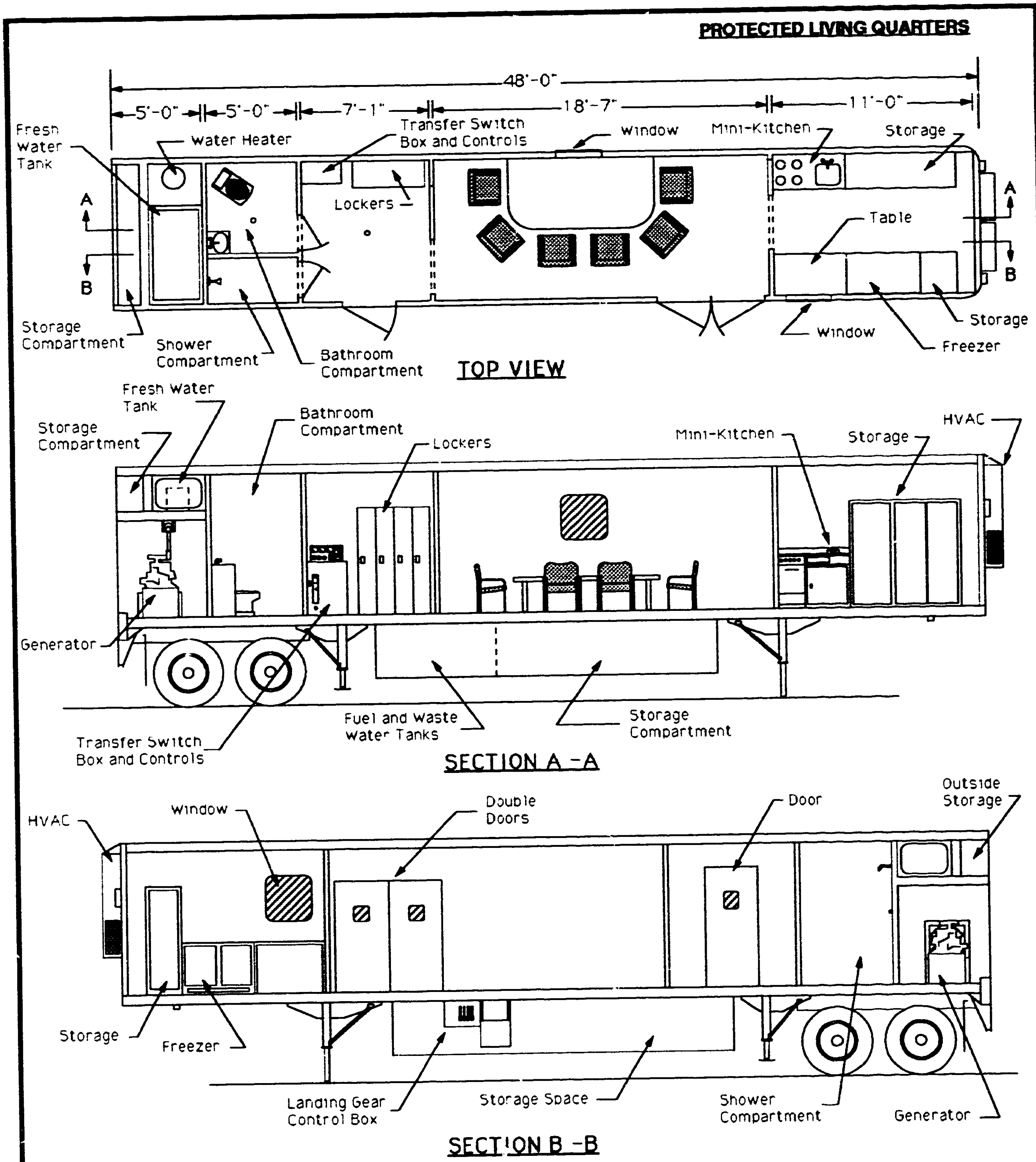
ECO, INC	Drawing No. ECO-975-001A
	Date: March 25, 1993 Revision:

Figure 24a. Field Analytical Laboratory - Interior Views



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ECO, INC	Drawing No ECO-600-001A
	Date December 7, 1992 Revision

Figure 27a. Protected Living Quarters - Interior Views

analyses. This system was designed to 20 samples per day for each analyte with a sample turnaround time of 16 hours (not counting sample preparation). The recommended system also complies with all requirements from the NQA-1 analysis.

PROJECTED COST AND TIME SAVINGS

ECO, Inc. has been a strong proponent of high performance on-site transportable laboratories as a way to lower sample analysis costs and reduce turnaround time while maintaining the highest levels of quality assurance and quality control. Cost and time projections, based on the recommended design developed, were performed.

Prices for environmental low-level radioactive sample analyses performed at a central laboratory were obtained from a commercial laboratory with nationwide facilities, i.e. laboratories near each of the active DOE sites. This commercial laboratory is a regular performer of low level radioactive sample analyses for the DOE and its contractors. The analytes of interest were chosen based on the report, "Analytical Laboratory Study Report for Pit 9 Remediation Activities" of July 1992 and the preliminary results (as of September 1992) of the DOE Office of Environmental Restoration and Waste Management study of projected analytical needs across the DOE complex. The commercial laboratory's prices for the analytes of interest in low level radioactive samples are provided in Table 4. Prices charged by this laboratory for non-radioactive samples are approximately 15% lower than the prices shown in Table 4. Unfortunately, this laboratory does not perform anion analyses so this analyte was not priced. This commercial laboratory offers discounts up to 15% for large numbers of samples. Their normal turnaround time is 45 days. There is a 100% surcharge for preliminary results within two weeks followed by a hardcopy report in 45 days. They also have a 50-100% surcharge for "difficult matrices." The prices shown in Table 4, the sample turnaround time, and the surcharges for faster response or "difficult" samples are typical of the industry.

The cost comparison analysis is based on the complete analysis of 20 samples per day for each analyte. It was assumed that samples would be processed 240 days each year (5 days per week for 48 weeks). This allows for federal holidays (10 per year), down-time for equipment maintenance, and days when samples are not collected. As shown in Table 4, the total cost for a complete set of analyses (excluding anions) on a single sample is $4,015. At 20 samples for each of the 240 operating days per year, a total of 4,800 samples will be processed annually. Thus, the annual cost (before discount) for sample analyses will be $19,272,000. Since the number of samples to be analyzed is large, a 20% discount is assumed for this cost comparison (even though this laboratory does not normally provide more than a 15% discount). The final annual cost, after provision for the larger

Table 4

Commercial Laboratory Analytical Costs

Analyte	Method	Price
Gross Alpha and Beta	EPA 900.0	$ 50.00
Gamma Emitters	EPA 901.1	125.00
Radioactive Strontium	EPA 905	150.00
Actinides	EPA 907	175.00
Semi-volatile Organic Analytes	EPA 8270A	598.00
Volatile Organic Analytes	EPA 8240	328.00
Polychlorinated Biphenyls	EPA 3520A (liquids) or EPA 3550A (solids) + EPA 3640 (Supercritical Extraction) + EPA 8080A (analysis)	242.00
Metals	EPA 3010A (aqueous) or EPA 3050A (sludges, etc.) +	46.00
	EPA 7470A/7471A (Hg by AA) +	92.00
	EPA 6010A (ICP)	420.00
TCLP	EPA 1311 (Extraction) +	230.00
	Organic/Inorganic Analyses	1,559.00
Anions		Not Priced
	TOTAL PRICE PER SAMPLE	$4,015.00
	TOTAL ANNUAL COST (4,800 samples)	$19,272 K
	TOTAL ANNUAL COST (20% discount)	$15,418 K

discount, is therefore $15,418,000 if the analyses are performed at this central laboratory. This price is for their standard 45 day turnaround time.

Table 5 provides an analysis of the annual costs for performing the same number and types of analyses (but including anion analysis), in the RTAL system. The analyses listed will be performed in the Radiochemistry Laboratory, the Organic Chemical Analysis Laboratory, and the Inorganic Chemical Analysis Laboratory. The collected samples will be subdivided in the sample screening portion of the Decontamination/Sample Screening Module. These four modules provide the full range of sample analyses listed in Table 4, meeting the highest QA/QC standards.

The annual capital costs for these RTAL modules and their analytical equipment are provided in the first category on Table 5. The annual capital cost was calculated from the total capital cost using straight-line depreciation. A 15 year life was used for the laboratory structures and a 10 year life was used for the analytical equipment within the labs. The capital cost of the Decontamination/Sample Screening Module structure was divided equally between the decontamination area and the sample screening area. The capital cost for the sample screening portion of the module structure (one-half the total structure cost), along with the entire cost for the analytical equipment in this module, was included in Table 5. The second category in Table 5 shows the annual personnel costs for operating the laboratories. This is based on a staffing of three full-time trained and experienced analytical chemists per module, one full-time laboratory manager and one Health Physicist (1/4 time), for a total of 13.25 man-years per year. Each laboratory is designed to be operated by two analysts, but three are provided for each laboratory module to ensure reliable performance during busy periods and to provide personnel coverage during illnesses, vacations, etc. This staffing level is considered conservative. The average annual cost (fully loaded) per person was assumed to be $150K, also a conservative assumption. The annual cost for consumables and maintenance supplies, estimated at $600 per operating day ($150 per operating day for each of the four laboratories), is provided in the third category of Table 5. Finally, a 30% contingency factor is provided in the fourth category of the table.

As shown in Table 5, the total annual cost of performing the 4,800 analyses in the RTAL was conservatively calculated to be $3,344,000. This represents an annual savings of over $12 million compared to performing the same analyses in the central laboratory discussed above. This very dramatic savings is based on the use of one RTAL system. If RTAL systems were used at the eight largest DOE facilities (at Hanford, Savannah River, Fernald, Oak Ridge, Idaho, Rocky Flats, Los Alamos, and the Nevada Test Site), the annual savings would be $96,589,000. The DOE's internal study of sample analysis needs projects 130,000 environmental samples requiring analysis in FY 1994, clearly supporting the need for the RTAL system.

Table 5

RTAI Annual Analytical Costs (Loaded)

Capital Depreciation	$ 440.8 K
Radioanalytical Lab	
Organic Chemical Analytical Lab	
Inorganic Chemical Analytical Lab	
Sample Screening Module	
Analytical Equipment	
Personnel	1,987.5 K
3 Analysts/lab x 4 labs = 12 analysts	
1 Operations Manager	
1 Health Physicist (1/4 time)	
Total of 13.25 man-years @ $150K/man-year	
Consumables and Maintenance	144.0 K
$150/day/lab x 4 labs x 240 operating days/year	
Contingency - 30%	771.7 K
TOTAL ANNUAL COST	$3,344.0 K
TOTAL COST PER SAMPLE	$696.67

Actually, the savings are even greater. The central laboratory costs in Table 4 did not include anion analysis. Also, the costs of shipping the samples to the central laboratory, and the manpower costs to complete the paperwork and package the samples were not included in this analysis. The inclusion of these costs would make the cost savings provided by the RTAL even greater.

The time savings provided by the RTAL is equally impressive. The comparison performed was based on the standard 45 day turnaround by the central laboratory. The RTAL will provide the same high quality data within 1 day. The availability of these high quality, reliable data will accelerate decision-making and improve the efficiency and pace of clean-up efforts.

Table 6 summarizes the dramatic cost and time savings that can be achieved with the RTAL system developed.

Table 6

COST AND TIME SAVINGS SUMMARY

Parameter	Commercial Lab	RTAL
Cost Per Sample	\$4,015.00	\$696.67
Annual Sample Costs (20 samples/day; 4,800 samples/year)	\$15,418 K (includes 20% volume discount)	\$3,344 K
Turnaround Time	45 days (can be shortened to 14 days for 100% premium)	1 day

CONCLUSIONS

This developmental effort clearly shows that a Road Transportable Analytical Laboratory System is a worthwhile and achievable goal. The RTAL is designed to fully analyze (radioanalytes, and organic and inorganic chemical analytes) 20 samples per day at the highest levels of quality assurance and quality control. It dramatically reduces the turnaround time for environmental sample analysis from 45 days (at a central commercial laboratory) to 1 day. At the same time each RTAL system will save the DOE over $12 million per year in sample analysis costs compared to the costs at a central commercial laboratory. If RTAL systems were used at the eight largest DOE facilities (at Hanford, Savannah River, Fernald, Oak Ridge, Idaho, Rocky Flats, Los Alamos, and the Nevada Test Site), the annual savings would be $96,589,000. The DOE's internal study of sample analysis needs projects 130,000 environmental samples requiring analysis in FY 1994, clearly supporting the need for the RTAL system. The cost and time savings achievable with the RTAL system will accelerate and improve the efficiency of clean-up and remediation operations throughout the DOE complex.

ROAD TRANSPORTABLE ANALYTICAL LABORATORY (RTAL) SYSTEM

APPENDIX A

NQA-1 ANALYSIS

JULY 1993

CONTRACT NO. DE-AC21-92MC29109

FOR:

U.S. DEPARTMENT OF ENERGY
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ABBREVIATIONS

AA	Atomic Absorption
AC	Air conditioner
AAMA	American Architectural Manufacturers Association
AASHTO	American Association of State Highway and Transportation Officials
ABL	Aquatic Biomonitoring Laboratory
ABS	Acrylonitrile-butadiene-styrene
ACGIH	American Conference of Govermental Industrial Hygienists
AES	Atomic emission spectroscopy
AISC	American Institute of Steel Construction
AISI	American Iron and steel Institute
ALARA	As Low As Reasonably Achievable
AMCA	Air Movement Contractors association
amu	Atomic mass units
ANSI	American National Standards Institute
API	American Petroleum Institute
ARI	American Refrigeration Institute
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
AWWA	American Water Works Association
BHP	Brake horsepower
CFR	Code of Federal Regulations
CPVC	Chlorinated polyvinyl chloride
CRI	Carpet and Rug Institute
DCM	Decontamination Module
DOE	Department of Energy
DOT	Department of Transportation
DPM	Disintegrations per minute
ECD	Electron capture detector
EPA	U.S. Environmental Protection Agency
ERDA	Energy Research and Development Administration (now DOE)
FAL	Field Analytical Laboratory
FCC	Federal Construction Council
FID	Flame ionization detector
FM	Factory Mutual
FMGA	Flat Glass Marketing Association
FS	Federal specifications
GC	Gas chromatograph
GPC	Gel permeation chromatography
HECD	Hall electrolytic conductivity detector
HEPA	High efficiency particulate air
HF	High frequency
HID	High intensity discharge
HLW	High-level waste
HPLC	High performance liquid chromatography
HVAC	Heating, ventilating and air conditioning

ICL	Inorganic Chemistry Laboratory
ICP	Inductively coupled plasma
IEEE	Institute of Electrical and Electronic Engineers
IES	Illumination Engineering Society
JSI	Steel Joist Institute
kVA	kilovolt ampere
LLW	Low-level waste
LPG	Liquid petroleum gas
MIL-HDBK	DOD military handbook
MS	Mass spectrophotometer
NC	Noise criteria
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSPC	National Standard Plumbing Code
NUREG	Nuclear Regulatory Commission-produced reference document
OCC	Operations Control Center
OCL	Organic Chemistry Laboratory
OSR	Operational safety requirement
PB	Polybutylene
PCB	Polychlorinated biphenyls
PID	Photo-ionization detector
PLQ	Protected Living Quarters
PVC	Polyvinyl chloride
RFCI	Resilient Floor Covering Institute
RAL	Radioanalytical Laboratory
RBS	Robotic Base Station
RTAL	Road Transportable Analytical Laboratory
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SSM	Sample Screening Module
TCLP	Toxicity Characteristic Leachate Procedure
TRU	Transuranic
UBC	Uniform Building Code
UCRL	University of California Research Laboratory
UHF	Ultra high frequency
UL	Underwriters Laboratory
UPS	Uninterruptible power supply
UV	Ultraviolet
VHF	Very high frequency
VOA	Volatile organic analytes
ZHE	Zero headspace extraction

1.0 INTRODUCTION

This appendix presents the functional, design, and engineering requirements; operating conditions; and construction codes and standards for the RTAL System. This analysis was conducted in accordance with ECO's Quality Assurance (QA) Program which was developed and implemented in compliance with DOE 5700.6B and using the elements of DOE 4700.1 and ANS ANSI/ASME NQA-1. DOE Order 6430.1A of April 6, 1989, "U.S. Department of Energy General Design Criteria," was used extensively in this analysis as a design reference document, providing general guidance on a wide range of construction and material requirements.

Requirements were established for the system (RTAL), subsystems (individual modules), and major components. The following criteria were incorporated in this analysis:

- What the system is to accomplish
- The range of operating conditions
- The required degree of reliability
- The intended useful life
- Ease of maintenance, repair, and replacement

The analysis documented in this appendix has encompassed all those planned and systematic actions and controls necessary to provide adequate confidence that a system or component will perform satisfactorily in service. Facility design is being conducted in accordance with these requirements to provide assurance that the system's performance and quality objectives are satisfied.

2.0 ROAD TRANSPORTABLE ANALYTICAL LABORATORY SYSTEM (RTAL)

A reliable RTAL system capable of performing the full range of radiological, chemical, and biological analyses on-site in contaminated areas at Department of Energy (DOE) facilities will be designed and developed.

2.1 Objective: The objective of the RTAL project is, the construction of a set of individual laboratory modules, deployable independently or as an interconnected group, to meet each DOE site's specific needs for rapid, accurate analysis of a wide variety of hazardous and radioactive contaminants in soil, and ground and surface waters. The system will consist of 8 to 10 independent subsystem modules defined in sections 3 through 12, below.

2.2 RTAL Requirements: Requirements were assessed in terms of transportability of the laboratory system to the various DOE sites, the laboratory functions to be performed within these mobile units, and the safety of the work-force, public and the environment.

2.2.1 Road Transportable: Because the DOE waste sites to be cleaned up encompass large land areas, are at diverse sites, and transportation of potentially radiation- and chemical-contaminated samples to central laboratories for analysis are costly, time-consuming, and inefficient, the laboratory system must be road transportable to sites where they will be utilized to provide rapid analyses meeting the highest quality assurance and quality control (QA/QC) requirements.

2.2.2 Functional: Remediation requires extensive sampling to determine the extent of the contamination, to monitor cleanup and remediation progress, and for post-cleanup monitoring of facilities. Shipping of samples is a slow and expensive process. Field instrumentation and the RTAL transportable laboratories will provide critical, high quality analytical data faster and at lower cost. The interior layout of each laboratory will be determined by its function and the equipment it carries. The units will be self-sustained for heating, air conditioning and electrical supply. Water supply and human waste generation will be addressed.

2.2.3 Operational: The laboratory system must be capable of performing a variety of laboratory functions associated with sample collection, processing and analysis.

2.2.3.1 Process Samples: Capability shall be provided to process soil, ground-water and surface water samples. Initial design shall consider the processing of up to 20 samples per day with expansion capability up to 100 per day. Samples may contain radioactive elements and/or organics, heavy metals and other inorganics, or high explosive materials.

2.2.3.2 Analyze Samples: The laboratory system will provide the field and analytical equipment and facilities required to detect and quantify radionuclides, organics, heavy metals and other inorganics, and high explosive materials.

2.2.3.3 Handling of Radioactive Samples: Four levels of sample activity may be present:

- R1 - Radiation (<10 mR/h, <10 nCi/g alpha) low enough for bench-top analysis
- R2 - Sample (10-200mR/h, <10 nCi/g alpha) handling must be performed in a hood
- R3 - Sample (>200 mR/h) handling must be performed in a hot cell
- R4 - Sample (<200 mR/h, >10 nCi/g alpha) handling must be performed in a glove box

The vast majority (84%) of the samples projected to be collected are expected to be R1. Another 14% are expected to be R2 and only 2% are expected to be category R3/R4.

2.2.4 Personnel, Public, and Environmental Protection: Because of the few R3 and R4 samples anticipated to be generated, this laboratory system does not require the provisions of "hot cell operations" but in general will provide for primary, secondary and tertiary confinement. The areas where samples are received, stored and analyzed within the laboratory must be separate with respect to engineering and administrative controls from those of the general laboratory. Facility design and engineering should include controlled access to laboratory and provisions to limit exposure of the public to radiation hazard and to minimize personnel exposure to internal and external sources of radiation and other hazardous materials.

2.2.4.1 Radiation Safety: A Radiation Safety Program based on the principles of As Low As Reasonably Achievable (ALARA) that combines engineering controls and work practices to limit exposure of personnel to radioactive samples is essential.

2.2.4.2 Wastes, Storage and Control: Waste from the laboratory may include both radioactive and non-radioactive materials which may be in the form of liquids, airborne contaminants, or solids. Facility design will incorporate provisions to allow for separation of waste forms to prevent mixing of radioactive and hazardous wastes. Areas to handle these types of activities must be provided.

2.2.4.3 Controlled Access: Limiting access to the laboratory complex or its sub-components is essential for safety and security of personnel and the operations within the laboratories.

2.3 Performance Criteria: Design criteria will conform to DOE 6430.1A, General Design Criteria.

2.3.1 Road Transportability: The laboratory complex will consist of multiple units. Each will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport. Each unit shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts 350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

2.3.2 Laboratory Function: Design features will minimize the probability of the spread of potential contamination from within potentially contaminated areas to areas that are not normally contaminated. The secondary confinement system shall remain functional for all normal operations, anticipated operational occurrences, and for the Design Basis Accidents that it is required to withstand.

2.3.2.1 Process Samples: Design shall consider processing samples in monitored hoods and ventilation systems, and design features for introduction and removal stations to ensure the safe introduction and removal of material and maintenance equipment to and from the primary confinement and safe sample disposal/return.

2.3.2.2 Analyze Samples: Provisions will be made for conducting the following types of analyses:

Volatile Organics by GC/MS
Semi-volatile Organics by GC/MS
Pesticides/PCBs by GC
Toxicity Characteristic Leaching Procedure (TCLP)
Metals by ICP-AES
Metals by AA
Anions
Gross Alpha and Beta
Gamma Spectroscopy
Nuclide-Specific Analysis

2.3.2.3 Handling of Radioactive Samples: Provision will be made for the early determination of the degree of radioactivity present in a sample, and thus determine the future handling of the sample. The system design should emphasize handling of samples on benches and in hoods, with an occasional sample requiring a glove box or "hot cell".

2.3.3 Personnel, Public, and Environment Protection: Complete HEPA filtration of exhaust systems may be required. In addition separate ventilation system or off-gas treatment system with appropriate air-cleaning capability, e.g., HEPA filtration, radioiodine absorbers, scrubbers, may also be required. The ventilation and cleanup systems associated with the primary confinement shall not be shared with secondary and tertiary confinement systems. The operating pressure shall be primary confinement < secondary confinement < tertiary confinement < atmosphere. Tanks within the primary confinement shall vent to the off-gas treatment system. Complete HEPA and charcoal filtration of air intake for some or all of the modules may be required. Provisions must be made to minimize the risk of undue exposure of personnel to potentially hazardous materials that might be contained in the clean-up site.

2.3.3.1 Radiation Safety: Provisions will be made for survey monitoring to screen samples as they are received, personnel and area dosimetry, air monitors for work and storage areas, and self-surveying of personnel upon exiting the controlled area.

2.3.3.2 Wastes, Storage and Control: The waste management systems shall provide facilities and equipment to handle wastes safely and to enable monitoring of all effluent waste streams. Collection systems should be provided, where applicable, to isolate incompatible waste forms, and dikes or berms should be constructed around the process/treatment system, a transfer capability of leaking waste should also be considered. All exhaust outlets that may contain radioisotopes other than background levels shall be provided with two monitoring systems.

2.3.3.3 Controlled Access: Provisions for access will be such that access is minimized. Personnel will enter and exit laboratory complex at limited, controlled areas.

3. OPERATIONS/CONTROL CENTER (OCC) MODULE

3.1 Purpose: The OCC module will provide the capability for command and control of the modular laboratory complex.

3.2 OCC Requirements:

3.2.1 Road Transportable: The OCC module will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport.

3.2.2 Structural: The OCC module structure will provide a protected environment for the performance of the required command and control functions (see 3.2.6, 3.3.6, 3.4.6, and 3.5.6). Exterior walls and roof will be resistant to damages from extremes of environment. Interior walls and floors will have rigid underlining.

3.2.3 Basic Utilities: Module will be equipped with electrical wiring, plumbing, ductwork, and communications hardwiring.

3.2.4 Environmental Protection: Thermal insulation is required in exterior walls, floors, and ceilings. Clean air input must be provided. Emphasis will be placed on maintaining a comfortable temperature and humidity by air conditioning or heating to meet operational needs.

3.2.5 Functional Design: The unit will be self-sustained for heat, air conditioning and electrical supply. Water supply and human and laboratory waste generation will be addressed.

3.2.6 Operational Requirements: The OCC requires the functionality of a command and control office center. Design of the module will address the needs of the personnel to enhance operational performance. The interior will be functional and well lighted. Adequate ventilation will be provided based on the anticipated temperature extremes of the outside environment. Facilities will be provided for limited personal hygiene needs, computer work stations, decontamination shower, and for small conference/meeting capability. Ability to communicate with other modules and to monitor data acquisition will be provided.

3.3 OCC Performance Requirements:

3.3.1 Road Transportability: The module shall be securely mounted on a fifth-wheel type trailer that shall meet DOT standards for road transportation. The trailer/module shall be equipped with leveling jacks, leveling indicators, and all necessary hook-ups for attachment to a towing vehicle. The module shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts

350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

3.3.2 Structural Performance Requirements: The module must provide adequate strength to withstand the multi-directional forces exhibited in the transportation mode and protection against exterior shock that could occur during transport (see 3.3.1). It must also minimize air infiltration during transportation and be equipped with rub rails of at least heavy duty extruded aluminum and a hydraulic leveling system to facilitate set-up on-site. The overall construction shall be of sufficient quality to minimize vibration and noise in the interior of the module. The module shall have removable steps with a handrail for each door and a ladder securely mounted on the module exterior to provide access to the roof. The module shall have a floor constructed in a manner that prevents water and dust entry. Doors and windows will be functional according to operational needs. Framework will be strong and light weight to minimize overall weight. Structure will be provided with emergency escape capabilities. The overall dimensions will not exceed: length - 48', height - 13'-6", and width - 8'-6".

3.3.3 Basic Utilities Performance Requirements: Appropriate water distribution system (also see 3.2.6 and 3.3.6) must be provided within the OCC module. The unit will be equipped to meet electrical and communicational needs. The unit will also be equipped to meet temperature and humidity requirements, see Environmental paragraphs, 3.2.4 and 3.3.4.

3.3.3.1 Electrical Wiring: AC wiring will be provided. Outlets, number and location, will conform to National Electrical Code (NEC). Receptacles shall be adequate in number and capacity for the initial and projected requirements.

3.3.3.2 Supply-side Plumbing: Potable water for personnel use will be supplied as an operational supply need; potable water storage for a minimum of 200 gallons will be provided. Provision will also be made to supply water to meet overall OCC requirements. An external water supply hook-up capability will be provided for potable and non-potable use.

3.3.3.3 Waste-side Plumbing: The waste management systems shall provide facilities and equipment to handle wastes safely, effectively, and in an environmentally responsible manner.

3.3.3.4 Ductwork: Distribution ductwork shall be provided to distribute air and to exhaust air from the module. Outlets from air supply ducts shall be fitted with closable louvers. If multiple blower/filter units are installed, there should be cross ductwork to permit some flexibility of operation and increased reliability. Ductwork is an integral part of the overall air-handling system.

3.3.3.5 Communications: Interior communications shall be designed to use standard, commercially available telephone, CB, cellular, and satellite communication equipment. An external communication capability will be provided.

3.3.4 Environmental Performance Requirements: Insulation will be at least R-11 (walls), R-19 (ceiling), R-11 doors and R-19 (floors). Insulation shall comply with UBC Chapter 17 and will be moisture resistant. Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90. Complete HEPA and charcoal filtration of air intake will be provided. Provisions must be made to minimize the risk of undue exposure of personnel to potentially hazardous materials that might be contained in the clean-up site. A climate control system shall be provided to maintain temperature and humidity at an acceptable level.

3.3.5 Functional Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRE Standard 90, section 6. Potable water needs must be supplied internally for personnel use. A mechanical support area, separate from the operational work area will be provided.

3.3.6 Operational Performance Requirements: Human engineering criteria will be applied to optimize man/machine interfaces. Toilet facilities to meet the needs of the laboratory complex (except Personnel Living Quarters module) shall be provided. Provision will be made for water storage, water delivery, and waste storage for drinking, and sanitary needs. Lighting will be available in accordance with the task to be performed in a particular space. A contrast in lighting will be achieved through the use of various color schemes within the module. Voice and data transmission capability with other associated modules shall be provided.

3.4 OCC Major Equipment/Subunit Requirements:

3.4.1 Road Transportability Items: Trailer/module will be a fifth-wheel type frame that shall meet DOT standards for road transportation. The trailer shall have tandem axle dual wheels. The braking system shall be vacuum over hydraulic type, capable of stopping the trailer/module in case of accidental detachment from the towing vehicle.

3.4.2 Structural: One single door for operational use of module and one double door for large equipment movement are required. Subject to laboratory design, window(s) are required. Walls, floors and ceilings will have a finished interior surface. Windows will be abrasion resistant and provide emergency escape capability.

3.4.3 Basic Utilities Systems:

3.4.3.1 Electrical Wiring: Demand and diversity factors shall comply with DOE 6430.1A, Section 1630-1.1, Load Requirements. Interior electrical system power factor shall comply with DOE 6430.1A, Section 1630-1.2, Power factor. Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120 volt single phase service provided, as applicable.

3.4.3.2 Supply-side Plumbing: A supply side water distribution system shall be provided. Fixtures appropriate for an office-type setting will be provided.

3.4.3.3 Waste-side Plumbing: A waste water collection and storage system will be provided.

3.4.3.4 Ductwork: Ductwork systems will provide efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy and duct size. Ductwork must be designed to resist corrosive contaminants.

3.4.3.5 Communications: The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B Provisions for voice and data transmission will be made. Provisions for telephone hook-up and hardwiring for computers will be provided.

3.4.4 Environmental: The ventilation-exhaust systems shall be provided for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists and excessive heat and for the provision of fresh air to the occupants.

3.4.4.1 Insulation: Insulation is required in module construction for the reduction of fire hazard and protection from heat or cold. The building envelope shall meet the minimum prescriptive energy requirements of ASHRAE Standard 90.

3.4.4.2 Climate Control Systems: An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 3.2.4.5.

3.4.4.3 Air-intake Filtration: Air-intake portals shall be provided with a filtration system to remove potentially harmful particulates and volatile chemicals.

3.4.5 Functional Equipment/Systems: The module power and emergency systems shall serve loads set forth in NFPA 110.

Additional standby systems shall be provided to support systems or equipment components that are vital for protection of health, life, property, and safeguards. Uninterruptable power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. Power generating areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain ambient temperatures for equipment operation or personnel access.

3.4.5.1 HVAC Equipment: HVAC equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook. Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in DOE 6430.1A, Section 1595.

3.4.5.2 Electrical Supply System: A reliable energy supply must be provided for the OCC.

3.4.5.3 Uninterruptable Power Supplies: Uninterruptable power supplies shall be provided for those loads requiring guaranteed continuous power.

3.4.5.4 Mechanical Support Space: A space separate from the operational area of the module is required to house the mechanical equipment, e.g., generator, HVAC, heat pump.

3.4.6 Operational Equipment/Systems:

3.4.6.1 Hygiene Facilities: Hygiene facilities will be provided for limited personal grooming, and elimination of human waste. Storage capability for waste water and human wastes must be provided.

3.4.6.2 Computers and Wordprocessors: A requirement for computing and wordprocessing capability exists.

3.4.6.3 Data Monitoring: A capability for data monitoring is required to provide 24-hour monitoring of data acquisition.

3.4.6.4 Furniture: Office-type furniture is required to meet operational requirements.

3.4.6.5 Interior Lighting: Adequate interior lighting to ensure effective performance is required in all work areas.

3.4.6.6 Emergency Lighting: Emergency lighting systems, including exit lights, shall be provided as required by NFPA 101.

3.5 OCC Major Equipment Performance Requirements:

3.5.1 Trailer Frame Structure: Structural systems for highway structures shall be consistent with the requirements of AASHTO HB-13. The fifth wheel height will be 47½". It will be equipped with suspension air ride, tubular axles with oil seals and single anchor line, and brakes to meet F.M.V.S.S. Aluminum material used shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2. The unifying weight-carrying framework (that also provides the floor support for the attached module, see 3.5.2) will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Use of steel shall comply UBC, AISC S326, AISC M011, AISI Specifications for the Design of Cold-Formed Steel Structural Members, and with AISC N690.

3.5.2 Structural Equipment/Systems: Aluminum material used in structure shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.

3.5.2.1 Module Frame Structure: The module will have a framework of extruded aluminum with aluminum sheet paneling on the exterior walls. The floor framework will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Frame support posts will be aluminum, hi-ten double slotted series. All exterior exposed surfaces will be protected against corrosion and will have a finished look appropriate for the structure. The roof will be one piece aluminum bonded to hat section bows. Interior wall lining and roof lining will be plywood. Floor will be lightweight and solid, and a chemical resistant floor will cover the hard underlayment. Materials, framing systems, and details shall be compatible with clear space and span requirements, serviceability requirements, security requirements, climatic conditions, and structural design loads. Unit weights of materials shall be those given for highway structures by AASHTO standards. Live loads for highway structures shall be as stipulated in AASHTO HB-13. Unless stipulated otherwise, an HS 20-44 loading shall be used. Structure shall meet wind loads for highway structures as stipulated in AASHTO HB-13. The earthquake loads for highway structures shall be as stipulated in AASHTO HB-13 and AASHTO GSDB. Other loads for highway structures shall be as stipulated in AASHTO HB-13. Combination of loads and design requirements for highway structures shall be as stipulated in AASHTO HB-13. Structural systems for highway structures shall be consistent with the requirements of AASHTO BB-13.

3.5.2.2 Doors and Windows: Doors and windows shall be corrosion-resistant or protected against corrosion. Windows and doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings and floors. Door and window hardware shall comply with ANSI A156 series.

3.5.2.2.1 Doors: Doors will be 36" wide and be equipped with abrasion resistant windows, e.g., low-E tempered glass with a lexan outer cover. An overlapping molding is required where the paired double doors meet, Door jambs will be reinforced to make it more difficult to open by wedge or similar tools.

3.5.2.2.2 Windows: Windows shall be made of insulated low-E tempered glass with a lexan outer cover and will be at least 30" x 30" to meet escape hatch requirement. Windows shall comply with NFPA 101, chapter 22. Window cleaning provisions shall comply with ANSI A39.1. Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc. Aluminum windows shall comply with AAMA 101.

3.5.2.3 Walls, Floors and Ceilings:

3.5.2.3.1 Walls, Floors and Ceilings, General Requirements: Interior walls will be fire retardant and resist mild acids, alkalis and fumes. Floors will be easy to clean and resistant to mild chemicals. Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering. Carpet, if used, shall comply with CRI Carpet Specifiers Handbook and CRI Standard for Installation of Textile Floor Covering Materials. Wall, floor, and ceiling, and roof and ceiling assemblies shall be tested by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Units shall be equipped with smoke/heat alarms. Appropriately rated fire extinguishers will be provided.

3.5.2.3.2 Waterproofing: Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water washdown, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base-course and through-the-wall flashings, and shall make a bond with these flashings.

3.5.2.4 Louvers, Vents, Grills, and Screens: Louvers, vents, grills, and screens shall be corrosion-resistant or protected against corrosion.

3.5.3 Basic Utilities Systems:

3.5.3.1 Electrical Wiring: Fifteen and twenty amp circuits, consistent with NEC will be provided. Wire shall be not smaller than No. 12-2 copper with ground. Receptacles and switches shall comply with general grade as defined in FS W-C-596. Receptacle circuits shall be provided with ground-fault circuit interrupters as directed by NFPA 70; receptacle circuits that serve receptacles that are within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters. Adverse effects of voltage level variations, transients, and frequency variations on equipment operation shall be minimized. Sensitive electrical equipment, such as data processing equipment, shall be isolated as needed for protection. Uninterruptable power systems, or power conditioners may be used for isolation.

3.5.3.2 Supply-side Plumbing: Plumbing shall comply with the NSPC, ASHRAE Handbooks, and ASHRAE Standard 90. Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. Type L copper tubing, CPVC, or PB plastic pipe and tubing may be used. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe or tubing shall be solvent cemented or shall use other forms of joining such as electric heat fusion. Stop valves shall be provided at each fixture. All fixtures shall comply with FS WW-P-541.

3.5.3.3 Waste-side Plumbing: Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. ABS or PVC plastic pipe may be used. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Toilet facility alternatives should be considered. Provision for the collection and storage of other non-hazardous or non-radioactive wastes shall also be provided, as appropriate.

3.5.3.4 Ductwork: Ductwork systems will meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following:

- ASHRAE Fundamentals Handbook
- SMACNA HVAC Duct Construction Standards-Metal and Flexible
- SMACNA Fibrous Glass Duct Construction Standards
- SMACNA Round Industrial Duct Construction Standards
- SMACNA HVAC Duct Design Manual
- ACGIH Industrial Ventilation Manual
- NFPA 45
- NFPA 90A
- NFPA 91 (exhaust ductwork)
- ERDA 76-21

Ductwork that handles air exhausted from moisture generating areas shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90 and shall be acoustically insulated to meet acceptable noise criteria. Ducting should be arranged so that outside air can be passed through appropriate filter systems (see 3.2.4 and 3.3.4).

3.5.3.5 Communications: Various methods will satisfy the requirements. These include commercial mobile telephone network, VHF/UHF radio, HF radio, satellite communication system, or provision for connection to a central facility, e.g., command module. Installation and operating costs and availability in remote areas will be considered. Hardwiring shall be shielded to minimize interference or interruption of transmission. Consideration should be given to fiberoptic cable, especially for data transmission.

3.5.4 Environmental:

3.5.4.1 Insulation: Foam-in-place or other suitable insulation shall be used. Loose fill will not be used. Insulation shall comply with UBC Chapter 17. Thermal insulation shall be moisture resistant and fire retardant. The thermal resistance of insulation and the degradation of thermal resistance over time will be considered in the selection of the type of insulation provided. As a minimum, the thermal transmittance values ("U" values) and overall maximum allowable combined transmittance values shall not exceed those values as determined from ASHRAE Standard 90.

3.5.4.2 Temperature and Humidity Control Systems: Internal temperature will be maintainable below 75° F with external temperature up to 125° F and maintained above 65° F when external temperature is down to -30° F. Humidity will be controlled to allow comfort (30 to 60%).

3.5.4.3 Air-intake Filtration: HEPA and charcoal filters shall be placed in-line in the air-intake portals. HEPA filters for inhabited spaces shall comply with ARI 850. In addition, an activated charcoal filter will be provided for the removal of volatile chemicals. Adsorbers for toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510. A minimum of 20 - 30ft^3/min/person fresh air will be provided.

3.5.5 Functional Equipment/Systems: All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. All air handling equipment shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. If the air handling equipment and air-distribution system cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems. The mechanical support area will be separate from the laboratory area and will be accessible from the exterior. Systems shall be designed to minimize and isolate vibration resulting from the operation of support equipment.

3.5.5.1 HVAC Equipment: HVAC equipment shall be sized to satisfy the module heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook.

3.5.5.1.1 Air Conditioner: The air conditioner (AC) shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. The units should be readily serviceable by most commercial refrigeration/air conditioning companies. The AC unit should be designed to permit sequential starting of its motors to decrease the electrical surge load during the starting phase of the HVAC system.

3.5.5.1.2 Heating Equipment: Heating system should be selected based on consideration of human health and safety requirements, initial costs, operating costs and maintenance costs according to procedures in DOE 3630.1A, 0110-12.7, Building Design Analysis. Any system that might generate CO or CO_2 within the module (open flame) should be discouraged.

3.5.5.1.3 Humidifier/Dehumidifier: The need for a humidifier/dehumidifier should be addressed. An air tight construction with a heat exchange - air ventilation system might address some heating and cooling requirements and humidity requirements.

3.5.5.1.4 Air-intake and Air-exhaust Fans: All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook. Fans shall be located within the ductwork system according to the requirements of AMCA Publication 210 and ACGIH Industrial Ventilation Manual. Motors shall be sized according to properly calculated BHP fan requirements and shall not be oversized fans and motors. All fans and accessories shall be designed to meet all smoke and flame spread requirements of NFPA 255.

3.5.5.1.5 Thermostat: Air handling and air distribution controls shall comply with DOE 6430.1A, section 1595-6, Control of Air Handling Systems.

3.5.5.2 Power Source: The module shall be designed to operate on external power or on an onboard electrical generator.

3.5.5.2.1 External Power: A capability for automatic switchover to the onboard generator will be provided in the event of external power failure. Switchover is to be completed within 2 seconds.

3.5.5.2.2 Electrical Generator: The power system shall be capable of maintaining full operation. The power system shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. The generator will be sized according to the electrical load that will be required in the OCC. For loads greater than 25 KVA, diesel engines shall generally be used. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. Lighting power budget shall be determined in conformance with ASHRAE Standard 9, (see also 3.5.6.5 and 3.5.6.6). The electrical generator shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. For generators with ≤25kVa loads, gasoline or LP gas engines may be used. For loads >25kVa, diesel engines generally should be used. Application of diesel engines shall comply with FCC Technical Report No. 69.

3.5.5.3 Uninterruptable Power Supplies: Application of UPSs shall comply with IEEE 446 or as modified by cognizant DOE authority. UPS installations may be by safety class 1 or standby type dependent on the classification of the loads served.

3.5.5.4 Mechanical Support Space: The mechanical support space shall be located so that it has its own separate opening to the outside which shall consist of two double doors (combined opening 99") with heavy duty hinges and locks. Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. Where mechanical ventilation cannot maintain a satisfactory environment, other cooling systems shall be provided. Exhaust air openings should be located to minimize ambient thermal loads.

3.5.5.5 Fuel Storage Tanks: Total storage capacity for 4 days operation at maximum load without refueling shall be provided. Fuel storage tanks shall comply with API 650.

3.5.6 Operational Equipment:

3.5.6.1 Hygiene Facilities: A sink with hot/cold running water and a mirror for personal grooming will be provided. A decontamination shower capable of providing full surface decontamination shall be provided. A toilet will be provided that meets contemporary U.S. standards of living. A system for collecting and storing waste water and human wastes must be provided as needed, see 11.5.3.

3.5.6.2 Computers and Wordprocessors: A wordprocessing capability that is compatible with all modules and a state-of-the-art PC capability for data analysis shall be provided.

3.5.6.3 Data Monitoring: An ability to monitor the programs in the laboratories will shall be provided. This will include the ability to operate the programs when the operators in the laboratory are not present and controlling the programs, to transfer files between the OCC and the laboratory modules, and to provide a LAN capability.

3.5.6.4 Office-type Furniture: Office landscape partitions and components shall comply with NFPA 101, Chapter 31 and UBC Chapter 17. Furniture systems shall comply with NFPA 101, Chapter 31 (furnishings, decorations, and treated finishes) and UBC, Chapter 17 (folding, portable and movable partitions).

3.5.6.5 Interior Lighting: Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing should be avoided. Lighting design shall consider environmental degradation effects, e.g., dust, to ensure adequate lighting intensities on a long-term basis. Maximum use shall be made of fluorescent and high intensity discharge (HID) lamps. When using HID lighting, careful consideration of the required color rendition shall be made from visual and safety perspectives. Interior lighting systems shall comply with the IES Lighting Handbook. Non-uniform lighting practices shall comply with CFR 101-20.116-2 and with DOE 6430.1A Section 1694 (Energy Conservation).

3.5.6.6 Emergency Lighting: Where high intensity discharge (HID) lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

4. AQUATIC BIOMONITORING LABORATORY (ABL) MODULE

4.1 Purpose: The ABL module will provide the capability for toxicological monitoring of surface and aquifer, processed and treated, waters by monitoring their effects on test aquatic organisms.

4.2 ABL Requirements:

4.2.1 Road Transportable: The ABL module will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport.

4.2.2 Structural: The ABL module structure will provide a protected environment for the performance of the required laboratory functions (see 4.2.6, 4.3.6, 4.4.6, and 4.5.6). Exterior walls and roof will be resistant to damages from extremes of environment. Interior walls and floors will have rigid underlining.

4.2.3 Basic Utilities: Module will be equipped with electrical wiring, plumbing, ductwork, and communications hardwiring.

4.2.4 Environmental Protection: Thermal insulation is required in exterior walls, floors, and ceilings. Filtration of input air must be provided to prevent ingress of outside airborne contaminants. Exhaust air will also be filtered to protect the environment. Comfortable temperature and humidity in the ABL will be maintained by air conditioning or heating to meet operational needs.

4.2.5 Functional Design: The unit will be self-sustained for heat, air conditioning and electrical supply. Water supply and laboratory waste generation will be addressed.

4.2.6 Operational Requirements: The ABL requires the functionality of an aquatic toxicological laboratory. The laboratory must be equipped to allow continuous exposure of fish and other aquatic organisms to test waters. Design of the module will address the needs of the personnel to enhance operational performance. The interior will be functional and well lighted. Adequate ventilation will be provided based on the anticipated temperature extremes of the outside environment. Facilities will be provided for laboratory equipment storage, and for laboratory-generated-waste storage and removal. Particular attention will be given to wastes containing radioactive residues.

4.3 ABL Performance Requirements:

4.3.1 Road Transportability: The module shall be securely mounted on a fifth-wheel type trailer that shall meet DOT standards for road transportation. The trailer/module shall be equipped with leveling jacks, leveling indicators, and all necessary hook-ups for attachment to a towing vehicle. The module shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts 350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

4.3.2 Structural: The module must provide adequate strength to withstand the multi-directional forces exhibited in the transportation mode and protection against exterior shock that could occur during transport (see 4.3.1). It must also minimize air infiltration during transportation and be equipped with rub rails of at least heavy duty extruded aluminum and a hydraulic leveling system to facilitate set-up on-site. The overall construction shall be of sufficient quality to minimize vibration and noise in the interior of the module. The module shall have removable steps with a handrail for each door and a ladder securely mounted on the module exterior to provide access to the roof. The module shall have a floor constructed in a manner that prevents water and dust entry. Doors and windows will be functional according to operational needs. Framework will be strong and light weight to minimize overall weight. Structure will be provided with emergency escape capabilities. The overall dimensions will not exceed: length - 48', height - 13'-6", and width - 8'-6".

4.3.3 Basic Utilities Performance Requirements: Appropriate water distribution system for three types of water (one of which is potable) (also see 4.2.6 and 4.3.6) must be provided within the ABL module. The unit will be equipped to meet electrical and communicational needs. The unit will also be equipped to meet temperature and humidity requirements, see Environmental paragraphs, 4.2.4 and 4.3.4.

4.3.3.1 Electrical Wiring: AC wiring will be provided. Outlets, number and location, will conform to National Electrical Code (NEC). Receptacles shall be adequate in number and capacity for the initial and projected requirements.

4.3.3.2 Supply-side Plumbing: Potable water for personnel use will be provided. Provision will also be made to supply an additional two types of test waters to meet overall laboratory requirements. External water supply hook-ups will be provided for the three types of waters. The supply system for each type shall be strictly segregated to prevent cross-contamination.

4.3.3.3 Waste-side Plumbing: The waste management systems shall provide facilities and equipment to handle wastes safely, effectively, and in an environmentally responsible manner.

4.3.3.4 Ductwork: Distribution ductwork shall be provided to distribute air to the laboratory and to exhaust air from the module. Outlets from air supply ducts shall be fitted with closable louvers. If multiple blower/filter units are installed, there should be cross ductwork to permit some flexibility of operation and increased reliability. Ductwork is an integral part of the overall air-handling system.

4.3.3.5 Communications: Interior communications shall be designed to use standard, commercially available telephone, CB, cellular, and satellite communication equipment. An external communication capability will be provided.

4.3.4 Environmental: Insulation will be at least R-11 (walls), R-19 (ceiling), R-11 doors and R-19 (floors). Insulation shall comply with UBC Chapter 17 and will be moisture resistant. Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90. Complete HEPA and charcoal filtration of air intake will be provided. Provisions must be made to minimize the risk of undue exposure of personnel to potentially hazardous materials that might be contained in the clean-up site. A climate control system shall be provided to maintain temperature and humidity at an acceptable level.

4.3.5 Functional Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRE Standard 90, section 6. Potable water needs must be supplied internally for personnel use. A mechanical support area, separate from the laboratory area will be provided.

4.3.6 Operational Performance Requirements: Human engineering criteria will be applied to optimize man/machine interfaces. The laboratory will be capable of conducting chronic exposure of fish to water that may be contaminated with low levels of toxic material.

4.4 ABL Major Equipment/Subunit Requirements:

4.4.1 Road Transportability Items: Trailer/module will be a fifth-wheel type frame that shall meet DOT standards for road transportation. The trailer shall have tandem axle dual wheels. The braking system shall be vacuum over hydraulic type, capable of stopping the trailer/module in case of accidental detachment from the towing vehicle.

4.4.2 Structural: One single door for operational use of module and one double door for large equipment movement are required. Subject to laboratory design, window(s) are required. Walls, floors and ceilings will have a finished interior surface. Windows will be abrasion resistant and provide emergency escape capability.

4.4.3 Basic Utilities Systems:

4.4.3.1 Electrical Wiring: Demand and diversity factors shall comply with DOE 6430.1A, Section 1630-1.1, Load Requirements. Interior electrical system power factor shall comply with DOE 6430.1A, Section 1630-1.2, Power factor. Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120 volt single phase service provided, as applicable.

4 4.3.2 Supply-side Plumbing: A supply side water distribution system shall be provided. Fixtures appropriate for a laboratory facility will be provided.

4.4.3.3 Waste-side Plumbing: A waste water collection and storage system will be provided. Use of double walled pipes shall be considered.

4.4.3.4 Ductwork: Ductwork systems will provide efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy and duct size. Ductwork must be designed to resist corrosive contaminants.

4.4.3.5 Communications: The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B Provisions for voice and data transmission will be made. Provisions for telephone hook-up and hardwiring for computers will be provided.

4.4.4 Environmental: The ventilation-exhaust systems shall be provided for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists and excessive heat and for the provision of fresh air to the occupants. Consideration shall be given to low levels of volatilized hazardous compounds that may be in the test waters.

4.4.4.1 Insulation: Insulation is required in module construction for the reduction of fire hazard and protection from heat or cold. The building envelope shall meet the minimum prescriptive energy requirements of ASHRAE Standard 90.

4.4.4.2 Climate Control Systems: An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 4.2.4.5.

4.4.4.3 Air-intake Filtration: Air-intake portals shall be provided with a filtration system to remove potentially harmful particulates and volatile chemicals.

4.4.5 Functional Equipment/Systems: The module power and emergency systems shall serve loads set forth in NFPA 110. Additional standby systems shall be provided to support systems or equipment components that are vital for protection of health, life, property, and safeguards. Uninterruptable power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. Power generating areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain ambient temperatures for equipment operation or personnel access.

4.4.5.1 HVAC Equipment: HVAC equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook. Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in DOE 6430.1A, Section 1595.

4.4.5.2 Electrical Supply System: A reliable energy supply must be provided for the ABL.

4.4.5.3 Uninterruptible Power Supplies: Uninterruptable power supplies shall be provided for those loads requiring guaranteed continuous power.

4.4.5.4 Mechanical Support Space: A space separate from the operational area of the module is required to house the mechanical equipment, e.g., generator, HVAC, heat pump.

4.4.6 Operational Equipment/Systems:

4.4.6.1 Aquatic Biomonitoring: Equipment is needed to conduct test exposure of fish and other aquatic organisms. Testing will require water tanks, water baths, water sampler, water purifiers, water purification tanks, and diluter(s).

4.4.6.2 Furniture: Laboratory benchwork and cabinets are required to meet operational requirements.

4.4.6.3 Interior Lighting: Adequate interior lighting to ensure effective performance is required in all work areas.

4.4.6.4 Emergency Lighting: Emergency lighting systems, including exit lights, shall be provided as required by NFPA 101.

4.5 ABL Major Equipment Performance Requirements:

4.5.1 Trailer Frame Structure: Structural systems for highway structures shall be consistent with the requirements of AASHTO HB-13. The fifth wheel height will be 47½". It will be equipped with suspension air ride, tubular axles with oil seals and single anchor line, and brakes to meet F.M.V.S.S. Aluminum material used shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2. The unifying weight-carrying framework (that also provides the floor support for the attached module, see 4.5.2) will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Use of steel shall comply UBC, AISC S326, AISC M011, AISI Specifications for the Design of Cold-Formed Steel Structural Members, and with AISC N690.

4.5.2 Structural Equipment/Systems: Aluminum material used in structure shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.

4.5.2.1 Module Frame Structure: The module will have a framework of extruded aluminum with aluminum sheet paneling on the exterior walls. The floor framework will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Frame support posts will be aluminum, hi-ten double slotted series. All exterior exposed surfaces will be protected against corrosion and will have a finished look appropriate for the structure. The roof will be one piece aluminum bonded to hat section bows. Interior wall lining and roof lining will be plywood. Floor will be lightweight and solid, and a chemical resistant floor will cover the hard underlayment. Materials, framing systems, and details shall be compatible with clear space and span requirements, serviceability requirements, security requirements, climatic conditions, and structural design loads. Unit weights of materials shall be those given for highway structures by AASHTO standards. Live loads for highway structures shall be as stipulated in AASHTO HB-13. Unless stipulated otherwise, an HS 20-44 loading shall be used. Structure shall meet wind loads for highway structures as stipulated in AASHTO HB-13. The earthquake loads for highway structures shall be as stipulated in AASHTO HB-13 and AASHTO GSDB. Other loads for highway structures shall be as stipulated in AASHTO HB-13. Combination of loads and design requirements for highway structures shall be as stipulated in AASHTO HB-13. Structural systems for highway structures shall be consistent with the requirements of AASHTO BB-13.

4.5.2.2 Doors and Windows: Doors and windows shall be corrosion-resistant or protected against corrosion. Windows and doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings and floors. Door and window hardware shall comply with ANSI A156 series.

4.5.2.2.1 Doors: Doors will be 36" wide and be equipped with abrasion resistant windows, e.g., low-E tempered glass with a lexan outer cover. An overlapping molding is required where the paired double doors meet, Door jambs will be reinforced to make it more difficult to open by wedge or similar tools.

4.5.2.2.2 Windows: Windows shall be made of insulated low-E tempered glass with a lexan outer cover and will be at least 30" x 30" to meet escape hatch requirement. Windows shall comply with NFPA 101, chapter 22. Window cleaning provisions shall comply with ANSI A39.1. Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc. Aluminum windows shall comply with AAMA 101.

4.5.2.3 Walls, Floors and Ceilings:

4.5.2.3.1 Walls, Floors and Ceilings, General Requirements: Interior walls will be fire retardant and resist mild acids, alkalis and fumes. Floors will be easy to clean and resistant to mild chemicals. Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering. Vinyl composition and rubber or vinyl cove base shall be used. Wall, floor, and ceiling, and roof and ceiling assemblies shall be tested by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Units shall be equipped with smoke/heat alarms. Appropriately rated fire extinguishers will be provided.

4.5.2.3.2 Waterproofing: Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water washdown, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base-course and through-the-wall flashings, and shall make a bond with these flashings.

4.5.2.4 Louvers, Vents, Grills, and Screens: Louvers, vents, grills, and screens shall be corrosion-resistant or protected against corrosion.

4.5.3 Basic Utilities Systems:

4.5.3.1 Electrical Wiring: Fifteen and twenty amp circuits, consistent with NEC will be provided. Wire shall be not smaller than No. 12-2 copper with ground. Receptacles and switches shall comply with general grade as defined in FS W-C-596. Receptacle circuits shall be provided with ground-fault circuit interrupters as directed by NFPA 70; receptacle circuits that serve receptacles that are within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters. Adverse effects of voltage level variations, transients, and frequency variations on equipment operation shall be minimized. Sensitive electrical equipment, such as data processing equipment, shall be isolated as needed for protection. Uninterruptable power systems, or power conditioners may be used for isolation.

4.5.3.2 Supply-side Plumbing: Plumbing shall comply with the NSPC, ASHRAE Handbooks, and ASHRAE Standard 90. Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. Type L copper tubing, CPVC, or PB plastic pipe and tubing may be used. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe or tubing shall be solvent cemented or shall use other forms of joining such as electric heat fusion. Stop valves shall be provided at each fixture. All fixtures shall comply with FS WW-P-541.

4.5.3.3 Waste-side Plumbing: Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. ABS or PVC plastic pipe may be used. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Waste handling areas shall comply with the standards of confinement and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled. Specific DOE design and operating requirements for radioactive wastes (HLW, LLW, and TRU) appear in DOE 5820.2A. Appropriate provisions for storage of containerized radioactive and/or hazardous wastes shall be provided. Provision for the collection and storage of other non-hazardous or non-radioactive wastes shall also be provided, as appropriate.

4.5.3.4 Ductwork: Ductwork systems will meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following:

- ASHRAE Fundamentals Handbook
- SMACNA HVAC Duct Construction Standards-Metal and Flexible
- SMACNA Fibrous Glass Duct Construction Standards
- SMACNA Round Industrial Duct Construction Standards
- SMACNA HVAC Duct Design Manual
- ACGIH Industrial Ventilation Manual
- NFPA 45
- NFPA 90A
- NFPA 91 (exhaust ductwork)
- ERDA 76-21

Ductwork that handles air exhausted from moisture generating areas shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90 and shall be acoustically insulated to meet acceptable noise criteria. Ducting should be arranged so that outside air can be passed through appropriate filter systems (see 4.2.4 and 4.3.4).

4.5.3.5 Communications: Various methods will satisfy the requirements. These include commercial mobile telephone network, VHF/UHF radio, HF radio, satellite communication system, or provision for connection to a central facility, e.g., command module. Installation and operating costs and availability in remote areas will be considered. Hardwiring shall be shielded to minimize interference or interruption of transmission. Consideration should be given to fiberoptic cable, especially for data transmission.

4.5.4 Environmental:

4.5.4.1 Insulation: Foam-in-place or other suitable insulation shall be used. Loose fill will not be used. Insulation shall comply with UBC Chapter 17. Thermal insulation shall be moisture resistant and fire retardant. The thermal resistance of insulation and the degradation of thermal resistance over time will be considered in the selection of the type of insulation provided. As a minimum, the thermal transmittance values ("U" values) and overall maximum allowable combined transmittance values shall not exceed those values as determined from ASHRAE Standard 90.

4.5.4.2 Temperature and Humidity Control Systems: Internal temperature will be maintainable below 75° F with external temperature up to 125° F and maintained above 65° F when external temperature is down to -30° F. Humidity will be controlled to allow comfort (30 to 60%).

4.5.4.3 Air-intake Filtration: HEPA and charcoal filters shall be placed in-line in the air-intake portals. HEPA filters for inhabited spaces shall comply with ARI 850. In addition, an activated charcoal filter will be provided for the removal of volatile chemicals. Adsorbers for toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510. A minimum of 20 - 30ft^3/min/person fresh air will be provided.

4.5.4.4 Air Distribution: Air distribution shall be designed to minimize exposure of operating personnel to the low levels of volatilized hazardous compounds which may be encountered in the test waters.

4.5.5 Functional Equipment/Systems: All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. All air handling equipment shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. If the air handling equipment and air-distribution system cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems. The mechanical support area will be separate from the laboratory area and will be accessible from the exterior. Systems shall be designed to minimize and isolate vibration resulting from the operation of support equipment.

4.5.5.1 HVAC Equipment: HVAC equipment shall be sized to satisfy the module heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook.

4.5.5.1.1 Air Conditioner: The AC shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. The units should be readily serviceable by most commercial refrigeration/air conditioning companies. The AC unit should be designed to permit sequential starting of its motors to decrease the electrical surge load during the starting phase of the HVAC system.

4.5.5.1.2 Heating Equipment: Heating system should be selected based on consideration of human health and safety requirements, initial costs, operating costs and maintenance costs according to procedures in DOE 3630.1A, 0110-12.7, Building Design Analysis. Any system that might generate CO or CO_2 within the module (open flame) should be discouraged.

4.5.5.1.3 Humidifier/Dehumidifier: The need for a humidifier/dehumidifier should be addressed. An air tight construction with a heat exchange - air ventilation system might address some heating and cooling requirements and humidity requirements.

4.5.5.1.4 Air-intake and Air-exhaust Fans: All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook. Fans shall be located within the ductwork system according to the requirements of AMCA Publication 210 and ACGIH Industrial Ventilation Manual. Motors shall be sized according to \properly calculated BHP fan requirements and shall not be oversized fans and motors. All fans and accessories shall be designed to meet all smoke and flame spread requirements of NFPA 255.

4.5.5.1.5 Thermostat: Air handling and air distribution controls shall comply with DOE 6430.1A, section 1595-6, Control of Air Handling Systems.

4.5.5.2 Power Source: The module shall be designed to operate on external power or on an onboard electrical generator.

4.5.5.2.1 External Power: A capability for automatic switchover to the onboard generator will be provided in the event of external power failure. Switchover is to be completed within 2 seconds.

4.5.5.2.2 Electrical Generator: The power system shall be capable of maintaining full operation. The power system shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. The generator will be sized according to the electrical load that will be required in the ABL. For loads greater than 25 KVA, diesel engines shall generally be used. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. Lighting power budget shall be determined in conformance with ASHRAE Standard 9 (see also 4.5.6.5 and 4.5.6.6). The electrical generator shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. For generators with ≤25kVa loads, gasoline or LP gas engines may be used. For loads >25kVa, diesel engines generally should be used. Application of diesel engines shall comply with FCC Technical Report No. 69.

4.5.5.3 Uninterruptible Power Supplies: Application of UPSs shall comply with IEEE 446 or as modified by cognizant DOE authority. UPS installations may be by safety class 1 or standby type dependent on the classification of the loads served.

4.5.5.4 Mechanical Support Space: The mechanical support space shall be located so that it has its own separate opening to the outside which shall consist of two double doors (combined opening 99") with heavy duty hinges and locks. Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. Where mechanical ventilation cannot maintain a satisfactory environment, other cooling systems shall be provided. Exhaust air openings should be located to minimize ambient thermal loads.

4.5.5.5 Fuel Storage Tanks: Total storage capacity for 4 days operation at maximum load without refueling shall be provided. Fuel storage tanks shall comply with API 650.

4.5.6 Operational Equipment:

4.5.6.1 Aquatic Biomonitoring:

4.5.6.1.1 Water Tanks: Commercial fish tanks of suitable size shall be provided. The requirement for replicate sample and multiple sample monitoring and organism group size per test group shall be considered.

4.5.6.1.2 Water Baths: Water baths shall be provided to contain fish-holding water tanks. Multiple tanks may be in one water bath. Water baths shall be constructed with type 316 stainless steel and shall be provided with drains connected to a waste water drainage collection and storage system. A secondary containment system shall be provided to collect any spillage from test tanks and water baths.

4.5.6.1.3 Water Sampler: Sampler selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications. Efficiency, cost and reliability are characteristics that need to be considered.

4.5.6.1.4 Water Purifiers: Water purifiers selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications. Efficiency, cost and reliability are characteristics that need to be considered.

4.5.6.1.5 Water Purification Tanks: Water purification tanks selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications. Efficiency, cost and reliability are characteristics that need to be considered.

4.5.6.1.6 Diluter: Diluter shall provide for mixing dilution water and toxicant solutions in six concentrations and a control solution. Provisions should include the ability to split the diluted samples and to maintain water flow rates of at least 100mL/min for each of the outputs. The diluter cycle shall be automatically controlled. Diluter chambers shall be constructed of glass of appropriate thickness glued together with silicone sealer. Fittings and flow splitting chambers shall be glass, polyethylene, polyfluorocarbon, or type 316 stainless steel. All piping shall be type 316 stainless steel. Water volumes in the various chambers shall be easily adjusted.

4.5.6.1.7 Ventilatory Diluter: The ventilatory diluter shall provide for mixing dilution water and toxicant solutions in multiple concentrations and a control solution. Provisions should include the ability to split the diluted samples and to maintain water flow rates of at least 50mL/min for each of 32 output lines. The diluter cycle shall be automatically controlled. Diluter chambers shall be constructed of glass of appropriate thickness glued together with silicone sealer. Fittings and flow splitting chambers shall be glass, polyethylene, polyfluorocarbon, or type 316 stainless steel. All piping shall be type 316 stainless steel. Water volumes in the various chambers shall be easily adjusted.

4.5.6.1.8 Multiple Test Water Input Ports: The module shall be equipped with a minimum of three sets of three test water input ports each to allow continuous sampling of aquifers and other test waters. Each long side of the module shall have at least one set test water input ports.

4.5.6.2 Laboratory Furniture: Furniture shall comply with NFPA 101, Chapter 31 and UBC Chapter 17, as applicable. Standard stock sizes, material, and finishes of a competitive type shall be considered. Base cabinets, bench tops, sinks, and hoods shall have nominal unit lengths that can be interchanged to make up the required combinations. In laboratories handling radioactive materials, the weight of shielding material to be placed on bench tops and hoods shall be considered in specifying bases and cabinets. Most commercial bases and cabinets for laboratory use can support 300-500 pounds per leg or corner. Laboratory furniture used for purposes requiring more than the general illumination levels should be designed and equipped to provide local task lighting of the required intensity.

4.5.6.3 Interior Lighting: Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing should be avoided. Lighting design shall consider environmental degradation effects, e.g., dust, to ensure adequate lighting intensities on a long-term basis. Maximum use shall be made of fluorescent and HID lamps. When using HID lighting, careful consideration of the required color rendition shall be made from visual and safety perspectives. Interior lighting systems shall comply with the IES Lighting Handbook. Non-uniform lighting practices shall comply with CFR 101-20.116-2 and with DOE 6430.1A Section 1694 (Energy Conservation).

4.5.6.4 Emergency Lighting: Where high intensity discharge (HID) lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

5. FIELD ANALYTICAL LABORATORY (FAL) MODULE

5.1 Purpose: The FAL module will provide the space and instrumentation for radiological safety personnel to screen equipment, clothing, floors, tables, etc., within the laboratory complex and a laboratory for personnel to perform field radiation screening that can provide gross determinations as to whether the sample to be submitted for analysis contains high concentrations, depending upon the sensitivity of the detection equipment. All samples to be analyzed in the laboratory must be field screened to determine gross activity. Only samples with a radioactive concentration within pre-specified limits for the laboratory complex will be allowed to be submitted for analysis.

5.2 FAL Requirements:

5.2.1 Road Transportable: The FAL module will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport.

5.2.2 Structural: The FAL module structure will provide a protected environment for the performance of the required command and control functions (see 5.2.6, 5.3.6, 5.4.6, and 5.5.6). Exterior walls and roof will be resistant to damages from extremes of environment. Interior walls and floors will have rigid underlining.

5.2.3 Basic Utilities: Module will be equipped with electrical wiring, plumbing, ductwork, and communications hardwiring.

5.2.4 Environmental Protection: Thermal insulation is required in exterior walls, floors, and ceilings. Clean air input must be provided. Emphasis will be placed on maintaining a comfortable temperature and humidity by air conditioning or heating to meet operational needs.

5.2.5 Functional Design: The unit will be self-sustained for heat, air conditioning and electrical supply. Water supply and laboratory waste generation will be addressed.

5.2.6 Operational Requirements: The FAL requires the functionality of a Field analytical laboratory and an instrument calibration unit. The FAL may also provide limited storage for laboratory complex supplies and small equipment storage. Design of the module will address the needs of the personnel to enhance operational performance. The interior will be functional and well lighted. Adequate ventilation will be provided based on the anticipated temperature extremes of the outside environment.

5.3 FAL Performance Requirements:

5.3.1 Road Transportability: The module shall be securely mounted on a fifth-wheel type trailer that shall meet DOT standards for road transportation. The trailer/module shall be equipped with leveling jacks, leveling indicators, and all necessary hook-ups for attachment to a towing vehicle. The module shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts 350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

5.3.2 Structural: The module must provide adequate strength to withstand the multi-directional forces exhibited in the transportation mode and protection against exterior shock that could occur during transport (see 5.3.1). It must also minimize air infiltration during transportation and be equipped with rub rails of at least heavy duty extruded aluminum and a hydraulic leveling system to facilitate set-up on-site. The overall construction shall be of sufficient quality to minimize vibration and noise in the interior of the module. The module shall have removable steps with a handrail for each door and a ladder securely mounted on the module exterior to provide access to the roof. The module shall have a floor constructed in a manner that prevents water and dust entry. Doors and windows will be functional according to operational needs. Framework will be strong and light weight to minimize overall weight. Structure will be provided with emergency escape capabilities. The overall dimensions will not exceed: length - 48', height - 13'-6", and width - 8'-6".

5.3.3 Basic Utilities Performance Requirements: Appropriate water distribution system (also see 5.2.6 and 5.3.6) must be provided within the FAL module. The unit will be equipped to meet electrical and communicational needs. The unit will also be equipped to meet temperature and humidity requirements, see Environmental paragraphs, 5.2.4 and 5.3.4.

5.3.3.1 Electrical Wiring: AC wiring will be provided. Outlets, number and location, will conform to National Electrical Code (NEC). Receptacles shall be adequate in number and capacity for the initial and projected requirements.

5.3.3.2 Supply-side Plumbing: Potable water will be supplied as an operational supply need; potable water storage for a minimum of 200 gallons will be provided. Provision will also be made to supply water to meet overall FAL requirements. An external water supply hook-up capability will be provided for potable and non-potable use.

5.3.3.3 Waste-side Plumbing: The waste management systems shall provide facilities and equipment to handle wastes safely, effectively, and in an environmentally responsible manner.

5.3.3.4 Ductwork: Distribution ductwork shall be provided to distribute air and to exhaust air from the module. Outlets from air supply ducts shall be fitted with closable louvers. If multiple blower/filter units are installed, there should be cross ductwork to permit some flexibility of operation and increased reliability. Ductwork is an integral part of the overall air-handling system.

5.3.3.5 Communications: Interior communications shall be designed to use standard, commercially available telephone, CB, cellular, and satellite communication equipment. An external communication capability will be provided.

5.3.4 Environmental: Insulation will be at least R-11 (walls), R-19 (ceiling), R-11 doors and R-19 (floors). Insulation shall comply with UBC Chapter 17 and will be moisture resistant. Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90. Complete HEPA and charcoal filtration of air intake will be provided. Provisions must be made to minimize the risk of undue exposure of personnel to potentially hazardous materials that might be contained in the clean-up site. A climate control system shall be provided to maintain temperature and humidity at an acceptable level.

5.3.5 Functional Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRE Standard 90, section 6. Potable water needs must be supplied internally for personnel use. A mechanical support area, separate from the operational work area will be provided.

5.3.6 Operational Performance Requirements: Human engineering criteria will be applied to optimize man/machine interfaces. The laboratory will be capable of conducting field radiation and chemical contamination screening analyses with portable instruments. The FAL must be designed to be able to function closely with the ROB to assess and monitor samples in the field. Lighting will be available in accordance with the task to be performed in a particular space. A contrast in lighting will be achieved through the use of various color schemes within the module.

5.4 FAL Major Equipment/Subunit Requirements:

5.4.1 Road Transportability Items: Trailer/module will be a fifth-wheel type frame that shall meet DOT standards for road transportation. The trailer shall have tandem axle dual wheels. The braking system shall be vacuum over hydraulic type, capable of stopping the trailer/module in case of accidental detachment from the towing vehicle.

5.4.2 Structural: One single door for operational use of module and one double door for large equipment movement are required. Subject to laboratory design, window(s) are required. Walls, floors and ceilings will have a finished interior surface. Windows will be abrasion resistant and provide emergency escape capability.

5.4.3 Basic Utilities Systems:

5.4.3.1 Electrical Wiring: Demand and diversity factors shall comply with DOE 6430.1A, Section 1630-1.1, Load Requirements. Interior electrical system power factor shall comply with DOE 6430.1A, Section 1630-1.2, Power factor. Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120 volt single phase service provided, as applicable.

5.4.3.2 Supply-side Plumbing: A supply side water distribution system shall be provided. Fixtures appropriate for a laboratory facility will be provided.

5.4.3.3 Waste-side Plumbing: A waste water collection and storage system will be provided.

5.4.3.4 Ductwork: Ductwork systems will provide efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy and duct size. Ductwork must be designed to resist corrosive contaminants.

5.4.3.5 Communications: The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B Provisions for voice and data transmission will be made. Provisions for telephone hook-up and hardwiring for computers will be provided.

5.4.4 Environmental: The ventilation-exhaust systems shall be provided for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists and excessive heat and for the provision of fresh air to the occupants.

5.4.4.1 Insulation: Insulation is required in module construction for the reduction of fire hazard and protection from heat or cold. The building envelope shall meet the minimum prescriptive energy requirements of ASHRAE Standard 90.

5.4.4.2 Climate Control Systems: An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 3.2.4.5.

5.4.4.3 Air-intake Filtration: Air-intake portals shall be provided with a filtration system to remove potentially harmful particulates and volatile chemicals.

5.4.5 Functional Equipment/Systems: The module power and emergency systems shall serve loads set forth in NFPA 110. Additional standby systems shall be provided to support systems or equipment components that are vital for protection of health, life, property, and safeguards. Uninterruptable power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. Power generating areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain ambient temperatures for equipment operation or personnel access.

5.4.5.1 HVAC Equipment: HVAC equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook. Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in DOE 6430.1A, Section 1595.

5.4.5.2 Electrical Supply System: A reliable energy supply must be provided for the FAL.

5.4.5.3 Uninterruptible Power Supplies: Uninterruptable power supplies shall be provided for those loads requiring guaranteed continuous power.

5.4.5.4 Mechanical Support Space: A space separate from the operational area of the module is required to house the mechanical equipment, e.g., generator, HVAC, heat pump.

5.4.6 Operational Equipment/Systems:

5.4.6.1 Health Physics Capability: A separate area and instrumentation are needed for health physics personnel to operate and maintain a state-of-the-art program.

5.4.6.2 Field Radiation Screening: Field radiation screening requires instrumentation to provide Level I and/or II data on alpha and beta particle levels and gamma rays emission levels in soil and water within the area to be sampled.

5.4.6.3 Chemical Contamination Screening: Chemical contamination screening requires instrumentation for detection of organic and inorganic contaminants in soil and water within the area to be sampled.

5.4.6.4 Limited Storage: Limited storage capability requires a separate area equipped with storage racks or shelving. The racks must be designed for instrument protection against breakage during transport. Space for storage of radiological and chemical monitoring instruments will be addressed.

5.4.6.5 Furniture: Laboratory benchwork and cabinets are required to meet operational requirements.

5.4.6.6 Interior Lighting: Adequate interior lighting to ensure effective performance is required in all work areas.

5.4.6.7 Emergency Lighting: Emergency lighting systems, including exit lights, shall be provided as required by NFPA 101.

5.5 FAL Major Equipment Performance Requirements:

5.5.1 Trailer Frame Structure: Structural systems for highway structures shall be consistent with the requirements of AASHTO HB-13. The fifth wheel height will be 47½". It will be equipped with suspension air ride, tubular axles with oil seals and single anchor line, and brakes to meet F.M.V.S.S. Aluminum material used shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2. The unifying weight-carrying framework (that also provides the floor support for the attached module, see 5.5.2) will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Use of steel shall comply UBC, AISC S326, AISC M011, AISI Specifications for the Design of Cold-Formed Steel Structural Members, and with AISC N690.

5.5.2 Structural Equipment/Systems: Aluminum material used in structure shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.

5.5.2.1 Module Frame Structure: The module will have a framework of extruded aluminum with aluminum sheet paneling on the exterior walls. The floor framework will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Frame support posts will be aluminum, hi-ten double slotted series. All exterior exposed surfaces will be protected against corrosion and will have a finished look appropriate for the structure. The roof will be one piece aluminum bonded to hat section bows. Interior wall lining and roof lining will be plywood. Floor will be lightweight and solid, and a chemical resistant floor will cover the hard underlayment. Materials, framing systems, and details shall be compatible with clear space and span requirements, serviceability requirements, security requirements, climatic conditions, and structural design loads. Unit weights of materials shall be those given for highway structures by AASHTO standards. Live loads for highway structures shall be as stipulated in AASHTO HB-13. Unless stipulated otherwise, an HS 20-44 loading shall be used. Structure shall meet wind loads for highway structures as stipulated in AASHTO HB-13. The earthquake loads for highway structures shall be as stipulated in AASHTO HB-13 and AASHTO GSDB. Other loads for highway structures shall be as stipulated in AASHTO HB-13. Combination of loads and design requirements for highway structures shall be as stipulated in AASHTO HB-13. Structural systems for highway structures shall be consistent with the requirements of AASHTO BB-13.

5.5.2.2 Doors and Windows: Doors and windows shall be corrosion-resistant or protected against corrosion. Windows and doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings and floors. Door and window hardware shall comply with ANSI A156 series.

5.5.2.2.1 Doors: Doors will be 36" wide and be equipped with abrasion resistant windows, e.g., low-E tempered glass with a lexan outer cover. An overlapping molding is required where the paired double doors meet, Door jambs will be reinforced to make it more difficult to open by wedge or similar tools.

5.5.2.2.2 Windows: Windows shall be made of insulated low-E tempered glass with a lexan outer cover and will be at least 30" x 30" to meet escape hatch requirement. Windows shall comply with NFPA 101, chapter 22. Window cleaning provisions shall comply with ANSI A39.1. Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc. Aluminum windows shall comply with AAMA 101.

5.5.2.3 Walls, Floors and Ceilings:

5.5.2.3.1 Walls, Floors and Ceilings, General Requirements: Interior walls will be fire retardant and resist mild acids, alkalis and fumes. Floors will be easy to clean and resistant to mild chemicals. Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering. Vinyl composition and rubber or vinyl cove base shall be used. Wall, floor, and ceiling, and roof and ceiling assemblies shall be tested by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Units shall be equipped with smoke/heat alarms. Appropriately rated fire extinguishers will be provided.

5.5.2.3.2 Waterproofing: Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water washdown, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base-course and through-the-wall flashings, and shall make a bond with these flashings.

5.5.2.4 Louvers, Vents, Grills, and Screens: Louvers, vents, grills, and screens shall be corrosion-resistant or protected against corrosion.

5.5.3 Basic Utilities Systems:

5.5.3.1 Electrical Wiring: Fifteen and twenty amp circuits, consistent with NEC will be provided. Wire shall be not smaller than No. 12-2 copper with ground. Receptacles and switches shall comply with general grade as defined in FS W-C-596. Receptacle circuits shall be provided with ground-fault circuit interrupters as directed by NFPA 70; receptacle circuits that serve receptacles that are within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters. Adverse effects of voltage level variations, transients, and frequency variations on equipment operation shall be minimized. Sensitive electrical equipment, such as data processing equipment, shall be isolated as needed for protection. Uninterruptable power systems, or power conditioners may be used for isolation.

5.5.3.2 Supply-side Plumbing: Plumbing shall comply with the NSPC, ASHRAE Handbooks, and ASHRAE Standard 90. Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. Type L copper tubing, CPVC, or PB plastic pipe and tubing may be used. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe or tubing shall be solvent cemented or shall use other forms of joining such as electric heat fusion. Stop valves shall be provided at each fixture. All fixtures shall comply with FS WW-P-541.

5.5.3.3 Waste-side Plumbing: Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. ABS or PVC plastic pipe may be used. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Waste handling areas shall comply with the standards of confinement and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled. Specific DOE design and operating requirements for radioactive wastes (HLW, LLW, and TRU) appear in DOE 5820.2A. Appropriate provisions for storage of containerized radioactive and/or hazardous wastes shall be provided. Provision for the collection and storage of other non-hazardous or non-radioactive wastes shall also be provided, as appropriate.

5.5.3.4 Ductwork: Ductwork systems will meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following:

- ASHRAE Fundamentals Handbook
- SMACNA HVAC Duct Construction Standards-Metal and Flexible
- SMACNA Fibrous Glass Duct Construction Standards
- SMACNA Round Industrial Duct Construction Standards
- SMACNA HVAC Duct Design Manual
- ACGIH Industrial Ventilation Manual
- NFPA 45
- NFPA 90A
- NFPA 91 (exhaust ductwork)
- ERDA 76-21

Ductwork that handles air exhausted from moisture generating areas shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90 and shall be acoustically insulated to meet acceptable noise criteria. Ducting should be arranged so that outside air can be passed through appropriate filter systems (see 5.2.4 and 5.3.4).

5.5.3.5 Communications: Various methods will satisfy the requirements. These include commercial mobile telephone network, VHF/UHF radio, HF radio, satellite communication system, or provision for connection to a central facility, e.g., command module. Installation and operating costs and availability in remote areas will be considered. Hardwiring shall be shielded to minimize interference or interruption of transmission. Consideration should be given to fiberoptic cable, especially for data transmission.

5.5.4 Environmental:

5.5.4.1 Insulation: Foam-in-place or other suitable insulation shall be used. Loose fill will not be used. Insulation shall comply with UBC Chapter 17. Thermal insulation shall be moisture resistant and fire retardant. The thermal resistance of insulation and the degradation of thermal resistance over time will be considered in the selection of the type of insulation provided. As a minimum, the thermal transmittance values ("U" values) and overall maximum allowable combined transmittance values shall not exceed those values as determined from ASHRAE Standard 90.

5.5.4.2 Temperature and Humidity Control Systems: Internal temperature will be maintainable below 75° F with external temperature up to 125° F and maintained above 65° F when external temperature is down to -30° F. Humidity will be controlled to allow comfort (30 to 60%).

5.5.4.3 Air-intake Filtration: HEPA and charcoal filters shall be placed in-line in the air-intake portals. HEPA filters for inhabited spaces shall comply with ARI 850. In addition, an activated charcoal filter will be provided for the removal of volatile chemicals. Adsorbers for toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510. A minimum of 20 - 30ft^3/min/person fresh air will be provided.

5.5.5 Functional Equipment/Systems: All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. All air handling equipment shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. If the air handling equipment and air-distribution system cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems. The mechanical support area will be separate from the laboratory area and will be accessible from the exterior. Systems shall be designed to minimize and isolate vibration resulting from the operation of support equipment.

5.5.5.1 HVAC Equipment: HVAC equipment shall be sized to satisfy the module heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook.

5.5.5.1.1 Air Conditioner: The AC shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. The units should be readily serviceable by most commercial refrigeration/air conditioning companies. The AC unit should be designed to permit sequential starting of its motors to decrease the electrical surge load during the starting phase of the HVAC system.

5.5.5.1.2 Heating Equipment: Heating system should be selected based on consideration of human health and safety requirements, initial costs, operating costs and maintenance costs according to procedures in DOE 3630.1A, 0110-12.7, Building Design Analysis. Any system that might generate CO or CO_2 within the module (open flame) should be discouraged.

5.5.5.1.3 Humidifier/Dehumidifier: The need for a humidifier/dehumidifier should be addressed. An air tight construction with a heat exchange - air ventilation system might address some heating and cooling requirements and humidity requirements.

5.5.5.1.4 Air-intake and Air-exhaust Fans: All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook. Fans shall be located within the ductwork system according to the requirements of AMCA Publication 210 and ACGIH Industrial Ventilation Manual. Motors shall be sized according to properly calculated BHP fan requirements and shall not be oversized fans and motors. All fans and accessories shall be designed to meet all smoke and flame spread requirements of NFPA 255.

5.5.5.1.5 Thermostat: Air handling and air distribution controls shall comply with DOE 6430.1A, section 1595-6, Control of Air Handling Systems.

5.5.5.2 Power Source: The module shall be designed to operate on external power or on an onboard electrical generator.

5.5.5.2.1 External Power: A capability for automatic switchover to the onboard generator will be provided in the event of external power failure. Switchover is to be completed within 2 seconds.

5.5.5.2.2 Electrical Generator: The power system shall be capable of maintaining full operation. The power system shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. The generator will be sized according to the electrical load that will be required in the FAL. For loads greater than 25 KVA, diesel engines shall generally be used. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. Lighting power budget shall be determined in conformance with ASHRAE Standard 90 (see also 5.5.6.5 and 5.5.6.6). The electrical generator shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. For generators with ≤25kVa loads, gasoline or LP gas engines may be used. For loads >25kVa, diesel engines generally should be used. Application of diesel engines shall comply with FCC Technical Report No. 69.

5.5.5.3 Uninterruptible Power Supplies: Application of UPSs shall comply with IEEE 446 or as modified by cognizant DOE authority. UPS installations may be by safety class 1 or standby type dependent on the classification of the loads served.

5.5.5.4 Mechanical Support Space: The mechanical support space shall be located so that it has its own separate opening to the outside which shall consist of two double doors (combined opening 99") with heavy duty hinges and locks. Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. Where mechanical ventilation cannot maintain a satisfactory environment, other cooling systems shall be provided. Exhaust air openings should be located to minimize ambient thermal loads.

5.5.5.5 Fuel Storage Tanks: Total storage capacity for 4 days operation at maximum load without refueling shall be provided. Fuel storage tanks shall comply with API 650.

5.5.6 Operational Equipment:

5.5.6.1 Health Physics Operation: Radiological safety personnel require instrumentation for screening equipment, clothing, floors, tables, etc. within the road transportable laboratory complex.

5.5.6.1.1 Alpha Particle Detector (portable): Any of several instruments will suffice. Examples of each type are provided in the following subsections:

5.5.6.1.1.1 Air Proportional Counter: Air proportional counter with probe will be portable and battery powered. The counter shall have a range of 0-100,000 disintegrations/min (DPM) over 100 cm^3. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.1.1.2 Gas Flow Counter: Gas flow counter with probe will be portable and battery powered. The counter shall have a range of 0-100,000 DPM over 100 cm^3. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.1.1.3 Scintillation Counter: Scintillation counter with probe will be portable and battery powered. The counter shall have a range of 0-100,000 DPM over 100 cm^3. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.1.1.4 Hand and Shoe Monitor:

5.5.6.1.1.4.1 Proportional Counter Type: The instrument selected must provide rapid contamination monitoring of hands and shoes. The instrument shall be automatically operated and shall have a range of 0-2,000 cpm over approximately 300 cm^3.

5.5.6.1.1.4.2 Scintillation Type: The instrument selected must provide rapid contamination monitoring of hands and shoes. The instrument shall have a range of 0-4,000 cpm over approximately 300 cm^3.

5.5.6.1.2 Beta Particle Detector (portable): This is a portable count rate meter as specified in the following subsections.

5.5.6.1.2.1 Thin Wall G-M Counter: Thin wall G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000 counts/min (CPM). Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.1.2.2 Thin Window G-M Counter: Thin window G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000 CPM. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.1.2.3 Hand and Shoe Monitor (G-M): Instrument selected must provide rapid contamination monitoring of hands and shoes. Instrument shall be automatically operated and shall have a range from 1½ to 2 times natural background.

5.5.6.1.2.4 Hand and Shoe Monitor (Scintillation): Instrument selected must provide rapid contamination monitoring of hands and shoes. Instrument shall be automatically operated and shall have a range from 1½ to 2 times natural background.

5.5.6.1.3 Gamma Ray Emissions (portable):

5.5.6.1.3.1 Thin Wall G-M Counter: Thin wall G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000 CPM. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.1.3.2 Thin Window G-M Counter: Thin window G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000 CPM. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.1.3.3 Hand and Shoe Monitor (G-M): Instrument selected must provide rapid contamination monitoring of hands and shoes. Instrument shall be automatically operated and shall have a range from 1½ to 2 times natural background.

5.5.6.1.3.4 Hand and Shoe Monitor (Scintillation): Instrument selected must provide rapid contamination monitoring of hands and shoes. Instrument shall be automatically operated and shall have a range from 1½ to 2 times natural background.

5.5.6.1.4 Surface Contamination Monitoring: A capability shall be provided to monitor for accidental contamination of surfaces in the various modules of the overall complex with radioactive material from the samples. This capability shall include instrumentation, sample collection and other laboratory supplies and equipment to conduct on-site monitoring.

5.5.6.1.4.1 Scintillation Counter: System selected shall have a detection sensitivity to 9 nanoCuries/gram. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.1.4.2 Gamma Counter: Instrument shall have the ability to distinguish emissions from a broad range of energy. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.2 Field Radiation Screening:

5.5.6.2.1 Alpha Particle Detector: Any of several instruments will suffice. Examples of each type are provided in the following subsections:

5.5.6.2.1.1 Air Proportional Counter: Air proportional counter with probe will be portable and battery powered. The counter shall have a range of 0-100,000 disintegrations/min (DPM) over 100 cm^3. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.2.1.2 Gas Flow Counter: Gas flow counter with probe will be portable and battery powered. The counter shall have a range of 0-100,000 DPM over 100 cm^3. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.2.1.3 Scintillation Counter: Scintillation counter with probe will be portable and battery powered. The counter shall have a range of 0-100,000 DPM over 100 cm^3. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.2.2 Beta Particle Detector: This is a portable count rate meter as specified in the following subsections.

5.5.6.2.2.1 Thin Wall G-M Counter: Thin wall G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000 counts/min (CPM). Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.2.2.2 Thin Window G-M Counter: Thin window G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000 CPM. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.2.3 Gamma Ray Emissions:

5.5.6.2.3.1 Thin Wall G-M Counter: Thin wall G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000 CPM. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.2.3.2 Thin Window G-M Counter: Thin window G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000 CPM. Efficiency, cost and count-time are trade-offs that need to be considered.

5.5.6.3 Field Chemical Contamination Screening:

5.5.6.3.1 Portable Gas Chromatograph: A portable gas chromatograph capable of detecting and providing degree of volatile chemical contamination shall be provided. Efficiency, cost and response-time are trade-offs that need to be considered.

5.5.6.3.2 Portable X-ray Fluorescence Analyzer: A portable X-ray fluorescence analyzer capable of detecting and providing degree of surface heavy metal contamination shall be provided. Efficiency, cost and response-time are trade-offs that need to be considered.

5.5.6.4 Limited Storage: Racks with shelving and equipment tie-downs shall be provided. Storage for health physics and field radiological and chemical monitoring equipment must be specifically addressed.

5.5.6.5 Laboratory Furniture: Furniture shall comply with NFPA 101, Chapter 31 and UBC Chapter 17, as applicable. Standard stock sizes, material, and finishes of a competitive type shall be considered. Base cabinets, bench tops, and sinks shall have nominal unit lengths that can be interchanged to make up the required combinations. Most commercial bases and cabinets for laboratory use can support 300-500 pounds per leg or corner. laboratory furniture used for purposes requiring more than the general illumination levels should be designed and equipped to provide local task lighting of the required intensity. Some laboratory bench and wall units may be equipped with shelving appropriate for instrument storage.

5.5.6.6 Interior Lighting: Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing should be avoided. Lighting design shall consider environmental degradation effects, e.g., dust, to ensure adequate lighting intensities on a long-term basis. Maximum use shall be made of fluorescent and HID lamps. When using HID lighting, careful consideration of the required color rendition shall be made from visual and safety perspectives. Interior lighting systems shall comply with the IES Lighting Handbook. Non-uniform lighting practices shall comply with CFR 101-20.116-2 and with DOE 6430.1A Section 1694 (Energy Conservation).

5.5.6.7 Emergency Lighting: Where high intensity discharge (HID) lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

6. ROBOTIC BASE STATION (RBS) MODULE

6.1 Purpose: The RBS module will provide the capability for remote sensing and monitoring the test site undergoing clean-up. Field radiation screening techniques involving robotic units and portable field instrumentation can rapidly and safely map contaminated areas for degree and geographical limits of contamination.

6.2 RBS Requirements:

6.2.1 Road Transportable: The RBS module will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport.

6.2.2 Structural: The RBS module structure will provide a protected environment for the performance of the required command and control functions (see 6.2.6, 6.3.6, 6.4.6, and 6.5.6). Exterior walls and roof will be resistant to damages from extremes of environment. Interior walls and floors will have rigid underlining.

6.2.3 Basic Utilities: Module will be equipped with electrical wiring, plumbing, ductwork, and communications hardwiring.

6.2.4 Environmental Protection: Thermal insulation is required in exterior walls, floors, and ceilings. Clean air input must be provided. Emphasis will be placed on maintaining a comfortable temperature and humidity by air conditioning or heating to meet operational needs.

6.2.5 Functional Design: The unit will be self-sustained for heat, air conditioning and electrical supply. Water supply and laboratory waste generation will be addressed.

6.2.6 Operational Requirements: The RBS requires the functionality of a robotics unit with accompanying all terrain robot units. The RBS will also have a personnel and equipment decontamination shower. Design of the module will address the needs of the personnel to enhance operational performance. The interior will be functional and well lighted. Adequate ventilation will be provided based on the anticipated temperature extremes of the outside environment.

6.3 RBS Performance Requirements:

6.3.1 Road Transportability: The module shall be securely mounted on a fifth-wheel type trailer that shall meet DOT standards for road transportation. The trailer/module shall be equipped with leveling jacks, leveling indicators, and all necessary hook-ups for attachment to a towing vehicle. The module shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts 350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

6.3.2 Structural: The module must provide adequate strength to withstand the multi-directional forces exhibited in the transportation mode and protection against exterior shock that could occur during transport (see 6.3.1). It must also minimize air infiltration during transportation and be equipped with rub rails of at least heavy duty extruded aluminum and a hydraulic leveling system to facilitate set-up on-site. The overall construction shall be of sufficient quality to minimize vibration and noise in the interior of the module. The module shall have removable steps with a handrail for each door and a ladder securely mounted on the module exterior to provide access to the roof. The module shall have a floor constructed in a manner that prevents water and dust entry. Doors and windows will be functional according to operational needs. Framework will be strong and light weight to minimize overall weight. Structure will be provided with emergency escape capabilities. The overall dimensions will not exceed: length - 48', height - 13'-6", and width - 8'-6".

6.3.3 Basic Utilities Performance Requirements: Appropriate water distribution system (also see 6.2.6 and 6.3.6) must be provided within the RBS module. The unit will be equipped to meet electrical and communicational needs. The unit will also be equipped to meet temperature and humidity requirements, see Environmental paragraphs, 6.2.4 and 6.3.4.

6.3.3.1 Electrical Wiring: AC wiring will be provided. Outlets, number and location, will conform to National Electrical Code (NEC). Receptacles shall be adequate in number and capacity for the initial and projected requirements.

6.3.3.2 Supply-side Plumbing: Potable water will be supplied as an operational supply need; potable water storage for a minimum of 200 gallons will be provided. Provision will also be made to supply water to meet overall RBS requirements. An external water supply hook-up capability will be provided for potable and non-potable use.

6.3.3.3 Waste-side Plumbing: The waste management systems shall provide facilities and equipment to handle wastes safely, effectively, and in an environmentally responsible manner.

6.3.3.4 Ductwork: Distribution ductwork shall be provided to distribute air and to exhaust air from the module. Outlets from air supply ducts shall be fitted with closable louvers. If multiple blower/filter units are installed, there should be cross ductwork to permit some flexibility of operation and increased reliability. Ductwork is an integral part of the overall air-handling system.

6.3.3.5 Communications: Interior communications shall be designed to use standard, commercially available telephone, CB, cellular, and satellite communication equipment. An external communication capability will be provided.

6.3.4 Environmental: Insulation will be at least R-11 (walls), R-19 (ceiling), R-11 doors and R-19 (floors). Insulation shall comply with UBC Chapter 17 and will be moisture resistant. Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90. Complete HEPA and charcoal filtration of air intake will be provided. Provisions must be made to minimize the risk of undue exposure of personnel to potentially hazardous materials that might be contained in the clean-up site. A climate control system shall be provided to maintain temperature and humidity at an acceptable level.

6.3.5 Functional Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRE Standard 90, section 6. Potable water needs must be supplied internally for personnel use. A mechanical support area, separate from the operational work area will be provided.

6.3.6 Operational Performance Requirements: Human engineering criteria will be applied to optimize man/machine interfaces. The laboratory will be capable of conducting field radiation and chemical contamination screening and monitoring with portable instruments mounted on the robotic vehicles. The RBS may function closely with the FAL to assess and monitor samples in the field. Lighting will be available in accordance with the task to be performed in a particular space. A contrast in lighting will be achieved through the use of various color schemes within the module.

6.4 RBS Major Equipment/Subunit Requirements:

6.4.1 Road Transportability Items: Trailer/module will be a fifth-wheel type frame that shall meet DOT standards for road transportation. The trailer shall have tandem axle dual wheels. The braking system shall be vacuum over hydraulic type, capable of stopping the trailer/module in case of accidental detachment from the towing vehicle.

6.4.2 Structural: One single door for operational use of module and one double door for large equipment movement are required. Subject to laboratory design, window(s) are required. Walls, floors and ceilings will have a finished interior surface. Windows will be abrasion resistant and provide emergency escape capability. For robot "garage", see 6.5.6.2.

6.4.3 Basic Utilities Systems:

6.4.3.1 Electrical Wiring: Demand and diversity factors shall comply with DOE 6430.1A, Section 1630-1.1, Load Requirements. Interior electrical system power factor shall comply with DOE 6430.1A, Section 1630-1.2, Power factor. Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120 volt single phase service provided, as applicable.

6.4.3.2 Supply-side Plumbing: A supply side water distribution system shall be provided. Fixtures appropriate for a laboratory facility will be provided.

6.4.3.3 Waste-side Plumbing: A waste water collection and storage system will be provided.

6.4.3.4 Ductwork: Ductwork systems will provide efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy and duct size. Ductwork must be designed to resist corrosive contaminants.

6.4.3.5 Communications: The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B Provisions for voice and data transmission will be made. Provisions for telephone hook-up and hardwiring for computers will be provided.

6.4.4 Environmental: The ventilation-exhaust systems shall be provided for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists and excessive heat and for the provision of fresh air to the occupants.

6.4.4.1 Insulation: Insulation is required in module construction for the reduction of fire hazard and protection from heat or cold. The building envelope shall meet the minimum prescriptive energy requirements of ASHRAE Standard 90.

6.4.4.2 Climate Control Systems: An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 3.2.4.5.

6.4.4.3 Air-intake Filtration: Air-intake portals shall be provided with a filtration system to remove potentially harmful particulates and volatile chemicals.

6.4.5 Functional Equipment/Systems: The module power and emergency systems shall serve loads set forth in NFPA 110.

Additional standby systems shall be provided to support systems or equipment components that are vital for protection of health, life, property, and safeguards. Uninterruptable power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. Power generating areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain ambient temperatures for equipment operation or personnel access.

6.4.5.1 HVAC Equipment: HVAC equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook. Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in DOE 6430.1A, Section 1595.

6.4.5.2 Electrical Supply System: A reliable energy supply must be provided for the RBS.

6.4.5.3 Uninterruptible Power Supplies: Uninterruptable power supplies shall be provided for those loads requiring guaranteed continuous power.

6.4.5.4 Mechanical Support Space: A space separate from the operational area of the module is required to house the mechanical equipment, e.g., generator, HVAC, heat pump.

6.4.6 Operational Equipment/Systems:

6.4.6.1 Robots: All-terrain robotic vehicles capable of distant remote radiological and chemical contamination monitoring and screening clean-up sites are required.

6.4.6.2 Robot Garage: A portion of the module is required to garage the robotic units.

6.4.6.3 Field Radiation Screening: Field radiation screening requires instrumentation to provide Level I and/or II data on alpha and beta particle levels and gamma rays emission levels in soil and water of area to be sampled.

6.4.6.4 Chemical Contamination Screening: Chemical contamination screening requires instrumentation for detection of organic and inorganic contaminants in soil and water within the area to be sampled.

6.4.6.5 Furniture: Laboratory benchwork and cabinets are required to meet operational requirements.

6.4.6.6 Interior Lighting: Adequate interior lighting to ensure effective performance is required in all work areas.

6.4.6.7 Emergency Lighting: Emergency lighting systems, including exit lights, shall be provided as required by NFPA 101.

6.5 RBS Major Equipment Performance Requirements:

6.5.1 Trailer Frame Structure: Structural systems for highway structures shall be consistent with the requirements of AASHTO HB-13. The fifth wheel height will be 47½". It will be equipped with suspension air ride, tubular axles with oil seals and single anchor line, and brakes to meet F.M.V.S.S. Aluminum material used shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2. The unifying weight-carrying framework (that also provides the floor support for the attached module, see 6.5.2) will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Use of steel shall comply UBC, AISC S326, AISC M011, AISI Specifications for the Design of Cold-Formed Steel Structural Members, and with AISC N690.

6.5.2 Structural Equipment/Systems: Aluminum material used in structure shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.

6.5.2.1 Module Frame Structure: The module will have a framework of extruded aluminum with aluminum sheet paneling on the exterior walls. The floor framework will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Frame support posts will be aluminum, hi-ten double slotted series. All exterior exposed surfaces will be protected against corrosion and will have a finished look appropriate for the structure. The roof will be one piece aluminum bonded to hat section bows. Interior wall lining and roof lining will be plywood. Floor will be lightweight and solid, and a chemical resistant floor will cover the hard underlayment. Materials, framing systems, and details shall be compatible with clear space and span requirements, serviceability requirements, security requirements, climatic conditions, and structural design loads. Unit weights of materials shall be those given for highway structures by AASHTO standards. Live loads for highway structures shall be as stipulated in AASHTO HB-13. Unless stipulated otherwise, an HS 20-44 loading shall be used. Structure shall meet wind loads for highway structures as stipulated in AASHTO HB-13. The earthquake loads for highway structures shall be as stipulated in AASHTO HB-13 and AASHTO GSDB. Other loads for highway structures shall be as stipulated in AASHTO HB-13. Combination of loads and design requirements for highway structures shall be as stipulated in AASHTO HB-13. Structural systems for highway structures shall be consistent with the requirements of AASHTO BB-13.

6.5.2.2 Doors and Windows: Doors and windows shall be corrosion-resistant or protected against corrosion. Windows and doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings and floors. Door and window hardware shall comply with ANSI A156 series.

6.5.2.2.1 Doors: Doors will be 36" wide and be equipped with abrasion resistant windows, e.g., low-E tempered glass with a lexan outer cover. An overlapping molding is required where the paired double doors meet, Door jambs will be reinforced to make it more difficult to open by wedge or similar tools.

6.5.2.2.2 Windows: Windows shall be made of insulated low-E tempered glass with a lexan outer cover and will be at least 30" x 30" to meet escape hatch requirement. Windows shall comply with NFPA 101, chapter 22. Window cleaning provisions shall comply with ANSI A39.1. Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc. Aluminum windows shall comply with AAMA 101.

6.5.2.3 Walls, Floors and Ceilings:

6.5.2.3.1 Walls, Floors and Ceilings, General Requirements: Interior walls will be fire retardant and resist mild acids, alkalis and fumes. Floors will be easy to clean and resistant to mild chemicals. Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering. Vinyl composition and rubber or vinyl cove base shall be used. Wall, floor, and ceiling, and roof and ceiling assemblies shall be tested by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Units shall be equipped with smoke/heat alarms. Appropriately rated fire extinguishers will be provided.

6.5.2.3.2 Waterproofing: Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water washdown, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base-course and through-the-wall flashings, and shall make a bond with these flashings.

6.5.2.4 Louvers, Vents, Grills, and Screens: Louvers, vents, grills, and screens shall be corrosion-resistant or protected against corrosion.

6.5.3 Basic Utilities Systems:

6.5.3.1 Electrical Wiring: Fifteen and twenty amp circuits, consistent with NEC will be provided. Wire shall be not smaller than No. 12-2 copper with ground. Receptacles and switches shall comply with general grade as defined in FS W-C-596. Receptacle circuits shall be provided with ground-fault circuit interrupters as directed by NFPA 70; receptacle circuits that serve receptacles that are within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters. Adverse effects of voltage level variations, transients, and frequency variations on equipment operation shall be minimized. Sensitive electrical equipment, such as data processing equipment, shall be isolated as needed for protection. Uninterruptable power systems, or power conditioners may be used for isolation.

6.5.3.2 Supply-side Plumbing: Plumbing shall comply with the NSPC, ASHRAE Handbooks, and ASHRAE Standard 90. Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. Type L copper tubing, CPVC, or PB plastic pipe and tubing may be used. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe or tubing shall be solvent cemented or shall use other forms of joining such as electric heat fusion. Stop valves shall be provided at each fixture. All fixtures shall comply with FS WW-P-541.

6.5.3.3 Waste-side Plumbing: Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. ABS or PVC plastic pipe may be used. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Waste handling areas shall comply with the standards of confinement and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled. Specific DOE design and operating requirements for radioactive wastes (HLW, LLW, and TRU) appear in DOE 5820.2A. Appropriate provisions for storage of containerized radioactive and/or hazardous wastes shall be provided. Provision for the collection and storage of other non-hazardous or non-radioactive wastes shall also be provided, as appropriate.

6.5.3.4 Ductwork: Ductwork systems will meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following:

ASHRAE Fundamentals Handbook
SMACNA HVAC Duct Construction Standards-Metal and Flexible
SMACNA Fibrous Glass Duct Construction Standards
SMACNA Round Industrial Duct Construction Standards
SMACNA HVAC Duct Design Manual
ACGIH Industrial Ventilation Manual
NFPA 45

NFPA 90A
NFPA 91 (exhaust ductwork)
ERDA 76-21

Ductwork that handles air exhausted from moisture generating areas shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90 and shall be acoustically insulated to meet acceptable noise criteria. Ducting should be arranged so that outside air can be passed through appropriate filter systems (see 6.2.4 and 6.3.4).

6.5.3.5 Communications: Various methods will satisfy the requirements. These include commercial mobile telephone network, VHF/UHF radio, HF radio, satellite communication system, or provision for connection to a central facility, e.g., command module. Installation and operating costs and availability in remote areas will be considered. Hardwiring shall be shielded to minimize interference or interruption of transmission. Consideration should be given to fiberoptic cable, especially for data transmission.

6.5.4 Environmental:

6.5.4.1 Insulation: Foam-in-place or other suitable insulation shall be used. Loose fill will not be used. Insulation shall comply with UBC Chapter 17. Thermal insulation shall be moisture resistant and fire retardant. The thermal resistance of insulation and the degradation of thermal resistance over time will be considered in the selection of the type of insulation provided. As a minimum, the thermal transmittance values ("U" values) and overall maximum allowable combined transmittance values shall not exceed those values as determined from ASHRAE Standard 90.

6.5.4.2 Temperature and Humidity Control Systems: Internal temperature will be maintainable below 75° F with external temperature up to 125° F and maintained above 65° F when external temperature is down to -30° F. Humidity will be controlled to allow comfort (30 to 60%).

6.5.4.3 Air-intake Filtration: HEPA and charcoal filters shall be placed in-line in the air-intake portals. HEPA filters for inhabited spaces shall comply with ARI 850. In addition, an activated charcoal filter will be provided for the removal of volatile chemicals. Adsorbers for toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510. A minimum of 20 - 30ft^3/min/person fresh air will be provided.

6.5.5 Functional Equipment/Systems: All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. All air handling equipment shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. If the air handling equipment and air-distribution system cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems. The mechanical support area will be separate from the laboratory area and will be accessible from the exterior. Systems shall be designed to minimize and isolate vibration resulting from the operation of support equipment.

6.5.5.1 HVAC Equipment: HVAC equipment shall be sized to satisfy the module heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook.

6.5.5.1.1 Air Conditioner: The AC shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. The units should be readily serviceable by most commercial refrigeration/air conditioning companies. The AC unit should be designed to permit sequential starting of its motors to decrease the electrical surge load during the starting phase of the HVAC system.

6.5.5.1.2 Heating Equipment: Heating system should be selected based on consideration of human health and safety requirements, initial costs, operating costs and maintenance costs according to procedures in DOE 3630.1A, 0110-12.7, Building Design Analysis. Any system that might generate CO or CO_2 within the module (open flame) should be discouraged.

6.5.5.1.3 Humidifier/Dehumidifier: The need for a humidifier/dehumidifier should be addressed. An air tight construction with a heat exchange - air ventilation system might address some heating and cooling requirements and humidity requirements.

6.5.5.1.4 Air-intake and Air-exhaust Fans: All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook. Fans shall be located within the ductwork system according to the requirements of AMCA Publication 210 and ACGIH Industrial Ventilation Manual. Motors shall be sized according to properly calculated BHP fan requirements and shall not be oversized fans and motors. All fans and accessories shall be designed to meet all smoke and flame spread requirements of NFPA 255.

6.5.5.1.5 Thermostat: Air handling and air distribution controls shall comply with DOE 6430.1A, section 1595-6, Control of Air Handling Systems.

6.5.5.2 Power Source: The module shall be designed to operate on external power or on an onboard electrical generator.

6.5.5.2.1 External Power: A capability for automatic switchover to the onboard generator will be provided in the event of external power failure. Switchover is to be completed within 2 seconds.

6.5.5.2.2 Electrical Generator: The power system shall be capable of maintaining full operation. The power system shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. The generator will be sized according to the electrical load that will be required in the RBS. For loads greater than 25 KVA, diesel engines shall generally be used. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. Lighting power budget shall be determined in conformance with ASHRAE Standard 90 (see also 6.5.6.5 and 6.5.6.6). The electrical generator shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. For generators with ≤25kVa loads, gasoline or LP gas engines may be used. For loads >25kVa, diesel engines generally should be used. Application of diesel engines shall comply with FCC Technical Report No. 69.

6.5.5.3 Uninterruptable Power Supplies: Application of UPSs shall comply with IEEE 446 or as modified by cognizant DOE authority. UPS installations may be by safety class 1 or standby type dependent on the classification of the loads served.

6.5.5.4 Mechanical Support Space: The mechanical support space shall be located so that it has its own separate opening to the outside which shall consist of two double doors (combined opening 99") with heavy duty hinges and locks. Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. Where mechanical ventilation cannot maintain a satisfactory environment, other cooling systems shall be provided. Exhaust air openings should be located to minimize ambient thermal loads.

6.5.5.5 Fuel Storage Tanks: Total storage capacity for 4 days operation at maximum load without refueling shall be provided. Fuel storage tanks shall comply with API 650.

6.5.6 Operational Equipment:

6.5.6.1 Robots: Robotic units shall be self operating under the remote control of the operator. The units shall be equipped with a guidance and control system such that the location will be accurate within a four feet to enable accurate sampling, monitoring and mapping of the site. A decontamination washdown capability for the robotic units will be provided.

6.5.6.2 Robot Garage: A portion of the module will be designed and equipped to house the robot units. The robot garage will be separate from the control and laboratory area of the RBS. A loading ramp and entry doors that provides easy entry into the garage shall be provided. The garage shall be provided with utilities, insulation, etc., appropriate for the protection and operation of the robot units.

6.5.6.3 Field Radiation Screening: All instrumentation performance requirements discussed below shall also be augmented by the capability of remote, automated operation and of telemetered data transmission to the base station.

6.5.6.3.1 Alpha Particle Detector: Any of several instruments will suffice. Examples of each type are as follows:

6.5.6.3.1.1 Air Proportional Counter: Air proportional counter with probe will be portable and battery powered. The counter shall have a range of 0-100,000 DPM over 100 cm^3 and be capable of providing analytical level II data. Efficiency, cost and count-time are trade-offs that need to be considered.

6.5.6.3.1.2 Gas Flow Counter: Gas flow counter with probe will be portable and battery powered. The counter shall have a range of 0-100,000 DPM over 100 cm^3 and be capable of providing analytical level II data. Efficiency, cost and count-time are trade-offs that need to be considered.

6.5.6.3.1.3 Scintillation Counter: Scintillation counter with probe will be portable and battery powered. The counter shall have a range of 0-100,000 DPM over 100 cm^3 and be capable of providing analytical level II data. Efficiency, cost and count-time are trade-offs that need to be considered.

6.5.6.3.2 Beta Particle Detector:

6.5.6.3.2.1 Thin Wall G-M Counter: Thin wall G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000, CPM and be capable of providing analytical level II data. Efficiency, cost and count-time are trade-offs that need to be considered.

6.5.6.3.2.2 Thin Window G-M Counter: Thin window G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000, CPM and be capable of providing analytical level II data. Efficiency, cost and count-time are trade-offs that need to be considered.

6.5.6.3.3 Gamma Ray Emissions:

6.5.6.3.3.1 Thin Wall G-M Counter: Thin wall G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000, CPM and be capable of providing analytical level II data. Efficiency, cost and count-time are trade-offs that need to be considered.

6.5.6.3.3.2 Thin Window G-M Counter: Thin window G-M Counter will be portable and battery powered. The counter shall have a range of 0-1,000, 0-10,000, 0-100,000, CPM and be capable of providing analytical level II data. Efficiency, cost and count-time are trade-offs that need to be considered.

6.5.6.4 Field Chemical Contamination Screening: All instrumentation performance requirements discussed below shall also be augmented by the capability of remote, automated operation and of telemetered data transmission to the base station.

6.5.6.4.1 Portable Gas Chromatograph: A portable gas chromatograph capable of detecting and providing degree of volatile chemical contamination shall be provided. Efficiency, cost and response-time are trade-offs that need to be considered.

6.5.6.4.2 Portable X-ray Fluorescence Analyzer: A portable X-ray fluorescence analyzer capable of detecting and providing degree of surface heavy metal contamination shall be provided. Efficiency, cost and response-time are trade-offs that need to be considered.

6.5.6.5 Laboratory Furniture: Laboratory furniture shall comply with NFPA 101, Chapter 31 and UBC Chapter 17, as applicable. Standard stock sizes, material, and finishes of a competitive type shall be considered. Base cabinets, bench tops, and sinks shall have nominal unit lengths that can be interchanged to make up the required combinations. Most commercial bases and cabinets for laboratory use can support 300-500 pounds per leg or corner. Laboratory furniture used for purposes requiring more than the general illumination levels should be designed and equipped to provide local task lighting of the required intensity.

6.5.6.6 Interior Lighting: Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing should be avoided. Lighting design shall consider environmental degradation effects, e.g., dust, to ensure adequate lighting intensities on a long-term basis. Maximum use shall be made of fluorescent and HID lamps. When using HID lighting, careful consideration of the required color rendition shall be made from visual and safety perspectives. Interior lighting systems shall comply with the IES Lighting Handbook. Non-uniform lighting practices shall comply with CFR 101-20.116-2 and with DOE 6430.1A Section 1694 (Energy Conservation).

6.5.6.7 Emergency Lighting: Where high intensity discharge (HID) lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

7. ORGANIC CHEMISTRY LABORATORY (OCL) MODULE

7.1 Purpose: The OCL module will provide the capability for Analysis of organic constituents contained in environmental (soil, ground water and surface water) samples and samples of other solid and liquid matrices.

7.2 OCL Requirements:

7.2.1 Road Transportable: The OCL module will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport.

7.2.2 Structural: The OCL module structure will provide a protected environment for the performance of the required laboratory functions (see 7.2.6, 7.3.6, 7.4.6, and 7.5.6). Exterior walls and roof will be resistant to damages from extremes of environment. Interior walls and floors will have rigid underlining.

7.2.3 Basic Utilities: Module will be equipped with electrical wiring, plumbing, ductwork, and communications hardwiring.

7.2.4 Environmental Protection: Thermal insulation is required in exterior walls, floors, and ceilings. Clean air input must be provided. Exhaust air will protect environment. Emphasis will be placed on maintaining a comfortable temperature and humidity by air conditioning or heating to meet operational needs.

7.2.5 Functional Design: The unit will be self-sustained for heat, air conditioning and electrical supply. Water supply and human and laboratory waste generation will be addressed.

7.2.6 Operational Requirements: The OCL requires the functionality of an organic analytical laboratory. Laboratory must be equipped to analyze for organic substances contained in the samples. Design of the module will address the needs of the personnel to enhance operational performance. The interior will be functional and well lighted. Adequate ventilation will be provided based on the anticipated temperature extremes of the outside environment. Facilities will be provided for limited personal hygiene needs, for limited laboratory storage, and for laboratory-generated-waste storage and removal. Particular attention will be given to wastes containing radioactive residues.

7.3 OCL Performance Requirements:

7.3.1 Road Transportability: The module shall be securely mounted on a fifth-wheel type trailer that shall meet DOT standards for road transportation. The trailer/module shall be

equipped with leveling jacks, leveling indicators, and all necessary hook-ups for attachment to a towing vehicle. The module shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts 350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

7.3.2 Structural: The module must provide adequate strength to withstand the multi-directional forces exhibited in the transportation mode and protection against exterior shock that could occur during transport (see 7.3.1). It must also minimize air infiltration during transportation and be equipped with rub rails of at least heavy duty extruded aluminum and a hydraulic leveling system to facilitate set-up on-site. The overall construction shall be of sufficient quality to minimize vibration and noise in the interior of the module. The module shall have removable steps with a handrail for each door and a ladder securely mounted on the module exterior to provide access to the roof. The module shall have a floor constructed in a manner that prevents water and dust entry. Doors and windows will be functional according to operational needs. Framework will be strong and light weight to minimize overall weight. Structure will be provided with emergency escape capabilities. The overall dimensions will not exceed: length - 48′, height - 13′-6", and width - 8′-6".

7.3.3 Basic Utilities Performance Requirements: Appropriate water distribution system (also see 7.2.6 and 7.3.6) must be provided within the OCL module. The unit will be equipped to meet electrical and communicational needs. The unit will also be equipped to meet temperature and humidity requirements, see Environmental paragraphs, 7.2.4 and 7.3.4.

7.3.3.1 Electrical Wiring: AC wiring will be provided. Outlets, number and location, will conform to National Electrical Code (NEC). Receptacles shall be adequate in number and capacity for the initial and projected requirements.

7.3.3.2 Supply-side Plumbing: Potable water for personnel use will be supplied as an operational supply need. Provision will also be made to supply water to meet overall laboratory requirements. An external water supply hook-up capability will be provided for potable and non-potable use.

7.3.3.3 Waste-side Plumbing: The waste management systems shall provide facilities and equipment to handle wastes safely, effectively, and in an environmentally responsible manner.

7.3.3.4 Ductwork: Distribution ductwork shall be provided to distribute air to the laboratory and to exhaust air from the module. Outlets from air supply ducts shall be fitted with closable louvers. If multiple blower/filter units are installed,

there should be cross ductwork to permit some flexibility of operation and increased reliability. Ductwork is an integral part of the overall air-handling system.

7.3.3.5 Communications: Interior communications shall be designed to use standard, commercially available telephone, CB, cellular, and satellite communication equipment. An external communication capability will be provided.

7.3.4 Environmental: Insulation will be at least R-11 (walls), R-19 (ceiling), R-11 doors and R-19 (floors). Insulation shall comply with UBC Chapter 17 and will be moisture resistant. Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90. Complete HEPA and charcoal filtration of air intake will be provided. Provisions must be made to minimize the risk of undue exposure of personnel to potentially hazardous materials that might be contained in the clean-up site. A climate control system shall be provided to maintain temperature and humidity at an acceptable level.

7.3.5 Functional Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRE Standard 90, section 6. Potable water needs must be supplied internally for personnel use. A mechanical support area, separate from the laboratory area will be provided.

7.3.6 Operational Performance Requirements: Human engineering criteria will be applied to optimize man/machine interfaces. The laboratory will be capable of conducting volatile organic analyses, semi-volatile organic analysis, and testing for (PCBs). A capability for conducting Toxicity Characteristic Leaching Procedure and subsequent analysis of the leachates will also be provided.

7.4 OCL Major Equipment/Subunit Requirements:

7.4.1 Road Transportability Items: Trailer/module will be a fifth-wheel type frame that shall meet DOT standards for road transportation. The trailer shall have tandem axle dual wheels. The braking system shall be vacuum over hydraulic type, capable of stopping the trailer/module in case of accidental detachment from the towing vehicle.

7.4.2 Structural: One single door for operational use of module and one double door for large equipment movement are required. Subject to laboratory design, window(s) are required. Walls, floors and ceilings will have a finished interior surface. Windows will be abrasion resistant and provide emergency escape capability.

7.4.3 Basic Utilities Systems:

7.4.3.1 Electrical Wiring: Demand and diversity factors shall comply with DOE 6430.1A, Section 1630-1.1, Load Requirements. Interior electrical system power factor shall comply with DOE 6430.1A, Section 1630-1.2, Power factor. Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120 volt single phase service provided, as applicable.

7.4.3.2 Supply-side Plumbing: A supply side water distribution system shall be provided. Fixtures appropriate for a laboratory facility will be provided.

7.4.3.3 Waste-side Plumbing: A waste water collection and storage system will be provided. Use of double walled pipes shall be considered.

7.4.3.4 Ductwork: Ductwork systems will provide efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy and duct size. Ductwork must be designed to resist corrosive contaminants.

7.4.3.5 Communications: The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B Provisions for voice and data transmission will be made. Provisions for telephone hook-up and hardwiring for computers will be provided.

7.4.4 Environmental: The ventilation-exhaust systems shall be provided for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists and excessive heat and for the provision of fresh air to the occupants.

7.4.4.1 Insulation: Insulation is required in module construction for the reduction of fire hazard and protection from heat or cold. The building envelope shall meet the minimum prescriptive energy requirements of ASHRAE Standard 90.

7.4.4.2 Climate Control Systems: An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 3.2.4.5.

7.4.4.3 Air-intake Filtration: Air-intake portals shall be provided with a filtration system to remove potentially harmful particulates and volatile chemicals.

7.4.4.4 Air-exhaust Filtration: HEPA filtration systems shall be used to minimize the release of particulate contaminants such as radioisotopes or highly toxic materials when deemed necessary.

7.4.4.5 Hoods: The OCL shall be equipped with fume hoods for the safe processing of samples.

7.4.4.6 Ventilation of Glove-Boxes/Hoods: A ventilation system shall be installed on all fully-enclosed glove-boxes/hoods to maintain a minimum negative pressure differential of 0.3 in. of water inside the enclosure with respect to the operating area. Open-faced hoods shall be ventilated such that flow from the operating area into the hood is maintained. Consideration should be given to the need to remove moisture, heat, and explosive and corrosive gases, as well as other contaminants.

7.4.5 Functional Equipment/Systems: The module power and emergency systems shall serve loads set forth in NFPA 110. Additional standby systems shall be provided to support systems or equipment components that are vital for protection of health, life, property, and safeguards. Uninterruptable power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. Power generating areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain ambient temperatures for equipment operation or personnel access.

7.4.5.1 HVAC Equipment: HVAC equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook. Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in DOE 6430.1A, Section 1595.

7.4.5.2 Electrical Supply System: A reliable energy supply must be provided for the OCL.

7.4.5.3 Uninterruptible Power Supplies: Uninterruptable power supplies shall be provided for those loads requiring guaranteed continuous power.

7.4.5.4 Mechanical Support Space: A space separate from the operational area of the module is required to house the mechanical equipment, e.g., generator, HVAC, heat pump.

7.4.6 Operational Equipment/Systems:

7.4.6.1 Volatile Organic Analysis: Equipment is needed to conduct VOA by EPA Method 8240A; this requires GC/MS (MS requirement - 35-260 amu every 3 seconds or less) with packed column, purge and trap device, data system, recirculation chiller, carrier gases (H_2 or He) analytical balance, and screening head space sampler (method 38/0) with GC (PID & HECD detectors) or extraction with hexadecane & analysis on GC with FID and/or ECD.

7.4.6.2 Semi-volatile Organic Analysis: The equipment discussed below is needed to conduct semi-VOA.

7.4.6.2.1 Sample Preparation:

Liquids by EPA Method 3520A: This requires continuous liquid-liquid extractors, Kuderna-danish concentrators, water bath, recirculation chillers and solvent storage.

Solids by EPA Method 3550A: This requires ultrasonic extractors, sound enclosures, vacuum pump, Kuderna-danish extractors, water bath, analytical balance and solvent storage.

Supercritical fluid extractions requires a carbon dioxide source.

Sample clean-up by EPA Method 3640: This requires gel permeation chromatography system that includes HPLC with GPC column, UV detector and a recorder.

7.4.6.2.2 Sample Analysis by EPA Method 8270A: This requires GC/MS (MS requirements - 35-500 amu every 1 second or less) with a fused silica column, data system and a carrier gas (H_2 or He).

7.4.6.3 PCB Assays: The equipment discussed below is need to conduct analysis for PCBs.

7.4.6.3.1 Sample Preparation:

Liquids by EPA Method 3520A: This requires continuous liquid-liquid extractors, Kuderna-danish concentrators, water bath, recirculation chillers and solvent storage.

Solids by EPA Method 3550A: This requires ultrasonic extractors, sound enclosures, vacuum pump, Kuderna-danish extractors, water bath, analytical balance and solvent storage.

Supercritical fluid extractions requires a carbon dioxide source.

Sample clean-up by EPA Method 3640: This requires gel permeation chromatography system that includes HPLC with GPC column, UV detector and a recorder.

7.4.6.3.2 Sample Analysis by EPA Method 8080A: This requires GC with ECD/HECD detector, data system and analytical balance(s).

7.4.6.4 TCLP by EPA Method 1311: This analytical method requires end over end agitation, extractors (including zero headspace extractors (ZHE)), filtration devices, vacuum or N_2 source and analytical balance. Analyses are performed on the leachates by VOA or semi-VOA methods as discussed above.

7.4.6.5 Furniture: Laboratory benchwork and cabinets are required to meet operational requirements.

7.4.6.6 Interior Lighting: Adequate interior lighting to ensure effective performance is required in all work areas.

7.4.6.7 Emergency Lighting: Emergency lighting systems, including exit lights, shall be provided as required by NFPA 101.

7.5 OCL Major Equipment Performance Requirements:

7.5.1 Trailer Frame Structure: Structural systems for highway structures shall be consistent with the requirements of AASHTO HB-13. The fifth wheel height will be 47½". It will be equipped with suspension air ride, tubular axles with oil seals and single anchor line, and brakes to meet F.M.V.S.S. Aluminum material used shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2. The unifying weight-carrying framework (that also provides the floor support for the attached module, see 7.5.2) will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Use of steel shall comply UBC, AISC S326, AISC M011, AISI Specifications for the Design of Cold-Formed Steel Structural Members, and with AISC N690.

7.5.2 Structural Equipment/Systems: Aluminum material used in structure shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.

7.5.2.1 Module Frame Structure: The module will have a framework of extruded aluminum with aluminum sheet paneling on the exterior walls. The floor framework will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Frame support posts will be aluminum, hi-ten double slotted series. All exterior exposed surfaces will be protected against corrosion and will have a finished look appropriate for the structure. The roof will be one piece aluminum bonded to hat section bows. Interior wall lining and roof lining will be plywood. Floor will be lightweight and solid, and a chemical resistant floor will cover the hard underlayment. Materials, framing systems, and details shall be compatible with clear space and span requirements, serviceability requirements, security requirements, climatic conditions, and structural design loads. Unit weights of materials shall be those given for highway structures by AASHTO standards. Live loads for highway structures shall be as stipulated in AASHTO HB-13. Unless stipulated otherwise, an HS 20-44 loading shall be used. Structure shall meet wind loads for highway structures as stipulated in AASHTO HB-13. The earthquake loads for highway structures shall be as stipulated in AASHTO HB-13 and AASHTO GSDB. Other loads for highway structures shall be as stipulated in AASHTO HB-13. Combination of loads and design requirements for highway structures shall be as stipulated in AASHTO HB-13. Structural systems for highway structures shall be consistent with the requirements of AASHTO BB-13.

7.5.2.2 Doors and Windows: Doors and windows shall be corrosion-resistant or protected against corrosion. Windows and doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings and floors. Door and window hardware shall comply with ANSI A156 series.

7.5.2.2.1 Doors: Doors will be 36" wide and be equipped with abrasion resistant windows, e.g., low-E tempered glass with a lexan outer cover. An overlapping molding is required where the paired double doors meet, Door jambs will be reinforced to make it more difficult to open by wedge or similar tools.

7.5.2.2.2 Windows: Windows shall be made of insulated low-E tempered glass with a lexan outer cover and will be at least 30" x 30" to meet escape hatch requirement. Windows shall comply with NFPA 101, chapter 22. Window cleaning provisions shall comply with ANSI A39.1. Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc. Aluminum windows shall comply with AAMA 101.

7.5.2.3 Walls, Floors and Ceilings:

7.5.2.3.1 Walls, Floors and Ceilings, General Requirements: Interior walls will be fire retardant and resist mild acids, alkalis and fumes. Floors will be easy to clean and resistant to mild chemicals. Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering. Vinyl composition and rubber or vinyl cove base shall be used. Wall, floor, and ceiling, and roof and ceiling assemblies shall be tested by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Units shall be equipped with smoke/heat alarms. Appropriately rated fire extinguishers will be provided.

7.5.2.3.2 Waterproofing: Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water washdown, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base-course and through-the-wall flashings, and shall make a bond with these flashings.

7.5.2.4 Louvers, Vents, Grills, and Screens: Louvers, vents, grills, and screens shall be corrosion-resistant or protected against corrosion.

7.5.3 Basic Utilities Systems:

7.5.3.1 Electrical Wiring: Fifteen and twenty amp circuits, consistent with NEC will be provided. Wire shall be not smaller than No. 12-2 copper with ground. Receptacles and switches shall comply with general grade as defined in FS W-C-596. Receptacle circuits shall be provided with ground-fault circuit interrupters as directed by NFPA 70; receptacle circuits that serve receptacles that are within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters. Adverse effects of voltage level variations, transients, and frequency variations on equipment operation shall be minimized. Sensitive electrical equipment, such as data processing equipment, shall be isolated as needed for protection. Uninterruptable power systems, or power conditioners may be used for isolation.

7.5.3.2 Supply-side Plumbing: Plumbing shall comply with the NSPC, ASHRAE Handbooks, and ASHRAE Standard 90. Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. Type L copper tubing, CPVC, or PB plastic pipe and tubing may be used. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe or tubing shall be solvent cemented or shall use other forms of joining such as electric heat fusion. Stop valves shall be provided at each fixture. All fixtures shall comply with FS WW-P-541.

7.5.3.3 Waste-side Plumbing: Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. ABS or PVC plastic pipe may be used. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Waste handling areas shall comply with the standards of confinement and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled. Specific DOE design and operating requirements for radioactive wastes (HLW, LLW, and TRU) appear in DOE 5820.2A. Appropriate provisions for storage of containerized radioactive and/or hazardous wastes shall be provided. Provision for the collection and storage of other non-hazardous or non-radioactive wastes shall also be provided, as appropriate.

7.5.3.4 Ductwork: Ductwork systems will meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following:

ASHRAE Fundamentals Handbook
SMACNA HVAC Duct Construction Standards-Metal and Flexible
SMACNA Fibrous Glass Duct Construction Standards
SMACNA Round Industrial Duct Construction Standards
SMACNA HVAC Duct Design Manual
ACGIH Industrial Ventilation Manual
NFPA 45
NFPA 90A
NFPA 91 (exhaust ductwork)
ERDA 76-21

Ductwork that handles air exhausted from moisture generating areas shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90 and shall be acoustically insulated to meet acceptable noise criteria. Ducting should be arranged so that outside air can be passed through appropriate filter systems (see 7.2.4 and 7.3.4).

7.5.3.5 Communications: Various methods will satisfy the requirements. These include commercial mobile telephone network, VHF/UHF radio, HF radio, satellite communication system, or provision for connection to a central facility, e.g., command module. Installation and operating costs and availability in remote areas will be considered. Hardwiring shall be shielded to minimize interference or interruption of transmission. Consideration should be given to fiberoptic cable, especially for data transmission.

7.5.3.6 Transfer Pipes and Encasements: Doublewalled pipes or pipes within a secondary confinement structure encasement shall be used in all areas where the primary pipe leaves the facility. In areas within the facility, the use of double-walled pipe shall be considered. Leakage monitoring shall be provided to detect leakage into the space between the primary pipe and the secondary confinement barrier.

7.5.4 Environmental:

7.5.4.1 Insulation: Foam-in-place or other suitable insulation shall be used. Loose fill will not be used. Insulation shall comply with UBC Chapter 17. Thermal insulation shall be moisture resistant and fire retardant. The thermal resistance of insulation and the degradation of thermal resistance over time will be considered in the selection of the type of insulation provided. As a minimum, the thermal transmittance values ("U" values) and overall maximum allowable combined transmittance values shall not exceed those values as determined from ASHRAE Standard 90.

7.5.4.2 Temperature and Humidity Control Systems: Internal temperature will be maintainable below 75° F with external temperature up to 125° F and maintained above 65° F when external temperature is down to -30° F. Humidity will be controlled to allow comfort (30 to 60%).

7.5.4.3 Air-intake Filtration: HEPA and charcoal filters shall be placed in-line in the air-intake portals. HEPA filters for inhabited spaces shall comply with ARI 850. In addition, an activated charcoal filter will be provided for the removal of volatile chemicals. Adsorbers for toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510. A minimum of 20 - 30ft^3/min/person fresh air will be provided.

7.5.4.4 Air-exhaust Filtration: HEPA filtration systems shall be designed with prefilters installed upstream of HEPA filters to extend the HEPA filter's life. The installation of prefilters if filtration requirements and consideration of the filter assembly justifies omission. Filters shall be designed according to the requirements given in DOE project criteria, ASHRAE Equipment handbook, and ACGIH Industrial Ventilation Manual, as applicable. Adsorbers for nuclear or toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510.

7.5.4.5 Hoods: Hood faces shall not be located within 10 ft. of the closest air supply or exhaust point. Hoods shall not be located in or along normal traffic routes. All open-faced hoods shall be designed and located to provide a minimum air velocity shall be 125 plus or minus 25 linear ft/min over the hood face area. All open-faced hoods shall be designed to provide appropriate face velocity to ensure capture of contaminants in the hood exhaust (see the ACGIH Industrial Ventilation Manual). Exhaust air from a hood shall not be recirculated to occupied areas.

7.5.4.6 Ventilation of Hoods: HEPA filters shall be provided at the interface of the enclosure outlet and the ventilation system to minimize the contamination of ductwork and at the enclosure inlet to prevent movement of contamination within the enclosure to the operating area in the event of a flow reversal. The system shall be designed to automatically ensure adequate inflow of air through a credible breach in the enclosure system. Minimum inward air velocity shall be 125 plus or minus 25 linear ft/min or as determined from guidance provided in the ACGIH Industrial Ventilation Manual. Small enclosure systems with positive-pressure supplied gases shall have positive-acting, pressure relief devices (connected into the exhaust system) to prevent pressurization of the enclosure.

7.5.5 Functional Equipment/Systems: All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard

90, Section 6. All air handling equipment shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. If the air handling equipment and air-distribution system cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems. The mechanical support area will be separate from the laboratory area and will be accessible from the exterior. Systems shall be designed to minimize and isolate vibration resulting from the operation of support equipment.

7.5.5.1 HVAC Equipment: HVAC equipment shall be sized to satisfy the module heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook.

7.5.5.1.1 Air Conditioner: The AC shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. The units should be readily serviceable by most commercial refrigeration/air conditioning companies. The AC unit should be designed to permit sequential starting of its motors to decrease the electrical surge load during the starting phase of the HVAC system.

7.5.5.1.2 Heating Equipment: Heating system should be selected based on consideration of human health and safety requirements, initial costs, operating costs and maintenance costs according to procedures in DOE 3630.1A, 0110-12.7, Building Design Analysis. Any system that might generate CO or CO_2 within the module (open flame) should be discouraged.

7.5.5.1.3 Humidifier/Dehumidifier: The need for a humidifier/dehumidifier should be addressed. An air tight construction with a heat exchange - air ventilation system might address some heating and cooling requirements and humidity requirements.

7.5.5.1.4 Air-intake and Air-exhaust Fans: All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook. Fans shall be located within the ductwork system according to the requirements of AMCA Publication 210 and ACGIH Industrial Ventilation Manual. Motors shall be sized according to \properly calculated BHP fan requirements and shall not be oversized fans and motors. All fans and accessories shall be designed to meet all smoke and flame spread requirements of NFPA 255.

7.5.5.1.5 Thermostat: Air handling and air distribution controls shall comply with DOE 6430.1A, section 1595-6, Control of Air Handling Systems.

7.5.5.2 Power Source: The module shall be designed to operate on external power or on an onboard electrical generator.

7.5.5.2.1 External Power: A capability for automatic switchover to the onboard generator will be provided in the event of external power failure. Switchover is to be completed within 2 seconds.

7.5.5.2.2 Electrical Generator: The power system shall be capable of maintaining full operation. The power system shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. The generator will be sized according to the electrical load that will be required in the RBS. For loads greater than 25 KVA, diesel engines shall generally be used. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. Lighting power budget shall be determined in conformance with ASHRAE Standard 90 (see also 7.5.6.5 and 7.5.6.6). The electrical generator shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. For generators with ≤25kVa loads, gasoline or LP gas engines may be used. For loads >25kVa, diesel engines generally should be used. Application of diesel engines shall comply with FCC Technical Report No. 69.

7.5.5.3 Uninterruptible Power Supplies: Application of UPSs shall comply with IEEE 446 or as modified by cognizant DOE authority. UPS installations may be by safety class 1 or standby type dependent on the classification of the loads served.

7.5.5.4 Mechanical Support Space: The mechanical support space shall be located so that it has its own separate opening to the outside which shall consist of two double doors (combined opening 99") with heavy duty hinges and locks. Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. Where mechanical ventilation cannot maintain a satisfactory environment, other cooling systems shall be provided. Exhaust air openings should be located to minimize ambient thermal loads.

7.5.5.5 Fuel Storage Tanks: Total storage capacity for 4 days operation at maximum load without refueling shall be provided. Fuel storage tanks shall comply with API 650.

7.5.6 Operational Equipment:

7.5.6.1 Volatile Organic Analysis:

7.5.6.1.1 Gas Chromatograph (GC): GC shall be equipped with PID & HECD detectors or with FID and/or ECD, depending on which sample analysis method is chosen. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.1.2 Mass Spectrometer (MS): MS requires 35-260 amu every 3 seconds (or less) with packed column, purge and trap device, data system, recirculation chiller and carrier gases (H_2 or He). Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.1.3 Analytical Balance: Analytical balance shall have an accuracy of 1 mg or better. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.1.4 Screening Head Space Sampler: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2 Semi-volatile Organic Analysis:

7.5.6.2.1 Liquid-liquid Extractors: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2.2 Kuderna-danish Concentrators: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2.3 Water Bath: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2.4 Recirculation Chillers: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2.5 Ultrasonic Extractors: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2.6 Vacuum Pump: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2.7 Kuderna-danish Extractors: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2.8 Analytical Balance: Analytical balance shall have an accuracy of 1 mg or better. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2.9 Gel Permeation Chromatography System: Gel permeation chromatography system shall includes HPLC with GPC column, UV detector and a recorder. System selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2.10 GC: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.2.11 MS: MS requires 35-500 amu every 1 second (or less) with a fused silica column, data system and a carrier gas (H_2 or He). Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.3 PCB Assays:

7.5.6.3.1 Liquid-liquid Extractors: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.3.2 Kuderna-danish Concentrators: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.3.3 Water Bath: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.3.4 Recirculation Chillers: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.3.5 Ultrasonic Extractors: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.3.6 Vacuum Pump: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.3.7 Kuderna-danish Extractors: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.3.8 Analytical Balance: Analytical balance shall have an accuracy of 1 mg or better. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.3.9 Gel Permeation Chromatography System: Gel permeation chromatography system shall includes HPLC with GPC column, UV detector and a recorder. System selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.3.10 GC: GC shall be equipped with an ECD/HECD detector. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.4 Toxicity Characteristic Leachate Procedure:

7.5.6.4.1 Zero Headspace Extraction Vessel: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.4.2 ZHE Extract Collection Devices: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.4.3 ZHE Extraction Fluid Transfer Devices: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.4.4 Analytical Balance: Analytical balance shall have an accuracy of 1 mg or better. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.4.5 Magnetic Stirrer: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

7.5.6.5 Laboratory Furniture: Furniture shall comply with NFPA 101, Chapter 31 and UBC Chapter 17, as applicable. Standard stock sizes, material, and finishes of a competitive type shall be considered. Base cabinets, bench tops, sinks, and hoods shall have nominal unit lengths that can be interchanged to make up the required combinations. In laboratories handling radioactive materials, the weight of shielding material to be placed on bench tops and hoods shall be considered in specifying bases and cabinets. Most commercial bases and cabinets for laboratory use can support 300-500 pounds per leg or corner. laboratory furniture used for purposes requiring more than the general illumination levels should be designed and equipped to provide local task lighting of the required intensity.

7.5.6.6 Interior Lighting: Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing should be avoided. Lighting design shall consider environmental degradation effects, e.g., dust, to ensure adequate lighting intensities on a long-term basis. Maximum use shall be made of fluorescent and HID lamps. When using HID lighting, careful consideration of the required color rendition shall be made from visual and safety perspectives. Interior lighting systems shall comply with the IES Lighting Handbook. Non-uniform lighting practices shall comply with CFR 101-20.116-2 and with DOE 6430.1A Section 1694 (Energy Conservation).

7.5.6.7 Emergency Lighting: Where high intensity discharge (HID) lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

8. INORGANIC CHEMISTRY LABORATORY (ICL) MODULE

8.1 Purpose: The ICL module will provide the capability for Analysis of inorganic constituents contained in environmental (soil, ground water and surface water) samples and samples of other solid and liquid matrices.

8.2 ICL Requirements:

8.2.1 Road Transportable: The ICL module will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport.

8.2.2 Structural: The ICL module structure will provide a protected environment for the performance of the required laboratory functions (see 8.2.6, 8.3.6, 8.4.6,and 8.5.6). Exterior walls and roof will be resistant to damages from extremes of environment. Interior walls and floors will have rigid underlining.

8.2.3 Basic Utilities: Module will be equipped with electrical wiring, plumbing, ductwork, and communications hardwiring.

8.2.4 Environmental Protection: Thermal insulation is required in exterior walls, floors, and ceilings. Clean air input must be provided. Exhaust air will protect environment. Emphasis will be placed on maintaining a comfortable temperature and humidity by air conditioning or heating to meet operational needs.

8.2.5 Functional Design: The unit will be self-sustained for heat, air conditioning and electrical supply. Water supply and human and laboratory waste generation will be addressed.

8.2.6 Operational Requirements: The ICL requires the functionality of an inorganic analytical laboratory. Laboratory must be equipped to analyze for inorganic substances contained in the samples. Design of the module will address the needs of the personnel to enhance operational performance. The interior will be functional and well lighted. Adequate ventilation will be provided based on the anticipated temperature extremes of the outside environment. Facilities will be provided for limited personal hygiene needs, for limited laboratory storage, and for laboratory-generated-waste storage and removal. Particular attention will be given to wastes containing radioactive residues.

8.3 ICL Performance Requirements:

8.3.1 Road Transportability: The module shall be securely mounted on a fifth-wheel type trailer that shall meet DOT standards for road transportation. The trailer/module shall be

equipped with leveling jacks, leveling indicators, and all necessary hook-ups for attachment to a towing vehicle. The module shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts 350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

8.3.2 Structural: The module must provide adequate strength to withstand the multi-directional forces exhibited in the transportation mode and protection against exterior shock that could occur during transport (see 8.3.1). It must also minimize air infiltration during transportation and be equipped with rub rails of at least heavy duty extruded aluminum and a hydraulic leveling system to facilitate set-up on-site. The overall construction shall be of sufficient quality to minimize vibration and noise in the interior of the module. The module shall have removable steps with a handrail for each door and a ladder securely mounted on the module exterior to provide access to the roof. The module shall have a floor constructed in a manner that prevents water and dust entry. Doors and windows will be functional according to operational needs. Framework will be strong and light weight to minimize overall weight. Structure will be provided with emergency escape capabilities. The overall dimensions will not exceed: length - 48′, height - 13′-6", and width - 8′-6".

8.3.3 Basic Utilities Performance Requirements: Appropriate water distribution system (also see 8.2.6 and 8.3.6) must be provided within the ICL module. The unit will be equipped to meet electrical and communicational needs. The unit will also be equipped to meet temperature and humidity requirements, see Environmental paragraphs, 8.2.4 and 8.3.4.

8.3.3.1 Electrical Wiring: AC wiring will be provided. Outlets, number and location, will conform to National Electrical Code (NEC). Receptacles shall be adequate in number and capacity for the initial and projected requirements.

8.3.3.2 Supply-side Plumbing: Potable water for personnel use will be supplied as an operational supply need. Provision will also be made to supply water to meet overall laboratory requirements. An external water supply hook-up capability will be provided for potable and non-potable use.

8.3.3.3 Waste-side Plumbing: The waste management systems shall provide facilities and equipment to handle wastes safely, effectively, and in an environmentally responsible manner.

8.3.3.4 Ductwork: Distribution ductwork shall be provided to distribute air to the laboratory and to exhaust air from the module. Outlets from air supply ducts shall be fitted with closable louvers. If multiple blower/filter units are installed,

there should be cross ductwork to permit some flexibility of operation and increased reliability. Ductwork is an integral part of the overall air-handling system.

8.3.3.5 Communications: Interior communications shall be designed to use standard, commercially available telephone, CB, cellular, and satellite communication equipment. An external communication capability will be provided.

8.3.4 Environmental: Insulation will be at least R-11 (walls), R-19 (ceiling), R-11 doors and R-19 (floors). Insulation shall comply with UBC Chapter 17 and will be moisture resistant. Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90. Complete HEPA and charcoal filtration of air intake will be provided. Provisions must be made to minimize the risk of undue exposure of personnel to potentially hazardous materials that might be contained in the clean-up site. A climate control system shall be provided to maintain temperature and humidity at an acceptable level.

8.3.5 Functional Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRE Standard 90, section 6. Potable water needs must be supplied internally for personnel use. A mechanical support area, separate from the laboratory area will be provided.

8.3.6 Operational Performance Requirements: Human engineering criteria will be applied to optimize man/machine interfaces. The laboratory will be capable of conducting analyses for heavy metals and anions. A capability for conducting Toxicity Characteristic Leaching Procedure and subsequent analysis of the leachates will also be provided.

8.4 ICL Major Equipment/Subsystems Requirements:

8.4.1 Road Transportability Items: Trailer/module will be a fifth-wheel type frame that shall meet DOT standards for road transportation. The trailer shall have tandem axle dual wheels. The braking system shall be vacuum over hydraulic type, capable of stopping the trailer/module in case of accidental detachment from the towing vehicle.

8.4.2 Structural: One single door for operational use of module and one double door for large equipment movement are required. Subject to laboratory design, window(s) are required. Walls, floors and ceilings will have a finished interior surface. Windows will be abrasion resistant and provide emergency escape capability.

8.4.3 Basic Utilities Systems:

8.4.3.1 Electrical Wiring: Demand and diversity factors shall comply with DOE 6430.1A, Section 1630-1.1, Load Requirements. Interior electrical system power factor shall comply with DOE 6430.1A, Section 1630-1.2, Power factor. Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120 volt single phase service provided, as applicable.

8.4.3.2 Supply-side Plumbing: A supply side water distribution system shall be provided. Fixtures appropriate for a laboratory facility will be provided.

8.4.3.3 Waste-side Plumbing: A waste water collection and storage system will be provided. Use of double walled pipes shall be considered.

8.4.3.4 Ductwork: Ductwork systems will provide efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy and duct size. Ductwork must be designed to resist corrosive contaminants.

8.4.3.5 Communications: The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B Provisions for voice and data transmission will be made. Provisions for telephone hook-up and hardwiring for computers will be provided.

8.4.4 Environmental: The ventilation-exhaust systems shall be provided for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists and excessive heat and for the provision of fresh air to the occupants.

8.4.4.1 Insulation: Insulation is required in module construction for the reduction of fire hazard and protection from heat or cold. The building envelope shall meet the minimum prescriptive energy requirements of ASHRAE Standard 90.

8.4.4.2 Climate Control Systems: An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 3.2.4.5.

8.4.4.3 Air-intake Filtration: Air-intake portals shall be provided with a filtration system to remove potentially harmful particulates and volatile chemicals.

8.4.4.4 Air-exhaust Filtration: HEPA filtration systems shall be used to minimize the release of particulate contaminants such as radioisotopes or highly toxic materials when deemed necessary.

8.4.4.5 Hoods: The ICL shall be equipped with fume hoods for the safe processing of samples.

8.4.4.6 Ventilation of Glove-Boxes/Hoods: A ventilation system shall be installed on all fully-enclosed glove-boxes/hoods to maintain a minimum negative pressure differential of 0.3 in. of water inside the enclosure (except open-faced hoods) with respect to the operating area. Open-faced hoods shall be ventilated such that flow from the operating area into the hood is maintained. Consideration should be given to the need to remove moisture, heat, and explosive and corrosive gases, as well as other contaminants.

8.4.5 Functional Equipment/Systems: The module power and emergency systems shall serve loads set forth in NFPA 110. Additional standby systems shall be provided to support systems or equipment components that are vital for protection of health, life, property, and safeguards. Uninterruptable power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. Power generating areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain ambient temperatures for equipment operation or personnel access.

8.4.5.1 HVAC Equipment: HVAC equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook. Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in DOE 6430.1A, Section 1595.

8.4.5.2 Electrical Supply System: A reliable energy supply must be provided for the OCL.

8.4.5.3 Uninterruptable Power Supplies: Uninterruptable power supplies shall be provided for those loads requiring guaranteed continuous power.

8.4.5.4 Mechanical Support Space: A space separate from the operational area of the module is required to house the mechanical equipment, e.g., generator, HVAC, heat pump.

8.4.6 Operational Equipment/Systems:

8.4.6.1 Analysis for Metals: Equipment is needed to conduct quantitative metals analyses.

8.4.6.1.1 Sample Preparation:

Liquids by EPA Method 3010A: This method does not require major equipment for the standard method. Consideration should be given to automated systems, including microwave digestion, to increase throughput.

Sludges, soils and sediments by EPA Method 3050A: This method requires an analytical balance. Otherwise it does not require major equipment for the standard method. Consideration should be given to automated systems, including microwave digestion, to increase throughput.

8.4.6.1.2 Sample Analysis: General equipment and supplies required are beakers, watch glasses, centrifuge, drying oven, thermometer, Whatman filter paper, computer controlled emission spectrometer, and radio frequency generator.

For Mercury by EPA Method 7470A (liquid) or 7471A (solids): Either method requires a cold trap atomic absorption spectrophotometer. Also required are mercury lamp, recorder, absorption cell, air pump, flowmeter, and a cold vapor generator.

For other metals by EPA Method 6010: This requires an inductively Coupled Plasma (ICP) emission spectrometer.

8.4.6.2 Analysis for Anions: Equipment is needed to conduct analyses for anions. This requires an Ion Chromatography system, data system and eluent storage.

8.4.6.3 TCLP by EPA Method 1311: This requires end over end agitation, extractors, filtration devices, vacuum or N_2 source, magnetic stirrer, and analytical balance. Analyses for metals and anions is as discussed above.

8.4.6.4 Furniture: Laboratory benchwork and cabinets are required to meet operational requirements.

8.4.6.5 Interior Lighting: Adequate interior lighting to ensure effective performance is required in all work areas.

8.4.6.6 Emergency Lighting: Emergency lighting systems, including exit lights, shall be provided as required by NFPA 101.

8.5 ICL Major Equipment Performance Requirements:

8.5.1 Trailer Frame Structure: Structural systems for highway structures shall be consistent with the requirements of AASHTO HB-13. The fifth wheel height will be 47½". It will be equipped with suspension air ride, tubular axles with oil seals and single anchor line, and brakes to meet F.M.V.S.S. Aluminum material used shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2. The unifying weight-carrying framework (that also provides the floor support for the attached module, see 8.5.2) will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Use of steel shall comply UBC, AISC S326, AISC M011, AISI Specifications for the Design of Cold-Formed Steel Structural Members, and with AISC N690.

8.5.2 Structural Equipment/Systems: Aluminum material used in structure shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.

8.5.2.1 Module Frame Structure: The module will have a framework of extruded aluminum with aluminum sheet paneling on the exterior walls. The floor framework will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Frame support posts will be aluminum, hi-ten double slotted series. All exterior exposed surfaces will be protected against corrosion and will have a finished look appropriate for the structure. The roof will be one piece aluminum bonded to hat section bows. Interior wall lining and roof lining will be plywood. Floor will be lightweight and solid, and a chemical resistant floor will cover the hard underlayment. Materials, framing systems, and details shall be compatible with clear space and span requirements, serviceability requirements, security requirements, climatic conditions, and structural design loads. Unit weights of materials shall be those given for highway structures by AASHTO standards. Live loads for highway structures shall be as stipulated in AASHTO HB-13. Unless stipulated otherwise, an HS 20-44 loading shall be used. Structure shall meet wind loads for highway structures as stipulated in AASHTO HB-13. The earthquake loads for highway structures shall be as stipulated in AASHTO HB-13 and AASHTO G3DB. Other loads for highway structures shall be as stipulated in AASHTO HB-13. Combination of loads and design requirements for highway structures shall be as stipulated in AASHTO HB-13. Structural systems for highway structures shall be consistent with the requirements of AASHTO BB-13.

8.5.2.2 Doors and Windows: Doors and windows shall be corrosion-resistant or protected against corrosion. Windows and doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings and floors. Door and window hardware shall comply with ANSI A156 series.

8.5.2.2.1 Doors: Doors will be 36" wide and be equipped with abrasion resistant windows, e.g., low-E tempered glass with a lexan outer cover. An overlapping molding is required where the paired double doors meet, Door jambs will be reinforced to make it more difficult to open by wedge or similar tools.

8.5.2.2.2 Windows: Windows shall be made of insulated low-E tempered glass with a lexan outer cover and will be at least 30" x 30" to meet escape hatch requirement. Windows shall comply with NFPA 101, chapter 22. Window cleaning provisions shall comply with ANSI A39.1. Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc. Aluminum windows shall comply with AAMA 101.

8.5.2.3 Walls, Floors and Ceilings:

8.5.2.3.1 Walls, Floors and Ceilings, General Requirements: Interior walls will be fire retardant and resist mild acids, alkalis and fumes. Floors will be easy to clean and resistant to mild chemicals. Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering. Vinyl composition and rubber or vinyl cove base shall be used. Wall, floor, and ceiling, and roof and ceiling assemblies shall be tested by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Units shall be equipped with smoke/heat alarms. Appropriately rated fire extinguishers will be provided.

8.5.2.3.2 Waterproofing: Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water washdown, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base-course and through-the-wall flashings, and shall make a bond with these flashings.

8.5.2.4 Louvers, Vents, Grills, and Screens: Louvers, vents, grills, and screens shall be corrosion-resistant or protected against corrosion.

8.5.3 Basic Utilities Systems:

8.5.3.1 Electrical Wiring: Fifteen and twenty amp circuits, consistent with NEC will be provided. Wire shall be not smaller than No. 12-2 copper with ground. Receptacles and switches shall comply with general grade as defined in FS W-C-596. Receptacle circuits shall be provided with ground-fault circuit interrupters as directed by NFPA 70; receptacle circuits that serve receptacles that are within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters. Adverse effects of voltage level variations, transients, and frequency variations on equipment operation shall be minimized. Sensitive electrical equipment, such as data processing equipment, shall be isolated as needed for protection. Uninterruptable power systems, or power conditioners may be used for isolation.

8.5.3.2 Supply-side Plumbing: Plumbing shall comply with the NSPC, ASHRAE Handbooks, and ASHRAE Standard 90. Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. Type L copper tubing, CPVC, or PB plastic pipe and tubing may be used. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe or tubing shall be solvent cemented or shall use other forms of joining such as electric heat fusion. Stop valves shall be provided at each fixture. All fixtures shall comply with FS WW-P-541.

8.5.3.3 Waste-side Plumbing: Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. ABS or PVC plastic pipe may be used. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Waste handling areas shall comply with the standards of confinement and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled. Specific DOE design and operating requirements for radioactive wastes (HLW, LLW, and TRU) appear in DOE 5820.2A. Appropriate provisions for storage of containerized radioactive and/or hazardous wastes shall be provided. Provision for the collection and storage of other non-hazardous or non-radioactive wastes shall also be provided, as appropriate.

8.5.3.4 Ductwork: Ductwork systems will meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following:

- ASHRAE Fundamentals Handbook
- SMACNA HVAC Duct Construction Standards-Metal and Flexible
- SMACNA Fibrous Glass Duct Construction Standards
- SMACNA Round Industrial Duct Construction Standards
- SMACNA HVAC Duct Design Manual
- ACGIH Industrial Ventilation Manual
- NFPA 45
- NFPA 90A
- NFPA 91 (exhaust ductwork)
- ERDA 76-21

Ductwork that handles air exhausted from moisture generating areas shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90 and shall be acoustically insulated to meet acceptable noise criteria. Ducting should be arranged so that outside air can be passed through appropriate filter systems (see 8.2.4 and 8.3.4).

8.5.3.5 Communications: Various methods will satisfy the requirements. These include commercial mobile telephone network, VHF/UHF radio, HF radio, satellite communication system, or provision for connection to a central facility, e.g., command module. Installation and operating costs and availability in remote areas will be considered. Hardwiring shall be shielded to minimize interference or interruption of transmission. Consideration should be given to fiberoptic cable, especially for data transmission.

8.5.3.6 Transfer Pipes and Encasements: Doublewalled pipes or pipes within a secondary confinement structure encasement shall be used in all areas where the primary pipe leaves the facility. In areas within the facility, the use of double-walled pipe shall be considered. Leakage monitoring shall be provided to detect leakage into the space between the primary pipe and the secondary confinement barrier.

8.5.4 Environmental:

8.5.4.1 Insulation: Foam-in-place or other suitable insulation shall be used. Loose fill will not be used. Insulation shall comply with UBC Chapter 17. Thermal insulation shall be moisture resistant and fire retardant. The thermal resistance of insulation and the degradation of thermal resistance over time will be considered in the selection of the type of insulation provided. As a minimum, the thermal transmittance values ("U" values) and overall maximum allowable combined transmittance values shall not exceed those values as determined from ASHRAE Standard 90.

8.5.4.2 Temperature and Humidity Control Systems: Internal temperature will be maintainable below 75° F with external temperature up to 125° F and maintained above 65° F when external temperature is down to -30° F. Humidity will be controlled to allow comfort (30 to 60%). Emphasis shall be placed in meeting these requirements despite the large and varying heat generation from the analytical equipment.

8.5.4.3 Air-intake Filtration: HEPA and charcoal filters shall be placed in-line in the air-intake portals. HEPA filters for inhabited spaces shall comply with ARI 850. In addition, an activated charcoal filter will be provided for the removal of volatile chemicals. Adsorbers for toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510. A minimum of 20 - 30ft^3/min/person fresh air will be provided.

8.5.4.4 Air-exhaust Filtration: HEPA filtration systems shall be designed with prefilters installed upstream of HEPA filters to extend the HEPA filter's life. The installation of prefilters if filtration requirements and consideration of the filter assembly justifies omission. Filters shall be designed according to the requirements given in DOE project criteria, ASHRAE

Equipment handbook, and ACGIH Industrial Ventilation Manual, as applicable. Adsorbers for nuclear or toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510.

8.5.4.5 Hoods: Hood faces shall not be located within 10 ft. of the closest air supply or exhaust point. Hoods shall not be located in or along normal traffic routes. An open-faced hood shall be designed and located to provide a minimum air velocity shall be 125 plus or minus 25 linear ft/min over the hood face area. All open-faced hoods shall be designed to provide appropriate face velocity to ensure capture of contaminants in the hood exhaust (see the ACGIH Industrial Ventilation Manual). Exhaust air from a hood shall not be recirculated tc occupied areas.

8.5.4.6 Ventilation of Glove-Boxes/Hoods: HEPA filters shall be provided at the interface of the enclosure outlet and the ventilation system to minimize the contamination of ductwork and at the enclosure inlet to prevent movement of contamination within the enclosure to the operating area in the event of a flow reversal. The system shall be designed to automatically ensure adequate inflow of air through a credible breach in the enclosure system. Minimum inward air velocity shall be 125 plus or minus 25 linear ft/min or as determined from guidance provided in the ACGIH Industrial Ventilation Manual. Small enclosure systems with positive-pressure supplied gases shall have positive-acting, pressure relief devices (connected into the exhaust system) to prevent pressurization of the enclosure.

8.5.5 Functional Equipment/Systems: All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. All air handling equipment shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. If the air handling equipment and air-distribution system cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems. The mechanical support area will be separate from the laboratory area and will be accessible from the exterior. Systems shall be designed to minimize and isolate vibration resulting from the operation of support equipment.

8.5.5.1 HVAC Equipment: HVAC equipment shall be sized to satisfy the module heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE

Fundamentals Handbook. Calculations shall include the large and varying heat generated by the analytical equipment.

8.5.5.1.1 Air Conditioner: The AC shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. The units should be readily serviceable by most commercial refrigeration/air conditioning companies. The AC unit should be designed to permit sequential starting of its motors to decrease the electrical surge load during the starting phase of the HVAC system.

8.5.5.1.2 Heating Equipment: Heating system should be selected based on consideration of human health and safety requirements, initial costs, operating costs and maintenance costs according to procedures in DOE 3630.1A, 0110-12.7, Building Design Analysis. Any system that might generate CO or CO_2 within the module (open flame) should be discouraged.

8.5.5.1.3 Humidifier/Dehumidifier: The need for a humidifier/dehumidifier should be addressed. An air tight construction with a heat exchange - air ventilation system might address some heating and cooling requirements and humidity requirements.

8.5.5.1.4 Air-intake and Air-exhaust Fans: All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook. Fans shall be located within the ductwork system according to the requirements of AMCA Publication 210 and ACGIH Industrial Ventilation Manual. Motors shall be sized according to \properly calculated BHP fan requirements and shall not be oversized fans and motors. All fans and accessories shall be designed to meet all smoke and flame spread requirements of NFPA 255.

8.5.5.1.5 Thermostat: Air handling and air distribution controls shall comply with DOE 6430.1A, section 1595-6, Control of Air Handling Systems.

8.5.5.2 Power Source: The module shall be designed to operate on external power or on an onboard electrical generator.

8.5.5.2.1 External Power: A capability for automatic switchover to the onboard generator will be provided in the event of external power failure. Switchover is to be completed within 2 seconds.

8.5.5.2.2 Electrical Generator: The power system shall be capable of maintaining full operation. The power system shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. The generator will be sized according to the electrical load that will be required in the RBS. For loads greater than 25 KVA, diesel engines shall generally be used. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. Lighting power budget shall be determined in conformance with ASHRAE Standard 90 (see also 8.5.6.5 and 8.5.6.6). The electrical generator shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. For generators with ≤25kVa loads, gasoline or LP gas engines may be used. For loads >25kVa, diesel engines generally should be used. Application of diesel engines shall comply with FCC Technical Report No. 69.

8.5.5.3 Uninterruptable Power Supplies: Application of UPSs shall comply with IEEE 446 or as modified by cognizant DOE authority. UPS installations may be by safety class 1 or standby type dependent on the classification of the loads served.

8.5.5.4 Mechanical Support Space: The mechanical support space shall be located so that it has its own separate opening to the outside which shall consist of two double doors (combined opening 99") with heavy duty hinges and locks. Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. Where mechanical ventilation cannot maintain a satisfactory environment, other cooling systems shall be provided. Exhaust air openings should be located to minimize ambient thermal loads.

8.5.5.5 Fuel Storage Tanks: Total storage capacity for 4 days operation at maximum load without refueling shall be provided. Fuel storage tanks shall comply with API 650.

8.5.6 Operational Equipment:

8.5.6.1 Analysis for Metals: Sample preparation of liquids or solids does not require major equipment for the standard method. Consideration should be given to automated systems, including microwave digestion, to increase throughput. The following sample analysis equipment is required.

8.5.6.1.1 Atomic Absorption Spectrophotometer: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.1.2 Inductively Coupled Argon Plasma Emission Spectrometer: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.1.3 Centrifuge: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.1.4 Drying Oven: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.1.5 Computer Controlled Emission Spectrometer: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.1.6 Radio Frequency Generator: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.2 Toxicity Characteristic Leachate Procedure: The requirements for this procedure may also be met, functionally, by using a portion of the sample prepared by this procedure in the OCL.

8.5.6.2.1 Zero Headspace Extraction Vessel: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.2.2 ZHE Extract Collection Devices: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.2.3 ZHE Extraction Fluid Transfer Devices: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.2.4 Analytical Balance: Analytical balance shall have an accuracy of 1 mg or better. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.2.5 Magnetic Stirrer: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.3 Ion Chromatography System: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

8.5.6.4 Laboratory Furniture: Furniture shall comply with NFPA 101, Chapter 31 and UBC Chapter 17, as applicable. Standard stock sizes, material, and finishes of a competitive type shall be considered. Base cabinets, bench tops, sinks, and hoods shall have nominal unit lengths that can be interchanged to make up the required combinations. In laboratories handling radioactive materials, the weight of shielding material to be placed on bench tops and hoods shall be considered in specifying bases and cabinets. Most commercial bases and cabinets for laboratory use can support 300-500 pounds per leg or corner. laboratory furniture used for purposes requiring more than the general illumination levels should be designed and equipped to provide local task lighting of the required intensity.

8.5.6.5 Interior Lighting: Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing should be avoided. Lighting design shall consider environmental degradation effects, e.g., dust, to ensure adequate lighting intensities on a long-term basis. Maximum use shall be made of fluorescent and HID lamps. When using HID lighting, careful consideration of the required color rendition shall be made from visual and safety perspectives. Interior lighting systems shall comply with the IES Lighting Handbook. Non-uniform lighting practices shall comply with CFR 101-20.116-2 and with DOE 6430.1A Section 1694 (Energy Conservation).

8.5.6.6 Emergency Lighting: Where high intensity discharge (HID) lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

9. RADIOANALYTICAL LABORATORY (RAL) MODULE

9.1 Purpose: The RAL module will provide the capability for Analysis of radioactive isotopes contained in environmental (soil, ground water and surface water) samples and samples of other solid and liquid matrices.

9.2 RAL Requirements:

9.2.1 Road Transportable: The RAL module will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport.

9.2.2 Structural: The RAL module structure will provide a protected environment for the performance of the required laboratory functions (see 9.2.6, 9.3.6, 9.4.6,and 9.5.6). Exterior walls and roof will be resistant to damages from extremes of environment. Interior walls and floors will have rigid underlining.

9.2.3 Basic Utilities: Module will be equipped with electrical wiring, plumbing, ductwork, and communications hardwiring.

9.2.4 Environmental Protection: Thermal insulation is required in exterior walls, floors, and ceilings. Clean air input must be provided. Exhaust air will protect environment. Emphasis will be placed on maintaining a comfortable temperature and humidity by air conditioning or heating to meet operational needs.

9.2.5 Functional Design: The unit will be self-sustained for heat, air conditioning and electrical supply. Water supply and human and laboratory waste generation will be addressed.

9.2.6 Operational Requirements: The RAL requires the functionality of a radionuclide analytical laboratory. Laboratory must be equipped to analyze for radioactive isotopes contained in the samples. Design of the module will address the needs of the personnel to enhance operational performance. The interior will be functional and well lighted. Adequate ventilation will be provided based on the anticipated temperature extremes of the outside environment. Facilities will be provided for limited personal hygiene needs, for limited laboratory storage, and for laboratory-generated-waste storage and removal. Particular attention will be given to wastes containing radioactive residues.

9.3 RAL Performance Requirements:

9.3.1 Road Transportability: The module shall be securely mounted on a fifth-wheel type trailer that shall meet DOT standards for road transportation. The trailer/module shall be

equipped with leveling jacks, leveling indicators, and all necessary hook-ups for attachment to a towing vehicle. The module shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts 350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

9.3.2 Structural: The module must provide adequate strength to withstand the multi-directional forces exhibited in the transportation mode and protection against exterior shock that could occur during transport (see 9.3.1). It must also minimize air infiltration during transportation and be equipped with rub rails of at least heavy duty extruded aluminum and a hydraulic leveling system to facilitate set-up on-site. The overall construction shall be of sufficient quality to minimize vibration and noise in the interior of the module. The module shall have removable steps with a handrail for each door and a ladder securely mounted on the module exterior to provide access to the roof. The module shall have a floor constructed in a manner that prevents water and dust entry. Doors and windows will be functional according to operational needs. Framework will be strong and light weight to minimize overall weight. Structure will be provided with emergency escape capabilities. The overall dimensions will not exceed: length - 48', height - 13'-6", and width - 8'-6".

9.3.3 Basic Utilities Performance Requirements: Appropriate water distribution system (also see 9.2.6 and 9.3.6) must be provided within the RAL module. The unit will be equipped to meet electrical and communicational needs. The unit will also be equipped to meet temperature and humidity requirements, see Environmental paragraphs, 9.2.4 and 9.3.4.

9.3.3.1 Electrical Wiring: AC wiring will be provided. Outlets, number and location, will conform to National Electrical Code (NEC). Receptacles shall be adequate in number and capacity for the initial and projected requirements.

9.3.3.2 Supply-side Plumbing: Potable water for personnel use will be supplied as an operational supply need. Provision will also be made to supply water to meet overall laboratory requirements. An external water supply hook-up capability will be provided for potable and non-potable use.

9.3.3.3 Waste-side Plumbing: The waste management systems shall provide facilities and equipment to handle wastes safely, effectively, and in an environmentally responsible manner.

9.3.3.4 Ductwork: Distribution ductwork shall be provided to distribute air to the laboratory and to exhaust air from the module. Outlets from air supply ducts shall be fitted with closable louvers. If multiple blower/filter units are installed,

there should be cross ductwork to permit some flexibility of operation and increased reliability. Ductwork is an integral part of the overall air-handling system.

9.3.3.5 Communications: Interior communications shall be designed to use standard, commercially available telephone, CB, cellular, and satellite communication equipment. An external communication capability will be provided.

9.3.4 Environmental: Insulation will be at least R-11 (walls), R-19 (ceiling), R-11 doors and R-19 (floors). Insulation shall comply with UBC Chapter 17 and will be moisture resistant. Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90. Complete HEPA and charcoal filtration of air intake will be provided. Provisions must be made to minimize the risk of undue exposure of personnel to potentially hazardous materials that might be contained in the clean-up site. A climate control system shall be provided to maintain temperature and humidity at an acceptable level.

9.3.5 Functional Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRE Standard 90, section 6. Potable water needs must be supplied internally for personnel use. A mechanical support area, separate from the laboratory area will be provided.

9.3.6 Operational Performance Requirements: Human engineering criteria will be applied to optimize man/machine interfaces. The laboratory will be capable of conducting qualitative and quantitative analyses for alpha, beta or gamma emissions from various radioactive isotopes that may be present in the soil and/or water samples.

9.4 RAL Major Equipment/Subunit Requirements:

9.4.1 Road Transportability Items: Trailer/module will be a fifth-wheel type frame that shall meet DOT standards for road transportation. The trailer shall have tandem axle dual wheels. The braking system shall be vacuum over hydraulic type, capable of stopping the trailer/module in case of accidental detachment from the towing vehicle.

9.4.2 Structural: One single door for operational use of module and one double door for large equipment movement are required. Subject to laboratory design, window(s) are required. Walls, floors and ceilings will have a finished interior surface. Windows will be abrasion resistant and provide emergency escape capability.

9.4.3 Basic Utilities Systems:

9.4.3.1 Electrical Wiring: Demand and diversity factors shall comply with DOE 6430.1A, Section 1630-1.1, Load Requirements. Interior electrical system power factor shall comply with DOE 6430.1A, Section 1630-1.2, Power factor. Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120 volt single phase service provided, as applicable.

9.4.3.2 Supply-side Plumbing: A supply side water distribution system shall be provided. Fixtures appropriate for a laboratory facility will be provided.

9.4.3.3 Waste-side Plumbing: A waste water collection and storage system will be provided. Use of double walled pipes shall be considered.

9.4.3.4 Ductwork: Ductwork systems will provide efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy and duct size. Ductwork must be designed to resist corrosive contaminants.

9.4.3.5 Communications: The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B Provisions for voice and data transmission will be made. Provisions for telephone hook-up and hardwiring for computers will be provided.

9.4.4 Environmental: The ventilation-exhaust systems shall be provided for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists and excessive heat and for the provision of fresh air to the occupants.

9.4.4.1 Insulation: Insulation is required in module construction for the reduction of fire hazard and protection from heat or cold. The building envelope shall meet the minimum prescriptive energy requirements of ASHRAE Standard 90.

9.4.4.2 Climate Control Systems: An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 3.2.4.5.

9.4.4.3 Air-intake Filtration: Air-intake portals shall be provided with a filtration system to remove potentially harmful particulates and volatile chemicals.

9.4.4.4 Air-exhaust Filtration: HEPA filtration systems shall be used to minimize the release of particulate contaminants such as radioisotopes or highly toxic materials when deemed necessary.

9.4.4.5 Hoods: The RAL shall be equipped with fume hoods for the safe processing of samples.

9.4.4.6 Ventilation of Hoods: A ventilation system shall be installed on all fully-enclosed hoods to maintain a minimum negative pressure differential of 0.3 in. of water inside the enclosure (except open-faced hoods) with respect to the operating area. Open-faced hoods shall be ventilated such that flow from the operating area into the hood is maintained. Consideration should be given to the need to remove moisture, heat, and explosive and corrosive gases, as well as other contaminants.

9.4.5 Functional Equipment/Systems: The module power and emergency systems shall serve loads set forth in NFPA 110. Additional standby systems shall be provided to support systems or equipment components that are vital for protection of health, life, property, and safeguards. Uninterruptable power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. Power generating areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain ambient temperatures for equipment operation or personnel access.

9.4.5.1 HVAC Equipment: HVAC equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook. Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in DOE 6430.1A, Section 1595.

9.4.5.2 Electrical Supply System: A reliable energy supply must be provided for the RAL.

9.4.5.3 Uninterruptable Power Supplies: Uninterruptable power supplies shall be provided for those loads requiring guaranteed continuous power.

9.4.5.4 Mechanical Support Space: A space separate from the operational area of the module is required to house the mechanical equipment, e.g., generator, HVAC, heat pump.

9.4.6 Operational Equipment/Systems:

9.4.6.1 Plutonium and Americium: The equipment described in the following sub-sections are needed to conduct analyses for plutonium and americium.

9.4.6.1.1 Sample (liquid) Preparation by EPA Method 907.0: This requires a drying oven, muffle furnace, hot-plates, centrifuge, vortex mixer, multichannel analyzer with HPGe Detector, Analytical balance, silica column, extraction vials, screens, transfer pipettes, laboratory glassware, stainless steel planchettes, and reagents. Americium and plutonium are separated by reagents.

9.4.6.1.2 Plutonium in Air Filters: This requires an alpha spectrometer, ion exchange resin, stainless steel planchettes, and reagents.

9.4.6.1.3 Plutonium and Americium Analysis: Plutonium and americium, following separation, are determined by alpha particle counting which requires an alpha counter.

9.4.6.2 Uranium: Determination of uranium isotopes in sediment and soil can be performed using radiochemical and/or fluorometric methods and in drinking water by EPA Radiochemical Method 907.0 and 908.9.

9.4.6.2.1 Radiochemical Methods: This method requires a gas flow proportional counting system or scintillation detection system and ion exchange columns, stainless steel planchettes, millipore filter apparatus, and reagents.

9.4.6.2.2 Fluorometric Method: This method requires a fluorometer, dish forming dye, fusion dish blanks, muffler furnace, microliter pipettes, associated glassware, and reagents.

9.4.6.2.3 Uranium in Air Filters: This requires an alpha spectrometer, ion exchange resin, stainless steel planchettes, and reagents.

9.4.6.3 Strontium^{90} Analysis: Strontium^{90} analysis is conducted using EPA Radiochemical Method 905.0. This requires an instrument to determine beta particle emission, centrifuge, drying oven, water bath, hot plates, analytical balance, pH meters, desiccator, stainless steel planchettes and other laboratory supplies.

9.4.6.4 Cobalt^{60} and Cesium^{137} Analysis: Cobalt^{60} and cesium^{137} analysis is conducted using EPA Radiochemical Method 901.1.

9.4.6.5 Furniture: Laboratory benchwork and cabinets are required to meet operational requirements.

9.4.6.6 Interior Lighting: Adequate interior lighting to ensure effective performance is required in all work areas.

9.4.6.7 Emergency Lighting: Emergency lighting systems, including exit lights, shall be provided as required by NFPA 101.

9.5 RAL Major Equipment Performance Requirements:

9.5.1 Trailer Frame Structure: Structural systems for highway structures shall be consistent with the requirements of AASHTO HB-13. The fifth wheel height will be 47½". It will be equipped with suspension air ride, tubular axles with oil seals and single anchor line, and brakes to meet F.M.V.S.S. Aluminum material used shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2. The unifying weight-carrying framework (that also provides the floor support for the attached module, see 9.5.2) will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Use of steel shall comply UBC, AISC S326, AISC M011, AISI Specifications for the Design of Cold-Formed Steel Structural Members, and with AISC N690.

9.5.2 Structural Equipment/Systems: Aluminum material used in structure shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.

9.5.2.1 Module Frame Structure: The module will have a framework of extruded aluminum with aluminum sheet paneling on the exterior walls. The floor framework will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Frame support posts will be aluminum, hi-ten double slotted series. All exterior exposed surfaces will be protected against corrosion and will have a finished look appropriate for the structure. The roof will be one piece aluminum bonded to hat section bows. Interior wall lining and roof lining will be plywood. Floor will be lightweight and solid, and a chemical resistant floor will cover the hard underlayment. Materials, framing systems, and details shall be compatible with clear space and span requirements, serviceability requirements, security requirements, climatic conditions, and structural design loads. Unit weights of materials shall be those given for highway structures by AASHTO standards. Live loads for highway structures shall be as stipulated in AASHTO HB-13. Unless stipulated otherwise, an HS 20-44 loading shall be used. Structure shall meet wind loads for highway structures as stipulated in AASHTO HB-13. The earthquake loads for highway structures shall be as stipulated in AASHTO HB-13 and AASHTO GSDB. Other loads for highway structures shall be as stipulated in AASHTO HB-13. Combination of loads and design requirements for highway structures shall be as stipulated in AASHTO HB-13. Structural systems for highway structures shall be consistent with the requirements of AASHTO BB-13.

9.5.2.2 Doors and Windows: Doors and windows shall be corrosion-resistant or protected against corrosion. Windows and doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings and floors. Door and window hardware shall comply with ANSI A156 series.

9.5.2.2.1 Doors: Doors will be 36" wide and be equipped with abrasion resistant windows, e.g., low-E tempered glass with a lexan outer cover. An overlapping molding is required where the paired double doors meet, Door jambs will be reinforced to make it more difficult to open by wedge or similar tools.

9.5.2.2.2 Windows: Windows shall be made of insulated low-E tempered glass with a lexan outer cover and will be at least 30" x 30" to meet escape hatch requirement. Windows shall comply with NFPA 101, chapter 22. Window cleaning provisions shall comply with ANSI A39.1. Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc. Aluminum windows shall comply with AAMA 101.

9.5.2.3 Walls, Floors and Ceilings:

9.5.2.3.1 Walls, Floors and Ceilings, General Requirements: Interior walls will be fire retardant and resist mild acids, alkalis and fumes. Floors will be easy to clean and resistant to mild chemicals. Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering. Vinyl composition and rubber or vinyl cove base shall be used. Wall, floor, and ceiling, and roof and ceiling assemblies shall be tested by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Units shall be equipped with smoke/heat alarms. Appropriately rated fire extinguishers will be provided.

9.5.2.3.2 Waterproofing: Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water washdown, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base-course and through-the-wall flashings, and shall make a bond with these flashings.

9.5.2.4 Louvers, Vents, Grills, and Screens: Louvers, vents, grills, and screens shall be corrosion-resistant or protected against corrosion.

9.5.3 Basic Utilities Systems:

9.5.3.1 Electrical Wiring: Fifteen and twenty amp circuits, consistent with NEC will be provided. Wire shall be not smaller than No. 12-2 copper with ground. Receptacles and switches shall comply with general grade as defined in FS W-C-596. Receptacle circuits shall be provided with ground-fault circuit interrupters as directed by NFPA 70; receptacle circuits that serve receptacles that are within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters. Adverse effects of voltage level variations, transients, and frequency variations on equipment operation shall be minimized. Sensitive electrical equipment, such as data processing equipment, shall be isolated as needed for protection. Uninterruptable power systems, or power conditioners may be used for isolation.

9.5.3.2 Supply-side Plumbing: Plumbing shall comply with the NSPC, ASHRAE Handbooks, and ASHRAE Standard 90. Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. Type L copper tubing, CPVC, or PB plastic pipe and tubing may be used. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe or tubing shall be solvent cemented or shall use other forms of joining such as electric heat fusion. Stop valves shall be provided at each fixture. All fixtures shall comply with FS WW-P-541.

9.5.3.3 Waste-side Plumbing: Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. ABS or PVC plastic pipe may be used. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Waste handling areas shall comply with the standards of confinement and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled. Specific DOE design and operating requirements for radioactive wastes (HLW, LLW, and TRU) appear in DOE 5820.2A. Appropriate provisions for storage of containerized radioactive and/or hazardous wastes shall be provided. Provision for the collection and storage of other non-hazardous or non-radioactive wastes shall also be provided, as appropriate.

9.5.3.4 Ductwork: Ductwork systems will meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following:

- ASHRAE Fundamentals Handbook
- SMACNA HVAC Duct Construction Standards-Metal and Flexible
- SMACNA Fibrous Glass Duct Construction Standards
- SMACNA Round Industrial Duct Construction Standards
- SMACNA HVAC Duct Design Manual
- ACGIH Industrial Ventilation Manual
- NFPA 45

NFPA 90A
NFPA 91 (exhaust ductwork)
ERDA 76-21

Ductwork that handles air exhausted from moisture generating areas shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90 and shall be acoustically insulated to meet acceptable noise criteria. Ducting should be arranged so that outside air can be passed through appropriate filter systems (see 9.2.4 and 9.3.4).

9.5.3.5 Communications: Various methods will satisfy the requirements. These include commercial mobile telephone network, VHF/UHF radio, HF radio, satellite communication system, or provision for connection to a central facility, e.g., command module. Installation and operating costs and availability in remote areas will be considered. Hardwiring shall be shielded to minimize interference or interruption of transmission. Consideration should be given to fiberoptic cable, especially for data transmission.

9.5.3.6 Transfer Pipes and Encasements: Doublewalled pipes or pipes within a secondary confinement structure encasement shall be used in all areas where the primary pipe leaves the facility. In areas within the facility, the use of double-walled pipe shall be considered. Leakage monitoring shall be provided to detect leakage into the space between the primary pipe and the secondary confinement barrier.

9.5.4 Environmental:

9.5.4.1 Insulation: Foam-in-place or other suitable insulation shall be used. Loose fill will not be used. Insulation shall comply with UBC Chapter 17. Thermal insulation shall be moisture resistant and fire retardant. The thermal resistance of insulation and the degradation of thermal resistance over time will be considered in the selection of the type of insulation provided. As a minimum, the thermal transmittance values ("U" values) and overall maximum allowable combined transmittance values shall not exceed those values as determined from ASHRAE Standard 90.

9.5.4.2 Temperature and Humidity Control Systems: Internal temperature will be maintainable below 75° F with external temperature up to 125° F and maintained above 65° F when external temperature is down to -30° F. Humidity will be controlled to allow comfort (30 to 60%).

9.5.4.3 Air-intake Filtration: HEPA and charcoal filters shall be placed in-line in the air-intake portals. HEPA filters for inhabited spaces shall comply with ARI 850. In addition, an activated charcoal filter will be provided for the removal of volatile chemicals. Adsorbers for toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510. A minimum of 20 - 30ft^3/min/person fresh air will be provided.

9.5.4.4 Air-exhaust Filtration: HEPA filtration systems shall be designed with prefilters installed upstream of HEPA filters to extend the HEPA filter's life. The installation of prefilters if filtration requirements and consideration of the filter assembly justifies omission. Filters shall be designed according to the requirements given in DOE project criteria, ASHRAE Equipment handbook, and ACGIH Industrial Ventilation Manual, as applicable. Adsorbers for nuclear or toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510.

9.5.4.5 Hoods: Hood faces shall not be located within 10 ft. of the closest air supply or exhaust point. Hoods shall not be located in or along normal traffic routes. An open-faced hood shall be designed and located to provide a minimum air velocity shall be 125 plus or minus 25 linear ft/min over the hood face area. All open-faced hoods shall be designed to provide appropriate face velocity to ensure capture of contaminants in the hood exhaust (see the ACGIH Industrial Ventilation Manual). Exhaust air from a hood shall not be recirculated to occupied areas.

9.5.4.6 Ventilation of Hoods: HEPA filters shall be provided at the interface of the enclosure outlet and the ventilation system to minimize the contamination of ductwork and at the enclosure inlet to prevent movement of contamination within the enclosure to the operating area in the event of a flow reversal. The system shall be designed to automatically ensure adequate inflow of air through a credible breach in the enclosure system. Minimum inward air velocity shall be 125 plus or minus 2[illegible] linear ft/min or as determined from guidance provided in the AC[illegible]H Industrial Ventilation Manual. Small enclosure systems w[illegible]h positive-pressure supplied gases shall have positive-acting, pressure relief devices (connected into the exhaust system) to prevent pressurization of the enclosure.

9.5.5 Functional Equipment/Systems: All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. All air handling equipment shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. If the air handling equipment and air-distribution system cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems. The mechanical support area will be separate from the laboratory area and will be accessible from the exterior. Systems shall be designed to minimize and isolate vibration resulting from the operation of support equipment.

9.5.5.1 HVAC Equipment: HVAC equipment shall be sized to satisfy the module heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook.

9.5.5.1.1 Air Conditioner: The AC shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. The units should be readily serviceable by most commercial refrigeration/air conditioning companies. The AC unit should be designed to permit sequential starting of its motors to decrease the electrical surge load during the starting phase of the HVAC system.

9.5.5.1.2 Heating Equipment: Heating system should be selected based on consideration of human health and safety requirements, initial costs, operating costs and maintenance costs according to procedures in DOE 3630.1A, 0110-12.7, Building Design Analysis. Any system that might generate CO or CO_2 within the module (open flame) should be discouraged.

9.5.5.1.3 Humidifier/Dehumidifier: The need for a humidifier/dehumidifier should be addressed. An air tight construction with a heat exchange - air ventilation system might address some heating and cooling requirements and humidity requirements.

9.5.5.1.4 Air-intake and Air-exhaust Fans: All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook. Fans shall be located within the ductwork system according to the requirements of AMCA Publication 210 and ACGIH Industrial Ventilation Manual. Motors shall be sized according to \properly calculated BHP fan requirements and shall not be oversized fans and motors. All fans and accessories shall be designed to meet all smoke and flame spread requirements of NFPA 255.

9.5.5.1.5 Thermostat: Air handling and air distribution controls shall comply with DOE 6430.1A, section 1595-6, Control of Air Handling Systems.

9.5.5.2 Power Source: The module shall be designed to operate on external power or on an onboard electrical generator.

9.5.5.2.1 External Power: A capability for automatic switchover to the onboard generator will be provided in the event of external power failure. Switchover is to be completed within 2 seconds.

9.5.5.2.2 Electrical Generator: The power system shall be capable of maintaining full operation. The power system shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. The generator will be sized according to the electrical load that will be required in the RBS. For loads greater than 25 KVA, diesel engines shall generally be used. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. Lighting power budget shall be determined in conformance with ASHRAE Standard 90 (see also 9.5.6.5 and 9.5.6.6). The electrical generator shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. For generators with ≤25kVa loads, gasoline or LP gas engines may be used. For loads >25kVa, diesel engines generally should be used. Application of diesel engines shall comply with FCC Technical Report No. 69.

9.5.5.3 Uninterruptible Power Supplies: Application of UPSs shall comply with IEEE 446 or as modified by cognizant DOE authority. UPS installations may be by safety class 1 or standby type dependent on the classification of the loads served.

9.5.5.4 Mechanical Support Space: The mechanical support space shall be located so that it has its own separate opening to the outside which shall consist of two double doors (combined opening 99") with heavy duty hinges and locks. Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. Where mechanical ventilation cannot maintain a satisfactory environment, other cooling systems shall be provided. Exhaust air openings should be located to minimize ambient thermal loads.

9.5.5.5 Fuel Storage Tanks: Total storage capacity for 4 days operation at maximum load without refueling shall be provided. Fuel storage tanks shall comply with API 650.

9.5.6 Operational Equipment Performance Requirements:

9.5.6.1 Plutonium and Americium:

9.5.6.1.1 Alpha Spectrometer: Isotopic analysis will identify specific radionuclides and provide quantitative analysis as required. The alpha spectrometer system shall have a detection sensitivity to 9 nanoCuries/gram and be capable of providing analytical level III data. Efficiency, cost and count-time are trade-offs that need to be considered.

9.5.6.1.2 Germanium Detector: Instrument shall have the ability to distinguish emissions from a broad range of energy and be capable of providing analytical level III data. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications. Efficiency, cost and count-time are trade-offs that need to be considered.
9.5.6.1.3 Multichannel analyzer: Several multichannel analyzers meet this performance requirement. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.1.4 Drying Oven: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.1.5 Muffle Furnace: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.1.6 Hotplates: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.1.7 Centrifuge: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.1.8 Vortex Mixer: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.1.9 Analytical Balance: Balance shall have an accuracy of 1 mg or better. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.1.10 Silica Column: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.1.11 Ion Exchange Resin: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.1.12 Gross Alpha and Beta Counter: Any of several instruments that discriminate between alpha and beta particles, will meet the requirement for gross alpha and beta particle counting. Efficiency, cost and count-time are trade-offs that need to be considered.

9.5.6.1.13 Automated Sample Changing: A customized automated sample changer should be considered to increase throughputs.

9.5.6.2 Uranium Analysis:

9.5.6.2.1 Muffle Furnace: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.2.2 Ion Exchange Resin: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.2.3 Liquid Scintillation: System selected shall have a detection sensitivity to 9 nanoCuries/gram and be capable of providing analytical level III data. Efficiency, cost and count-time are trade-offs that need to be considered.

9.5.6.2.4 Fluorometer: System selected shall have a detection sensitivity to 9 nanoCuries/gram and be capable of providing analytical level III data. Efficiency, cost and count-time are trade-offs that need to be considered.

9.5.6.2.5 Alpha Spectrometer: Isotopic analysis will identify specific radionuclides and provide quantitative analysis as required. The alpha-spectrometer system shall have a detection sensitivity to 9 nanoCuries/gram and be capable of providing analytical level III data. Efficiency, cost and count-time are trade-offs that need to be considered.

9.5.6.2.6 Gross Alpha, Beta Counter: Any, of several instruments that discriminate between alpha and beta particles, will meet the requirement for gross alpha and beta particle counting. Efficiency, cost and count-time are trade-offs that need to be considered.

9.5.6.2.7 Automated Sample Changing: A customized automated sample changer should be considered to increase throughput.

9.5.6.3 Strontium^{90} Analysis:

9.5.6.3.1 Liquid Scintillation: System selected shall have a detection sensitivity to .9 nanoCuries/gram. Efficiency, cost and count-time are trade-offs that need to be considered.

9.5.6.3.2 Centrifuge: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.3.3 Drying Oven: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.3.4 Water Bath: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.3.5 Hot Plates: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.3.6 Analytical Balance: Balance shall have an accuracy of 1 mg or better. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.3.7 pH Meter: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.3.8 Automated Sample Changing: A customized automated sample changer should be considered to increase throughput.

9.5.6.4 Cobalt^{60} and Cesium^{137} Analysis:

9.5.6.4.1 Liquid Scintillation: System selected shall have a detection sensitivity to .9 nanoCuries/gram. Instrument shall have the ability to distinguish emissions from a broad range of energy. Efficiency, cost and count-time are trade-offs that need to be considered.

9.5.6.4.2 Gas Flow Proportional Counter: System selected shall have a detection sensitivity to .9 nanoCuries/gram. Instrument shall have the ability to distinguish emissions from a broad range of energy. Efficiency, cost and count-time are trade-offs that need to be considered.

9.5.6.4.3 Germanium Detector: Instrument shall have the ability to distinguish emissions from a broad range of energy and be capable of providing analytical level III data. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications. Efficiency, cost and count-time are trade-offs that need to be considered.

9.5.6.4.4 Drying Oven: Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.4.5 Analytical Balance: Balance shall have an accuracy of 1 mg or better. Instrument selected shall be specified to be adequate by manufacturer and shall meet manufacturer's stated specifications.

9.5.6.4.6 Automated Sample Changing: A customized automated sample changer should be considered to increase throughput.

9.5.6.5 Laboratory Furniture: Furniture shall comply with NFPA 101, Chapter 31 and UBC Chapter 17, as applicable. Standard stock sizes, material, and finishes of a competitive type shall be considered. Base cabinets, bench tops, sinks, and hoods shall have nominal unit lengths that can be interchanged to make up the required combinations. In laboratories handling radioactive materials, the weight of shielding material to be placed on bench tops and hoods shall be considered in specifying bases and cabinets. Most commercial bases and cabinets for laboratory use can support 300-500 pounds per leg or corner. laboratory furniture used for purposes requiring more than the general illumination levels should be designed and equipped to provide local task lighting of the required intensity.

9.5.6.6 Interior Lighting: Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing should be avoided. Lighting design shall consider environmental degradation effects, e.g., dust, to ensure adequate lighting intensities on a long-term basis. Maximum use shall be made of fluorescent and HID lamps. When using HID lighting, careful consideration of the required color rendition shall be made from visual and safety perspectives. Interior lighting systems shall comply with the IES Lighting Handbook. Non-uniform lighting practices shall comply with CFR 101-20.116-2 and with DOE 6430.1A Section 1694 (Energy Conservation).

9.5.6.7 Emergency Lighting: Where high intensity discharge (HID) lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

10. DECONTAMINATION (DCM) MODULE

10.1 Purpose: The DCM module will provide the capability for personnel decontamination resulting from radioactive or chemical contamination of person, clothing or protective clothing.

10.2 DCM Requirements:

10.2.1 Road Transportable: The DCM module will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport.

10.2.2 Structural: The DCM module structure will provide a protected environment for the performance of the required laboratory functions (see 10.2.6, 10.3.6, 10.4.6,and 10.5.6). Exterior walls and roof will be resistant to damages from extremes of environment. Interior walls and floors will have rigid underlining.

10.2.3 Basic Utilities: Module will be equipped with electrical wiring, plumbing, ductwork, and communications hardwiring, as required.

10.2.4 Environmental Protection: Thermal insulation is required in exterior walls, floors, and ceilings. Emphasis will be placed on maintaining a comfortable temperature and humidity by air conditioning or heating to meet operational needs.

10.2.5 Functional Design: The unit will be self-sustained for heat, air conditioning and electrical supply. Water supply and human and laboratory waste generation will be addressed.

10.2.6 Operational Requirements: The DCM requires the functionality of a decontamination unit. Design of the module will address the needs of the personnel to enhance operational performance. The interior will be functional. Adequate ventilation will be provided based on the anticipated temperature extremes of the outside environment. Facilities will be provided for generated-waste storage and removal. Particular attention will be given to wastes containing radioactive residues.

10.3 DCM Performance Requirements:

10.3.1 Road Transportability: The module shall be securely mounted on a fifth-wheel type trailer that shall meet DOT standards for road transportation. The trailer/module shall be equipped with leveling jacks, leveling indicators, and all necessary hook-ups for attachment to a towing vehicle. The module shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts

350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

10.3.2 Structural: The module must provide adequate strength to withstand the multi-directional forces exhibited in the transportation mode and protection against exterior shock that could occur during transport (see 10.3.1). It must also minimize air infiltration during transportation and be equipped with rub rails of at least heavy duty extruded aluminum and a hydraulic leveling system to facilitate set-up on-site. The overall construction shall be of sufficient quality to minimize vibration and noise in the interior of the module. The module shall have removable steps with a handrail for each door and a ladder securely mounted on the module exterior to provide access to the roof. The module shall have a floor constructed in a manner that prevents water and dust entry. Windows (if any) and doors will be functional according to operational needs. Framework will be strong and light weight to minimize overall weight. Structure will be provided with emergency escape capabilities. The overall dimensions will not exceed: length - 48′, height - 13′-6", and width - 8′-6".

10.3.3 Basic Utilities Performance Requirements: Appropriate water distribution system (also see 10.2.6 and 10.3.6) must be provided within the DCM module. The unit will be equipped to meet electrical and communicational needs, as required. The unit will also be equipped to meet temperature and humidity requirements, see Environmental paragraphs, 10.2.4 and 10.3.4.

10.3.3.1 Electrical Wiring: AC wiring will be provided. Outlets, number and location, will conform to National Electrical Code (NEC). Receptacles shall be adequate in number and capacity for the initial and projected requirements.

10.3.3.2 Supply-side Plumbing: Potable water for personnel use will be supplied as an operational supply need; potable water storage for a minimum of 200 gallons will be provided. Provision will also be made to supply water to meet overall operational requirements. An external water supply hook-up capability will be provided for potable and non-potable use.

10.3.3.3 Waste-side Plumbing: The waste management systems shall provide facilities and equipment to handle wastes safely, effectively, and in an environmentally responsible manner.

10.3.3.4 Ductwork: Distribution ductwork shall be provided to distribute air to the unit and to exhaust air from the module. Outlets from air supply ducts shall be fitted with closable louvers. If multiple blower/filter units are installed, there should be cross ductwork to permit some flexibility of operation and increased reliability. Ductwork is an integral part of the overall air-handling system.

10.3.3.5 Communications: Interior communications, as required, shall be designed to use standard, commercially available telephone, CB, cellular, and satellite communication equipment. An external communication capability will be provided.

10.3.4 Environmental: Insulation will be at least R-11 (walls), R-19 (ceiling), R-11 doors and R-19 (floors). Insulation shall comply with UBC Chapter 17 and will be moisture resistant. Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90. A climate control system shall be provided to maintain temperature and humidity at an acceptable level.

10.3.5 Functional Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRE Standard 90, section 6. Potable water needs must be supplied internally for personnel use. A mechanical support area, separate from the decontamination area will be provided.

10.3.6 Operational Performance Requirements: Human engineering criteria will be applied to optimize man/machine interfaces. The unit will be capable of enabling personnel decontamination.

10.4 DCM Major Equipment/Subunit Requirements:

10.4.1 Road Transportability Items: Trailer/module will be a fifth-wheel type frame that shall meet DOT standards for road transportation. The trailer shall have tandem axle dual wheels. The braking system shall be vacuum over hydraulic type, capable of stopping the trailer/module in case of accidental detachment from the towing vehicle.

10.4.2 Structural: One or more single doors for operational use of module are required. Subject to laboratory design, window(s) are required. Walls, floors and ceilings will have a finished interior surface. Windows will be abrasion resistant and provide emergency escape capability.

10.4.3 Basic Utilities Systems:

10.4.3.1 Electrical Wiring: Demand and diversity factors shall comply with DOE 6430.1A, Section 1630-1.1, Load Requirements. Interior electrical system power factor shall comply with DOE 6430.1A, Section 1630-1.2, Power factor. Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120 volt single phase service provided, as applicable.

10.4.3.2 Supply-side Plumbing: A supply side water distribution system shall be provided. Fixtures appropriate for a decontamination facility will be provided.

10.4.3.3 Waste-side Plumbing: A waste water collection and storage system will be provided.

10.4.3.4 Ductwork: Ductwork systems will provide efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy and duct size. Ductwork must be designed to resist corrosive contaminants.

10.4.3.5 Communications: The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B

10.4.4 Environmental: The ventilation-exhaust systems shall be provided for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists and excessive heat and for the provision of fresh air to the occupants.

10.4.4.1 Insulation: Insulation is required in module construction for the reduction of fire hazard and protection from heat or cold. The building envelope shall meet the minimum prescriptive energy requirements of ASHRAE Standard 90.

10.4.4.2 Climate Control Systems: An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 3.2.4.5.

10.4.5 Functional Equipment/Systems: The module power and emergency systems shall serve loads set forth in NFPA 110. Additional standby systems shall be provided to support systems or equipment components that are vital for protection of health, life, property, and safeguards. Uninterruptable power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. Power generating areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain ambient temperatures for equipment operation or personnel access.

10.4.5.1 HVAC Equipment: HVAC equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook. Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in DOE 6430.1A, Section 1595.

10.4.5.2 Electrical Supply System: A reliable energy supply must be provided for the DCM.

10.4.5.3 Uninterruptible Power Supplies: Uninterruptable power supplies shall be provided for those loads requiring guaranteed continuous power.

10.4.5.4 Mechanical Support Space: A space separate from the operational area of the module is required to house the mechanical equipment, e.g., generator, HVAC, heat pump.

10.4.6 Operational Equipment/Systems Requirements: The DCM requires a decontamination shower and a shower for the individual.

10.5 DCM Major Equipment Performance Requirements:

10.5.1 Trailer Frame Structure: Structural systems for highway structures shall be consistent with the requirements of AASHTO HB-13. The fifth wheel height will be 47½". It will be equipped with suspension air ride, tubular axles with oil seals and single anchor line, and brakes to meet F.M.V.S.S. Aluminum material used shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2. The unifying weight-carrying framework (that also provides the floor support for the attached module, see 10.5.2) will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Use of steel shall comply UBC, AISC S326, AISC M011, AISI Specifications for the Design of Cold-Formed Steel Structural Members, and with AISC N690.

10.5.2 Structural Equipment/Systems: Aluminum material used in structure shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.

10.5.2.1 Module Frame Structure: The module will have a framework of extruded aluminum with aluminum sheet paneling on the exterior walls. The floor framework will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Frame support posts will be aluminum, hi-ten double slotted series. All exterior exposed surfaces will be protected against corrosion and will have a finished look appropriate for the structure. The roof will be one piece aluminum bonded to hat section bows. Interior wall lining and roof lining will be plywood. Floor will be lightweight and solid, and a chemical resistant floor will cover the hard underlayment. Materials, framing systems, and details shall be compatible with clear space and span requirements, serviceability requirements, security requirements, climatic conditions, and structural design loads. Unit weights of materials shall be those given for highway structures by AASHTO standards. Live loads for highway structures shall be as stipulated in AASHTO HB-13. Unless stipulated otherwise, an HS 20-44 loading shall be used. Structure shall meet wind loads for highway structures as stipulated in AASHTO HB-13. The earthquake loads for highway structures shall be as stipulated in AASHTO HB-13 and AASHTO GSDB. Other loads for highway structures shall be as stipulated in AASHTO HB-13. Combination of loads and design requirements for highway structures shall be as stipulated in AASHTO HB-13. Structural systems for highway structures shall be consistent with the requirements of AASHTO BB-13.

10.5.2.2 Doors and Windows: Doors and windows shall be corrosion-resistant or protected against corrosion. Windows and doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings and floors. Door and window hardware shall comply with ANSI A156 series.

10.5.2.2.1 Doors: Doors will be 36" wide and be equipped with abrasion resistant windows, if appropriate, e.g., low-E tempered glass with a lexan outer cover. An overlapping molding is required where the paired double doors meet, Door jambs will be reinforced to make it more difficult to open by wedge or similar tools.

10.5.2.2.2 Windows: Windows shall be made of insulated low-E tempered glass with a lexan outer cover and will be at least 30" x 30" to meet escape hatch requirement. Windows shall comply with NFPA 101, chapter 22. Window cleaning provisions shall comply with ANSI A39.1. Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc. Aluminum windows shall comply with AAMA 101.

10.5.2.3 Walls, Floors and Ceilings:

10.5.2.3.1 Walls, Floors and Ceilings, General Requirements: Interior walls will be fire retardant and resist mild acids, alkalis and fumes. Floors will be easy to clean and resistant to mild chemicals. Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering. Vinyl composition and rubber or vinyl cove base shall be used. Wall, floor, and ceiling, and roof and ceiling assemblies shall be tested by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Units shall be equipped with smoke/heat alarms. Appropriately rated fire extinguishers will be provided.

10.5.2.3.2 Waterproofing: Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water washdown, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base-course and through-the-wall flashings, and shall make a bond with these flashings.

10.5.2.4 Louvers, Vents, Grills, and Screens: Louvers, vents, grills, and screens shall be corrosion-resistant or protected against corrosion.

10.5.3 Basic Utilities Systems:

10.5.3.1 Electrical Wiring: Fifteen and twenty amp circuits, as required to meet operational needs, consistent with NEC will be provided. Wire shall be not smaller than No. 12-2 copper with ground. Receptacles and switches shall comply with general grade as defined in FS W-C-596. Receptacle circuits shall be provided with ground-fault circuit interrupters as directed by NFPA 70; receptacle circuits that serve receptacles that are within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters.

10.5.3.2 Supply-side Plumbing: Plumbing shall comply with the NSPC, ASHRAE Handbooks, and ASHRAE Standard 90. Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. Type L copper tubing, CPVC, or PB plastic pipe and tubing may be used. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe or tubing shall be solvent cemented or shall use other forms of joining such as electric heat fusion. Stop valves shall be provided at each fixture. All fixtures shall comply with FS WW-P-541.

10.5.3.3 Waste-side Plumbing: Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. ABS or PVC plastic pipe may be used. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Waste handling areas shall comply with the standards of confinement and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled. Specific DOE design and operating requirements for radioactive wastes (HLW, LLW, and TRU) appear in DOE 5820.2A. Appropriate provisions for storage of containerized radioactive and/or hazardous wastes shall be provided. Provision for the collection and storage of other non-hazardous or non-radioactive wastes shall also be provided, as appropriate.

10.5.3.4 Ductwork: Ductwork systems will meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following:

ASHRAE Fundamentals Handbook
SMACNA HVAC Duct Construction Standards-Metal and Flexible
SMACNA Fibrous Glass Duct Construction Standards

SMACNA Round Industrial Duct Construction Standards
SMACNA HVAC Duct Design Manual
ACGIH Industrial Ventilation Manual
NFPA 45
NFPA 90A
NFPA 91 (exhaust ductwork)
ERDA 76-21

Ductwork that handles air exhausted from moisture generating areas shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90 and shall be acoustically insulated to meet acceptable noise criteria.

10.5.3.5 Communications: Hardwiring shall be shielded to minimize interference or interruption of transmission and for moisture protection.

10.5.3.6 Transfer Pipes and Encasements: The use of double-walled pipe shall be considered. Doublewalled pipes or pipes within a secondary confinement structure encasement shall be used in all areas where the primary pipe leaves the facility. Leakage monitoring shall be provided to detect leakage into the space between the primary pipe and the secondary confinement barrier.

10.5.4 Environmental:

10.5.4.1 Insulation: Foam-in-place or other suitable insulation shall be used. Loose fill will not be used. Insulation shall comply with UBC Chapter 17. Thermal insulation shall be moisture resistant and fire retardant. The thermal resistance of insulation and the degradation of thermal resistance over time will be considered in the selection of the type of insulation provided. As a minimum, the thermal transmittance values ("U" values) and overall maximum allowable combined transmittance values shall not exceed those values as determined from ASHRAE Standard 90.

10.5.4.2 Temperature and Humidity Control Systems: Internal temperature will be maintainable below 75° F with external temperature up to 125° F and maintained above 65° F when external temperature is down to -30° F. Humidity will be controlled to allow comfort (30 to 60%).

10.5.5 Functional Equipment/Systems Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. All air handling equipment shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. If the air handling equipment and air-distribution system cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems. The mechanical support area will be separate from the laboratory area and will be accessible from the exterior. Systems shall be designed to minimize and isolate vibration resulting from the operation of support equipment.

10.5.5.1 HVAC Equipment: HVAC equipment shall be sized to satisfy the module heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook.

10.5.5.1.1 Air Conditioner: The AC shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. The units should be readily serviceable by most commercial refrigeration/air conditioning companies. The AC unit should be designed to permit sequential starting of its motors to decrease the electrical surge load during the starting phase of the HVAC system.

10.5.5.1.2 Heating Equipment: Heating system should be selected based on consideration of human health and safety requirements, initial costs, operating costs and maintenance costs according to procedures in DOE 3630.1A, 0110-12.7, Building Design Analysis. Any system that might generate CO or CO_2 within the module (open flame) should be discouraged.

10.5.5.1.3 Humidifier/Dehumidifier: The need for a humidifier/dehumidifier should be addressed. An air tight construction with a heat exchange - air ventilation system might address some heating and cooling requirements and humidity requirements.

10.5.5.1.4 Air-intake and Air-exhaust Fans: All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook. Fans shall be located within the ductwork system according to the requirements of AMCA Publication 210 and ACGIH Industrial Ventilation Manual. Motors shall be sized according to \properly calculated BHP fan requirements and shall not be oversized fans and motors. All fans and accessories shall be designed to meet all smoke and flame spread requirements of NFPA 255.

10.5.5.1.5 Thermostat: Air handling and air distribution controls shall comply with DOE 6430.1A, section 1595-6, Control of Air Handling Systems.

10.5.5.2 Power Source: The module shall be designed to operate on external power or on an onboard electrical generator.

10.5.5.2.1 External Power: A capability for automatic switchover to the onboard generator will be provided in the event of external power failure. Switchover is to be completed within 2 seconds.

10.5.5.2.2 Electrical Generator: The power system shall be capable of maintaining full operation. The power system shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. The generator will be sized according to the electrical load that will be required in the RBS. For loads greater than 25 KVA, diesel engines shall generally be used. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. Lighting power budget shall be determined in conformance with ASHRAE Standard 90 (see also 10.5.6.5 and 10.5.6.6). The electrical generator shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. For generators with ≤25kVa loads, gasoline or LP gas engines may be used. For loads >25kVa, diesel engines generally should be used. Application of diesel engines shall comply with FCC Technical Report No. 69.

10.5.5.3 Uninterruptible Power Supplies: Application of UPSs shall comply with IEEE 446 or as modified by cognizant DOE authority. UPS installations may be by safety class 1 or standby type dependent on the classification of the loads served.

10.5.5.4 Mechanical Support Space: The mechanical support space shall be located so that it has its own separate opening to the outside which shall consist of two double doors (combined opening 99") with heavy duty hinges and locks. Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. Where mechanical ventilation cannot maintain a satisfactory environment, other cooling systems shall be provided. Exhaust air openings should be located to minimize ambient thermal loads.

10.5.5.5 Fuel Storage Tanks: Total storage capacity for 4 days operation at maximum load without refueling shall be provided. Fuel storage tanks shall comply with API 650.

10.5.6 Operational Equipment:

10.5.6.1 Decontamination Shower: Decontamination shower shall be capable of providing full surface decontamination. A system for collecting and storing decontamination waste water in segregated tanks must be provided.

10.5.6.2 Personnel Shower: A shower with hot and cold or hot/cold running water shall be provided. A system for collecting and storing waste water must be provided, see 10.5.3.

10.5.6.3 Lockers: Lockers shall be of rigid, moisture resistant material, providing full length storage and accessibility. A louvered ventilation system should also be considered. A positive latching mechanism with a locking provision shall also be included.

10.5.6.4 Interior Lighting: Adequate light levels are necessary to ensure optimum performance. Maximum use shall be made of fluorescent. Interior lighting systems shall comply with the IES Lighting Handbook. Non-uniform lighting practices shall comply with CFR 101-20.116-2 and with DOE 6430.1A Section 1694 (Energy Conservation).

10.5.6.5 Emergency Lighting: Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

11. SAMPLE SCREENING (SSM) MODULE

11.1 Purpose: The SSM module will provide the capability to prescreen samples for radioactivity levels to determine appropriate handling procedures. Samples containing radioactivity at levels above the safe handling capabilities, i.e., R3 and R4 samples, will be packaged for shipment and analysis at a suitably equipped fixed facility. Other samples will be further processed and analyzed in the RTAL modular laboratory complex.

11.2 SSM Requirements:

11.2.1 Road Transportable: The SSM module will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport.

11.2.2 Structural: The SSM module structure will provide a protected environment for the performance of the required laboratory functions (see 11.2.6, 11.3.6, 11.4.6,and 11.5.6). Exterior walls and roof will be resistant to damages from extremes of environment. Interior walls and floors will have rigid underlining.

11.2.3 Basic Utilities: Module will be equipped with electrical wiring, plumbing, ductwork, and communications hardwiring.

11.2.4 Environmental Protection: Thermal insulation is required in exterior walls, floors, and ceilings. Clean air input must be provided. Exhaust air will protect environment. Emphasis will be placed on maintaining a comfortable temperature and humidity by air conditioning or heating to meet operational needs.

11.2.5 Functional Design: The unit will be self-sustained for heat, air conditioning and electrical supply. Water supply and human and laboratory waste generation will be addressed.

11.2.6 Operational Requirements: The SSM requires the functionality of a small "hot" laboratory with limited analytic capability. Laboratory must be equipped to prescreen for level and type of radioactive emissions present in the samples. Design of the module will address the needs of the personnel to enhance operational performance. The interior will be functional and well lighted. Adequate ventilation will be provided based on the anticipated temperature extremes of the outside environment. Facilities will be provided for limited personal hygiene needs, for limited laboratory storage, and for laboratory-generated-waste storage and removal. Particular attention will be given to wastes containing radioactive residues.

11.3 SSM Performance Requirements:

11.3.1 Road Transportability: The module shall be securely mounted on a fifth-wheel type trailer that shall meet DOT standards for road transportation. The trailer/module shall be equipped with leveling jacks, leveling indicators, and all necessary hook-ups for attachment to a towing vehicle. The module shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts 350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

11.3.2 Structural: The module must provide adequate strength to withstand the multi-directional forces exhibited in the transportation mode and protection against exterior shock that could occur during transport (see 11.3.1). It must also minimize air infiltration during transportation and be equipped with rub rails of at least heavy duty extruded aluminum and a hydraulic leveling system to facilitate set-up on-site. The overall construction shall be of sufficient quality to minimize vibration and noise in the interior of the module. The module shall have removable steps with a handrail for each door and a ladder securely mounted on the module exterior to provide access to the roof. The module shall have a floor constructed in a manner that prevents water and dust entry. Doors and windows will be functional according to operational needs. Framework will be strong and light weight to minimize overall weight. Structure will be provided with emergency escape capabilities. The overall dimensions will not exceed: length - 48', height - 13'-6", and width - 8'-6".

11.3.3 Basic Utilities Performance Requirements: Appropriate water distribution system (also see 11.2.6 and 11.3.6) must be provided within the SSM module. The unit will be equipped to meet electrical and communicational needs. The unit will also be equipped to meet temperature and humidity requirements, see Environmental paragraphs, 11.2.4 and 11.3.4.

11.3.3.1 Electrical Wiring: AC wiring will be provided. Outlets, number and location, will conform to National Electrical Code (NEC). Receptacles shall be adequate in number and capacity for the initial and projected requirements.

11.3.3.2 Supply-side Plumbing: Potable water for personnel use will be supplied as an operational supply need. Provision will also be made to supply water to meet overall laboratory requirements. An external water supply hook-up capability will be provided for potable and non-potable use.

11.3.3.3 Waste-side Plumbing: The waste management systems shall provide facilities and equipment to handle wastes safely, effectively, and in an environmentally responsible manner.

11.3.3.4 Ductwork: Distribution ductwork shall be provided to distribute air to the laboratory and to exhaust air from the module. Outlets from air supply ducts shall be fitted with closable louvers. If multiple blower/filter units are installed, there should be cross ductwork to permit some flexibility of operation and increased reliability. Ductwork is an integral part of the overall air-handling system.

11.3.3.5 Communications: Interior communications shall be designed to use standard, commercially available telephone, CB, cellular, and satellite communication equipment. An external communication capability will be provided.

11.3.4 Environmental: Insulation will be at least R-11 (walls), R-19 (ceiling), R-11 doors and R-19 (floors). Insulation shall comply with UBC Chapter 17 and will be moisture resistant. Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90. Complete HEPA and charcoal filtration of air intake will be provided. Provisions must be made to minimize the risk of undue exposure of personnel to potentially hazardous materials that might be contained in the clean-up site. A climate control system shall be provided to maintain temperature and humidity at an acceptable level. Measures must also be taken to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in DOE 6430.1A, Section 1300-1.4, Guidance on Limiting Exposure of the Public.

11.3.5 Functional Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRE Standard 90, section 6. Potable water needs must be supplied internally for personnel use. A mechanical support area, separate from the laboratory area will be provided.

11.3.6 Operational Performance Requirements: Human engineering criteria will be applied to optimize man/machine interfaces. The laboratory will be capable of conducting prescreening examination for radioactive emissions.

11.4 SSM Major Equipment/Subunit Requirements:

11.4.1 Road Transportability Items: Trailer/module will be a fifth-wheel type frame that shall meet DOT standards for road transportation. The trailer shall have tandem axle dual wheels. The braking system shall be vacuum over hydraulic type, capable of stopping the trailer/module in case of accidental detachment from the towing vehicle.

11.4.2 Structural: One single door for operational use of module and one double door for large equipment movement are required. Subject to laboratory design, window(s) are required.

Walls, floors and ceilings will have a finished interior surface. Windows will be abrasion resistant and provide emergency escape capability.

11.4.3 Basic Utilities Systems:

11.4.3.1 Electrical Wiring: Demand and diversity factors shall comply with DOE 6430.1A, Section 1630-1.1, Load Requirements. Interior electrical system power factor shall comply with DOE 6430.1A, Section 1630-1.2, Power factor. Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120 volt single phase service provided, as applicable.

11.4.3.2 Supply-side Plumbing: A supply side water distribution system shall be provided. Fixtures appropriate for a laboratory facility will be provided.

11.4.3.3 Waste-side Plumbing: A waste water collection and storage system will be provided. Use of double walled pipes shall be considered.

11.4.3.4 Ductwork: Ductwork systems will provide efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy and duct size. Ductwork must be designed to resist corrosive contaminants.

11.4.3.5 Communications: The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B Provisions for voice and data transmission will be made. Provisions for telephone hook-up and hardwiring for computers will be provided.

11.4.4 Environmental: The ventilation-exhaust systems shall be provided for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists and excessive heat and for the provision of fresh air to the occupants. This laboratory will need to operate as a Hot Laboratory; therefore, primary containment consisting of items such as a hot cell, glove box, process piping (see 11.4.3.3), tank, fume hood, etc., may be required.

11.4.4.1 Insulation: Insulation is required in module construction for the reduction of fire hazard and protection from heat or cold. The building envelope shall meet the minimum prescriptive energy requirements of ASHRAE Standard 90.

11.4.4.2 Climate Control Systems: An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 3.2.4.5.

11.4.4.3 Air-intake Filtration: Air-intake portals shall be provided with a filtration system to remove potentially harmful particulates and volatile chemicals.

11.4.4.4 Air-exhaust Filtration: HEPA filtration systems shall be used to minimize the release of particulate contaminants such as radioisotopes or highly toxic materials when deemed necessary.

11.4.4.5 Hoods: The SSM shall be equipped with fume hoods for the safe processing of samples.

11.4.4.6 Ventilation of Glove-Boxes/Hoods: A ventilation system shall be installed on all fully-enclosed glove-boxes/hoods to maintain a minimum negative pressure differential of 0.3 in. of water inside the enclosure (except open-faced hoods) with respect to the operating area. Open-faced hoods shall be ventilated such that flow from the operating area into the hood is maintained. Consideration should be given to the need to remove moisture, heat, and explosive and corrosive gases, as well as other contaminants.

11.4.4.7 Hot Cell: Because samples may potentially be highly radioactive with one or more isotopes, prescreening in a safe environment, i.e., a hot cell, will be required. The hot cell will be a triple containment area

11.4.4.8 Glove Box: Some samples may require handling in a glove box due to their levels of radioactivity. Glove boxes will be double containment areas.

11.4.4.9 Containment Pressurization: Differential pressures between the various containment systems are required to ensure air flow is always from lower to higher containment areas.

11.4.5 Functional Equipment/Systems: The module power and emergency systems shall serve loads set forth in NFPA 110. Additional standby systems shall be provided to support systems or equipment components that are vital for protection of health, life, property, and safeguards. Uninterruptable power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. Power generating areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain ambient temperatures for equipment operation or personnel access.

11.4.5.1 HVAC Equipment: HVAC equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook.

Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in DOE 6430.1A, Section 1595.

11.4.5.2 Electrical Supply System: A reliable energy supply must be provided for the SSM.

11.4.5.3 Uninterruptible Power Supplies: Uninterruptable power supplies shall be provided for those loads requiring guaranteed continuous power.

11.4.5.4 Mechanical Support Space: A space separate from the operational area of the module is required to house the mechanical equipment, e.g., generator, HVAC, heat pump.

11.4.6 Operational Equipment/Systems:

11.4.6.1 Gross Alpha and Beta Analysis: Equipment is required to determine level of alpha and beta particle emissions by EPA Method 900.0.

11.4.6.2 Gross Gamma Ray Analysis: Equipment is required to determine level of gamma ray emissions by EPA Method 901.1.

11.4.6.3 Multichannel Analyzer: A multichannel analyzer may be required to enable acceptable discrimination and/or identification.

11.4.6.4 Furniture: Laboratory benchwork and cabinets are required to meet operational requirements.

11.4.6.5 Interior Lighting: Adequate interior lighting to ensure effective performance is required in all work areas.

11.4.6.6 Emergency Lighting: Emergency lighting systems, including exit lights, shall be provided as required by NFPA 101.

11.5 SSM Major Equipment Performance Requirements:

11.5.1 Trailer Frame Structure: Structural systems for highway structures shall be consistent with the requirements of AASHTO HB-13. The fifth wheel height will be 47½". It will be equipped with suspension air ride, tubular axles with oil seals and single anchor line, and brakes to meet F.M.V.S.S. Aluminum and steel material used shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2. The unifying weight-carrying framework (that also provides the floor support for the attached module, see 11.5.2) will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Use of steel shall comply with UBC, AISC S326, AISC M011, AISI Specifications for the Design of Cold-Formed Steel Structural Members, and AISC N690.

11.5.2 Structural Equipment/Systems: Aluminum material used in structure shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.

11.5.2.1 Module Frame Structure: The module will have a framework of extruded aluminum with aluminum sheet paneling on the exterior walls. The floor framework will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Frame support posts will be aluminum, hi-ten double slotted series. All exterior exposed surfaces will be protected against corrosion and will have a finished look appropriate for the structure. The roof will be one piece aluminum bonded to hat section bows. Interior wall lining and roof lining will be plywood. Floor will be lightweight and solid, and a chemical resistant floor will cover the hard underlayment. Materials, framing systems, and details shall be compatible with clear space and span requirements, serviceability requirements, security requirements, climatic conditions, and structural design loads. Unit weights of materials shall be those given for highway structures by AASHTO standards. Live loads for highway structures shall be as stipulated in AASHTO HB-13. Unless stipulated otherwise, an HS 20-44 loading shall be used. Structure shall meet wind loads for highway structures as stipulated in AASHTO HB-13. The earthquake loads for highway structures shall be as stipulated in AASHTO HB-13 and AASHTO GSDB. Other loads for highway structures shall be as stipulated in AASHTO HB-13. Combination of loads and design requirements for highway structures shall be as stipulated in AASHTO HB-13. Structural systems for highway structures shall be consistent with the requirements of AASHTO BB-13.

11.5.2.2 Doors and Windows: Doors and windows shall be corrosion-resistant or protected against corrosion. Windows and doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings and floors. Door and window hardware shall comply with ANSI A156 series.

11.5.2.2.1 Doors: Doors will be 36" wide and be equipped with abrasion resistant windows, e.g., low-E tempered glass with a lexan outer cover. An overlapping molding is required where the paired double doors meet, Door jambs will be reinforced to make it more difficult to open by wedge or similar tools.

11.5.2.2.2 Windows: Windows shall be made of insulated low-E tempered glass with a lexan outer cover and will be at least 30" x 30" to meet escape hatch requirement. Windows shall comply with NFPA 101, chapter 22. Window cleaning provisions shall comply with ANSI A39.1. Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc. Aluminum windows shall comply with AAMA 101.

11.5.2.3 Walls, Floors and Ceilings:

11.5.2.3.1 Walls, Floors and Ceilings, General Requirements: Interior walls will be fire retardant and resist mild acids, alkalis and fumes. Floors will be easy to clean and resistant to mild chemicals. Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering. Vinyl composition and rubber or vinyl cove base shall be used. Wall, floor, and ceiling, and roof and ceiling assemblies shall be tested by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Units shall be equipped with smoke/heat alarms. Appropriately rated fire extinguishers will be provided.

11.5.2.3.2 Waterproofing: Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water washdown, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base-course and through-the-wall flashings, and shall make a bond with these flashings.

11.5.2.4 Louvers, Vents, Grills, and Screens: Louvers, vents, grills, and screens shall be corrosion-resistant or protected against corrosion.

11.5.3 Basic Utilities Systems:

11.5.3.1 Electrical Wiring: Fifteen and twenty amp circuits, consistent with NEC will be provided. Wire shall be not smaller than No. 12-2 copper with ground. Receptacles and switches shall comply with general grade as defined in FS W-C-596. Receptacle circuits shall be provided with ground-fault circuit interrupters as directed by NFPA 70; receptacle circuits that serve receptacles that are within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters. Adverse effects of voltage level variations, transients, and frequency variations on equipment operation shall be minimized. Sensitive electrical equipment, such as data processing equipment, shall be isolated as needed for protection. Uninterruptable power systems, or power conditioners may be used for isolation.

11.5.3.2 Supply-side Plumbing: Plumbing shall comply with the NSPC, ASHRAE Handbooks, and ASHRAE Standard 90. Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. Type L copper tubing, CPVC, or PB plastic pipe and tubing may be used. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe or tubing shall be solvent cemented or shall use other forms of joining such as electric heat fusion. Stop valves shall be provided at each fixture. All fixtures shall comply with FS WW-P-541.

11.5.3.3 Waste-side Plumbing: Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. ABS or PVC plastic pipe may be used. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Waste handling areas shall comply with the standards of confinement and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled. Specific DOE design and operating requirements for radioactive wastes (HLW, LLW, and TRU) appear in DOE 5820.2A. Appropriate provisions for storage of containerized radioactive and/or hazardous wastes shall be provided. Provision for the collection and storage of other non-hazardous or non-radioactive wastes shall also be provided, as appropriate.

11.5.3.4 Ductwork: Ductwork systems will meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following:

ASHRAE Fundamentals Handbook
SMACNA HVAC Duct Construction Standards-Metal and Flexible
SMACNA Fibrous Glass Duct Construction Standards
SMACNA Round Industrial Duct Construction Standards
SMACNA HVAC Duct Design Manual
ACGIH Industrial Ventilation Manual
NFPA 45
NFPA 90A
NFPA 91 (exhaust ductwork)
ERDA 76-21

Ductwork that handles air exhausted from moisture generating areas shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90 and shall be acoustically insulated to meet acceptable noise criteria. Ducting should be arranged so that outside air can be passed through appropriate filter systems (see 11.2.4 and 11.3.4).

11.5.3.5 Communications: Various methods will satisfy the requirements. These include commercial mobile telephone network, VHF/UHF radio, HF radio, satellite communication system, or provision for connection to a central facility, e.g., command module. Installation and operating costs and availability in remote areas will be considered. Hardwiring shall be shielded to minimize interference or interruption of transmission.

Consideration should be given to fiberoptic cable, especially for data transmission.

11.5.3.6 Transfer Pipes and Encasements: Doublewalled pipes or pipes within a secondary confinement structure encasement shall be used in all areas where the primary pipe leaves the facility. In areas within the facility, the use of double-walled pipe shall be considered. Leakage monitoring shall be provided to detect leakage into the space between the primary pipe and the secondary confinement barrier.

11.5.4 Environmental:

11.5.4.1 Insulation: Foam-in-place or other suitable insulation shall be used. Loose fill will not be used. Insulation shall comply with UBC Chapter 17. Thermal insulation shall be moisture resistant and fire retardant. The thermal resistance of insulation and the degradation of thermal resistance over time will be considered in the selection of the type of insulation provided. As a minimum, the thermal transmittance values ("U" values) and overall maximum allowable combined transmittance values shall not exceed those values as determined from ASHRAE Standard 90.

11.5.4.2 Temperature and Humidity Control Systems: Internal temperature will be maintainable below 75° F with external temperature up to 125° F and maintained above 65° F when external temperature is down to -30° F. Humidity will be controlled to allow comfort (30 to 60%).

11.5.4.3 Air-intake Filtration: HEPA and charcoal filters shall be placed in-line in the air-intake portals. HEPA filters for inhabited spaces shall comply with ARI 850. In addition, an activated charcoal filter will be provided for the removal of volatile chemicals. Adsorbers for toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510. A minimum of 20 - 30ft^3/min/person fresh air will be provided.

11.5.4.4 Air-exhaust Filtration: HEPA filtration systems shall be designed with prefilters installed upstream of HEPA filters to extend the HEPA filter's life. The installation of prefilters if filtration requirements and consideration of the filter assembly justifies omission. Filters shall be designed according to the requirements given in DOE project criteria, ASHRAE Equipment handbook, and ACGIH Industrial Ventilation Manual, as applicable. Adsorbers for nuclear or toxic applications shall comply with ERDA 76-21, ASME N509, and ASME N510. Ventilation system must be separate from the ventilation systems that are a part of hot cells or glove boxes.

11.5.4.5 Hoods: Hood faces shall not be located within 10 ft. of the closest air supply or exhaust point. Hoods shall not be located in or along normal traffic routes. An open-faced hood shall be designed and located to provide a minimum air velocity shall be 125 plus or minus 25 linear ft/min over the hood face area. All open-faced hoods shall be designed to provide appropriate face velocity to ensure capture of contaminants in the hood exhaust (see the ACGIH Industrial Ventilation Manual). Exhaust air from a hood shall not be recirculated to occupied areas.

11.5.4.6 Ventilation of Hoods: HEPA filters shall be provided at the interface of the enclosure outlet and the ventilation system to minimize the contamination of ductwork and at the enclosure inlet to prevent movement of contamination within the enclosure to the operating area in the event of a flow reversal. The system shall be designed to automatically ensure adequate inflow of air through a credible breach in the enclosure system. Minimum inward air velocity shall be 125 plus or minus 25 linear ft/min or as determined from guidance provided in the ACGIH Industrial Ventilation Manual. Small enclosure systems with positive-pressure supplied gases shall have positive-acting, pressure relief devices (connected into the exhaust system) to prevent pressurization of the enclosure.

11.5.4.7 Hot Cell: The hot cell should be compartmentalized in the secondary confinement system to isolate high-risk areas. Provisions shall be made to ensure the safe introduction and removal of material and maintenance equipment to and from the hot cell. Space and equipment shall be provided as needed to support accountability, and material control and to meet the performance requirements contained in DOE 5633.3. Exhaust prefilters (see, also, 11.5.4.4) shall be installed in such a manner as to facilitate changing and repairs. Standby filters shall be incorporated for backup protection during filter changes to allow filter changing without shutting down the exhaust fans. Standby filters shall be installed outside the cell and sealed in an acceptable enclosure for direct maintenance. All exhaust systems shall have monitors that will provide an alarm if the concentration of the hazardous material in the exhaust exceeds the limits specified in the facility OSR. Sufficient hold-up capacity shall be provided for the retention of liquid process wastes until they can be analyzed to determine the need for processing or shown to be within acceptable discharge limits. The hot cell shall be shielded as appropriate to maintain occupational radiation exposure ALARA and within the limits specified in DOE 5480.11.

11.5.4.8 Glove Box: Provisions shall be made to ensure the safe introduction and removal of material and maintenance equipment to and from the glove box. Corrosive gases shall be neutralized prior to reaching HEPA off-gas filters. A single filtered exhaust path shall be acceptable when working with low-toxicity materials that do not require dilution. Required exhaust flow rates (for air-ventilated glove boxes) shall have the ability to confine safely in-box contaminants when an access port is opened or a glove ruptures (minimum air velocity of 125 linear ft. per minute).

11.5.4.9 Containment Pressurization: The operating pressure in the primary confinement system shall be negative with respect to the secondary confinement system. Similarly the operating pressure in the secondary confinement system shall be negative with respect to the tertiary confinement system.

11.5.5 Functional Equipment/Systems: All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. All air handling equipment shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. If the air handling equipment and air-distribution system cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems. The mechanical support area will be separate from the laboratory area and will be accessible from the exterior. Systems shall be designed to minimize and isolate vibration resulting from the operation of support equipment.

11.5.5.1 HVAC Equipment: HVAC equipment shall be sized to satisfy the module heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook.

11.5.5.1.1 Air Conditioner: The AC shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. The units should be readily serviceable by most commercial refrigeration/air conditioning companies. The AC unit should be designed to permit sequential starting of its motors to decrease the electrical surge load during the starting phase of the HVAC system.

11.5.5.1.2 Heating Equipment: Heating system should be selected based on consideration of human health and safety requirements, initial costs, operating costs and maintenance costs according to procedures in DOE 3630.1A, 0110-12.7, Building Design Analysis. Any system that might generate CO or CO_2 within the module (open flame) should be discouraged.

11.5.5.1.3 Humidifier/Dehumidifier: The need for a humidifier/dehumidifier should be addressed. An air tight construction with a heat exchange - air ventilation system might address some heating and cooling requirements and humidity requirements.

11.5.5.1.4 Air-intake and Air-exhaust Fans: All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook. Fans shall be located within the ductwork system according to the requirements of AMCA Publication 210 and ACGIH Industrial Ventilation Manual. Motors shall be sized according to \properly calculated BHP fan requirements and shall not be oversized fans and motors. All fans and accessories shall be designed to meet all smoke and flame spread requirements of NFPA 255.

11.5.5.1.5 Thermostat: Air handling and air distribution controls shall comply with DOE 6430.1A, section 1595-6, Control of Air Handling Systems.

11.5.5.2 Power Source: The module shall be designed to operate on external power or on an onboard electrical generator.

11.5.5.2.1 External power: A capability for automatic switchover to the onboard generator will be provided in the event of external power failure. Switchover is to be completed within 2 seconds.

11.5.5.2.2 Electrical Generator: The power system shall be capable of maintaining full operation. The power system shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. The generator will be sized according to the electrical load that will be required in the SSM. For loads greater than 25 KVA, diesel engines shall generally be used. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. Lighting power budget shall be determined in conformance with ASHRAE Standard 90 (see also 11.5.6.5 and 11.5.6.6). The electrical generator shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. For generators with ≤25kVa loads, gasoline or LP gas engines may be used. For loads >25kVa, diesel engines generally should be used. Application of diesel engines shall comply with FCC Technical Report No. 69.

11.5.5.3 Uninterruptible Power Supplies: Application of UPSs shall comply with IEEE 446 or as modified by cognizant DOE authority. UPS installations may be by safety class 1 or standby type dependent on the classification of the loads served.

11.5.5.4 Mechanical Support Space: The mechanical support space shall be located so that it has its own separate opening to the outside which shall consist of two double doors (combined opening

99") with heavy duty hinges and locks. Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. Where mechanical ventilation cannot maintain a satisfactory environment, other cooling systems shall be provided. Exhaust air openings should be located to minimize ambient thermal loads.

11.5.5.5 Fuel Storage Tanks: Total storage capacity for 4 days operation at maximum load without refueling shall be provided. Fuel storage tanks shall comply with API 650.

11.5.6 Operational Equipment:

11.5.6.1 Radioactivity Measurements: Any of several standard instruments discussed below will meet the requirements for gross alpha and beta particle counting and for gamma ray activity determination.

11.5.6.1.1 Sodium Iodide Gamma Detector: Sodium iodide detectors can be used for gamma ray analysis. Efficiency, cost and count-time are trade-offs that need to be considered.

11.5.6.1.2 Germanium Detector: Germanium detectors can be used for gamma ray analysis. Efficiency, cost and count-time are trade-offs that need to be considered.

11.5.6.1.3 Gross Alpha, Beta Detector: Any of several instruments that discriminate between alpha and beta particles will meet the requirement for gross alpha and beta particle counting. Efficiency, cost and count-time are trade-offs that need to be considered.

11.5.6.1.4 Multichannel Analyzer: A multichannel analyzer that meets manufacturer's specifications to meet requirements shall satisfy this requirements.

11.5.6.2 Laboratory Furniture: Furniture shall comply with NFPA 101, Chapter 31 and UBC Chapter 17, as applicable. Standard stock sizes, material, and finishes of a competitive type shall be considered. Base cabinets, bench tops, sinks, and hoods shall have nominal unit lengths that can be interchanged to make up the required combinations. In laboratories handling radioactive materials, the weight of shielding material to be placed on bench tops and hoods shall be considered in specifying bases and cabinets. Most commercial bases and cabinets for laboratory use can support 300-500 pounds per leg or corner. laboratory furniture used for purposes requiring more than the general illumination levels should be designed and equipped to provide local task lighting of the required intensity.

11.5.6.3 Interior Lighting: Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing should be avoided. Lighting design shall consider environmental degradation effects, e.g., dust, to ensure adequate lighting intensities on a long-term basis. Maximum use shall be made of fluorescent and HID lamps. When using HID lighting, careful consideration of the required color rendition shall be made from visual and safety perspectives. Interior lighting systems shall comply with the IES Lighting Handbook. Non-uniform lighting practices shall comply with CFR 101-20.116-2 and with DOE 6430.1A Section 1694 (Energy Conservation).

11.5.6.4 Emergency Lighting: Where high intensity discharge (HID) lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

12. PROTECTED LIVING QUARTERS (PLQ) MODULE (OPTIONAL)

This module provides support for personnel who must be at the site for long periods. The need for protected living quarters is perceived to be infrequent and therefore this module is considered an optional item.

12.1 Purpose: The protected living quarters shall provide a shelter that is safe from external contamination for personnel and equipment and structural support for contents, equipment and personnel.

12.2 PLQ Requirements:

12.2.1 Road Transportable: The PLQ module will meet requirements for road transportation with standard semi, will provide shock and vibration protection for equipment and supplies during transport, and will be easily prepared for transport.

12.2.2 Structural: Structure will provide a protected environment for the performance of the required laboratory functions (see 12.2.6, 12.3.6, 12.4.6, and 12.5.6). Exterior walls and roof will be resistant to damages from extremes of environment. Interior walls and floors will have rigid underlining.

12.2.3 Basic Utilities: Module will be equipped with electrical wiring, plumbing, ductwork, and communications hardwiring.

12.2.4 Environmental Protection: Thermal insulation is required in exterior walls, floors, and ceilings. Clean air input must be provided. Emphasis will be placed on maintaining a comfortable temperature and humidity by air conditioning or heating to meet operational needs.

12.2.5 Functional Requirements: The unit will be self-sustained for heat, air conditioning and electrical supply. Water supply and human waste generation will be addressed.

12.2.6 Operational Requirements: The PLQ requires the amenities for basic living, e.g., eating, sleeping and personal hygiene. Design of the module will address the needs of the personnel to enhance operational performance. The interior will be pleasant, well lighted and suitable for comfortable living. Adequate ventilation will be provided based on the anticipated temperature extremes of the outside environment. Facilities will be provided for personal hygiene and for proper food and waste storage.

12.3 PLQ Performance Requirements:

12.3.1 Road Transportability: The module shall be securely mounted on a fifth-wheel type trailer that shall meet DOT standards for road transportation. The trailer/module shall be equipped with leveling jacks, leveling indicators, and all necessary hook-ups for attachment to a towing vehicle. The module shall meet the requirements contained in CFR Title 49, Subchapter B (Federal Motor Carrier Safety Regulation), Parts 350-399 and other applicable Federal Regulations as well as state and local regulations as appropriate.

12.3.2 Structural: The module must provide adequate strength to withstand the multi-directional forces exhibited in the transportation mode and protection against exterior shock that could occur during transport (see 6.3.1). It must also minimize air infiltration during transportation and be equipped with rub rails of at least heavy duty extruded aluminum and a hydraulic leveling system to facilitate set-up on-site. The overall construction shall be of sufficient quality to minimize vibration and noise in the interior of the module. The module shall have removable steps with a handrail for each door and a ladder securely mounted on the module exterior to provide access to the roof. The module shall have a floor constructed in a manner that prevents water and dust entry. Doors and windows will be functional according to operational needs. Framework will be strong and light weight to minimize overall weight. Structure will be provided with emergency escape capabilities. The overall dimensions will not exceed: length - 48′, height - 13′-6", and width - 8′-6".

12.3.3 Basic Utilities Performance Requirements: A complete water and sanitation system (also see 12.2.6 and 12.3.6) must be provided within the PLQ module. The unit will be equipped to meet electrical and communicational needs. The unit will also be equipped to meet temperature and humidity requirements, see Environmental paragraphs, 12.2.4 and 12.3.4.

12.3.3.1 Electrical Wiring: AC wiring will be provided. Outlets, number and location, will conform to National Electrical Code (NEC).

12.3.3.2 Supply-side Plumbing: Potable water for personnel use will be supplied as an operational supply need; potable water storage for a minimum of 200 gallons will be provided. An external water supply hook-up capability will be provided for potable and non-potable use.

12.3.3.3 Waste-side Plumbing: A system to collect waste water from shower and sink areas and transfer of this collected wastes to a waste water storage tank must be provided. A system for collection and storage (or disposal) of human wastes will also be provided.

12.3.3.4 Ductwork: Distribution ductwork shall be provided to distribute air to living, working, galley, dress area, and bath and toilet areas and to exhaust air from the module. Outlets from air supply ducts shall be fitted with closable louvers. If multiple blower/filter units are installed, there should be cross ductwork to permit some flexibility of operation and increased reliability.

12.3.3.5 Communications: Interior communications shall be designed to use standard, commercially available telephone, CB, cellular, and satellite communication equipment. An external communication capability will be provided.

12.3.4 Environmental: Insulation will be at least R-11 (walls), R-19 (ceiling), R-11 doors and R-19 (floors). Insulation shall comply with UBC Chapter 17 and will be moisture resistant. Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90. Complete HEPA and charcoal filtration of air intake will be provided. Provisions must be made to minimize the risk of undue exposure of personnel to potentially hazardous materials that might be contained in the clean-up site. A climate control system shall be provided to maintain temperature and humidity at an acceptable level.

12.3.5 Functional Performance Requirements: All HVAC equipment shall meet the performance and efficiency standards of ASHRE Standard 90, section 6. Potable water needs must be supplied internally for personnel use. A mechanical support area, separate from the living/working area will be provided.

12.3.6 Operational Performance Requirements: Human engineering criteria will be applied to optimize man/machine interfaces. Bathing and toilet facilities shall be provided. Provision will be made for water storage, water delivery, and waste storage for drinking, cooking, showering/bathing, and sanitary needs. Storage of personal items will be made available. A one piece refrigerator, oven, stove and storage for cooking and food storage must also be provided. Lighting will be available in accordance with the task to be performed in a particular space. A contrast in lighting will be achieved through the use of various color schemes within the module.

12.4 PLQ Major Equipment/Subunit Requirements:

12.4.1 Road Transportability Items: Trailer/module will be a fifth-wheel type frame that shall meet DOT standards for road transportation. The trailer shall have tandem axle dual wheels. The braking system shall be vacuum over hydraulic type, capable of stopping the trailer/module in case of accidental detachment from the towing vehicle.

12.4.2 Structural: One single door for operational use of module and one double door for large equipment movement are required. Subject to laboratory design, window(s) are required.

Walls, floors and ceilings will have a finished interior surface. Windows will be abrasion resistant and provide emergency escape capability.

12.4.3 Basic Utilities Systems:

12.4.3.1 Electrical Wiring: At least 4 circuits with circuit breakers are required. Outlets will be not less than 8 feet apart; closer in potentially heavy use area, i.e., kitchen area.

12.4.3.2 Supply-side Plumbing: A supply side water distribution system shall be provided. Fixtures appropriate for a living quarters will be provided.

12.4.3.3 Waste-side Plumbing: A waste water collection and storage system will be provided.

12.4.3.4 Ductwork: Ductwork systems will provide efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy and duct size. Ductwork must be designed to resist corrosive contaminants.

12.4.3.5 Communications: The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B Provisions for voice and data transmission will be made. Provisions for telephone hook-up and hardwiring for computers will be provided.

12.4.4 Environmental: The ventilation-exhaust systems shall be provided for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists and excessive heat and for the provision of fresh air to the occupants.

12.4.4.1 Insulation: Insulation is required in module construction for the reduction of fire hazard and protection from heat or cold. The building envelope shall meet the minimum prescriptive energy requirements of ASHRAE Standard 90.

12.4.4.2 Climate Control Systems: An effective climate control system shall maintain temperature and humidity at an acceptable level. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 3.2.4.5.

12.4.4.3 Air-intake Filtration: Air-intake portals shall be provided with a filtration system to remove potentially harmful particulates and volatile chemicals.

12.4.5 Functional Equipment/Systems: The module power and emergency systems shall serve loads set forth in NFPA 110. Additional standby systems shall be provided to support systems or equipment components that are vital for protection of health, life, property, and safeguards. Uninterruptable power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. Power generating areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain ambient temperatures for equipment operation or personnel access.

12.4.5.1 HVAC Equipment: HVAC equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook. Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in DOE 6430.1A, Section 1595.

12.4.5.2 Electrical Supply System: A reliable energy supply must be provided for the PLQ.

12.4.5.3 Uninterruptible Power Supplies: Uninterruptable power supplies shall be provided for those loads requiring guaranteed continuous power.

12.4.5.4 Mechanical Support Space: A space separate from the operational area of the module is required to house the mechanical equipment, e.g., generator, HVAC, heat pump.

12.4.6 Operational Equipment/Systems:

12.4.6.1 Hygiene Facilities Requirement: Hygiene facilities will be provided for personal grooming, bathing and elimination of human waste. Storage capability for waste water and human wastes must be provided.

12.4.6.2 Personal Storage Requirement: Each crew member will be provided individual lockers.

12.4.6.3 Food and Storage: Eating, cooking and storage space for six crew persons is required.

12.4.6.4 Furniture: Furniture for eating, sleeping and relaxing are required.

12.4.6.5 Interior Lighting: Adequate interior lighting to ensure effective performance is required in all work areas.

12.4.6.6 Emergency Lighting: Emergency lighting systems, including exit lights, shall be provided as required by NFPA 101.

12.5 PLQ Major Equipment/Subunit Performance Requirements:

12.5.1 Trailer Frame Structure: Structural systems for highway structures shall be consistent with the requirements of AASHTO HB-13. The fifth wheel height will be 47½". It will be equipped with suspension air ride, tubular axles with oil seals and single anchor line, and brakes to meet F.M.V.S.S. Aluminum material used shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2. The unifying weight-carrying framework (that also provides the floor support for the attached module, see 6.5.2) will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Use of steel shall comply UBC, AISC S326, AISC M011, AISI Specifications for the Design of Cold-Formed Steel Structural Members, and with AISC N690.

12.5.2 Structural Equipment/Systems: Aluminum material used in structure shall comply with AASHTO HB-13 and AASHTO LTS-1. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.

12.5.2.1 Module Frame Structure: The module will have a framework of extruded aluminum with aluminum sheet paneling on the exterior walls. The floor framework will consist of steel, wide flange "I" beams with fabricated steel cross-members with appropriate overlayments. Frame support posts will be aluminum, hi-ten double slotted series. All exterior exposed surfaces will be protected against corrosion and will have a finished look appropriate for the structure. The roof will be one piece aluminum bonded to hat section bows. Interior wall lining and roof lining will be plywood. Floor will be lightweight and solid, and a chemical resistant floor will cover the hard underlayment. Materials, framing systems, and details shall be compatible with clear space and span requirements, serviceability requirements, security requirements, climatic conditions, and structural design loads. Unit weights of materials shall be those given for highway structures by AASHTO standards. Live loads for highway structures shall be as stipulated in AASHTO HB-13. Unless stipulated otherwise, an HS 20-44 loading shall be used. Structure shall meet wind loads for highway structures as stipulated in AASHTO HB-13. The earthquake loads for highway structures shall be as stipulated in AASHTO HB-13 and AASHTO GSDB. Other loads for highway structures shall be as stipulated in AASHTO HB-13. Combination of loads and design requirements for highway structures shall be as stipulated in AASHTO HB-13. Structural systems for highway structures shall be consistent with the requirements of AASHTO BB-13.

12.5.2.2 Doors and Windows: Doors and windows shall be corrosion-resistant or protected against corrosion. Windows and doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings and floors. Door and window hardware shall comply with ANSI A156 series.

12.5.2.2.1 Doors: Doors will be 36" wide and be equipped with abrasion resistant windows, e.g., low-E tempered glass with a lexan outer cover. An overlapping molding is required where the paired double doors meet, Door jambs will be reinforced to make it more difficult to open by wedge or similar tools.

12.5.2.2.2 Windows: Windows shall be made of insulated low-E tempered glass with a lexan outer cover and will be at least 30" x 30" to meet escape hatch requirement. Windows shall comply with NFPA 101, chapter 22. Window cleaning provisions shall comply with ANSI A39.1. Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc. Aluminum windows shall comply with AAMA 101.

12.5.2.3 Walls, Floors and Ceilings:

12.5.2.3.1 Walls, Floors and Ceilings, General Requirements: Interior walls will be fire retardant and resist mild acids, alkalis and fumes. Floors will be easy to clean and resistant to mild chemicals. Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering. Carpet, if used, shall comply with CRI Carpet Specifiers Handbook and CRI Standard for Installation of Textile Floor Covering Materials. Wall, floor, and ceiling, and roof and ceiling assemblies shall be tested by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Units shall be equipped with smoke/heat alarms. Appropriately rated fire extinguishers will be provided.

12.5.2.3.2 Hygiene Facilities: Waterproofing shall be used at walls, floors, and other building elements to prevent water leakage from showers, areas using water washdown, and other types of water basins. Where water is to be contained, waterproofing shall extend up walls above the expected high water level. Where water washdown is used, waterproofing shall extend to fully cover the expected wall areas to be washed. Wall, floor, and other building element waterproofing shall meet base-course and through-the-wall flashings, and shall make a bond with these flashings.

12.5.2.4 Louvers, Vents, Grills, and Screens: Louvers, vents, grills, and screens shall be corrosion-resistant or protected against corrosion.

12.5.3 Basic Utilities Systems:

12.5.3.1 Electrical Wiring: Fifteen and twenty amp circuits, consistent with NEC will be provided. Wire shall be not smaller than No. 12-2 copper with ground. Receptacles and switches shall comply with general grade as defined in FS W-C-596. Receptacle circuits shall be provided with ground-fault circuit interrupters as directed by NFPA 70; receptacle circuits that serve receptacles that are within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters. .

12.5.3.2 Supply-side Plumbing: Plumbing shall comply with the NSPC , ASHRAE Handbooks, and ASHRAE Standard 90. Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. Type L copper tubing, CPVC, or PB plastic pipe and tubing may be used. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe or tubing shall be solvent cemented or shall use other forms of joining such as electric heat fusion. Stop valves shall be provided at each fixture. All fixtures shall comply with FS WW-P-541.

12.5.3.3 Waste-side Plumbing: Water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100. ABS or PVC plastic pipe may be used. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Toilet facility alternatives should be considered. Provision for the collection and storage of other non-hazardous or non-radioactive wastes shall also be provided, as appropriate.

12.5.3.4 Ductwork: Ductwork systems will meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following:

- ASHRAE Fundamentals Handbook
- SMACNA HVAC Duct Construction Standards-Metal and Flexible
- SMACNA Fibrous Glass Duct Construction Standards
- SMACNA Round Industrial Duct Construction Standards
- SMACNA HVAC Duct Design Manual
- ACGIH Industrial Ventilation Manual
- NFPA 45
- NFPA 90A
- NFPA 91 (exhaust ductwork)
- NFPA 96 (kitchen exhaust systems)
- ERDA 76-21

Ductwork that handles air exhausted from moisture generating areas shall be of aluminum construction, have welded joints and seams, and have drainage at low points. Ductwork thermal insulation shall comply with ASHRAE Standard 90 and shall be acoustically insulated to meet acceptable noise criteria. Ducting should be arranged so that outside air can be passed through appropriate filter systems (see 12.2.4 and 12.3.4).

12.5.3.5 Communications: Various methods will satisfy the requirements. These include commercial mobile telephone network, VHF/UHF radio, HF radio, satellite communication system, or provision for connection to a central facility, e.g., command module. Installation and operating costs and availability in remote areas will be considered. Hardwiring shall be shielded to minimize interference or interruption of transmission. Consideration should be given to fiberoptic cable, especially for data transmission.

12.5.4 Environmental:

12.5.4.1 Insulation: Foam-in-place or other suitable insulation shall be used. Loose fill will not be used. Insulation shall comply with UBC Chapter 17. Thermal insulation shall be moisture resistant and fire retardant. The thermal resistance of insulation and the degradation of thermal resistance over time will be considered in the selection of the type of insulation provided. As a minimum, the thermal transmittance values ("U" values) and overall maximum allowable combined transmittance values shall not exceed those values as determined from ASHRAE Standard 90.

12.5.4.2 Temperature and Humidity Control Systems: Internal temperature will be maintainable below 75° F with external temperature up to 125° F and maintained above 65° F when external temperature is down to -30° F. Humidity will be controlled to allow comfort (30 to 60%).

12.5.4.3 Air-intake Filtration: HEPA and charcoal filters shall be placed in-line in the air-intake portals. HEPA filters for inhabited spaces shall comply with ARI 850. In addition, an activated charcoal filter will be provided for the removal of volatile chemicals. efficiency? A minimum of 20 - 30ft^3/min/person fresh air will be provided.

12.5.5 Functional Equipment/Systems: All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. All air handling equipment shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. If the air handling equipment and air-distribution system cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems. The mechanical support area will be separate from the living/working area and will be accessible from the exterior. Systems shall be designed to minimize and isolate vibration resulting from the operation of support equipment.

12.5.5.1 HVAC Equipment: HVAC equipment shall be sized to satisfy the module heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Equipment Handbook, ASHRAE Systems Handbook, ASHRAE Applications Handbook and ASHRAE Refrigeration Handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and the appropriate chapters of the ASHRAE Fundamentals Handbook.

12.5.5.1.1 Air Conditioner: The AC shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6. The units should be readily serviceable by most commercial refrigeration/air conditioning companies. The AC unit should be designed to permit sequential starting of its motors to decrease the electrical surge load during the starting phase of the HVAC system.

12.5.5.1.2 Heating Equipment: Heating system should be selected based on consideration of human health and safety requirements, initial costs, operating costs and maintenance costs according to procedures in DOE 3630.1A, 0110-12.7, Building Design Analysis. Any system that might generate CO or CO_2 within the module (open flame) should be discouraged.

12.5.5.1.3 Humidifier/Dehumidifier: The need for a humidifier/dehumidifier should be addressed. An air tight construction with a heat exchange - air ventilation system might address some heating and cooling requirements and humidity requirements.

12.5.5.1.4 Air-intake and Air-exhaust Fans: All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook. Fans shall be located within the ductwork system according to the requirements of AMCA Publication 210 and ACGIH Industrial Ventilation Manual. Motors shall be sized according to properly calculated BHP fan requirements and shall not be oversized fans and motors. All fans and accessories shall be designed to meet all smoke and flame spread requirements of NFPA 255.

12.5.5.1.5 Thermostat: Air handling and air distribution controls shall comply with DOE 6430.1A, section 1595-6, Control of Air Handling Systems.

12.5.5.2 Power Source: The module shall be designed to operate on external power or on an onboard electrical generator.

12.5.5.2.1 External Power: A capability for automatic switchover to the onboard generator will be provided in the event of external power failure. Switchover is to be completed within 2 seconds.

12.5.5.2.2 Electrical Generator: The power system shall be capable of maintaining full operation. The power system shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. The generator will be sized according to the electrical load that will be required in the OCC. For loads greater than 25 KVA, diesel engines shall generally be used. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. Lighting power budget shall be determined in conformance with ASHRAE Standard 90 (see also 12.5.6.5 and 12.5.6.6). The electrical generator shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. For generators with ≤25kVa loads, gasoline or LP gas engines may be used. For loads >25kVa, diesel engines generally should be used. Application of diesel engines shall comply with FCC Technical Report No. 69.

12.5.5.3 Uninterruptible Power Supplies: Application of UPSs shall comply with IEEE 446 or as modified by cognizant DOE authority. UPS installations may be by safety class 1 or standby type dependent on the classification of the loads served.

12.5.5.4 Mechanical Support Space: The mechanical support space shall be located so that it has its own separate opening to the outside which shall consist of two double doors (combined opening 99") with heavy duty hinges and locks. Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. Where mechanical ventilation cannot maintain a satisfactory environment, other cooling systems shall be provided. Exhaust air openings should be located to minimize ambient thermal loads.

12.5.5.5 Fuel Storage Tanks: Total storage capacity for 4 days operation at maximum load without refueling shall be provided. Fuel storage tanks shall comply with API 650.

12.5.6 Operational Equipment:

12.5.6.1 Hygiene Facilities: A sink with hot/cold running water and a mirror for personal grooming will be provided. A shower stall with hot/cold running water will be provided. A toilet will be provided that meets contemporary U.S. standards of living. A system for collecting and storing waste water and human wastes must be provided, see 12.5.3.

12.5.6.2 Lockers: Lockers shall be of rigid, moisture resistant material, providing full length storage and accessibility. A louvered ventilation system should also be considered. A positive latching mechanism with a locking provision shall also be included.

12.5.6.3 Dining and Food Preparation and Storage: A minimum of 12 linear feet of eating space will be provided. Table top will be impervious to water and resistant to mild acids, alkalis and chemicals. Chairs will be comfort-oriented and durable. Food preparation facilities will consist, at a minimum, of one refrigerator, stove top with cover for food preparation, oven, sink area, microwave oven, under-counter freezer, food storage cabinets and closets, and tableware. A second refrigerator to increase food variety and additional food and drink storage and food preparation space is desirable.

12.5.6.4 Furniture: Furniture for eating, sleeping and relaxing will conform to practical norms for short term occupation. Consideration will be given to dual-use furniture and furniture arrangement. Furniture systems shall comply with NFPA 101, Chapter 31 (furnishings, decorations, and treated finishes) and UBC, Chapter 17 (folding, portable and movable partitions).

12.5.6.5 Interior Lighting: Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing should be avoided. Lighting design shall consider environmental degradation effects, e.g., dust, to ensure adequate lighting intensities on a long-term basis. Maximum use shall be made of fluorescent and HID lamps. When using HID lighting, careful consideration of the required color rendition shall be made from visual and safety perspectives. Interior lighting systems shall comply with the IES Lighting Handbook. Non-uniform lighting practices shall comply with CFR 101-20.116-2 and with DOE 6430.1A Section 1694 (Energy Conservation).

12.5.6.6 Emergency Lighting: Where high intensity discharge (HID) lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

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